Lagunitas Creek Stewardship Plan

Marin Municipal Water District

Final – June 2011

MARIN MUNICIPAL
WATER DISTRICT

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Acknowledgements

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Acronyms, Abbreviations, and Terms

Acronyms & Abbreviations

CESA	California Endangered Species Act
cfs	Cubic Feet per Second/Cubic Foot per Second
COE	U.S. Department of the Army, Corps of Engineers
DFG	California Department of Fish and Game
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FL	Fork Length
FishNet4C	Fishery Network of the Central California Coastal Counties
GPS	Global Positioning System
HSA	Hydrologic Subarea
IRWMP	Integrated Regional Water Management Program
MMWD	Marin Municipal Water District
NOAA	National Oceanic and Atmospheric Administration
NMFS	National Marin Fisheries Service
NPS	National Park Service
RCD	Marin County Resource Conservation District
RWQCB	San Francisco Regional Water Quality Control Board
SPAWN	Salmon Protection and Watershed Network
State Parks	California Department of Parks and Recreation
SWRCB	California State Water Resources Control Board
TAC	Lagunitas Creek Technical Advisory Committee
TBWC	Tomales Bay Watershed Council
TU	Trout Unlimited
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geologic Survey
WSP	Watershed Stewards Project (AmeriCorps)
YOY	young of the year (salmonids)

Terms

Aquatic Resources – Mainly refers to coho, steelhead, and California freshwater shrimp populations but may also include other fish and aquatic species.

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Executive Summary

This plan addresses actions to be taken by the Marin Municipal Water District (MMWD, District) to manage the habitat of Lagunitas Creek for the benefit of the aquatic resource populations of coho salmon, steelhead, and California freshwater shrimp. This is a planning document, intended to describe ongoing and approved actions as well as future actions which the District Board of Directors has not yet approved, adopted, or funded, but which will provide a basis for the Board adopting, approving and funding over the next ten year time period. This final plan has been prepared following consideration of comments received on a public review draft plan, released on December 15, 2010.

The District operates seven water supply reservoirs in Marin County, five of which are within the Lagunitas Creek watershed. The District diverts water from the Lagunitas Creek basin to supply water for over 190,000 residents in southern and central Marin County. The State Water Resources Control Board (SWRCB) regulates these diversions. In 1995, the SWRCB issued Order WR95-17 which stipulates actions MMWD must take to mitigate impacts to the fishery resources of Lagunitas Creek from the operations of Kent Lake, formed by the raising of Peters Dam.

In 1997, MMWD developed the *Lagunitas Creek Sediment and Riparian Management Plan* (MMWD 1997). The plan was developed and implemented in response to SWRCB Order WR95-17. That plan was established as a ten-year plan. The ten-year milestone was reached in September of 2007. While MMWD's role and responsibility for aquatic resource management in Lagunitas Creek did not end then, it marked a time for MMWD to re-set its actions into the future. This Stewardship Plan lays out those actions, as a feasibility and planning tool, for the purposes of future budgeting and to provide District staff direction on actions to pursue.

There are a number of enhancement actions MMWD is currently involved in. These are projects the District Board has already approved, that have already undergone environmental review and permitting, and that staff has begun to implement. These projects have identical goals and objectives as the future actions identified in this Stewardship Plan. The future actions will go through environmental review and permitting as they are implemented.

This plan is composed of eight sections: introduction, background, stewardship goals, stewardship actions, schedule, consistency with other plans, costs, and references. The heart of the plan is presented in the stewardship actions section (Section 4). The actions in the plan are listed below and reviewed in Table ES-1.

The Stewardship Plan has ten distinct implementation elements:

1. Ongoing mandatory requirements of SWRCB Order WR95-17;
2. Winter habitat enhancement;
3. Sediment reduction and management;
4. Instream and riparian habitat enhancement;
5. Biotechnical bank stabilization;
6. California freshwater shrimp habitat enhancement;
7. Monitoring;
8. Aquatic Invasive species management;
9. Programs and policies; and
10. Collaboration and outreach

The goals and targets for this plan are focused on habitat enhancement, monitoring, outreach, and policy. They are consistent with the goals and objectives of other aquatic resource management and recovery plans developed for the region. While the ultimate goal of habitat enhancement actions is to increase and stabilize the populations of coho, steelhead, and California freshwater shrimp, this plan does not specifying any numeric targets for coho, steelhead, or shrimp. We have attempted to describe goals that can be quantified and evaluated, however, in many instances the goals state more of a process to pursue than a quantifiable condition to achieve. These goals and targets are what the District will work to achieve and the actions described in this plan will be beneficial to the aquatic resources of Lagunitas Creek.

MMWD's approach to implementing the plan has been to group the actions into one of three categories of District involvement. These categories are characterized as:

1. On-Going Mandatory Requirements of SWRCB Order WR95-17;
2. Actions MMWD will lead; and
3. Actions MMWD will participate in but may not lead.

This plan is intended to cover the ten-year period of 2011 – 2020. The actions will be implemented over that period, with some actions occurring annually over the full ten year time period, some occurring every other year, and others being implementing within the first five years.

The actions are intended to be implemented in an integrated and adaptive manner. The goals and specific measures of one element of the plan will dovetail with those of another element. The actions will not be implemented in isolation from one another but rather conducted in concert with each other. In addition, MMWD will seek to collaborate with and integrate its actions with those of the other stakeholders who are conducting related actions in the watershed. It is anticipated that most of the actions will be coordinated through the Lagunitas Creek Technical Advisory Committee (TAC) and in conjunction with State and federal recovery efforts for coho, steelhead, and freshwater shrimp.

The ten-year cost for implementing the actions in the plan is estimated at $7.8 million, as summarized in Table ES-2. MMWD will have significant staff commitments dedicated to the implementation of the plan and the District will make other financial contributions. MMWD will also seek grants and other funding sources for many, but not all, of the actions described in the plan. The District will pursue these actions in collaboration with other entities involved with Lagunitas Creek. In some cases, other stakeholders will likely lead implementation of some actions, with District participation. The Stewardship Plan is a guide to protect and enhance the aquatic resources of Lagunitas Creek.

LAGUNITAS CREEK STEWARDSHIP PLAN - Marin Municipal Water District (MMWD)

- MMWD will pursue these activities under the Lagunitas Creek Stewardship Plan.
- MMWD will pursue these actions in collaboration with other entities involved with Lagunitas Creek.
- MMWD will seek grants and other funding sources for these actions, along with commitments of staff time and finacial contributions.

ELEMENT	ACTION	DESCRIPTION	Collaborators
Category 1: On-Going Mandatory Requirements of SWRCB Order WR95-17.			
Compliance with Ongoing Requirements of WR95-17	Instream Flows	Maintain the minimum flows at the SP Taylor stream gage, per the schedule specified in Order WR95-17.	SWRCB
"	Upstream Migration Flows	Ensure that four upstream migration flows are provided between Nov. 1st and Feb. 3rd each year, as stipulated in Order WR95-17	SWRCB
"	Water Year Classification	Determine the water year classification, as a normal or dry year, and maintain stream flows under the normal or dry year requirements of Order WR95-17.	SWRCB
"	Water Temperature	Ensure sufficient water releases are made from Kent Lake, into Lagunitas Creek, to meet and maintain the minimum stream flows at the SP Taylor gage and that mean daily water temperatures at the gage are being recorded and reported.	SWRCB
"	Special Circumstances	Follow the Special Circumstance reporting procedures of Order WR95-17 if the stream flow and/or water temperature conditions of the Order cannot be met.	SWRCB, DFG, NMFS, USFWS
"	Ramping	Control releases from Kent Lake in order to minimize rapid changes in flow in Lagunitas Creek.	SWRCB
"	Gages	Ensure that the USGS stream gage at SP Taylor Park remains in operation and that the mean daily stream flow and temperature of Lagunitas Creek are recorded through continuous monitoring.	SWRCB, USGS, State Parks
"	Reporting	Compile and submit an annual report to the SWRCB, describing MMWD's activities and compliance with Order WR95-17.	SWRCB

Table ES-1. Summary of actions for the Lagunitas Creek Stewardship Plan.

ELEMENT	ACTION	DESCRIPTION	Collaborators
Category 2: Actions MMWD Will Lead.			
Winter Habitat Enhancement	Winter Habitat Enhancement - Assessment	Conduct a two-phase concept & design assessment of Lagunitas Creek and lower Olema Creek to enhance overwinter habitat for salmonids.	Fish & Game, USFWS, NPS, State Parks, NOAA
Sediment Reduction and Management	Sediment Source Treatments in the Watershed	Implements prescribed sediment reduction treatments at priority road-related sites in Lagunitas Creek watershed, under the 319(h) Lagunitas Cr. Water Quality & Habitat Improvement Project - Cheda Cr., McIsaac Cr., Cross-Marin Trail, and Dog Creek.	SWRCB, RWQCB, State Parks, NPS
"	Sediment Source Roads Assessment	Complete a comprehensive assessment of unpaved roads in the Lagunitas Creek Watershed, including a site inventory and prioritizing sediment source repair sites on about 105 miles of unpaved roads, under the Lagunitas Cr. Roads Assessment Project.	DFG, NOAA, State Parks, NPS, RCD
"	Sediment Source Management Roads GIS	Update the GIS of roads in the Lagunitas Creek watershed, completed in 2007, with new information on road assessments, treatments, and maintenance.	Marin County, NPS, State Parks, RCD, SPAWN
"	Sediment Source Treatments in the Watershed	Implement repairs at some of the sediment source sites identified in previous watershed assessments; focus on roads and other human-induced erosion sites, on public lands in the mainstem Lagunitas Creek watershed between Peters Dam and Nicasio Creek.	State Parks, NPS
"	Streambed Gravel Management	Evaluate goals and opportunities for gravel augmentation and enhancement in Lagunitas Creek and tributaries; implement a gravel management strategy in mainsteam Laguntias Creek.	TAC
Instream & Riparian Habitat Enhancement	Rearing Habitat Enhancement with Large Woody Debris (LWD)	Install and maintain LWD structures in mainstem Lagunitas Creek, downstream of Peters Dam and through S.P. Tayor State Park and on MMWD lands along San Geronimo Creek.	State Parks
"	Riparian Vegetation Enhancement	Plant and maitain native riparian vegetation between Peters Dam and Shafter Bridge, under the Mt. Tamalpais Watershed Gateway Project and future efforts.	Coast Conservancy, Resources Agency, SPAWN
Biotechnical Bank Stabilization	Biotechnical Bank Stabilization - Lagunitas Booster Station	Develop and implement biotechnical bank stabilization on San Geronimo Creek at MMWDs Lagunitas Booster Station site; coupled with water discharge dissipation from the site.	n/a
"	Biotechnical Bank Stabilization - Below Peters Dam	Develop and implement biotechnical bank stabilization and riparian revegetation at Below Peters Dam site.	n/a
Ca. Freshwater Shrimp Habitat Enhancement	Freshwater Shrimp Habitat Enhancement - Assessment	Data review and evaluation to develop habitat enhancement measures specifically designed to benefit freshwater shrimp.	USFWS, USGS, NPS, State Parks
Survey & Monitoring	Survey & Monitoring Workgroup	Coordinate monitoring surveys and protocols for consistent methodologies and data sharing.	TAC, TBWC
"	Stream Flow Monitoring	Conduct continous monitoring of stream flow at two gages: the USGS gage at Point Reyes Station, on Lagunitas Creek; and the MMWD gage Lagunitas Rd. on San Geronimo Creek.	USGS, NPS, County, North Marin Water District
"	Juvenile Salmonid Surveys	Annual juvenile salmonid survey; mainstem Lagunitas Creek, mainstem San Geronimo Creek, and Devil's Gulch.	NPS
"	Salmon Spawner Surveys	Annual salmon spawner survey; mainstem Lagunitas Creek, mainstem San Geronimo Creek, and Devil's Gulch.	NPS, SPAWN

Table ES-1. Summary of actions for the Lagunitas Creek Stewardship Plan.

ELEMENT	ACTION	DESCRIPTION	Collaborators
Survey & Monitoring	Salmon Smolt Surveys	Annual salmon smolt survey; mainstem Lagunitas Creek.	NPS, SPAWN
"	Salmon Winter Survey	Conduct a juvenile coho winter habitat utilization study in Lagunitas Creek, including track movement of PIT tagged fish.	State Parks, NPS, TAC
"	Salmon Fry Emergence Survey	Investigate conducting another emergence study to further investigate the question of juvenile mortality during the emergence stage, as a potential limiting factor.	State Parks, NPS, TAC
"	California Freshwater Shrimp Surveys	Annual Ca. freshwater shrimp survey; mainstem Lagunitas Creek.	USFWS
"	Habitat Typing Surveys	Habitat typing surveys every 5 years through Lagunitas Creek, San Geronimo Creek, and Devil's Gulch.	Fish & Game, AmeriCorps/WSP
"	Sediment & Streambed Monitoring	Sampling in Lagunitas Creek, San Geronimo Creek, and Devil's Gulch for: bed elevation; grain sizes; fine sediments; gravels; and characteristics of large woody debris.	RWQCB
"	Water Quality Monitoring	Monthly grab samples at 4 sites in Lagunitas, Nicasio, and San Geronimo Creek for: Temperature; pH; Turbidity; Alkalinity; Hardness; Copper; Total Suspended Solids; and Settleable Solids	TBWC
"	Project Site Monitoring	Annual inspections of project sites.	TAC
Programs and Policies	Roads MOU	Follow the guidelines and practices included in the MOU for Maintenance and Management of Unpaved Roads in the Lagunitas Creek Watershed.	County. MCOSD, State Parks, NPS, RCD, TAC
"	Woody Debris MOU	Follow the guidelines and practices included in the MOU for Woody Debris Management in Riparian Areas of the Lagunitas Creek Watershed.	County. MCOSD, State Parks, NPS, RCD, TAC
	Mt. Tamalpais Watershed Management Policy	Follow MMWD Board Policy No. 7 - Mt. Tamalpais Watershed Management Policy.	n/a
"	Wells Policy	Revised MMWD Board Policy No. 3 - Wells and other Private Sources Policy; incorporate protection of stream flows into the policy.	TAC
Collaboration and Outreach	Lagunitas TAC	Remain an active participating entity of the TAC; continue to facilitate TAC meetings.	TAC
"	Partnerships & Collaboration	Partnerships and Coordination with other agencies through the Lagunitas Creek TAC, TBWC, North Bay Watershed Association, State & Federal coho & steelhead recovery efforts, and the Bay Area IRWMP Coordinating Committee.	TAC, TBWC, NBWA, and others
"	Public Involvement & Education	Public involvement and outreach through public meetings, volunteer events, participation in Trout-in-the-Classroom, and other educational opportunities	Public, TAC

Table ES-1. Summary of actions for the Lagunitas Creek Stewardship Plan.

ELEMENT	ACTION	DESCRIPTION	Collaborators
Category 3: Actions MMWD Will Participate In But Not Necessarily Lead.			
Winter Habitat Enhancement	Winter Habitat Enhancement - Construction	Construct the winter habitat enhancement features, as designed, in Lagunitas Creek and lower Olema Creek.	Fish & Game, NOAA, NPS, State Parks, RCD
Sediment Reduction and Management	Sediment Source Treatments in the Watershed	Implement repairs at some of the sediment source sites identified in previous watershed assessments, focus on roads and other human-induced erosion sites, in the San Geronimo Valley and Olema Creek.	County. MCOSD, State Parks, NPS, RCD
"	Streambed Gravel Management	Implement a gravel management strategy in the tributaries to Laguitas Creek.	TAC
Instream & Riparian Habitat Enhancement	Rearing Habitat Enhancement with Large Woody Debris (LWD)	Install and maintain LWD structures in mainstem Lagunitas Creek, downstream of S.P. Taylor State Park, and in Devil's Gulch.	State Parks, NPS, TU
"	Devil's Gulch Habitat Enhancement	Evaluate, develop, and implement habitat enhancement strategies for Devil's Gulch.	TU, State Parks, NPS, RCD
"	Riparian Vegetation Enhancement	Install native plants along the edge of the stream channel, to enhance habitat for the California freshwater shrimp, at various locations through the lower State Park and Tocaloma reaches of Lagunitas Creek.	USFWS, NPS, State Parks
Biotechnical Bank Stabilization	Biotechnical Bank Stabilization - S.P. Taylor Park	Develop and implement biotechnical bank stabilization and riparian revegetation at Nicasio Transmission Line retaining wall site in S.P. Taylor Park.	State Parks
Ca. Freshwater Shrimp Habitat Enhancement	Freshwater Shrimp Habitat Enhancement - Construction	Installation of habtat enhancement projects, identified in prior assessment, for shrimp habitat enhancement; may include woody debris structures and riparian vegetation plantings along the lower State Park and Tocaloma reaches.	USFWS, USGS, NPS, State Parks
Aquatic Invasive Species (AIS) Management	Early Dectection/Rapid Response	Conduct baseline surveys of AIS and conduct monitoring for detection of New Zealand mud snail, quagga & zebra mussels.	TAC, TBWC
"	Protocols for cleaning, storage, and inspections of field equipment and gear	Develop and put into practice protocols for AIS controls through cleaning, storage, and inspections of field gear and equipment that will enter any water body within the watershed.	TAC, TBWC
"	Education	Develop and provide educational material about AIS; disseminate to all stakeholders and the general public visiting the watershed.	TAC, TBWC
"	Invasive Plant Control	Remove invasive plants from the riparian corridor; target species: cape ivy; take a systematic, piece-meal approach to minimize impacts to existing habitat.	NPS, State Parks, County, SPAWN

Table ES-1. Summary of actions for the Lagunitas Creek Stewardship Plan.

LAGUNITAS CREEK STEWARDSHIP PLAN - Marin Municipal Water District (MMWD)

- MMWD will pursue the actions in the Lagunitas Creek Stewardship Plan in priority.
- MMWD will pursue the actions in collaboration with other entities involved with Lagunitas Creek.
- MMWD will seek grants and other funding sources for the actions, along with commitments of staff time and other finacial contributions.

CATEGORY	DESCRIPTION	TOTAL COST
Category 1	On-Going Mandatory Requirements of SWRCB Order WR95-17.	$215,500
Category 2	Actions MMWD Will Lead.	$5,746,445
Category 3	Actions MMWD Will Participate In But Not Necessarily Lead.	$1,832,500
	TOTAL	$7,794,445

Table ES-2. Summary of costs to implement actions in the Lagunitas Creek Stewardship Plan.

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1.0 Introduction

The Lagunitas Creek watershed supports extremely important populations of threatened and endangered coho salmon, steelhead, and California freshwater shrimp. These three species are considered the aquatic resources of Lagunitas Creek that are the focus of this stewardship plan. Other species in the watershed are also important. This plan addresses actions to be taken by the Marin Municipal Water District to manage the habitat of Lagunitas Creek for the benefit of the aquatic resource populations and to monitor the status, trends, and habitat conditions of those populations.

The Marin Municipal Water District (MMWD, District) has been very actively involved in the management of the aquatic resources of Lagunitas Creek since the 1970s. The District operates seven water supply reservoirs in Marin County, five of which are within the Lagunitas Creek watershed. The District diverts water from the Lagunitas Creek basin to supply water for over 190,000 residents in southern and central Marin County. The State Water Resources Control Board (SWRCB) regulates these diversions.

In 1997, MMWD developed the *Lagunitas Creek Sediment and Riparian Management Plan* (MMWD 1997). The plan was developed and implemented in response to an order from the California State Water Resources Control Board (SWRCB) for MMWD's water supply operations. That plan was established as a ten-year plan. The ten-year milestone was reached in September of 2007. While MMWD's role and responsibility for aquatic resource management in Lagunitas Creek did not end in 2007, it marked a time for MMWD to re-establish its actions into the future. This new Stewardship Plan lays out that direction. This document is intended to serve as a feasibility and planning tool, for the purposes of future budgeting and to provide District staff direction for actions to pursue. Some of the actions described here are continuing, ongoing actions and some others are projects that are already underway.

1.1 Outline of the Plan

This plan is composed of eight sections: introduction, background, stewardship goals, stewardship actions, schedule, consistency with other plans, costs, and references. The heart of the plan is presented in the stewardship actions section. The plan first reviews background information on the history of MMWD's involvement with Lagunitas Creek and the biology of the aquatic resources associated with the creek. This section also outlines the rationale for MMWD having an ongoing responsibility for aquatic resource management. In addition, it summarizes the major conclusions and lessons learned from the past 12 years of MMWD activities implemented under the *Lagunitas Creek Sediment and Riparian Management Plan.*

We then describe the goals of the plan. They include goals for optimal habitat conditions as well as goals related habitat enhancement, monitoring, outreach, and policy. We also describe the mechanisms to evaluate the goals and actions.

Section 4 describes the stewardship actions of the plan. These are the actions MMWD will be involved with implementing over the next ten-year time period. The actions are organized into ten distinct implementation elements:

1. Ongoing mandatory requirements of SWRCB Order WR95-17;
2. Winter habitat enhancement;
3. Sediment reduction and management;
4. Instream and riparian habitat enhancement;
5. Biotechnical bank stabilization;
6. California freshwater shrimp habitat enhancement;
7. Monitoring;
8. Aquatic Invasive species management;
9. Programs and policies; and
10. Collaboration and outreach

For each action, we describe the District's planned involvement with implementing the action, which are grouped into one of three categories:

1. On-Going Mandatory Requirements of SWRCB Order WR95-17;
2. Actions MMWD will lead; and
3. Actions MMWD will participate in but may not lead.

Following the description of the stewardship actions, we review the anticipated schedule for implementing the actions. We then present a brief discussion of the consistency of this plan with other, similar plans and programs covering the Lagunitas Creek watershed. The plan concludes with cost estimates and opportunities for funding.

2.0 Background

2.1 History of the District's Involvement with Lagunitas Creek

A chronology of events for MMWD and the Lagunitas Creek watershed is presented in Table 1.

In 1912, MMWD received its charter as the first municipal water district in California. Until then, water in central and southern Marin was provided by a number of small, unrelated companies, many of which were subsidiaries of real estate developers. Prior to MMWD being formed, Lagunitas Dam was built in 1872 by the Marin County Water Company to form Lake Lagunitas; when completed, the dam was the third largest on the West Coast. Lagunitas Dam was followed by the construction of Alpine Dam in 1918, Bon Tempe Dam in 1948, Peters Dam in 1953, and Seeger Dam (which formed Nicasio Reservoir) in 1960.

Peters Dam forms Kent Lake and is MMWD's largest reservoir. The dam was built without a fish ladder and it marks the upstream limit of anadromous fish migration in the main stem of Lagunitas Creek. Nicasio Reservoir, formed by Seeger Dam, is situated on Nicasio Creek, the largest tributary to Lagunitas Creek. Peters Dam and Seeger Dam block anadromous salmonid fish passage to about 50% of their historically available habitat. Upstream of Kent Lake are Alpine Dam, Bon Tempe Dam, and Lagunitas Dam which actually blocked fish passage prior to Kent Lake.

MMWD's involvement with Lagunitas Creek dates back to the mid-1970s. Between 1960 and the mid-1970s, the water supply picture for MMWD remained stable. Then, in 1976 and 1977, a severe, two-year drought prompted MMWD to increase water storage capacity within Marin County and to start importing Russian River water from the Sonoma County Water Agency. Water storage was increased by the construction of Soulajule Dam in the Walker Creek drainage and by the raising of Peters Dam in 1982. Peters Dam was raised by 45 feet. This did not double the height of the dam but because Kent Lake is in a long, narrow, deep canyon, it effectively doubled the storage capacity of the reservoir.

The raising of Peters Dam, with the increased water diversion and storage from Lagunitas Creek, is a water rights issue regulated by the SWRCB. In 1982, the SWRCB issued Decision 1582, authorizing the additional diversion of water and directed MMWD to conduct studies of the impacts from the diversion. The primary issues of concern were the impacts to coho, steelhead, and California

freshwater shrimp. The SWRCB indicated that final mitigation measures would be decided upon following the completion of the studies. Throughout the 1980's and early 1990's, the District conducted studies on the fisheries and hydro-geomorphology of Lagunitas Creek. Additional studies were conducted by the California Department of Fish and Game (DFG). Then, beginning in 1990, the SWRCB held water rights hearings that culminated in 1995, with the SWRCB issuing Order WR95-17 (Appendix A).

In its Decision WR95-17, the SWRCB ordered MMWD to develop and implement a ten-year sediment and riparian management plan. The order was intended as mitigation to address the impacts of MMWD water diversions at Kent Lake on Lagunitas Creek and the subsequent deleterious effects to the aquatic resources of the creek. In response to the SWRCB order, MMWD developed the *Lagunitas Creek Sediment and Riparian Management Plan* (MMWD 1997).

The Sediment and Riparian Management Plan included: implementing erosion control projects (sediment source control) throughout the watershed; constructing in-stream, large woody debris structures to enhance habitat within the mainstream channel of Lagunitas Creek; implementing some riparian revegetation and biotechnical bank stabilization projects; conducting numerous and extensive monitoring studies to track aquatic resource population and habitat trends; outreach and collaboration with other agencies and stakeholders through the Lagunitas Creek Technical Advisory Committee (TAC), and spearheading the development of multi-agency policy agreements on managing roads and the riparian corridors within the watershed.

MMWD implemented the Sediment and Riparian Management Plan and carried out the prescribed strategies and projects. Over the course of the ten-year time frame, the District also implemented projects and conducted several assessments that were not tied directly to the Sediment and Riparian Management Plan (i.e., they were not mitigation requirements of the SWRCB Order) but it was very similar type of work that was essentially identical to the goals of the plan.

The District has participated in several important, corollary efforts to protect and enhance the aquatic resources of Lagunitas Creek. The *Recovery Strategy for California Coho Salmon* (DFG 2004) established goals and tasks for all coastal drainages, including specific recommendations for Lagunitas Creek. The Tomales Bay Watershed Council (TBWC) developed the *Tomales Bay Integrated Coastal Watershed Management Plan* (TBWC 2007) which further defined goals and projects for the watershed. In Between 2004 and 2008, the Marin County Resource Conservation District (RCD) conducted the *Lagunitas Limiting Factors Analysis* (Stillwater 2008); funded through the

SWRCB/San Francisco Regional Water Quality Control Board (RWQCB). Marin County developed the *Middle Lagunitas Creek Watershed Sediment Delivery Analysis* (Stillwater 2007); also funded through the SWRCB/San Francisco Regional Water Quality Control Board (RWQCB). In addition, the County developed the *San Geronimo Valley Salmon Enhancement Plan* (Prunuske Chatham, Inc., PCI, 2010). The National Marine Fisheries Service is currently developing recovery plans for coho and steelhead, under the Federal Endangered Species Act. The County's San Geronimo plan and the National Marine Fisheries Service's (NMFS's) draft recovery plans were developed concurrently with the MMWD's development of the Lagunitas Creek Stewardship Plan, although each within its own specific time frame. The District, as well as a host of other agencies, organizations, and individuals have contributed to each of these efforts. In particular, MMWD's monitoring data has been used extensively in these projects and staff participated in review and collaborative discussions for them.

It is fair to say that MMWD has been a leader and important participant in the aquatic resource management of Lagunitas Creek. The period leading up to the issuance of SWRCB Order WR95-17 may have seen MMWD in an adversarial role but the MMWD Board made a decision to settle the matter and move forward. Since that time, MMWD has recognized its responsibilities to participate in the management of aquatic resources of Lagunitas Creek and has been very active in that effort. Many other agencies and organizations have also been actively involved and MMWD welcomes the collaboration to achieve a common goal of sustaining and hopefully increasing the populations of coho, steelhead, and California freshwater shrimp in Lagunitas Creek.

2.2 Reasons for MMWD Involvement with Lagunitas Creek

In reaching the ten-year milestone of implementing the *Lagunitas Creek Sediment and Riparian Management Plan*, MMWD did not assume that its responsibilities for Lagunitas Creek ended. The District has recognized it has a continuing responsibility to manage the aquatic resources of Lagunitas Creek, since its water supply operations continue to have an impact on the creek, downstream of reservoirs.

Aside from a general desire to support efforts to protect and enhance aquatic resources, there are several regulatory stipulations and policy guidelines that provide the basis for MMWD to stay involved with the management of Lagunitas Creek. They include: the SWRCB Order WR95-17, District policy, California Fish and Game Code, the Federal Endangered Species Act and California Endangered Species Act, and Public Trust doctrine. Each of these provisions and principles are reviewed here.

State Water Board Order WR95-17

The SWRCB Order provides the clearest and most direct mandate to MMWD, since it dictates mitigation measures that MMWD must implement for its water supply operations. The Order amended Water Right Permits 5633, 9390, and 18546 and it consists of eleven requirements (Table 2 and Appendix A). Most of the requirements do not have any time frame associated with them, other than perhaps the life of the Peters Dam project. For only three of the requirements (control of sediment, riparian management plan, and monitoring of fishery resources) did the SWRCB indicate a need for plan development and implementation and that these plans could have a ten-year time frame. Thus, the *Lagunitas Creek Sediment and Riparian Management Plan* was set out as a ten-year plan.

The Order established goals for sediment and riparian management and fishery resource monitoring. The goals do not have a time frame associated with them; the goals continue beyond the time period of implementing the sediment and riparian management objectives. Those goals are:

- Control of Sediment: Reduce sedimentation and provide an appreciable improvement in the fishery habitat within the Lagunitas Creek watershed.
- Riparian Management: Improve the riparian vegetation and woody debris within the Lagunitas Creek watershed in order to improve habitat for fishery resources.
- Monitoring Fishery Resources: Monitor the coho salmon, steelhead, and freshwater shrimp populations of Lagunitas Creek.

MMWD Policy

There are two policy statements that establish direction for the District to maintain its involvement in the management of Lagunitas Creek:

- District's Mission and Goals Statement; and
- Mt. Tamalpais Watershed Management Policy

The District's mission statement:

> "*To manage our natural resources in a sustainable manner and to provide our customers with reliable, high quality water at a reasonable price*." (MMWD Board Policy No. 1; revised 2-26-09)

The mission statement clearly articulates a commitment to promote environmental stewardship and sustainability, which includes balancing mandates for safeguarding ecological integrity and water quality. Continued management of Lagunitas Creek is clearly consistent with the District's mission statement.

The Mt. Tamalpais Watershed Management Policy sets priorities for the management of District-owned lands on the Mt. Tamalpais Watershed (which includes the upper portion of the Lagunitas Creek watershed, upstream of Samuel P. Taylor State Park lands). The policy focuses on the protection of water quality as the overriding goal for the management of these watershed lands but it also recognizes the watershed as an important natural resource:

> "*Besides this primary purpose, the watershed is held in trust as a natural wildland of great biological diversity, as scenic open space, and as an area for passive outdoor recreation for Marin and much of the Bay Area*." (MMWD Board Policy No. 7, dated 10-03-01)

The watershed management policy includes specific reference to continued participation in the management of Lagunitas Creek and other streams within the District's sphere of influence:

> "*Fishery Management - Streams: The District will take actions to protect native fishery resources, in streams within the District's sphere of influence, consistent with California public trust doctrine and Fish and Game Code. The District will be an active partner in stream protection and enhancement efforts that other agencies and groups are pursuing in streams within the Districts sphere of influence. The District's sphere of influence includes those streams that are directly affected by the District's land or water management activities. Fishery protection and enhancement activities in Lagunitas Creek, below Kent Lake, complies with California State Water Resource Control Board mandates related to the raising of Peters Dam*."

The other biological diversity sections of the Mt. Tam policy address management on District lands for: protection of species richness and habitats; conservation of special status species; population management; controlling exotic species; pest management, and lake (i.e., reservoir) fishery management. Further, the policy provides guidance for: general use of the watershed; erosion control; fire management; recreational use; and limiting watershed commercial use.

An older District policy that specifically addresses ongoing involvement of the Lagunitas Creek watershed is the policy on Land Use in the Nicasio, Soulajule, and San Geronimo Watersheds.

> "*The Marin Municipal Water District must protect water quality within the watershed of its several potable water supply reservoirs. It intends to protect and enhance the fishery habitat of Lagunitas and Walker Creeks*." (MMWD Board Policy No. 14; reviewed 1/26/94)

Collectively, these District policies provide the foundation for an agency that is engaged and active in the management of watershed resources, including and specifically relating to the aquatic resources of Lagunitas Creek.

Fish & Game Code

The District must ensure that its operations and management efforts are in compliance with Fish and Game Code. Fish and Game Code, Section 1600, establishes State interest and responsibility to conserve fish and wildlife, in general:

> "*The Legislature finds and declares that the protection and conservation of the fish and wildlife resources of this state are of utmost public interest. Fish and wildlife are the property of the people and provide a major contribution to the economy of the state, as well as providing a significant part of the people's food supply; therefore their conservation is a proper responsibility of the state*." (Fish and Game Code 1600)

The State extends the responsibility for conservation efforts to other entities, through regulatory measures, to limit actions that may impact fish and wildlife resources, such as Streambed Alteration Agreements (Fish and Game Code 1601-1603) and "take" restrictions under the California Endangered Species Act (Fish and Game Code 2050-2085).

Furthermore, Fish and Game Code, Section 5937 imposes a responsibility onto the owners of dams to ensure that fish below the dam are kept in good condition:

> "*The owner of any dam shall allow sufficient water at all times to pass through a fishway, or in the absence of a fishway, allow sufficient water to pass over, around or through the dam, to keep in good condition any fish that may be planted or exist below the dam. During the minimum flow of water in any river or stream, permission may be granted by the department to the owner of any dam to allow sufficient water to pass through a culvert, waste gate, or over or around the dam, to keep in good condition any fish that may be planted or exist below the dam, when, in the judgment of the department, it is impracticable or detrimental to the owner to pass the water through the fishway*." (Fish and Game Code 5937)

While the code does not provide any definition of "good condition," it can broadly be taken to mean that there must be sufficient water below the dam to support all life history phases of the fish below the dam.

State and Federal Endangered Species Act

The Federal Endangered Species Act (ESA) and the California Endangered Species Act (CESA) prohibit the "take" of listed species without prior authorization. Under the ESA and CESA, the District must ensure that its water supply operations and watershed management activities do not result in unauthorized "take" of the listed aquatic resource species of Lagunitas Creek: coho, steelhead, or California freshwater Shrimp. The ESA defines "take" as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." (ESA, Section 3(18). The CESA definition differs slightly but significantly in that it does not consider harass or harm to be take; rather, "take" is to "hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill." (Fish and Game Code 86).

In addition, the ESA and CESA both set out the goal of species becoming delisted through recovery efforts. The District has been and will continue to collaborate and partner with State and Federal agencies to implement recovery actions for the benefit of these listed species.

Public Trust Doctrine

The Public Trust Doctrine is not a legal construct but rather an underlying principle of politics looking after the general welfare of a state's water and its entities to benefit public interest. Furthermore, the philosophy of public trust doctrine can be extended into protection of ecological integrity, if there was a governing body to see it through. Public Trust Doctrine is the basis for California law codes related to natural resource conservation. An overview of Public Trust Doctrine is presented in Appendix B.

As a public trust resource, the aquatic resources of Lagunitas Creek belong to the people of the state and so the District's activities need to ensure that these resources are maintained for the state. Certainly, this responsibility does not fall solely onto the shoulders of the District but the District does have a role in maintaining the public trust resources of Lagunitas Creek, at least in as much as District activities affect these resources.

2.3 Watershed Description

Lagunitas Creek

Lagunitas Creek drains 103 square miles of west central Marin County, California and is the largest watershed in the county (Figure 1). The creek originates on Mt. Tamalpais and flows 22 miles before emptying into the southern end of Tomales Bay. There are four dams on the upper eight miles of Lagunitas Creek: Lagunitas Dam (built in 1872), Alpine Dam (1918), Bon Tempe Dam (1948), and Peters Dam (1954). Peters Dam, the most downstream of these dams, was raised in 1982, which made Kent Lake the largest of the water supply reservoirs operated by MMWD. Downstream of Peters Dam, Lagunitas Creek flows 14 miles and is accessible to anadromous fish. Several unregulated tributaries join the stream in this stretch including San Geronimo Creek, Irving Creek, Barnabe Creek, Deadman's Gulch, Devil's Gulch, Cheda Creek, McIsaac Creek, and Olema Creek. The most important of these unregulated tributaries for salmonids are San Geronimo Creek, Devil's Gulch, and Olema Creek. The other major tributary is Nicasio Creek, which is largely impounded by MMWD's Nicasio Reservoir. Seegar Dam (1960), which forms Nicasio Reservoir, is located approximately one mile upstream of the confluence with Lagunitas Creek; anadromous salmonids are supported within that one mile stretch.

Noteworthy landmarks along the main stem of Lagunitas Creek (going in a downstream direction) are: Peters Dam, Shafter Bridge, Inkwells Bridge (at the mouth of San Geronimo Creek), Irving Bridge, Samuel P. Taylor State Park campground and the campground bridge, Swimming Hole Bridge (i.e., the green bridge at Big Bend), Big Bend, Jewel, Tocaloma, the Tocaloma bridges (both the old bridge and newer Sir Frances Drake Boulevard Bridge), Platform Bridge Road, the Zanardi Ranch, Platform Bridge, the Point Reyes-Petaluma Road, the Gallagher Ranch and Gallagher bridge, Highway 1 Bridge, and the town of Point Reyes Station (see Figure 1). The U.S. Geologic Survey (USGS) topographic maps that cover the project vicinity are the Inverness, San Geronimo and Bolinas quadrangles.

The USGS operates two stream gage stations on Lagunitas Creek (Figure 2):

- Samuel P. Taylor State Park gage (station #11460400) located in Samuel P. Taylor State Park, about 1,000 feet upstream from the mouth of Devil's Gulch; and
- Point Reyes Station gage (station #11460600) located on the Gallagher Ranch, about halfway between the mouth of Nicasio Creek and the town of Point Reyes Station.

In addition, MMWD operates a gage station on San Geronimo Creek (station #K4) located at the Lagunitas Road bridge, in the lower quarter segment of the San Geronimo Creek drainage.

Between Shafter Bridge and Tocaloma, Sir Frances Drake Boulevard and a bike path (the old railroad grade; also called the Cross Marin Trail) run parallel to Lagunitas Creek, on opposite sides of the creek from one another. Between Tocaloma and the mouth of Nicasio Creek, Platform Bridge Road runs parallel to the east side of Lagunitas Creek with a dirt road (the old railroad grade) running along the west side. From the mouth of Nicasio Creek to Point Reyes Station, the Petaluma-Point Reyes Road follows the creek, along the northern side, with the old railroad grade and agricultural lands on the other side.

Downstream of Kent Lake, Lagunitas Creek is a perennial stream with minimum flows maintained by releases from Peters Dam. The summer flow, wetted stream channel is generally about 20-50 feet wide with typical flow patterns of pools, glides, riffles, and runs. The substrate is a mix of sand/silt, gravel, cobbles, small boulders, and bedrock. The stream banks support a relatively dense forest dominated by redwood, bay, alder, tanoak, big leaf maple, box elder, and willow. The understory layer is dominated by tree saplings with shrubs such as thimbleberry and dogwood, as well as blackberry

and poison oak vines. The herbaceous layer is composed of ferns, nettle, and scattered tussocks of sedge. In some areas, the understory is a dense blanket of periwinkle.

Most of the land along main stem Lagunitas Creek is publicly owned (see Figure 1). Landowners include MMWD, the California Department of Parks and Recreation (State Parks), and the National Parks Service (NPS). MMWD manages Lagunitas Creek and its watershed, upstream of the confluence with San Geronimo Creek, for water supply, habitat, and public use open space. Downstream of the confluence with San Geronimo Creek, the watershed runs through Samuel P. Taylor State Park, Golden Gate National Recreation Area, and privately owned parcels near the mouth. The State Parks land are managed for public recreation and habitat. The NPS lands are managed for habitat, public use open space, and as agricultural grazing lands. The private lands are mostly managed as agricultural grazing lands.

San Geronimo Creek

The San Geronimo Creek watershed is a 9.3 square mile sub-basin that might best be characterized as a semi-rural area. The majority of land within the San Geronimo Valley is privately owned, however, the Marin County Open Space District owns and manages about 2,240 acres of open space lands that account for about 37% of the watershed (these lands include Roy's Redwoods, the Gary Giacomini Open Space Preserve, and the Maurice Thorner Memorial Open Space Preserve). The privately owned lands are residential properties with some agricultural grazing land and other agricultural uses, two horse stables, and the 158-acre San Geronimo Golf Course. There are several important tributaries to San Geronimo Creek that support anadromous salmonids, including: Woodacre Creek, Willis Evans Canyon, Larsen Creek, Montezuma Creek, and Arroyo Creek. Within the main stem of San Geronimo Creek, anadromous fish passage extends upstream to the Dixon Weir in Woodacre. MMWD owns a water treatment plant and the surrounding land along the creek. There are seven bridge crossings of San Geronimo Creek: Railroad Avenue, San Geronimo Valley Drive, Creamery Road, Meadow Way, Montezuma Road, Mountain View Avenue, and Lagunitas Road. Other notable landmarks include: the Dixon Weir, MMWD's San Geronimo Treatment Plant, the San Geronimo Golf Course, Roy's Pools, Forest Knolls at Montezuma Road Bridge, Castro Pool, MMWD's Lagunitas Booster Station, and the Inkwells. San Geronimo Creek merges with Lagunitas Creek at Shafter Bridge just below the bedrock feature known as the Inkwells. The confluence is approximately ½ mile below Peter's Dam.

Nicasio Creek

The Nicasio Creek watershed is a 37 square mile sub-basin and Nicasio Creek is the largest tributary to Lagunitas Creek. The watershed is made up almost entirely of privately owned properties that are managed as agricultural ranch and residential lands. The watershed is notably less densely forested than the rest of Lagunitas Creek, although there is a fairly densely wooded riparian corridor along the 1-mile stretch of Nicasio Creek that is downstream of Seeger Dam. There are no tributaries that enter Nicasio Creek downstream of Seeger Dam. Along this 1-mile stretch, the creek is crossed twice by the Point Reyes-Petaluma Road. A small concrete ready-mix plant at the confluence of Nicasio Creek and Lagunitas Creek is the most notable landmark below Seeger Dam.

Olema Creek

The Olema Creek watershed is a 14.5 square mile sub-basin with Olema Creek flowing in nearly a straight line through the rift valley of the San Andreas Fault. Most of the watershed is NPS land, managed for habitat, public use open space, and agricultural grazing. The town of Olema is situated in the lower portion of the drainage. The most important tributary is the John West Fork of Olema Creek, which supports anadromous salmonids. Olema Creek is crossed by Bear Valley Road, in the town of Olema, and John West Fork is crossed by Highway 1.Olema Marsh at the confluence of Olema Creek, Bear Creek, and Lagunitas Creek is one of the largest freshwater marshes in Marin County. In the early 1920s, Olema Creek between the town of Olema and its confluence with Lagunitas Creek was straightened into the 3-kilometer long “Olema Canal” that drained the surrounding land for agricultural production. Olema Creek is currently reclaiming its historic configuration in an interesting example of restoration through a change in management, which in this case consists of no longer maintaining the straightened channel.

At the mouth of Lagunitas Creek lies the Giacomini Marsh. This is nearly 600 acres of historic tidal marsh land that had been diked, drained and managed as a dairy ranch. Then, in 2008, the NPS restored this area to tidal action by breaching dikes, thus reestablishing estuarine habitat that is once again available as rearing habitat for salmonid smolts and other aquatic resources.

2.4 Watershed Resources

The Lagunitas Creek watershed is of statewide significance for coho salmon (*Onchorynchus kisutch*), steelhead trout (*O. mykiss*), and California freshwater shrimp (*Syncaris pacifica,* endangered). The Central California Coast Evolutionarily Significant Units (ESUs) of coho and steelhead have been listed as endangered and threatened, respectively, under the federal and California Endangered Species Acts. The California freshwater shrimp is also listed as endangered under both state and federal ESAs.

Coho salmon populations have declined substantially from historic levels throughout their California range. Coho are now found in fewer than half of the streams they once inhabited in California. Although present coho numbers in Lagunitas Creek watershed are considerably lower than historic levels, the watershed supports the largest and most stable coho population south of Noyo Creek, Mendocino County, CA and is of great importance to the Central California Coast ESU. Coho salmon are anadromous fish; they spend their adult life in the ocean, migrate up freshwater streams, like Lagunitas Creek, to spawn from late October to early February. Their eggs hatch and the fry emerge in the late winter/early spring. Then they rear for about a year in freshwater, and migrate to the ocean as juveniles (transitioning to smolts in their outmigration).

Lagunitas Creek also supports an important population of Central California Coast steelhead. Steelhead numbers have also declined throughout their range in California, but in Lagunitas Creek, as well as other small coastal streams, they have not been as affected as coho. Steelhead are an anadromous form of rainbow trout and utilize the Lagunitas Creek watershed for spawning and rearing much as coho do, though the species' life histories differ in a couple of important ways. Steelhead juveniles spend one to three years rearing in freshwater, whereas coho generally migrate to the ocean after one year. Also, adult steelhead often survive spawning, return to the ocean, and spawn again in a later year, whereas coho die after spawning.

Resident rainbow trout have not been confirmed to occur in Lagunitas Creek watershed downstream of any reservoirs but there has not been any systematic sampling and analysis (i.e., otolith analysis) of fish in the upper tributary drainages to confirm that they do not have any resident rainbow trout. The four main stem Lagunitas Creek reservoirs (Lagunitas, Bon Tempe, Alpine, and Kent) have all been stocked with hatchery-raised rainbow trout at various times. Lake Lagunitas and Bon Tempe Reservoir are regularly stocked with catchable-size rainbow trout, between the months of October and June. Kent Lake was periodically stocked with rainbow trout fingerlings up until May 2002 and has not

been stocked since. Stocking of fingerlings into Alpine Lake continued but it was last stocked in May 2004. The 1.5 mile section of Lagunitas Creek between Alpine Dam and Kent Lake does support a population of self-sustaining (i.e., reproducing) rainbow trout. Juvenile trout observed in the spring and summer of 2005 appeared to be the offspring of reproduction of trout spawning in this section of the creek. They were not any of the trout that were planted as fingerlings in Kent Lake, nor were they fingerlings from Alpine Lake, because the juvenile trout observed in 2005 were much too small to be any of the stocked fish and could only have been the offspring of spawning reproduction. There have also been juvenile trout observed in the tributary streams to Lake Lagunitas (East, Middle, and West Fork Lagunitas Creek) that appeared to be the offspring of successful reproduction but this may not be a self-sustaining population.

The California freshwater shrimp is endemic to lowland, perennial streams in Marin, Napa, and Sonoma Counties. Human related impacts including channelization, introduced fish predators, pollution, and water withdrawal have extirpated the shrimp from the majority of the habitat within their historic range. Lagunitas Creek has one of the largest remaining populations of California freshwater shrimp and is the only shrimp stream to run through protected lands making it a significant stronghold for the only extant *Syncara* species.

A small array of other native fish species inhabit Lagunitas Creek and its tributaries, including California roach (*Lavina symmetricus*), Sacramento sucker (*Catostomus occidentalis*), Pacific lamprey (*Lampetra tridentata*), three-spined stickleback (*Gasterosteus aculeatus*), prickly sculpin (*Cottus asper*), riffle sculpin (*C. gulosus*), and coast range sculpin (*C. aleuticus*). The lamprey, like the coho and steelhead, is an anadromous species.

Chinook salmon (*O. tshawytscha*) and chum salmon (*O. keta*) have been observed in Lagunitas Creek in recent years. Ranchers in the watershed also report having seen these salmonids in the 1960s and ‘70s. The Chinook salmon that have been observed are a fall-run population, which are listed as threatened within the Coastal California ESU. However, this ESU ends at the Russian River and does not extend down to include the Lagunitas Creek watershed, so the status of the Chinook that have been observed in the creek is uncertain.

Other special status species that occur in the watershed include the spotted owl (*Strix occidentalis,* threatened), California red-legged frog (*Rana draytonii,* threatened), foothill yellow-legged frog (*R. boylii*, California Species of Special Concern), and tidewater goby (*Eucyclogobius newberryi,* endangered). Surveys for spotted owls have determined that they occur within Marin County in fairly

high density with several nesting pairs occupying territories in the Lagunitas Creek watershed. Red-legged frogs occur within the Olema Creek drainage and the tidally influenced portion of main stem Lagunitas Creek, and have only rarely been observed elsewhere in the watershed. The foothill yellow-legged frog occupies a couple of tributary streams to Kent Lake and may sporadically occur in streams throughout the watershed. The tidewater goby has been documented in the tidal estuary of Lagunitas Creek (Reichmuth 2007).

Notable aquatic species that also occur in the watershed include river otter (*Lutra canadensis*), Pacific giant salamander (*Dicamptodon ensatus*), California and rough-skinned newts (*Taricha torosa* and *T. granulosa*, respectively), northwestern pond turtles (*Actinemys marmorata marmorata*; California Species of Special Concern*)*, and the non-native signal crayfish (*Pacifasticus leniusculus*). In addition, there are other amphibians and a myriad of macroinvertebrate species.

2.5 Life Histories and Habitat Requirements

Salmon Life Histories

The Lagunitas Creek watershed provides habitat for many native aquatic and terrestrial species including the federally endangered coho salmon (*Oncorhynchus kisutch*) and the federally threatened steelhead trout (*Oncorhynchus mykiss*). Coho and steelhead are anadromous salmonids, spending part of their lives in freshwater streams and part in the ocean. They are born in a freshwater stream, hatching from eggs laid by their mother, and they rear as juvenile fish for at least a year (one year for coho and one to three years for steelhead). They then migrate out to the estuary and ocean as smolts and mature, then spend one or two years in the ocean as adults before they return to the stream to spawn and end their life cycle. Coho have a fairly rigid three year life span and all coho die after spawning. Steelhead are more variable in their life history, living up to 5 years and some will go back to the ocean after spawning for the first time and can spawn again in a later year before dying.

The decline of many of these native species populations, including the salmonids, can be attributed to the destruction of freshwater habitat. In fact, freshwater habitat degradation is one of the major causes of long-term coho and steelhead productivity declines (McEwan and Jackson 1996). Human activities, including dam construction, have blocked access to large areas of the watershed and have degraded the remaining habitat through increased sedimentation, loss of riparian vegetation, and

simplification of the stream channel. In recent years, ocean productivity is also thought to have had a significant role in the decline of coho in coastal California streams.

Coho Salmon Life History

Spawning

Starting in September, after having spent two years in the ocean, adult coho will begin to arrive at the mouths of coastal streams in California. At these estuarine areas, there may be sand bars that obstruct the fishes' passage into the stream. The first heavy rains will open sand bars and clear these obstructions, allowing the first batch of spawners through. Subsequent storms will then trigger further batches of spawners to swim upstream (Shapovalov and Taft 1954). Some stream systems, such as Lagunitas, do not have a sand bar and are not sand bar limited, and where the only barrier to coho passage is sufficient stream flows.

Once in fresh water, the fish will typically migrate upstream to their stream or tributary of origin, called their natal stream, occasionally stopping at deep pools to rest and hide from predation (Sandercock 1991, Opperman et. al 2006). Resting also allows time for more rain to fall, easing their passage, and bringing in additional spawning mates. The spawning run can begin as early as October but usually occurs between November and January, with the peak of the run often occurring in December, depending on rain events.

Female coho prefer to create redds near the head of a riffle or tail of a pool, where the smooth pool surface first begins to break (Beacham and Murray 2003; Shapovalov and Taft 1954). Stream velocities between 0.30 m/s and 0.55 m/s and gravel sizes of 15 cm diameter or less are considered ideal for redd building (DFG 2004). Females will turn on her side and flip her body to excavate a pit in the gravel and then deposit an average of 2,600 eggs inside while a male, or two, will simultaneously fertilize them. She will then immediately cover her fertilized eggs with gravel. The pits can be oval, round, or even irregularly-shaped and the female will deposit the eggs in several pockets scattered within the pit. Once completed, a redd will characteristically consist of a pit in the streambed that transitions into a mound of gravel, downstream of the pit, with the eggs buried under the mound. A female will guard her redd from superimposition for as long as she is able, dying eight to twelve days after constructing her redd (Briggs 1953).

Because of their three year life history, coho salmon populations can be tracked by discrete year class. However, while most spawning coho are three year old adults, some males return to their stream to spawn as only two year old fish. These precocious males, called jacks, contribute to the genetic diversity of the coho populations. They can be an important factor in maintaining the genetic integrity of any given year class.

Incubation & Emergence

Coho eggs incubate within the redd for 35-50 days, depending on water flow and temperature, and then they hatch. Hatching usually occurs in the late winter – early spring time period. At first, the eggs become eyed and then transform into tiny fish with a yolk sac, called alevins. The alevins are the form in which the fish hatch from their eggs. The alevins will slowly absorb their yolk sacs while they move within the gravel. Once their yolk sac is absorb, or buttoned up, the young fish emerge from the redd and into the stream as fry. Excessive fine sediment content in a stream will hamper gravel permeability and decrease flow through redds. This lowers the dissolved oxygen available to eggs and alevins, reduces the flushing of wastes away from the fish, and can affect growth (CDFG 2004). Dissolved oxygen levels need to be at least 8.0 mg/l for both healthy alevin and embryonic development (Phillips and Campbell 1961). Higher water temperatures speed incubation (Shapovalov and Taft 1954). Temperatures of 4^{o}C-11^{o}C are considered optimal, while excessive temperatures may result in premature and underdeveloped alevins, lowering survival rates (Bell 1973; Reiser and Bjornn 1979).

Fresh Water Habitat and Rearing

Habitat and Large Woody Debris: Coho require complex and diverse habitat. Diverse substrates like varying boulder and gravel sizes and various habitat types such as side channels, back waters, deep pools, floodplains and other slow velocity refugia, all constitute habitat complexity. Coho also benefit from stream sinuosity, the tendency of the stream channel and thalweg to meander, and perhaps most importantly, from large woody debris. Human actions tend to simplify habitat, usually resulting in straight, wide, heavily eroded shallow channels that are much less suitable for coho production. The quantity and complexity of habitat are very often the limiting factors for coho production in most stream systems (Chapman 1962, 1966).

One of the most important contributors to habitat complexity is large woody debris (LWD). LWD will create slow velocity refugia by scouring out deep pools in the stream bed. This provides direct cover

from high flows as well as protection from predators (Opperman et. al. 2006). It can also enhance stream sinuosity (Fischenich and Morrow 2000), organic matter (nutrient) retention, bank stability, and biological community diversity (Bilby and Ward 1989). Many field studies have correlated coho density with the availability of pools and the abundance of LWD (Bisson et al. 1988, Bugert et al. 1991). Nickelson et al. (1992) demonstrated that pool habitat enhanced by LWD shows significantly greater coho densities than those without LWD enhancement.

Summer Habitat

Between March and May, alevins become fry, emerge from the gravel and enter slow velocity areas of the stream with cover and good foraging (Shapovalov and Taft 1954; Lestelle 2007). During the summer, coho are predominately found in pools but can also be found in the shallow margins of glides and riffles (Everest et al. 1986). LWD and vegetation are important during the summer for protection since coho are very vulnerable to predation during this season (Bustard and Narver 1975, Taylor 1988, Nielsen 1992).

Winter Habitat

In late summer and early fall the juveniles, several months old now, move to deeper pools and side channels with large woody debris, overhanging logs, and areas of dense riparian vegetation (DFG 2004). This habitat type is critical for refuge from the high flows they will encounter during winter. Riffles, glides or runs are hardly used at all during winter since they offer little protection against winter flows (Bisson 1988). The recent limiting factors study by Stillwater Sciences (2008) states that quality winter habitat is the limiting factor to coho smolt production in the Lagunitas watershed (see Section 2.6 below). Efforts are being made to study and enhance winter habitat in the Lagunitas watershed in order to increase its long term productivity of coho salmon.

After about a year in freshwater, coho undergo smoltification, a process of physiological adaptations for life in salt water. These changes are endocrinely regulated and are triggered by increases in temperature, photoperiod and feeding activity. One of the most important changes is development of the hypoosmoregulatory function. This system of enzymes will allow the fish to maintain their ion concentration below that of the surrounding seawater, essential for ocean survival (Dickoff 1997). Coho also undergo a change in appearance when adapting to seawater. Due to the increased presence of guanine crystals in the skin, coho lose their parr marks, and appear more silvery and reflective (Denton and Saunders 1972). This is the color of all ocean faring coho.

Estuaries and the Ocean

Smolts may inhabit estuaries for up to several weeks to complete smoltification (DFG 2004). Smolts undergo very rapid growth in estuaries, which aids them in nearshore survival (Holtby et al. 1990). In fact, coho smolts which enter the ocean directly without first inhabiting estuaries have much lower survival rates than those that do (Lestelle 2007). Estuaries play a very significant role on coho survival and that alteration or destruction of estuarine habitat will have direct effects on population viability (NOAA 2004). The Tomales Bay estuary is just beginning to be studied regarding its benefits to the coho salmon population.

Once in the ocean, coho may reside in nearby feeding areas and remain there until they return to the stream to spawn, or they may travel for thousands of miles in the open oceans. Most coho from California are believed to spend their time in the ocean off the California coast while some travel north and spend the summer along the central Alaskan coast (Brodeur 2003).

Crucial to nearshore oceanic survival is upwelling. Upwelling is created by northerly winds blowing down the Pacific coast from April to September. These winds push surface water from the coastal region to further offshore. This forces high salinity, nutrient-rich water from the bottom of the ocean up towards the surface. Primary production in this area receives a boost from this influx of nutrients, which subsequently benefits a large array of fish up through the food chain, including coho salmon (Scarnecchia, D.L. 1981, NOAA 2009)

Steelhead Life History

Spawning and Incubation

Steelhead (*Oncorhynchus mykiss*) exhibit various life history patterns including an anadromous form called steelhead trout, and a permanent freshwater resident form called rainbow trout. These two forms of the same species of fish, which can interbreed, are indiscernible genetically (McEwan and Jackson 1996). Resident rainbow trout are not specifically known to occur in Lagunitas Creek, downstream of any reservoirs.

Steelhead are known to enter their natal streams at two separate times of the year. Some steelhead enter in the spring, mature sexually through the summer, and spawn in the winter. Other steelhead,

already sexually mature, enter the stream in the winter and spawn immediately. These are called summer (or stream maturing) and winter (or ocean maturing) steelhead, respectively (Shapovalov and Taft 1954; McEwan and Jackson 1996). Steelhead in Lagunitas Creek are all of the winter variety and spawn from December to April (Stillwater 2008).

An interesting characteristic of steelhead that differentiates the species from coho and other salmon is iteroparity, meaning steelhead can spawn multiples times. Shapovalov and Taft (1954) found that 17% of spawners in Waddell Creek, CA had spawned previously.

Steelhead exhibit greater flexibility than coho and other Pacific salmon with regard to time spent in freshwater vs. the ocean. While coho will almost always spend roughly one year in freshwater, steelhead can spend anywhere from one to three years in freshwater and one to two years in the ocean. Two years in freshwater and two years in the ocean is most common for central and northern California steelhead (Shapovalov and Taft 1954). The majority of steelhead smolts migrating to the ocean from Lagunitas Creek are two years of age (Stillwater 2008).

Like coho, steelhead prefer certain hydraulic conditions, gravel sizes, and temperature ranges for redd construction. Steelhead redds can be found in riffles, tops of riffles and pool tailouts. Optimal values for spawning and egg incubation are water velocities from 0.2 to 1.6 m/sec, gravel sizes from 0.6 cm to 10 cm (but can use sand-gravel and gravel-cobble substrate), and temperatures between 4^{o}C and 11^{o}C (Bovee 1978, Bjornn and Reiser 1991). Also like coho, steelhead redds need sufficient dissolved oxygen for incubation and emergence. Fine sediment intrusion into the redd causes poor flow and thus low oxygen levels and waste flushing through redds, which can impact fry emergence rates, especially if it occurs earlier rather than later in the incubation period (Bjornn and Reiser 1991). Depending on temperature and other factors, eggs will incubate for 3-14 weeks, and alevins will remain in the redd for another 2-5 weeks, emerging as fry in the spring (Shapovalov and Taft 1954)

Freshwater Habitat and Rearing

Most California steelhead live in freshwater for two years and will prefer different habitat types during summer and winter. The following is a description of the types of habitat steelhead tend to occupy at certain life stages. However, juvenile steelhead are very flexible; they are able to live and can be found in a wide range of velocities, depths and habitat types (Bisson 1988).

When steelhead fry emerge in spring, they form schools and move to the margins of the stream, close to banks where velocity levels are low (Shapovalov and Taft 1954, Moyle 2008). Soon thereafter they begin to exhibit territorial behavior, a characteristic of juvenile steelhead throughout their freshwater existence (Shapovalov and Taft 1954). As they continue to grow through the summer and fall, they are increasingly found over larger substrates in riffles, runs and higher velocity pools (Everest and Chapman 1972). These fry will utilize the higher velocity habitat types in order to exploit greater invertebrate drift for feeding purposes, despite the increased energy costs of swimming (Smith and Li 1983). This high velocity habitat is also more abundant than low velocity pools in Lagunitas Creek, where coho salmon may outcompete steelhead (Ettlinger 2008) This ability to capitalize on better feeding opportunities as well as live in varied habitat may strongly benefit steelhead species survival. For these reasons, 0+ steelhead (less than a year old) prefer run and riffle habitat over pools in the Lagunitas Creek Watershed.

Come winter, slow velocity refugia is very important to steelhead. The juveniles, several months old now, will seek refuge from high flows and predation in the interstitial places between gravels, cobbles, and boulders on the stream bed (Bjornn 1971, Bustard and Narver 1975, Swales et al. 1986, Everest et al. 1986). Steelhead may also find protection, alongside coho salmon, in deep cold pools with plenty of cover (Swales 1986, Bisson 1988). Large woody debris creates winter habitat for steelhead just as it does for coho salmon, scouring out deep pools and providing cover. However, while steelhead and coho may share this same type of habitat, steelhead are not as dependent on pool habitat as are coho (Swales 1986).

Since most steelhead stay in freshwater for two years, each juvenile typically spends two summers and two winters in the stream system. Steelhead that are more than one year old (1+ steelhead) typically utilize the same type of habitat as steelhead that are less than a year old (0+ steelhead) except that they do require larger interstitial spaces (i.e. larger substrates) in the stream bed for flow refuge. The 1+ steelhead will also occupy deeper channels and will utilize more pools (Bisson et al. 1988), where they can compete better with coho.

In the spring, after roughly two years rearing in freshwater, the same physiological change is initiated within steelhead as in coho that triggers smoltification. From a combination of genetic and environmental factors, this process prepares the fish for salt water, and induces the steelhead to begin the migration towards the ocean. During this process, steelhead smolts develop a silvery coloration, a black edges on their caudal fin, and a loss of their parr marks (Wedemeyer 1980).

Estuary and Ocean Life Stages

While migrating toward the ocean, steelhead smolts may either head straight to the open ocean or stay in estuarine waters for up to nine months (Bond 2006). In Scott Creek, Bond (2006) found that estuary reared steelhead, while a minority among those migrating to the ocean, comprised 85% of returning spawners. From this and other data, Bond concluded that steelhead reared in the estuary had a greater ocean survival rate than purely stream-reared steelhead. Although estuaries comprise only 3% of the habitat in the Scott Creek watershed, it has an enormous impact on steelhead ocean survival. The role of the Lagunitas Creek estuary, including Tamales Bay, for steelhead survival is just beginning to be studied.

Steelhead will spend roughly two years travelling great distances across the North Pacific (Light et al. 1989). Also, according to Light et al. (1989), steelhead do not utilize the coastal waters of their natal streams but move quickly towards the Gulf of Alaska where they stay for a year. After the first year they undergo a cyclic, counter-clockwise movement in the North Pacific until they are ready to spawn and return to their natal streams. It is not known how far steelhead from Lagunitas Creek migrate in the ocean.

California Freshwater Shrimp Life History

The life history and habitat requirements of California freshwater shrimp (*Syncaris pacifica*) has best been described by Serpa (1991 and 2010), Eng (1981), the U.S. Fish and Wildlife Service (1998 and 2007), and Martin et al (2009). The following review comes from those citations.

The California freshwater shrimp (Figure 3) is a decapod crustacean of the family Atyidae. Individuals are generally less than 50 millimeters (2.17 inches) in length and females are generally larger than males. California freshwater shrimp are detritus feeders, and the hairy tufts at the ends of their small claws help them to scrape up food particles. Shrimp coloration is quite variable with males being translucent to nearly transparent, with small surface and internal chromatophores (color-producing cells) clustered in a pattern to help disrupt their body outline and to maximize the illusion that they are submerged, decaying vegetation. The digestive tract is almost always completely full of the material they have eaten. This does not disrupt the camouflage of the shrimp, even though they are otherwise mostly translucent. The digestive tract simply looks like another root, helping them to blend even more with the surrounding habitat.

California freshwater shrimp is endemic to perennial lowland streams in Sonoma, Marin and Napa counties. Most of these are low elevation streams (below 500 feet above sea level) and have a gentle (<1%) gradient. The species is currently known from only 21 streams in 7 watersheds within the three counties. Lagunitas Creek has one of the largest populations and it is the only *Syncaris* stream that runs through protected lands.

The shrimp are found along the edges of stream pools, in areas away from the main current, where there are often undercut banks, exposed riparian tree roots, as well as adventitious roots that develop on the submerged portions of some herbaceous plants, shrubs, and vines that hang into the water (particularly dogwood, willow, and blackberry). In addition, the shrimp tend to only occupy portions of the pools that are around one to four feet deep at the shoreline (not gradually sloping shorelines).

During high-flow storm events, they can seek refuge to avoid the stream currents by moving into the more protected areas provided by undercut banks and in amongst the tree roots along the edges of the pools. During the summer dry season, they can survive as long as some water remains in the pools, even if there is no longer any surface flow between the pools.

The optimum ranges or min./max. limits of temperature, stream flow, and water quality regimes for the shrimp has not been defined. However, they do seem to have evolved to tolerate and survive a broad range of water quality conditions, within those that are typical of the coastal and bay draining streams in the area. Some of the shrimp-bearing streams in low gradient areas, with minimal base flow and cover, can see water temperatures that reach 31 degrees Celsius (88 degrees Fahrenheit) during summer months and 6 degrees Celsius (43 degrees Fahrenheit) in winter months. Due to the variable rainfall stream flows are markedly different throughout the year with flash flood flows in the winter to minimal or zero flows in the summer and fall months. The mean water temperature in Lagunitas Creek ranges between 50 and 60 degrees Fahrenheit and stream flows in the main stem of Lagunitas Creek range from 8 cubic feet per second (cfs) to upwards of 2,000 cfs during the peak flow of a 2-year storm event (with some flood flows recorded at 5,000 - 10,000 cfs). Turbidity measurements for the main stem of Lagunitas Creek indicate a min./max. range between 0.3 and 154.0 NTU with a mean range of 2.4 – 10.0 NTU (Piovarcsik and Andrew 2008).

The presence of fine roots appears to be the most important habitat requirement for freshwater shrimp, with water velocity, sandy substrate, emergent vegetation, and overhanging vegetation also being important variables. The study of habitat requirements of freshwater shrimp in Lagunitas and Olema Creeks (Martin et all 2009) found that shrimp were positively associated with dissolved oxygen

concentration, and percentage of sandy substrate, overhanging vegetation, emergent vegetation, large woody debris, and fine roots. Additionally, they found a positive association of *Syncaris* with temperature, depth, and percentages of overhanging bank, instream woody vegetation, and medium roots. The shrimp were negatively associated with current velocity, percentages of gravel and cobble substrates, and absence of vegetation.

The reproductive ecology of the California freshwater shrimp is somewhat speculative and is not fully known. Reproduction seems to occur once a year, in September, when stream conditions are still relatively calm. The shrimp probably breed immediately after the female's last molt, before autumn. The timing of mating has been deduced from the presence of egg-bearing females starting in September and the observation that by November most adult females are bearing eggs. Adult females produce relatively few eggs, generally 50 to 120 and upwards of 200. The female retains the fertilized eggs on her swimming legs (pleopods) throughout the winter. This protects the vulnerable eggs during the wet season, when the streams usually flow heavily. The young are released as miniature adults in late spring, after stream flows diminish. Juveniles are approximately 6 millimeters (0.24 inch) in length and they then have time to grow significantly before they are subjected to the rapid water of the next rainy season. Approximately sixteen months after they were released into the water, they will be mature enough to breed. Newly hatched young (post-larvae) grow rapidly and reach 19 millimeters (0.75 inch) in length by early autumn. Growth then slows until the following summer. A size difference between males and females is apparent at the end of their second summer and the larger female size is consistent with characteristics of other freshwater shrimp. The California freshwater shrimp may live longer than 3 years. Their long life cycle is an adaption to the climatological pattern of the area.

Much of the shrimp's food material is in drift that settles out on the fine roots and other vegetation as the water slows in the habitats the shrimp prefer. The shrimp eat algae and plant matter in the drift, along with detritus and insects, and they can scavenge dead fish and shrimp. Their food sources include fecal material produced by shredders, organic fines, periphytic and planktonic algae, aquatic macrophyte fragments, zooplankton, dissolved organic matter particles formed into clusters by flocculation, and aufwuch (the algae, plant and animal forms that become encrusted on rocks and other hard surfaces). In captivity, they have been seen to both scrape particles up indiscriminately from the substrate with the hairy tufts, and to deliberately search out and pick up more preferred food items, such as commercial fish food flakes, with the claws themselves. The shrimp may use visual, tactile, or chemical cues to key in on food sources while foraging on the roots, twigs, vegetation, and substrate of the pool margins they inhabit.

2.6 Limiting Factors for Coho, Steelhead, and Shrimp in Lagunitas Creek

One of the primary goals of MMWD's Lagunitas Creek Stewardship Plan is to enhance the aquatic habitat elements that are limiting the expansion of target populations, namely coho salmon, steelhead, and California freshwater shrimp. This strategy requires an understanding of habitat carrying capacities and sources of mortality for each species throughout their life cycles. By identifying the habitat constraints that regulate survival during key life stages, habitat enhancement efforts can be targeted to reduce those constraints.

Between 2005 and 2008, a limiting factors analysis (LFA) was conducted for coho salmon and steelhead in Lagunitas Creek. The Marin RCD, with funding from the SWRCB/RWQCB, investigated the potential factors that may be limiting survivorship and growth of these two populations. The study was conducted by Stillwater Sciences (2008). This section will summarize the results of that study, as well as related, but independent, analyses conducted by MMWD. The LFA did not investigate limiting factors for the California freshwater shrimp, but numerous hypotheses have been proposed for factors limiting the shrimp population in Lagunitas Creek. Those hypotheses will also be summarized here.

Coho Salmon

The *Sediment and Riparian Management Plan* identified a shortage of summer habitat for juvenile coho salmon as the primary factor limiting the growth of the population. Habitat enhancement efforts during the ensuing years have focused on improving pool habitat by installing large woody debris within the main stem of Lagunitas Creek and on reducing inputs of fine sediments through erosion control projects throughout the watershed. Other habitat constraints were also identified, including spawning riffles and high-flow refuge, but have not been the primary focus of MMWD's restoration efforts.

The LFA reviewed existing data and collected data in the field on various coho salmon life stages to identify periods of low survival. Potentially limiting factors which were investigated included spawning habitat, egg survival, spring and summer fry survival, and winter habitat. The LFA relied heavily on the multiple years of spawner and juvenile coho data collected by MMWD, along with a limited set of smolt survey data.

Spawning habitat was quickly ruled out as a limiting factor based on redd data collected by MMWD since 1995. Spawner surveys have documented the distribution of coho salmon redds and the frequency of superimposed redds. Superimposition of redds can destroy incubating eggs, and a high level of superimposition may indicate a shortage of spawning habitat. Spawner surveys have recorded a consistently low level of redd superimposition, particularly among coho, indicating that spawning habitat is not limited, at least not for the numbers of spawning coho observed during this period.

The survival of incubating eggs was also investigated as part of the LFA. Egg survival is an unlikely limiting factor given the high fecundity of coho salmon. Female coho lay an average of 2,600 eggs (Shapovalov and Taft 1954), which would add up to over 600,000 eggs in an average spawning season. Egg survival would need to be below 3% in most years to account for the low numbers of juvenile coho observed in the late summer. In the spring of 2006, Stillwater Sciences conducted a study of fry emergence from coho salmon redds in Lagunitas and Olema Creeks. After the 2005/06 winter, with a peak discharge of approximately 1,800 cfs, the average fry emergence rate from seven monitored redds was 15%. This was considered a minimum emergence rate because some emergence traps were removed during part of the study, and some fry escaped during sampling. This minimum rate of emergence, however, would have produced at least 74,000 coho fry, which is far higher than the 22,500 estimated that summer. A concurrent study, as part of the LFA, found no evidence of redd scour during the winter of 2005/2006. The LFA concluded that while redd scour and high rates of egg mortality may occur during some years (such as in 1997/98 and 2005/06), there was little evidence to suggest that egg survival was a controlling factor in coho population dynamics.

The next crucial life stage for coho salmon is the post-emergence period in March and April. The LFA identified a strong negative correlation between stream flows during this period and juvenile coho population estimates in the late summer. This correlation indicates that newly-emerged coho fry are vulnerable to displacement by moderate to high flows, particularly in April. Coho fry swim to the stream margins shortly after emergence, where they seek low-velocity habitat. Potential enhancements to spring flow refuge habitat are discussed in Section 4.2.

Summer rearing habitat has been the focus of habitat enhancement work by MMWD to date. Large wood structures have been constructed at over 40 sites in Lagunitas Creek and were generally designed to enhance pool habitat and provide cover during the summer rearing period. Snorkel surveys conducted by MMWD have confirmed that coho densities in the pools where large wood structures were placed, increased following the installation of the large wood. While not specifically designed to investigate summer survival, these snorkel surveys have provided evidence of high coho

survival during the summer months. Sites snorkeled during the early summer have similar densities of coho as those snorkeled at the end of the summer. Snorkel surveys at the juvenile sample sites conducted in August and again in October have likewise documented high rates of survival. Further evidence is provided by modeling work performed by MMWD. In that work, 96% of the variability in the juvenile coho population estimates can be explained by three factors: the number of coho redds, the peak winter stream flow, and the peak April stream flow. Juvenile coho population variability cannot be explained by either year-to-year variability in summer habitat, predation, or water temperatures. Neither the LFA nor MMWD's analyses could find evidence that summer habitat has limited the growth of the coho population during the past ten years.

The LFA identified winter habitat as the single factor most likely controlling coho population dynamics. In their analysis, Stillwater Sciences (2008) back-calculated the number of smolts that may have emigrated from Lagunitas Creek between 1994 and 2005, based on redd counts and assumed ocean survival rates. These back-calculated estimates, as well as actual smolt estimates each year between 2006 and 2009, indicate an overwinter carrying capacity of approximately 7,000 coho smolts. Evidence for this carrying capacity was observed when the coho population plunged from an estimated 37,000 fry in the late summer of 2007 to approximately 6,700 smolts during the spring of 2008. This high rate of mortality occurred despite peak winter stream flows below 2,000 cfs, or approximately a "bankfull" discharge. The exact mechanism of this mortality is unknown. Coho fry may have been washed out of Lagunitas Creek during the peak flow event, or displaced into the Tocaloma reach, where intraspecific competition for limited habitat forced fry to emigrate prior to the start of smolt monitoring. Coho smolts that migrate to the ocean during the winter likely survive at lower rates than spring migrants, due to their smaller size and the reduced ocean productivity during the winter.

In summary, the unifying factor behind coho salmon population dynamics in the Lagunitas Creek watershed is stream flow. High winter flows, such as those that occurred in 1997/98 and 2005/06, appear to scour redds. Winter flows are also likely responsible for the apparently high rate of coho fry mortality in 2008, and possibly in other years as well, but the exact mechanism of mortality is unknown. Moderate stream flows during March and April can displace newly-emerged coho fry. Enhancing flow refuge for coho during multiple life stages will be a critical element of the Stewardship Plan, and will be addressed in Section 4.2.

Steelhead

Steelhead population dynamics in Lagunitas Creek are less well understood than for coho salmon. Until recently, spawner surveys focused almost exclusively on coho salmon, and even now are conducted for only part of the steelhead spawning season, so adult steelhead run data is limited. The relationships between stream flows and juvenile steelhead production are also unclear, so yearly fluctuations in the young-of-the-year (age 0+) steelhead population estimates are poorly understood.

One thing that is clear, however, is that the numbers of age 1+ steelhead are consistently low, regardless of the abundance of age 0+ steelhead in the previous year. Age 0+ steelhead population estimates have ranged from approximately 26,000 to 75,000 since 1995, while the 1+ steelhead estimate has fluctuated between approximately 2,000 and 4,000. This indicates an age 0+ mortality rate of 90-96%. There is no evidence to suggest that summer habitat is limited for age 1+ steelhead, so it is likely that, as for coho, winter habitat is limiting (Stillwater Sciences 2008).

Steelhead use different habitats than coho salmon during the winter, although both species will use side channels, floodplains, and other off-channel habitats during high flows. Under moderate flows, where coho prefer woody debris, steelhead prefer to seek shelter in the substrate (Bustard and Narver 1975). Cobble substrate with abundant pore spaces is ideal, but this habitat appears to be extremely limited in the Lagunitas Creek watershed. It is likely that age 1+ steelhead quickly fill the available streambed flow refugia in and amongst the larger substrate on the bed, while the vast majority of steelhead are either displaced downstream or do not survive.

Potential enhancements to steelhead winter flow refuge will be discussed in Section 4.2.

California Freshwater Shrimp

The first surveys of California freshwater shrimp in Lagunitas Creek were conducted in 1981 by Stacey Li. Additional surveys were conducted in 1991, 1994 and then annually starting in 1996 by Larry Serpa. Each of these surveys was conducted at the same locations using similar methods, and therefore the data are comparable over that time period. Overall, the observed numbers of shrimp show high interannual variability, with no overall trend.

The distribution of shrimp within Lagunitas Creek has changed, however, during the sampling period. In 1991 shrimp were found as far upstream as Shafter Bridge. Since then, surveys have documented

the disappearance of shrimp at upstream sites, as well as an overall decline in the number of surveyed pools that contain shrimp. Shrimp have now lost over 2.8 miles of formerly occupied habitat (Serpa 2010), but the causes of this loss are unknown. Either shrimp are being washed out of suitable habitats and, for some reason, are unable to return, or these habitats are accessible but no longer suitable for the shrimp.

Between 1996 and 2009, Serpa (2010) has documented a decline in undercut banks at the annual shrimp survey sites, and these undercuts provide crucial flow refugia during the winter. Habitat typing surveys have also documented a decline in undercut banks between 1997 and 2006, although only in lower Lagunitas Creek. Upstream of Devil's Gulch, undercut banks appeared to be as prevalent in 2006 as they were in 1997. Summer habitat for shrimp, on the other hand, has declined in this reach. Root mass, aquatic vegetation and terrestrial vegetation have declined by 73% during this period. Large and small woody debris has increased in this reach, largely due to MMWD's enhancement efforts, which has benefited salmonids but seemingly provides little benefit for shrimp. There were also more pools in 2006 upstream of Devil's Gulch than there were in 1997, and their depths haven't changed. On the whole, however, shrimp habitat in upper Lagunitas Creek has degraded during the last ten years, which may explain the near disappearance of shrimp in this reach.

The presence of fine roots appears to be the most important habitat requirement for freshwater shrimp, with water velocity, sandy substrate, emergent vegetation, and overhanging vegetation also being important variables. The study of habitat requirements of freshwater shrimp in Lagunitas and Olema Creeks (Martin et all 2009) found that shrimp were most strongly positively associated with, percentages of fine roots, sandy substrate, and overhanging vegetation. Additionally, they found a lesser but still positive association of Syncaris with temperature, dissolved oxygen concentration, depth, and percentages of overhanging bank, instream woody and emergent vegetation, medium roots., and large woody debris. The shrimp were negatively associated with current velocity, percentages of gravel and cobble substrates, and absence of vegetation.

The reduction in shrimp distribution in Lagunitas Creek may alternatively be related to changes in stream flows. Beginning in 1996, MMWD increased summer base flows in the creek to eight cfs, as required by Order WR95-17. These flows increased water velocities over riffles, which may impair the upstream movement of shrimp. The timing of shrimp upstream movement is unknown, but may historically have occurred during the summer, when water velocities were low. Larry Serpa (personal communication) has hypothesized that shrimp may migrate upstream during high flows, when bankside vegetation is inundated. This is a question meriting further study.

Much remains unknown about California freshwater shrimp in Lagunitas Creek, including the factors controlling their population dynamics. While the shrimp population does not appear to be declining, its range is contracting within the lower portion of the creek and good shrimp habitat in upper Lagunitas Creek is less abundant than it was in 1997. Conservation measures for California freshwater shrimp should focus on expanding the distribution of shrimp within Lagunitas Creek to prevent the population from becoming overly isolated and vulnerable to a localized, catastrophic event. Facilitating the recolonization of upper Lagunitas Creek will first require an understanding of the factors, or at least potential factors, that have led to the elimination of shrimp from much of this reach. The next step will be to identify the enhancement actions that can ameliorate these factors. Potential future habitat enhancement measures are discussed in Section 4.2.

2.7 Invasive and Non-Native Species Concerns

Invasive species can have severe impacts on native species by reducing habitat quality or availability, increasing competition for resources, introducing diseases or pathogens, or through direct predation. Invasive species are the second leading cause of extinction or endangerment of native species (Smith 2009). Other impacts from invasive species includes: loss of biodiversity, economic impacts (damage to infrastructure, loss of resources), and, in some cases, human health risks (e.g., West Nile virus, Asian lung fluke).

Controlling or eradicating invasive species, if even feasible, can be extremely expensive. Preventing introductions is always preferable.

Current Non-Native Aquatic Animals

Unlike most coastal streams in California, Lagunitas Creek retains a complete native fish assemblage with low numbers of non-native fish. The non-native fish that are present are generally confined to District reservoirs and the lowest reaches of Lagunitas Creek, and include black crappie (*Pomoxis nigromaculatus*), white crappie (*Pomoxis annularis*), bluegill (*Lepomis macrochirus*), channel catfish (*Ictalurus punctatus*), green sunfish (*Lepomis cyanellus*), redear sunfish (*Lepomis microlophus*), common carp (*Cyprinus carpio*), golden shiner (*Notemigonus crysoleucas*), largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieui*), goldfish (*Carassius auratus*), and mosquitofish (*Gambusia affini*). These species are unlikely to survive the cold temperatures and high water velocities present throughout most of Lagunitas Creek during the winter.

Other non-native aquatic animals in the Lagunitas Creek watershed include bullfrogs (*Rana catesbeiana*) and red-eared sliders (*Trachemys scripta elegans*). Bullfrogs are large frogs native to North America east of the Rocky Mountains. Bullfrogs have been observed in Lagunitas Creek and its tributaries, and are abundant in District reservoirs and the San Geronimo Golf Course ponds. They eat any animal they can fit in their mouths, and have been implicated in the decline of red-legged frogs and other native aquatic species. Red-eared sliders are fairly large, semi-aquatic turtles native to the southeastern United States. They are common as pets, and many have been released into District reservoirs by pet owners. Sliders are occasionally observed in Lagunitas Creek. They may outcompete the smaller, native northwestern pond turtle for basking sites and food, or may introduce disease to the native turtles.

Potential Aquatic Invasive Animals

Zebra mussels (*Dreissena polymorpha*) were accidentally introduced to the Great Lakes in the 1980's through ship ballast water. Since then they have spread across the country and have recently been found in one location in California: San Justo Lake in San Benito County. Zebra mussels are prolific filter feeders which consume phytoplankton and reduce food supplies for native species. Zebra mussels are rapid breeders and can colonize large areas quickly. They can completely cover surfaces; outcompeting or even smothering native mussels. They also cause economic harm by clogging intake pipes and pumps for municipal and other water sources.

Quagga mussels (*Dreissena rostriformis bugensis*) are closely related to zebra mussels and were also introduced into the Great Lakes through ship ballast water. Like zebra mussels, quagga mussels have spread across the country and have caused similar ecological and economic harm. In California, all reservoirs receiving raw water from the Colorado River have been exposed to quagga mussels, and their presence has been confirmed at 20 locations in southern California (USGS 2009).

New Zealand mudsnail (*Potamopyrgus antipodarum*) is a tiny (5mm) snail native to New Zealand that is quickly spreading throughout California. It is currently found in the Russian River, Napa River, Alameda Creek and San Lorenzo River. In Yellowstone National Park mudsnails were observed to reach densities of 300,000 per square meter, consumed 75% of one stream's gross primary productivity (Hall et al. 2003) and reduced substrate colonization by other macroinvertebrates (Keran et al. 2005). Mudsnail densities have been documented as upwards of 750,000 individuals per square meter (Smith 2009). Rainbow trout fed a diet of New Zealand mudsnails lost weight, and more than

half of the mudsnails consumed survived the passage through the trout's digestive tract (Vinson and Baker 2008). Introduction of mudsnails into Lagunitas Creek would likely have significant ecological impacts. Like the zebra and quagga mussels, the sheer biomass of mudsnails can impact and blocks pipes, filters, and other infrastructure.

Myxobolus cerebralis is a myxosporean parasite that causes Whirling Disease in salmonids. Whirling disease affects nerves and causes damage to cartilage. It can kill young fish directly or causes an infected fish to swim in a circular motion, which prevents the fish from evading predators or foraging for food. Other symptoms include a black tail in younger fish and deformities to the head or body in older fish. The disease can be a serious problem in hatcheries. Whirling disease spores can spread downstream from an infected dead fish and infect other fish. The presence of whirling disease does not necessarily mean that salmonid populations will suffer large declines. It was first identified in California in 1965 near Monterey (Modin 1998) and has since been detected in many parts of the state. Whirling Disease is notably absent from most coastal watersheds, with the exception of five streams in Monterey, Santa Cruz and San Mateo Counties. Modin (1998) hypothesized that high gradients, frequent flushing, and the oligotrophic nature of most California streams discourage the growth of tubificid worm populations (an alternative host for *Myxobolus cerebralis*) and therefore reduce the incidence of Whirling Disease.

Current Aquatic Invasive Plants

The invasive aquatic plant of biggest concern in the Lagunitas Creek watershed is Eurasian watermilfoil (*Myriophyllum spicatum*), which infests Lake Lagunitas, Bon Tempe Reservoir, Alpine Reservoir and Kent Lake (Aquatic Environments, Inc. 2007). During a 2006 survey of Kent Lake, watermilfoil was found in a cove in the northeastern arm of the lake, in several small coves along the eastern side of the main arm, and was most prolific in the upper end of the lake where Lagunitas Creek enters the lake (Figure 4). Eurasian watermilfoil is much more prevalent in Bon Tempe Reservoir where is has spread around the entire shoreline and covers about 20 percent of the lake bottom. The steep slopes of Kent Lake probably prevent milfoil from becoming more abundant there.

Native to Eurasia and northern Africa, *Myriophyllum spicatum* is one of the most invasive aquatic plants in North America. Watermilfoil is a submerged plant with feather-like leaves and fibrous roots that often develops from plant fragments. It is a rooted plant but can grow in depths of 3 to 34 feet. During the growing season, the plant undergoes autofragmentation, with the abscising fragments

often developing roots at the nodes prior to separation from the parent plant. Fragments are also produced by wind and wave action and boating activities, with each fragment having the potential to develop into a new plant colony.

Eurasian watermilfoil forms dense canopies that often shade out native aquatic vegetation. Monospecific stands of this species provide poor habitat for waterfowl, fish, and other wildlife. Die back and decomposition of watermilfoil can consume large quantities of dissolved oxygen. High nutrient levels and low dissolved oxygen levels are precursors to fish kills, algal blooms, and poor water quality.

Eurasian watermilfoil grows in either still or flowing water, and could potentially spread from MMWD reservoirs to Lagunitas Creek. Growth accelerates as water approaches 15 °C, which is common during the summer in lower Lagunitas Creek and San Geronimo Creek. High flows would likely uproot watermilfoil, but recolonization could occur in years when Kent Lake spills.

Two other known invasive aquatic plants are creeping water primrose (*Ludwigia hexapetala*) and Water smartweed (*Polygonum amphibium*). Both species were identified in scattered clumps around the shoreline of Nicasio Reservoir during a 2006 survey (Figure 5; Aquatic Environments, Inc. 2007). Water primrose is an invasive perennial plant that typically forms dense mats in the margins and shallows of lakes, sloughs, and canals. Although it can propagate by seeds, seedlings are rarely encountered. Most of its propagation appears to be vegetative from creeping stems and plant fragments. Water primrose can extend out into water depths of 12 feet. The seeds can be consumed by water birds but are not considered a valuable food source. Water smartweed is a sprawling perennial shoreline plant that is also known as swamp smartweed. This plant can form dense growth along the margins of shoreline but is generally considered to be not as much of a nuisance as creeping water primrose. Because of its long rhizomes (up to 13 meters in aquatic environments), water smartweed may extend out into deep water. Propagation of this species is by seeds and roots from trailing stems. Stem pieces develop roots rapidly and can disperse great distances to form new colonies. Populations derived from a single clone do not produce seeds. Water smartweed seeds are an important food source to many species of songbirds, waterfowl, and mammals.

Current Invasive Riparian Plants

French, Scotch and Spanish broom (*Genista monspessulana*, *Cytisus scoparius* and *Spartium junceum*, respectively) are well-established in the Lagunitas Creek watershed and tend to grow in

sunny to lightly shaded areas. Brooms are not found under coast redwoods (*Sequoia sempervirens*) or in other dense shade. These plants crowd out native plants, increase the risk of catastrophic wildfire, and provide poor habitat for terrestrial wildlife in the riparian corridor.

Greater periwinkle (*Vinca major*) is a low-growing forb that forms dense mats which crowd out native plants. It generally spreads vegetatively, and fragments washed downstream during high flows can take root and form new infestations. It can also prevent the growth of trees and shrubs, which can lead to bank erosion and failure.

Cape ivy (*Delairea odorata*) is a South African vine that thrives in moist, shady riparian conditions. It can smother shrubs and trees, inhibiting growth and crowding out other native species. It will also cover the ground and prevent native seeds from germinating.

English ivy (*Hedera helix*) is a tough vine native to Europe, northern Africa and western Asia, and can grow both as a ground cover and as a climbing vine. As English Ivy climbs into the canopy, it blocks sunlight from reaching the leaves of trees and other vegetation. The host plant can be smothered by ivy or be made unstable by the weight of the vine. English ivy also serves as a reservoir for bacterial leaf scorch (*Xylella fastidiosa*), a plant pathogen that is harmful to oaks, maples and other native plants.

Himalayan blackberry (*Rubus discolor*) is a shrubby vine native to Eurasia. It thrives in riparian areas where it can form immense, impenetrable thickets that shade out all other vegetation. Himalayan blackberry can be distinguished from the native California blackberry (*Rubus ursinus*) by its thick, five-angled stems and leaves generally clustered in fives. California blackberry has round stems and leaves clustered in threes. Himalayan blackberry can reproduce both vegetatively and by seed. Eradication is difficult since resprouting often occurs from both roots and the seed bank. In Lagunitas Creek, Himalayan blackberry can provide habitat for California freshwater shrimp, which cling to the aquatic, adventitious roots that form when blackberry vines trail in the water.

Potential Invasive Plants

The deep shade, cool water, and relatively swift flows make several of the more common aquatic and terrestrial invasive plants unlikely to invade the area. Species such as Uruguayan waterprimrose (*Ludwigia hexapetala*), or common reed (*Phragmites australis*), prefer sunnier spots and slower-moving or ponding water. Russian olive (*Elaegnus angustifolia*) and red sesbania (*Sesbania punicea*)

have generally been found in warmer areas, and—while possible—remain unlikely. The two species discussed below are the most likely to invade and cause impacts, given their current distribution.

Panic veldt grass (*Ehrharta erecta*) is a perennial ground covering grass from South Africa. It is already growing in several locations along Sir Francis Drake and Lagunitas Creek, where it thrives in the shade under coast redwoods. As a relatively new invader and potential impacts are unclear at this time, but its habit suggests the ability to exclude native species.

Giant reed (*Arundo donax*) is a bamboo-like grass from the Mediterranean and tropical Asia which can form dense, impenetrable thickets 15-20 feet tall. The grass generally spreads by fragments and while it prefers sun, it can be found in dappled shade. The closest known infestation is in a fenceline along Sir Francis Drake near Lagunitas School Road.

2.8 MMWD Operations

Summary of Impacts from District Operations

The main impact to aquatic resources of Lagunitas Creek, from MMWD water supply operations, is that reservoir dams block salmonid access to approximately 50% of the watershed. Historically, anadromous salmonids may have migrated through the main stem of Lagunitas Creek, upstream into the forks of Lagunitas Creek (east, west, and middle forks), above where Lake Lagunitas now lies. They also migrated upstream into Nicasio Creek and Hallack Creek (a tributary to Nicasio Creek), above where Nicasio Reservoir lies.

SWRCB Findings in Order WR95-17

The main findings of the State Water Board, in Order WR95-17 were that:

- MMWD water rights permits should be amended to require minimum flows to maintain fish in good condition, specifically for the benefit of coho, steelhead, and California freshwater shrimp;
- MMWD dams have changed the hydrograph and reduced sediment flushing flows in Lagunitas Creek, with the raising of Peters Dam reducing sediment transport capacity by an average of 10-20% (600 tons/year); and

- MMWD dams hold back wood and additional woody debris within the creek would improve fishery habitat.

Order WR95-17 concluded:

> "The required minimum flows can be met from release of water from Kent 'Lake or from natural inflow to Lagunitas Creek and its tributaries above the USGS gage located in the Samuel P. Taylor State Park. The minimum flow requirements established in this order represent an equitable allocation of water which will maintain fish in good condition while allowing continued diversion of substantial quantities of water for municipal use and irrigation." (State Water Board Order WR95-17)

Other Impacts

MMWD believes that the minimum flow regime, established by Order WR95-17, has been more than adequate to maintain fish in good condition. However, there has been an unintended consequence, operationally. Because the minimum flow requirements at the USGS gage can, at times, be met by natural runoff, particularly with flows from San Geronimo Creek, the District can, at these times, operate Kent Lake with a metered release of 1 cubic foot per second (cfs). In a couple of instances, this release has coincided with a period of relatively low runoff into the half-mile segment of Lagunitas Creek between Peters Dam and Shafter Bridge, and when salmonid redds have been established in this stream segment and salmonid eggs are incubating in the redd gravels. Portions of some of those redds have become partially exposed. District and NMFS staff investigated these occurrences and conducted some monitoring to document flow conditions around these redds. While there was never any evidence that any incubating eggs were exposed or desiccated, this is not a desirable condition. However, since the incidents several years ago, it has been District practice to release about 4.5 cfs from Peters Dam during the salmonid spawning season which has addressed the condition.

Adjacent to San Geronimo Creek, in the town of Lagunitas, the District operates its Lagunitas Booster Station. This facility pumps raw (untreated) water en route from Kent Lake and Nicasio Reservoir to MMWD's San Geronimo Treatment Plant, in Woodacre. The pump station contains pressure relief valves in order to relieve pressure surges to prevent pipeline ruptures. The facility was configured such that the relief values shunt water to discharge pipes that exit the facility and run to the stream bank of San Geronimo Creek. When the pressure surges occur, there can be discharges of raw water into San Geronimo Creek. These are usually very short-duration discharges (in the order of a few

seconds) but can be relatively high velocity that cause scouring of the stream bed of San Geronimo Creek. While the pressure relief valves are necessary, the discharges directly into San Geronimo creek is not an ideal configuration, because of potential impacts to habitat through bed scour.

The routing of raw water from Nicasio Reservoir to the San Geronimo Treatment Plant is via the Nicasio Transmission Pipeline. This is a 33-inch water pipe that runs from Nicasio Reservoir westerly to and under Lagunitas Creek, then along (under) the old railroad grade/Cross-Marin Trail to the Inkwells Bridge, where it joins with the transmission line from Kent Lake, and then continues easterly along Sir Frances Drake Boulevard to the San Geronimo Treatment Plant. Under normal operation of these transmission lines, there are no impacts to Lagunitas Creek. However, there are a variety of valves along the route that can be operated to drain segments of the transmission lines. Operating these values discharges raw water to Lagunitas Creek. The transmission lines cross a number of unnamed streams; the Nicasio Transmission Line crosses under Lagunitas Creek just downstream from Irving Bridge; the Kent Lake Transmission Line crosses San Geronimo Creek as an above-ground pipe attached to the Inkwells Bridge. Some of the fill crossings of the unnamed stream crossings could be subject to erosion or failure. During major storm and flooding events in 2005/2006, stream bank failures occurred along sections of both the Nicasio and Kent Lake Transmission Line, threatening the pipes. Repairs were made with the construction of drilled pier retaining walls. These repairs secured the pipelines and roads but the stream banks below the retaining walls have remained partially unvegetated and continue to be subjected to erosion during winter storm events.

There are a few unpaved roads on MMWD property that are situated downstream of Kent Lake and drain to Lagunitas Creek between Peters Dam and Shafter Bridge. The District is responsible for the maintenance and management of these roads. The two main roads are:

- Shafter Grade, running from Shafter Bridge, along the west side of Lagunitas Creek, and then uphill to Bolinas Ridge; and
- Peters Dam Road, running from Shafter Bridge, along the east side of Lagunitas Creek, and then up onto Peters Dam (with a spur that continues along Lagunitas Creek to the base of the dam and the stream flow release structure.

There is also the San Geronimo Ridge Road, which starts at the Peters Dam Road and runs up hill to San Geronimo Ridge. In addition, there are some old haul roads on the west side that provide access to the west side of Peters Dam. Road drainage improvements were made to portions of these roads

under MMWD's Mt. Tamalpais Road and Trail Management Plan. Other drainage improvements, to reduce the potential for sedimentation into Lagunitas Creek, are being planned.

MMWD maintains the Leo T. Cronin Fish Viewing Area at Shafter Bridge, on the west side of Lagunitas Creek. This is a small parking lot that is open to the public during the spawning season (Nov. – Feb.) to provide an opportunity for people to view spawning salmon in the creek. Visitors are allowed to park for up to one hour and walk along Shafter Grade to look down on Lagunitas Creek.

District Policies

The District's mission statement and Mt. Tamalpais Watershed Management Policy are described above (see Section 2.2). Two other policies are directly or indirectly related to MMWD's involvement in aquatic resource management (Appendix C):

- Board Policy No. 3 – Wells and Other Private Water Sources (revised 9/23/92; reviewed 2/23/94); and
- Board Policy No. 14 – Land Use in the Nicasio, Soulajule, and San Geronimo Watersheds (revised 10/31/90; reviewed 1/26/94).

Board Policy No. 3, regarding wells, provides encouragement for wells and other private water sources to be used for non-potable purposes, to supplement District service. The policy was written and intended as a water conservation measure. The policy indicates it is not the intent of MMWD to limit the use of private wells for landscape irrigation. What the policy does not mention, is a consideration of how wells or other private water sources can impact stream habitat and fisheries.

Board Policy No. 14, regarding land use, describes MMWD's interests in protecting water quality and fishery habitat within the Lagunitas Creek and Walker Creek watersheds. This policy established MMWD's program for Watershed Protection Agreements, which are agreements between the District and applicants for land use changes to implement best management practices to control sedimentation into creeks. This policy also highlights the District's water rights interests and requires agreements for approval of wells and ponds, that the applicant will not stake a water rights claim because of the well or pond.

2.9 Conclusions from the Sediment and Riparian Management Plan

The actions implemented by MMWD under the Lagunitas Creek Sediment and Riparian Management Plan have been reviewed (Andrew 2011). The major conclusions from that review and evaluation are:

- For much of the period from 1995 to 2007, the juvenile coho population appeared to be increasing, while the juvenile steelhead population did not show a strong upward or downward trend. Since 2007, however, the coho population has declined sharply, both in Lagunitas Creek and throughout coastal California. The scientific consensus attributes this decline to a drop in ocean productivity. This unfortunate episode demonstrates that salmonid populations are influenced by many factors, including floods, droughts, ocean conditions, and freshwater habitat quality. Population gains resulting from habitat enhancement efforts can be undone by larger forces. Over the long term, however, habitat enhancement efforts stand the best chance of increasing salmonid populations and preventing their extinction.

- The woody debris project work has provided a diversity of habitats that help to ensure that salmonid populations do not fall below sustainable levels. These efforts alone, however, have not been enough to increase salmonid populations in the face of declining ocean productivity, floods, and other phenomena.

- To date the streambed monitoring effort has not detected an overall improvement in streambed conditions. Sediment dynamics are largely driven by episodic events, such as floods, that tend to overwhelm incremental, longer-term improvements in sediment delivery to the creek. Detecting an appreciable improvement in streambed conditions may require longer-term monitoring than what has been conducted so far.

- The water temperatures in Lagunitas Creek have remained within a suitable range for coho salmon during the monitoring period; on the hottest days of each year water temperatures did exceeded the requirements established by the State Board.

3.0 Stewardship Goals and Targets

The goals and target habitat conditions identified for this Stewardship Plan combine statements articulated by MMWD and six other sources:

- SWRCB, in Order WR95-17 (SWRCB 1995);
- NMFS, in their draft coho recovery plan (NMFS 2010);
- DFG, in their coho recovery strategy for coho (DFG 2004);
- USFWS, in their California freshwater shrimp recovery plan (USFWS 1998 and 2007);
- Marin County, in their San Geronimo Valley salmon enhancement plan (PCI 2010); and
- TBWC, in the integrated coastal watershed management plan (TBWC 2007).

The goals and targets for this plan are focused on habitat enhancement, monitoring, outreach, and policy. While the ultimate goal of habitat enhancement actions is to increase and stabilize the populations of coho, steelhead, and California freshwater shrimp, this plan does not specifying any numeric targets for coho, steelhead, or shrimp. We have attempted to describe goals that can be quantified and evaluated, however, in many instances the goals state more of a process to pursue than a quantifiable condition to achieve. For each of the goal/target statements below, we identify the source of that goal, be it by MMWD, the SWRCB Order, or one of the other sources mentioned here.

These goals and targets are what the District will work to achieve, through the actions to be implemented over the next ten years. While it may be difficult to meet some of the targets, the District recognizes that they represent habitat conditions important to the species of concern and they are what the District will strive for. The actions described in this plan will move towards these targets and the District's effort overall will be beneficial to the aquatic resources of Lagunitas Creek.

3.1 Compliance with SWRCB Order WR95-17

Goal:

- Remain in compliance with the ongoing conditions of SWRCB Order WR95-17 (Source: MMWD; SWRCB 1995); see Section 4.1.

The District recognizes that Order WR95-17 specifies ongoing requirements and that compliance is not optional. Among other things, the Order specifies instream flow requirements for MMWD, so

complying with the Order will also meet fish passage flow, water temperature, and other hydrology goals and criteria stated by other sources, for the main stem of Lagunitas Creek.

3.2 Optimal Habitat Conditions for Salmonids and Freshwater Shrimp

Goal:

- Strive to achieve and/or maintain suitable to optimal habitat conditions for coho, steelhead, and California freshwater shrimp, in the Lagunitas Creek watershed (Source: MMWD).

NMFS (2010) characterized optimal habitat for successful coho rearing to include six main habitat features:

(1) Deep complex pools formed by large woody debris;
(2) Adequate quantities of water;
(3) Cool water temperatures;
(4) Unimpeded passage to spawning grounds (adults) and back to the ocean (smolts);
(5) Adequate quantities of clean spawning gravel; and
(6) Access to floodplains, side channels and low velocity habitat during high flow events.

They acknowledge that there are other requirements that are met when the six habitat features are present and functioning, including adequate quantities of food, dissolved oxygen, low turbidity, *etc.*

DFG (2004) reviews references that describe suitable ranges of various habitat elements, by life stage, with the optimal ranges of some parameters specified. These include:

- Large woody debris >400 ft^3/100 ft. reach;
- Riparian cover >80%; and
- Sediment and substrate <5% fines

USFWS (1998 and 2007) described habitat conditions where California freshwater shrimp occur, with some inference to optimal habitat conditions, including:

- Low elevation (<380 feet) and low gradient (<1 percent) stream reaches;
- Stream banks structurally diverse with undercut banks, exposed roots, overhanging woody debris, or overhanging vegetation;

- Depths of 30 to 90 centimeters with exposed live roots, overhanging stream vegetation and vines;
- Undercut banks with exposed fine root systems or dense, overhanging vegetation; and
- Submerged leafy branches and other submerged vegetation.

No data are available for defining the optimum temperature and stream flow regime for the shrimp or the minimum and maximum limits it can tolerate (USFWS 2007), however, shrimp are found along the edges of stream pools, in areas away from the main current.

3.3 Habitat Conditions in the Lagunitas Creek Watershed

Goals:

- Winter Habitat Enhancement - Evaluate, develop plans for, and implement winter habitat enhancement projects, in the main stem of Lagunitas Creek, to reduce or eliminate the winter habitat limitations for the juvenile and smolt life stages of coho and steelhead populations in Lagunitas Creek (Source: MMWD).

- Winter Habitat Enhancement – Improve floodplain habitat complexity, in the main stem of Lagunitas Creek, from the NMFS rating of "poor" (<50%), in a CAP[1] or equivalent assessment); quantify the habitat parameters that contribute to floodplain complexity (Source: NMFS 2010; MMWD).

- Winter Habitat Enhancement – Improve floodplain connectivity, in the main stem of Lagunitas Creek, from the NMFS rating of "poor" (<50%), in a CAP or equivalent assessment (Source: NMFS 2010).

- Sediment Reduction and Management - Reduce sedimentation and provide an appreciable (i.e., measureable) improvement in the fishery habitat within the Lagunitas Creek watershed (Source: SWRCB).

- Sediment Reduction and Management – Use recommendations of existing sediment source surveys to restore habitat for salmonids; augment and expand surveys as needed for a comprehensive watershed approach (Source: DFG 2004).

[1] CAP – Conservation Action Planning (NMFS 2010).

- Sediment Reduction and Management – Increase the amount of beneficial gravel, in the fish bearing streams of the Lagunitas Creek watershed and improve on the NMFS gravel quantity rating of "poor" (<600m^2), in a CAP or equivalent assessment (Source: NMFS 2010).

- Instream and Riparian Management - Improve the riparian vegetation and woody debris within the Lagunitas Creek watershed in order to improve habitat for fishery resources (Source: SWRCB 1995).

- Instream and Riparian Management - Enhance rearing habitat and the condition of the riparian corridor to benefit the aquatic resources of the Lagunitas Creek watershed (Source: MMWD).

- Instream and Riparian Management – Improve the shelter rating of pools, in the main stem of Lagunitas Creek, from the NMFS rating of "poor" (<60), in a CAP or equivalent assessment (Source: NMFS 2010).

- Instream and Riparian Management – Increase the LWD frequency in pools, in the main stem of Lagunitas Creek, from the NMFS rating of "fair" (1 - 1.3 pieces/100m, for streams 10-100m bank full width), in a CAP or equivalent assessment (Source: NMFS 2010, and Marin County/PCI 2010).

- Instream and Riparian Management – Maintain the proportion of pools, in the main stem of Lagunitas Creek, at a rating of "good" (40-50% by stream length) in a CAP or equivalent assessment (Source: NMFS 2010).

- Instream and Riparian Management – Enhance and maintain the riparian corridor along Lagunitas Creek, between Peters Dam and Shafter Bridge, with a riparian vegetation canopy cover of >75% (shading over the creek), in a CAP or equivalent assessment (Source: NMFS 2010, and Marin County/PCI 2010).

- BioTechnical Bank Stabilization - Utilize biotechnical materials and techniques for any and all bank stabilization projects in the Lagunitas Creek watershed (Source: MMWD; PCI/Marin County 2010).

- California Freshwater Shrimp Habitat Enhancement – Research species biology, optimal habitat conditions, and carrying capacity (K), and develop proper habitat restoration techniques, for the main stem of Lagunitas Creek (Source: USFWS 1998 and 2007).

- California Freshwater Shrimp Habitat Enhancement – Enhance habitat conditions, in the main stem of Lagunitas Creek, to provide favorable habitat for freshwater shrimp such that the shrimp may be distributed throughout the length of Lagunitas Creek (Source: MMWD and USFWS 1998).

NMFS (2010) has identified and ranked habitat conditions and threats for coho throughout the Central California Coast ESU and for the Lagunitas Creek watershed. Their viability analysis, conducted as a Conservation Action Planning tool (CAP) rates habitat features on a scale of poor, fair, good, or very good. Their viability analysis also rates threats on a scale of low, medium, high, or very high. For some habitat attributes (e.g., floodplain habitat complexity), the indicators and rating system used in the CAP had no widely available source of data and warrant further refinement. A goal for this Stewardship Plan is to improve certain habitat attributes that were given a poor or fair rating up to a good rating. We have identified those habitat attributes that are relevant to MMWD's efforts for stewardship. This can provide quantifiable targets for MMWD's actions. Of course, we would also want those habitat attributes that were given a good rating to remain as such, or improve further. We assume that a CAP analysis, or some equivalent assessment, would be done in the future to evaluate if the goals have been met; the District is not planning to conduct such an analysis as part of this Stewardship Plan but would rely on NMFS or others to conduct the assessment.

The USFWS (2007) reviewed the status of recovery for California freshwater shrimp. As a concluding recommendation, they suggest that range wide surveys should be initiated to evaluate the current distribution, habitat conditions, and population trends of shrimp, They also recommend determining the carrying capacity (K) of each stream supporting shrimp, acknowledging that there has been insufficient data to calculate K for any population of shrimp within their range. The value K could represent the upper population density or the maximum number of individuals a stream could support. Calculating K could allow the USFWS to adequately assess the success of shrimp recovery.

TBWC (2007) described objectives for the Tomales Bay watershed related to environmental restoration and habitat improvement. The objectives are to: 1) protect, restore and/or rehabilitate hydrologic and ecological integrity; 2) restore, protect and maintain viable populations and habitats of special status species (specifically coho), and 3) remove and/or control invasive non-native species. We believe the first two of these objectives are incorporated into the goals stated here for this Stewardship Plan and we have included the third objective as a goal for AIS management (See Section 3.5).

3.4 Monitoring

Goals:

- Monitor the coho salmon, steelhead, and freshwater shrimp populations of Lagunitas Creek at all life stages, and evaluate their population dynamics and trends (Source: SWRCB 1995, MMWD, DFG 2004, NMFS 2010).

- Monitor and evaluate aquatic resource habitat conditions in the Lagunitas Creek watershed and evaluate their influences on coho, steelhead, and California freshwater shrimp populations for all life stages (Source: MMWD, DFG 2004, NMFS 2010).

- Monitor and evaluate effectiveness of habitat enhancement efforts (Source: MMWD, DFG 2004, NMFS 2010).

- Coordinate all monitoring efforts within the Lagunitas Creek watershed, and collaborate on a regional/State-wide level (Source: MMWD).

3.5 Aquatic Invasive Species (AIS) Management

Goals:

- Develop, implement, and promote protocols to reduce the potential for introductions of AIS into the Lagunitas Creek watershed, or elsewhere in Marin County (Source: MMWD).
- Remove and/or control invasive non-native species in the Lagunitas Creek watershed (Source: TBWC 2007)

3.6 Programs and Policies

Goals:

- Ensure that MMWD policies are consistent with aquatic resource protection (Source: MMWD).
- Follow and implement policies relevant to Lagunitas Creek watershed management (Source: MMWD).

3.7 Collaboration and Outreach

Goals:

- Remain a leader and collaborator among the multitude of agencies and interest groups that are involved with watershed management for Lagunitas Creek.
- Participate in watershed and water use planning with local, county, State, and federal agencies that have responsibilities and/or stakeholder interest in practices within the Lagunitas Creek watershed (Source: NMFS 2010, TBWC 2007).
- Collaborate with the Lagunitas TAC on activities conducted within the Lagunitas Creek watershed (Source: MMWD).
- Provide and participate in educational opportunities, about watershed and aquatic resource management, with schools, environmental organizations, and the general public (Source: MMWD).

3.8 Evaluating the Stewardship Goals and Targets

We expect to be able to evaluate the goals and targets through the monitoring effort described here (see Section 4.7) and through periodic assessments of the plan. The monitoring actions include surveys of habitat conditions and project effectiveness and are expected to provide a useful analysis to determine if goals have been met or to what extent they have been met. The District will also conduct an annual assessment of the Stewardship Plan, when we report on the District's actions on Lagunitas Creek to the SWRCB (see Section 4.1). In addition, we will conduct an assessment during the development of the District's budget for the upcoming fiscal year(s). In addition, as stated above (see Section 3.3), we assume that NMFS will conduct another CAP analysis, or some equivalent assessment, to evaluate if the goals of the federal coho recovery plan (NMFS 2010) have been met.

4.0 Stewardship Actions

Implementation Elements

The District has identified actions for this Stewardship Plan, and we have organized the actions into ten distinct implementation elements:

1. Ongoing mandatory requirements of SWRCB Order WR95-17;
2. Winter habitat enhancement;
3. Sediment reduction and management;
4. Instream and riparian habitat enhancement;
5. Biotechnical bank stabilization;
6. California freshwater shrimp habitat enhancement;
7. Monitoring;
8. Aquatic invasive species (AIS) management;
9. Programs and policies; and
10. Collaboration and outreach.

All actions in this plan are described below, presented in Table 3, and in Table ES-1. For each action, we have identified other entities that are most likely to be collaborators for implementation.

Implementation Approach

The actions have been grouped into one of three categories of District involvement with regards to the implementation of each action. All of the actions identified in this plan are understood to be vital to managing the Lagunitas Creek watershed for the benefit of the aquatic resources. The District recognizes these actions as being important and beneficial to Lagunitas Creek. The District is not financially capable of funding every action and it is reasonable for the District to prioritize its efforts in some way. We believe the categories described here help to do that while still demonstrating a significant commitment by the District and an acknowledgement of its responsibilities. The three categories of actions are:

1. Ongoing mandatory requirements of SWRCB Order WR95-17:

   These are actions that the District must conduct in compliance with the ongoing requirements of Order WR95-17. The District will implement these actions entirely with District funding and resources.

2. Actions MMWD will lead:

   These are actions in which the District will have a leading role in implementation. The District will actively organize and coordinate the efforts that are needed to conduct the actions. Any actions that entail work on MMWD-owned lands will be led by the District. Also, generally, many of the other actions in this category are those that the District has developed a particular expertise in or had historically been leading. The District will implement these actions through a combination of: District funding and commitment of resources; grants the District receives from a variety of possible grant programs; and other sources that may become available. We have not identified any particular percentage of District funding vs. funding from other sources for these actions; each will be funded in whatever way is appropriate and available. In all instances, the District will provide staff time to help conduct the action. For many of the actions, the District will cover other costs besides staff time but we will actively seek grants where funding sources are available. Collaborations with other entities working on the Lagunitas watershed will also be an important part of these actions being implemented.

3. Actions in which MMWD will participate but not necessarily lead:

   These are actions in which the District will participate but may not necessarily take the lead to implement. Other organizations may be more appropriate to take the lead on some of these actions and some of the actions will need to be a collaboration of many organizations. Some of the actions in this category are projects that will be located on property owned by another agency or on privately owned lands and it may be more appropriate for the landowner to take the lead on these projects. The District can contribute to these efforts in several ways. The results of our monitoring efforts can provide important data to help seek grant funding or to evaluate and describe a project. In other instances, MMWD staff and equipment may be able to assist with planning or implementation. The District may also be able to contribute financially and there may be actions that that District does ultimately lead. As with the actions MMWD will lead, we have not identified any particular percentage of District funding vs. funding from other sources to implement the action.

As we describe each action below, we begin by describing the category of MMWD involvement associated with the action.

Integrated and Adaptive Management Plan

The actions described below are intended to be implemented in an integrated manner. The goals and specific measures of one element of the plan will dovetail with those of another element. The actions will not be implemented in isolation from one another but rather conducted in concert with each other. In addition, MMWD will seek to integrate its actions with those of the other stakeholders who are conducting related actions in the watershed.

This plan will be implemented in an adaptive fashion. There will undoubtedly be many changing factors over the ten-year time period of this plan and some may influence where the priorities and actions need to be directed, not just for MMWD but for all the stakeholders collaborating on resource management in the Lagunitas Creek watershed. The District will coordinate its efforts through the Lagunitas Creek TAC (see Section 4.10) and seek consensus on adaptations to the plan, as the need arises.

4.1 Ongoing Mandatory Requirements of SWRCB Order WR95-17

These are the requirements of Order WR95-17 that had no time frame associated with them and are ongoing conditions. The District must implement these actions and remain in compliance with the Order.

Instream Flows

MMWD will maintain the minimum instream flows stipulated in Order WR95-17; the schedule of instream flows are shown in Table 2 and Appendix A. The minimum instream flows will be maintained at the USGS stream gage on Lagunitas Creek, at Samuel P. Taylor State Park. These minimum instream flows range between 8 cfs and 25 cfs, in a normal water year; and between 6 cfs and 20 cfs in a dry year. MMWD will release sufficient water into Lagunitas Creek, from Kent Lake at Peters Dam, as needed, to ensure that the stipulated stream flows are met at all times. MMWD will maintain a release of at least 1 cfs at all times.

Associated with the stream flow requirement is the need for MMWD to monitor stream flows continuously at the SP Taylor Park gage (see below), in order to determine what releases from Kent Lake are needed. At times, particularly during the winter and spring, the minimum stream flows are met and exceeded, at the SP Taylor Park gage, by contributions from San Geronimo Creek and other tributaries. At other times, usually throughout the summer, the minimum flows are maintained almost exclusively by releases from Kent Lake.

Upstream Migration Flows

MMWD will ensure that the upstream migration flows will be provided as stipulated in Order WR95-17 (see Table 2 and Appendix A). Four upstream migration flows will be provided between November 1st and February 3rd, each year, with the four flows beginning by November 15th, December 1st, January 1st, and February 1st. The upstream migration flows will consist of a continuous flow of at least 35 cfs, for 3 consecutive days, as measured at the SP Taylor gage. When possible, releases from Kent Lake to provide for the upstream migration flows will be timed to coincide with storm events; this will likely increase the potential for adult salmonids to move upstream, in response to these flows, and spawn. In some instances, the upstream flows will be provided by runoff during storm events, so that releases from Kent Lake are not needed.

Water Year Classification

MMWD will determine the water year classification, as a normal or dry year. The determination will be based on total precipitation that has occurred by January 1st and April 1st of each year and follow the formula specified in Order WR95-17 (see Appendix A). A normal year classification will be a January 1st measurement of at least 48 inches of precipitation during the preceding 15 months and an April 1st measurement of at least 28 inches of precipitation during the preceding 6 months. A dry year classification will be a January 1st measurement of less than 48 inches during the preceding 15 months and an April 1st measurement of less than 28 inches during the preceding 6 months. The January 1st precipitation measurements will dictate a normal or dry year flow regime from January 1st through March 31st. The April measurements will dictate a normal or dry year flow regime from April 1st through to the first upstream migration flow in November.

Water Temperature

MMWD will release water from Kent Lake to ensure compliance with the instream flow and upstream migration flow requirements of Order WR95-17. MMWD will also continue to monitor water temperature in Lagunitas Creek, at the SP Taylor gage, and document and report mean daily water temperatures. MMWD anticipates that the water temperature threshold of 58 degrees Fahrenheit between May 1st and October 31st will continue to be exceeded during the hottest days of the summer and that mean daily water temperatures on those days will range between 58 and 62 degrees Fahrenheit, and rarely approaching 64 degrees. We do not anticipate mean daily water temperatures to exceed 64 degrees Fahrenheit. During an average summer day, the water temperatures will be at or below 58 degrees. Also, we do not anticipate that the water temperature threshold of 56 degrees Fahrenheit between November 1st and April 30th will be exceeded, except perhaps in the circumstance of an exceptionally hot day in late March or April.

MMWD will continue to seek and pursue reasonable approaches to maintain water temperatures under the 58 degree threshold established by Order WR95-17. We do not believe that releasing additional water from Kent Lake would ensure water temperatures at the SP Taylor gage could be maintained at or below 58 degrees on the hottest days of the summer. Prior monitoring of water temperatures through Lagunitas Creek, and in San Geronimo Creek, indicated that ambient air temperature is the driving mechanism of water temperatures in the creek. In addition, there has been no evidence that the water temperatures that have been documented in Lagunitas Creek are detrimental to salmonid populations.

MMWD will collaborate with the Tomales Bay Watershed Council on water quality monitoring and the District will continue to monitor water temperatures at the SP Taylor Park gage and other locations in Lagunitas Creek and San Geronimo Creek (see Section 4.10). This monitoring effort will allow for a complete picture of water temperature ranges throughout the watershed. The District will provide a review of the water temperature monitoring effort to the SWRCB, DFG, NMFS, and U.S. Fish and Wildlife Service (USFWS).

Special Circumstances

If needed, MMWD will follow the reporting procedures laid out under the Special Circumstances condition of Order WR95-17 (see Appendix A). These procedures will only be implemented should MMWD find that it cannot meet the stream flow and/or water temperature conditions of the Order.

Since the Order was issued and as of the time of this writing, MMWD has been able to meet the stream flow conditions and has not needed to implement the Special Circumstances procedures, for any issues related to stream flow. MMWD has not been able to meet the water temperature conditions at all times, as described above. The District has previously notified the SWRCB of this in the annual reports submitted to SWRCB, describing MMWD's activities and compliance with Order WR95-17. In 2002, the District submitted a notification to the SWRCB, DFG, USFWS, and NMFS that the District had been unable to comply with the water temperature requirement of the Order. It is expected that the water temperature condition in Order WR95-17 will continue to not be met at all times and so MMWD will submit an updated notice to these agencies about this issue.

Ramping

MMWD will control releases from Kent Lake in order to minimize rapid changes in flow in Lagunitas Creek. The releases that have been made for the upstream migration flows have resulted in a noticeable but not dramatic change in the stream flow. The November upstream migration flow has been the largest change in flow, in some years resulting in the flow increasing from 8 cfs to 35 cfs, and that transition has occurred over about a 4-hour time period.

Gages

MMWD will ensure that the USGS stream gage at Samuel P. Taylor State Park will remain in operation with continuous monitoring and recording of daily stream flow. This gage (USGS station #11460400) is located about 1,000 feet upstream from the mouth of Devil's Gulch. MMWD will also ensure that a continuous record of mean daily water temperature at the SP Taylor gage is maintained.

Although not required by Order WR95-17, MMWD will also contribute to the continued operation of the USGS Point Reyes Station gage (station #11460600) located on the Gallagher Ranch, about halfway between the mouth of Nicasio Creek and the town of Point Reyes Station. In addition, MMWD will also continue to operate the San Geronimo Creek stream gage (station #K4) located at the Lagunitas Road Bridge, in the town of Lagunitas. Operation of these two gages is a component of the monitoring program (see Section 4.10 below) rather than a compliance issue for Order WR95-17.

Reporting

MMWD will compile and submit an annual report to the SWRCB, describing MMWD's activities and compliance with Order WR95-17. The annual reports will be submitted by December 31st of each year and cover the time period of the preceding water year, running from October 1st through September 30th. With each annual compliance report submitted to the SWRCB, MMWD will also submit any monitoring reports (see Section 4.10), completed in that year, and the reports of any other special studies conducted by MMWD.

4.2 Winter Habitat Enhancement

MMWD will pursue a winter habitat enhancement program, for main stem of Lagunitas Creek and lower Olema Creek (Figure 6). This effort will be conducted in collaboration with NPS, State Parks, and other landowners along the main stem of Lagunitas Creek. In addition, support from DFG, NMFS, and other potential funding sources will be sought. It will entail MMWD contracting with a qualified engineering consulting firm. MMWD will conduct all contract oversight and ensure all reporting is completed. This will be a long-term effort that will also entail collaboration with the TAC.

Problem Statement

The Lagunitas Limiting Factors Analysis (Stillwater Sciences 2008) identified winter habitat as the limiting factor for the coho salmon population in Lagunitas Creek. Fall juvenile and spring smolt survey data indicate dramatic declines in the numbers of juvenile coho during the winter months. Whether these declines are due to in-stream mortality or early emigration of coho smolts to the ocean (prior to smolt surveys commencing) is under investigation, but it is hypothesized that winter habitat in Lagunitas Creek is limited during either high flow or base flow periods.

Habitat Enhancement Concept

Survival of juvenile coho salmon through the winter could be improved by enhancing high flow refuge habitat both in- and off-channel, and by enhancing pool habitat in Lower Lagunitas Creek to allow for higher densities of coho at winter base flows. Winter habitat enhancement may be achieved through one or all of three approaches and would likely benefit steelhead as well as coho salmon:

1. Within the State Park reach of Lagunitas Creek (downstream of Shafter Bridge), install large wood structures that would provide backwater eddies as flow refuge;
2. Within the National Park/Tocaloma reach of the creek, create side channels and backwaters within the floodplain that salmonids could access during high flow events; and/or
3. Within the National Park/Tocaloma reach, install cross-channel, large wood structures at creek constrictions that would back up water and inundate the floodplain at lower flows, as well as provide in-stream cover and deepen pools.

Winter habitat enhancement work within the National Park/Tocaloma reach should also consider flow refuge enhancement for California freshwater shrimp, which may also be limited by winter habitat but which may very well require a different set of design criteria.

4.2.1 Winter Habitat Enhancement Assessment & Design

MMWD will lead the effort to evaluate and design winter habitat enhancement opportunities in the main stem of Lagunitas Creek.

Approach:

Accomplishing the goals of this program, especially the off-channel enhancement within the National Park/Tocaloma reach, will be approached in a two-phase planning study:

1) Assessment - Evaluate the feasibility of enhancing floodplain and/or in-channel habitat throughout the study area to increase the winter carrying capacity of coho salmon; and
2) Design - Develop site specific designs to enhance floodplain and/or in-channel habitat; ideally to a level of detail that the projects could move to construction.

Assessment Needs:

It is anticipated that the assessment will need detailed hydraulic modeling and engineering design work, developed in collaboration with a biological understanding of the needs of the fish and practical aspects of providing habitat enhancement. The assessment will require expertise in engineering, hydrology, geomorphology, fisheries biology, and environmental restoration. Detailed topographic mapping (i.e., a LIDAR survey; Figure 7) and a thalweg longitudinal profile survey will be useful for

both the concept and design assessment phases. The LIDAR survey and longitudinal profile survey have already been completed.

Winter Habitat Assessment Tasks

Collect Information on Other Winter and Floodplain Habitat Enhancement Projects:

A review of existing plans and completed floodplain and winter habitat enhancement projects, for coastal streams in the western U.S. will be conducted. This effort will gather information on other projects for lessons that can be learned about the successes and failures as well as the complexities of implementing similar projects.

Compile Existing Data for the Project:

The tremendous amount of survey, monitoring, and habitat data that has already been collected on Lagunitas Creek and Olema Creek will be brought forward for the project team to have at their disposal. There have already been several reviews and evaluations of the available data. This task will ensure the data is available to the project team. These data sets include: stream flow records, coho and steelhead population monitoring survey data (juvenile, smolt, and spawner data as well as some fry emergence data), habitat typing surveys, streambed and sediment studies, as well as topographic, GIS, and LIDAR survey data sets.

Complete Longitudinal Channel Bed Elevation Survey:

The LIDAR surveys that have been completed for Lower Lagunitas Creek and Olema Creek did not penetrate the water column to capture the stream bed elevation. This will be critical information for completing the assessment. A longitudinal channel bed elevation survey (long-profile survey) has been completed for the main stem of San Geronimo Creek and Lagunitas Creek, from Woodacre downstream to Devil's Gulch. A long-profile survey is a stream bed elevation survey through the thalweg of the channel. For this assessment, the long-profile survey will be completed for the main stem of Lagunitas Creek, from Devil's Gulch downstream to the Highway 1 Bridge at Point Reyes Station. A long-profile will also be completed for Olema Creek, from the Bear Valley Road Bridge (in the Town of Olema) downstream to the confluence with Lagunitas Creek (at the Giacomini Wetland Restoration site). A select number of cross-sectional stream profiles will also be surveyed to assist with the hydraulic modeling task of this project.

Conduct Hydraulic Modeling and Quantify Existing Winter Habitat:

This task will entail developing and running a hydraulic model to characterize present flow and flooding regimes through Lagunitas Creek and to predict flow and flooding regimes at potential winter habitat enhancement sites. The modeling effort will include the following:

- Adapt the LIDAR and streambed elevation data for a two-dimensional hydraulic model;
- Construct a 2-D hydraulic model for the study area;
- Field observe and collect other data at various winter flows and sites and use the data to constrain the hydraulic model and develop a rationale for the general accuracy of the model results and reliability for predicting habitat enhancement benefits of potential projects;
- Use the model to quantify existing winter habitat at both winter base flows and during relatively high-frequency floods; and
- Use the model to identify constraints on both floodplain and in-channel habitat.

Identify Feasible Winter Habitat Enhancement Approaches:

Based on the results of the hydraulic modeling, lessons learned from enhancement efforts in other watersheds, and knowledge of salmonid biology, we will identify potential winter habitat enhancement opportunities. It will be an open-ended evaluation of all enhancement options. The hydraulic model could help the team identifying locations of potential habitat enhancement projects that appear most practical and beneficial in terms of habitat enhancement success, construction feasibility, construction cost, impacts, and other factors. Some of the approaches that have already been identified include:

- Installing large wood structures that would provide backwater eddies as flow refuge (focused within the State Park reach and within the base flow channel of lower Lagunitas Creek and Olema Creek;
- Creating side channels and backwater habitats within the floodplain that salmonids could access during high flow events (focused within Lower Lagunitas Creek, especially the National Park/Tocaloma reach, and Lower Olema Creek, downstream of the town of Olema);
- Installing cross-channel large wood structures at creek constrictions that would back up water and inundate the floodplain at lower flows, as well as provide in-stream cover and deepen pools (focused within Lower Lagunitas Creek, especially the National Park/Tocaloma reach);

- Configuring and/or connecting floodplain channels to include connected parallel side channels, side channels with pool habitat, and/or oxbow channels;
- Creating opportunities for backwater refuge habitat at the mouth of tributary streams where they enter Lagunitas Creek;
- Using the LIDAR data and site visits to identify existing and historic or relic floodplain side channels that would be enhanced with minimal modifications; and
- Providing the full complement of salmonid rearing habitat features (woody debris cover, undercut banks, etc.) in any created floodplain channels.

We will prepare hydrology/hydraulic design reports documenting model results and other methods of evaluating the likely project benefits.

Identify Large Woody Debris (LWD) Habitat Enhancement Sites:

Opportunities to enhance winter habitat through the State Park reach will be identified during a field survey of the creek, by the project team. We will be seeking locations for installation and anchoring of LWD structures above the low-flow channel where backwater eddy habitat can be created.

Identify Base Flow Habitat Enhancement Opportunities:

Coupling existing habitat typing survey data, LIDAR and long-profile data, hydraulic modeling and field survey observations, the project team will identify where in-channel, base flow habitat enhancement could be achieved.

Select Winter Habitat Enhancement Sites and Designs:

The project team will finalize the Winter Habitat Assessment phase of the project and select the sites and conceptual designs to pursue for further consideration to move forward into the Habitat Enhancement Design phase.

Complete Winter Habitat Assessment Report:

The Habitat Assessment phase of the project will be documented through a draft and final Winter Habitat Assessment Report that will pull together and summarize the effort completed during this first phase of the project.

Winter Habitat Enhancement Design Tasks

Conduct Site Specific Topographic Surveys:

Detailed topographic surveys of habitat enhancement project sites will be needed for the design drawings. These surveys will be targeted at specific elevation data needs to compliment and fill data gaps not available from the exiting topographic data set or LIDAR data set for the study area. These will be limited theodolite site surveys, used to develop topographic site plans for each project.

Complete Construction Drawings:

Prepare permit- and construction-level engineering designs drawings of the selected winter habitat enhancement project sites. The plans will be prepared at 50% completion draft drawings and then final drawings, suitable for bid and construction. We anticipate preparing design drawings for 4-6 floodplain enhancement sites, a similar number of in-channel, base flow habitat enhancement sites, and up to 10 large wood debris habitat enhancement sites.

4.2.2 Construction of Winter Habitat Enhancement Projects

MMWD will participate in efforts to implement construction and maintenance of winter habitat enhancement projects.

Once the assessment and design work, described above, is completed, construction of specific enhancement projects can be pursued. This effort will be implemented in collaboration with NPS, State Parks, and the Marin RCD. If any projects are identified along the MMWD-owned section of Lagunitas Creek, between Peters Dam and Shafter Bridge, the District will take the lead. Further downstream, State Parks or NPS may be the most appropriate agency to lead. Collaboration and partnerships with other landowners and the Marin RCD will be sought, should project sites be designed on private lands, downstream of the NPS lands. Maintenance of the enhancement sites will also be conducted, on an as-needed basis. Funding from NMFS and DFG are likely sources that will be pursued.

4.3 Sediment Reduction and Management

This element will implement actions aimed at fine sediment reduction as well as efforts for sediment management that may enhance the streambed conditions. Sediment reduction efforts will focus on sediment source control (i.e., erosion control) at human-induced sources, particularly from roads. These efforts will be aimed at reducing fine sediment loading into the main stem of Lagunitas Creek and to its fish-bearing tributary streams. The streambed enhancement efforts will be aimed at increasing the gravel and cobble fraction of the streambed. It is recognized that there may be an inherent conflict between optimal habitat for coho and steelhead, which prefer a coarse substrate streambed, and California freshwater shrimp, which appear to be positively associated with sandy substrate. For the purposes of distinguishing fine from coarse sediments, sediments less than 4 mm will be considered fine sediment and consist of sand, silt, and organic matter.

MMWD has launched sediment reduction efforts, in collaboration with the SWRCB/RWQCB, and DFG, through these agency's grant-funded programs: the Lagunitas Water Quality and Habitat Improvement Project; and the Lagunitas Watershed Unpaved Roads Assessment Project. These projects are being conducted collaboratively on MMWD, State Park, and NPS lands, as well as some private properties within the watershed, in collaboration with the Marin RCD.

4.3.1 Lagunitas Water Quality and Habitat Improvement Project

MMWD is taking the lead to implement this project, in collaboration with the SWRCB/RWQCB, NPS, and State Parks. The project is being funded by the SWRCB and U.S. EPA, through a Clean Water Act 319(h) grant, with a cost share by MMWD (Agreement No. 08-611-552).

Project Description

This project implements prescribed sediment reduction treatments at priority road-related sites in Lagunitas Creek watershed. This work is intended to reduce sediment loading into the creek system to improve water quality, as well as benefit habitat for threatened and endangered salmonid fish species. The project includes work at 44 sites which were previously identified by Pacific Watershed Associates (PWA) through assessments conducted in 2003 and 2007. The sites have been grouped within five sub-watersheds (Figure 8). Treatments include drainage improvements such as outsloping, rolling dips, culvert replacements, road reconstruction, wet crossings and construction of sediment

basins. In total, it is estimated that implementing restoration treatments at these 44 sites will result in 5,494 cubic yards of sediment saved from entering the Lagunitas Creek stream system. Specific sites and treatments are as follows:

Samuel P. Taylor, Cheda Creek, and McIsaac Creek

Pacific Watershed Associates (2007) assessment work yielded a comprehensive inventory of road-related erosion and sediment delivery to streams along 9.2 miles of roads in the Lagunitas Creek watershed. The assessment report provides field data to identifiy and quantify currently observable and possible future sources of sediment and erosion along roads in three portions of the watershed, including McIsaac Ranch, Cheda Ranch and Samuel P. Taylor State Park. This project includes implementing prescribed treatments at 42 sites along 9.2 miles of roads, as detailed below:

McIsaac Creek Ranch:

Eight project sites located along 2.27 miles of unpaved roads on McIsaac Ranch lands, along McIsaac Creek, tributary to Lagunitas Creek (Figure 9). Sediment reduction work at these sites will include constructing outsloping, rolling dips, armored and wet crossings. The McIsaac Creek sites are located on federal, National Park Service lands.

Cheda Creek Ranch:

Twelve project sites located along 3.89 miles of unpaved roads on Cheda Ranch lands, along Cheda Creek, tributary to Lagunitas Creek (Figure 10). Sediment reduction work at these sites will include constructing outsloping, rolling dips, critical dips, culvert repairs, ditch relief culverts and downspouts. The Cheda Creek sites are located on federal, National Park Service lands.

Samuel P. Taylor State Park:

Twenty-two project sites located along a 3.04 mile length of the Cross Marin Trail in Samuel P. Taylor State Park, running adjacent to Lagunitas Creek (Figure 11). Sediment reduction work at these sites will include constructing rolling dips and critical dips, installing and repairing culverts, ditch relief culverts and downspouts, and installing armored fill crossings. The work in Samuel P. Taylor Park is on State Parks land.

In total, treating the above 42 sites would result in an estimated 5,011 cubic yards of sediment saved from entering the stream system.

The specific treatments for the McIsaac, Cheda, and Samuel P. Taylor State Park are provided below at the end of this attachement.

Lagunitas Creek and Dog Creek

Pacific Watershed Associates' 2003 assessment on MMWD lands yielded a comprehensive inventory of road-related erosion and sediment delivery sites, and forms the basis for the District's *Mt. Tamalpais Watershed Roads and Trails Management Plan* and associated EIR (2005). This project includes implementing prescribed treatments at Dog Creek, as follows:

Dog Creek:

This site is where Shafter Grade crosses Dog Creek (Figure 12) which is a high gradient perennial stream at the point of the crossing. The outflow of the Dog Creek is immediately adjacent to Lagunitas Creek. Shafter Grade is a critical access road to Peters Dam and is an important recreational route that allows public access to nearby state and federal parklands. The 48 inch culvert currently in place at the crossing is severely rusted, poorly aligned, undersized, and needs replacement. Also, Dog Creek has been observed to attract spawning steelhead. There is a natural bedrock fall 20 yards upstream of the crossing that serves as a barrier to spawning fish. Our evaluations suggest that construction of an arched culvert would be the most cost effective fish-friendly solution. This site was evaluated as a High-Medium treatment priority (site #73 in PWA's 2003 assessment) with a potential sediment savings of 238 cubic yards.

4.3.2 Lagunitas Watershed Unpaved Roads Assessment Project

MMWD is taking the lead to implement this project, in collaboration with the DFG & NOAA, NPS, State Parks, and the Marin RCD. The assessment is being funded by DFG and NOAA Fisheries, through a DFG Fisheries Restoration Grant Program grant, with a cost-share by MMWD (Grant Agreement No. PO083040900).

Project Description

This project includes performing a comprehensive assessment of unpaved roads in the Lagunitas Creek Watershed, including developing a site inventory and prioritizing sediment source repair sites on 105 miles of unpaved roads. The goal of the assessment is to identify the highest priority sites so that restoration efforts can be implemented in the most beneficial manner in order to reduce sediment loading into Lagunitas Creek and improve instream habitat conditions in the creek. The assessment is being conducted within the portion of the watershed that is downstream from dams (i.e., downstream of Kent Lake and Nicasio Reservoir; Figure 13) and only in areas where an assessment has not already been completed.

MMWD completed a GIS effort in 2007 that identified 598 miles of roads within the entire Lagunitas Creek watershed; consisting of 430 miles of unpaved roads and 168 miles of paved roads (Kelleher 2007). More than half of the unpaved roads are publicly owned and/or maintained, providing a variety of uses including access to water supply and other publicly owned facilities, access for agricultural management, fire protection, and recreation. In 2001, MMWD initiated development of a Memorandum of Understanding (MOU) for Maintenance and Management of Unpaved Roads in the Lagunitas Creek Watershed (attached); participating agencies include MMWD, National Park Service, California State Parks, the County of Marin, Marin County Open Space District, and Marin County Resource Conservation District. The goal of the MOU is to manage and maintain unpaved roads in the most beneficial ways possible to minimize soil loss from dirt roads, reduce the potential for erosion, and reduce the amount of sediments entering the stream system. The MOU covers all unpaved roads throughout the watershed and distinguishes the watershed downstream of dams from the watershed upstream from dams, as the Primary and Secondary Resource Areas, respectively (see Figure 13). Peters Dam, which forms Kent Lake, and Seeger Dam, forming Nicasio Reservoir, are the two dams that are the boundaries between the Primary (downstream) and Secondary (upstream) Resource Areas.

The objective of this project is to complete a detailed assessment of all unpaved roads in the Lagunitas Creek watershed, downstream of Kent Lake & Nicasio Reservoir (Figure 14), that have not already been or are not already planned for assessment. The assessment will identify road drainage improvements that can be implemented to reduce sediment loading into streams, to improve instream habitat conditions for coho and steelhead. The assessment will also identify where fish passage problems exist at road crossings of fish-bearing streams. This project furthers the multi-agency MOU

for Maintenance and Management of Unpaved Roads in the Lagunitas Creek Watershed (October 2001); this is the next step that follows the completion of the GIS of all roads in the watershed.

This erosion prevention planning project will result in the inventory and assessment of approximately 105 miles of public and private open space, ranch, and rural residential access roads in the Lagunitas Creek watershed. The objective of the project is to conduct an inventory and assessment of road-related erosion sites, which will be used to produce a detailed erosion prevention and erosion control plan that protects and improves habitat for salmonids by preventing controllable erosion and sedimentation in the project area. Only sediment sources that will deliver sediment to a stream channel are being considered for inclusion in the plan. Sources of erosion which do not deliver sediment to a stream will not be considered for remediation, but are being mapped so as to inform the landowner.

Road Assessment Work Completed to Date

Road assessments have already been completed on some portions of the Lagunitas Creek watershed. To date, these include: the entire watershed area that is upstream of Peters Dam/Kent Lake (these are lands owned by MMWD); the half mile of Lagunitas Creek between Peters Dam and Shafter Bridge; those portions of the San Geronimo Creek sub-watershed that are owned by the Marin County Open Space District; the 3 miles of the Cross-Marin Trail/old railroad grade road along Lagunitas Creek in Samuel P. Taylor State Park; a majority of unpaved roads in the Devil's Gulch sub-watershed; the 3.9 miles of unpaved roads in the Cheda Creek sub-watershed; and the 2.3 miles of unpaved roads in the McIsaac Creek sub-watershed. Other areas where assessments are in progress or planned include: about 6 miles of residential, non-County maintained private roads in the San Geronimo Valley; and a short segment of the Barnabe fire road in Samuel P. Taylor State Park. All of these areas are being excluded from the roads assessment as they are already covered.

Road Assessment Tasks

The assessment project consists of three main work tasks:

1) Field inventory of upland sediment sources (sites of erosion and sediment delivery), primarily road-related sediment sources but including inventorying all road crossings of streams and drainages for potential erosion and fish passage;
2) Data entry and analysis; and
3) Preparation of a prioritized plan-of-action for erosion prevention and erosion control.

All inventory methods, calculations, prioritization and recommended treatments will follow guidelines and standards described in the "*Handbook for Forest and Ranch Roads, a Guide for Constructing, Re-constructing and Maintaining Wildland Roads" (Weaver and Hagans 1994),* commissioned by the California Department of Forestry and Fire Protection (CDF&FP), the Natural Resource Conservation Service (NRCS) and the Mendocino County Resource Conservation District, and the "*California Salmonid Stream Habitat Restoration Manual, Chapters 9 and 10*" (Flosi et al 1998 and 2002). MMWD is contracting with a qualified consulting firm to complete the assessment field survey, data analysis, and action plan. All oversight and management of the project is being be conducted by MMWD.

4.3.3 Roads GIS Update

MMWD is taking the lead to implement this GIS effort, in collaboration with the Marin County, NPS, State Parks, Marin RCD, and SPAWN.

MMWD will update the GIS of roads in the Lagunitas Creek watershed, completed in 2007 (Kelleher 2007). The GIS was completed as part of the collaborative effort to manage and maintain unpaved roads, through the multi-agency memorandum of understand (MOU; see Section 4.8 below). The GIS is intended to be available to all stakeholders to use for identifying, evaluating, maintaining, and monitoring road in the watershed.

As MMWD completes activities associated with the management and maintenance of roads in the watershed, the GIS will be updated to add any new data or other information on those roads. Starting with the roads assessment project described above (see Section 4.3.2, and Figure 14), information from that assessment will be added to the GIS. As implementation of road drainage improvements are completed, those treatments will be built into the GIS database. When monitoring and maintenance activities are conducted, additional data can be incorporated into the GIS.

MMWD will collaborate with other agencies and stakeholders who conduct road management and maintenance activities to make the GIS available to them and so their data can also be incorporated into the GIS. This collaborative approach to maintaining the GIS has been conducted since the 2007 GIS was compiled.

4.3.4 Sediment Source Treatments in the Watershed

MMWD will lead implementation of sediment source site treatments on publically-owned land in the Lagunitas Creek watershed between Peters Dam and Nicasio Creek. The District will participate in similar efforts in the San Geronimo Valley and Olema Creek drainage.

Once the roads assessment described above is completed (see Section 4.3.2), MMWD will pursue implementation of road drainage improvements in collaboration with other stakeholders in the watershed. This effort will require partnerships with the land owners and other agencies or interest groups. The assessment and action plan will be a resource that all stakeholders can utilize to implement road drainage improvements throughout the watershed. It will identify discrete sediment source sites to treat and stabilize. In some instances, MMWD will be able to take the lead in implementation but not in all cases. Other stakeholders may be a more appropriate and better suited entity to pursue implementation. MMWD will focus its efforts on the portion of the Lagunitas Creek watershed that owned by MMWD, State Parks, and NPS between Peters Dam and Nicasio Creek.

Since the *Lagunitas Creek Sediment and Riparian Management Plan*, there have been a few inventories and assessments of sediment source sites throughout the Lagunitas Creek watershed. Each of these assessments has identified sediment sources and done some prioritization of the sites. In most cases, sediment control (i.e., erosion control) and stabilization repairs were then implemented at the highest priority sites. However, there remain many sediment source sites that have not been treated.

MMWD will implement repairs at some of the sediment source sites previously identified during sediment source inventories conducted between 1988 and 2006 (Figures 15 & 16). The focus of this effort will be to review sediment sites identified during the following assessments:

- *Lagunitas Creek Sediment and Riparian Management Plan* (MMWD 1997);
- *San Geronimo Creek Watershed Sediment Source Sites Assessment and Evaluation* (Stetson Engineers 2002, prepared for MMWD); and
- *Middle Lagunitas Creek Watershed Sediment Delivery Analysis* (Stillwater Sciences 2007, prepared for County of Marin).

The focus of source control actions will be on road-related sites and other human-induced erosion sites. Hillslope erosion sites will not be a focus of this effort. MMWD will focus its efforts on publically-owned lands in the main stem Lagunitas Creek portion of the watershed, between Peters Dam and Nicasio Creek; these will be lands owned by MMWD, State Parks, and NPS.

Sediment source treatments will follow the techniques that have been previously employed through the *Lagunitas Creek Sediment and Riparian Management Plan* and that are prescribed in the following guidance manuals:

- *Handbook for Forest and Ranch Roads, a Guide for Constructing, Re-constructing and Maintaining Wildland Roads (*Mendocino County Resource Conservation District 1994*);*
- *California Salmonid Stream Habitat Restoration Manual (*DFG 2002); and
- *Groundwork: A Handbook for Small-Scale Erosion Control in Coastal California* (Marin County Resource Conservation District).

4.3.5 Streambed Gravel Management

The District will lead an evaluation to describe and identify opportunities for gravel augmentation and enhancement in the watershed. The evaluation will be conducted in collaboration with the Lagunitas TAC. MMWD will also take the lead on implementation of a gravel management strategy within the main stem of Lagunitas Creek. We will participate in gravel management activities implemented in the tributaries to Lagunitas Creek.

Under the *Sediment and Riparian Management*, MMWD placed creek gravels into Lagunitas Creek, between Peters Dam and Shafter Bridge. This effort was fairly limited and only somewhat successful. There are likely continuing opportunities to enhance streambed conditions for spawning, and possibly for flow refuge with larger cobbles, through gravel augmentation. However, a more thorough evaluation of gravel management is needed before proceeding with any specific action.

MMWD will spearhead an evaluation of streambed gravel management opportunities that will consider the main stem of Lagunitas Creek and the tributaries of San Geronimo Creek, Devil's Gulch, and Olema Creek. This assessment will be conducted in collaboration with representatives from the Lagunitas TAC. The assessment will consider continuing gravel augmentation between Peters Dam

and Shafter Bridge but also more broadly evaluate gravel source opportunities; flow refuge potential, for steelhead, with cobbles; along with spawning densities and superimposition at riffle sites and spawning habitat enhancement options with gravel.

An implementation strategy will also be developed by MMWD, in collaboration with the TAC. MMWD will then seek to implement gravel management projects, if and where they have been identified for the main stem Lagunitas Creek (downstream of Peters Dam), and at MMWD properties on San Geronimo Creek. MMWD will collaborate with State Parks, NPS, Trout Unlimited, and others if and where gravel management projects are identified for San Geronimo Creek, Devil's Gulch, and Olema Creek.

4.4 Instream and Riparian Habitat Enhancement

4.4.1 Rearing Habitat Enhancement with Large Woody Debris (LWD)

MMWD will lead the design, installation, and maintenance LWD structures in the main stem of Lagunitas Creek downstream of Peters Dam and through Samuel P. Taylor State Park (and on District lands along San Geronimo Creek), in collaboration with State Parks. The District will participate in the design, installation, and maintenance of LWD structures downstream of Samuel P. Taylor State Park and in Devil's Gulch, in collaboration with NPS and Trout Unlimited.

MMWD will maintain those LWD structures that have already been installed in the main stem of Lagunitas Creek, under the *Sediment and Riparian Management Plan* (Figure 17). The maintenance will be conducted on an as-needed basis. The LWD structures will be inspected annually and repairs will be made each year. In some instances, LWD structures will become dislodged and move downstream such that replacement structures will be needed. In these instances, the replacement structures will need to go through design and permitting, as if they were new structures, and it may take longer than a year to complete.

MMWD will install new LWD structures within the summer low flow channel of main stem Lagunitas Creek, to enhance pool and rearing habitat. However, this effort will be dependent upon the outcome of the winter habitat enhancement evaluation (see Section 4.2 above). An outcome may be to provide high flow refuge within the base flow channel of Lagunitas Creek. If that proves to be the case, then a LWD structure could serve to provide both winter flow refuge and summer rearing habitat. MMWD will

also take the lead on installing LWD structures on District-owned property along San Geronimo Creek. The two MMWD parcels on San Geronimo Creek include the San Geronimo Treatment Plant property, in Woodacre, and the Lagunitas Booster Station property, in Lagunitas.

MMWD will participate on similar LWD projects in Devil's, in collaboration with Trout Unlimited, State Parks, and NPS. State Parks and NPS are the two land owners and Trout Unlimited has expressed a commitment to salmonid habitat enhancement for Devil's Gulch. Any LWD structures in this smaller, more narrow tributary will warrant designs that are appropriate to the scale of this stream.

The planning, design, and implementation of new or replacement LWD structures will be based upon MMWD's extensive experience in LWD construction under the *Sediment and Riparian Management Plan*, as well as the guidance provided in the *California Salmonid Stream Habitat Restoration Manual (*DFG 2002). The following strategies and approaches to for LWD structures will be implemented:

- The site specific goal for each LWD structure will be identified and dictate the design;
- LWD site selection will seek to utilize existing standing trees as anchoring points;
- LWD site selection will utilize a longitudinal streambed profile survey of Lagunitas Creek, San Geronimo Creek, and Devil's Gulch as a tool to identify optimal site locations;
- LWD site selection and design will strive to avoid impacts to existing spawning habitat;
- The preference will be to place LWD structures on the surface of the stream bed and bank, rather than to anchor logs by burying them into the bed or bank;
- The design and anchoring of LWD structures will anticipate some movement or shifting of the structure (i.e., anchoring will not use an excessive amount of boulders to hold the structures rigidly in place);
- No heavy equipment will enter the low-flow channel of the creek during LWD construction;
- LWD construction will be conducted between Aug 1 and October 15.

4.4.2 Devil's Gulch Habitat Enhancement

MMWD will participate in an effort to develop and implement a habitat enhancement strategy for Devil's Gulch, in collaboration with Trout Unlimited, Marin RCD, State Parks, NPS.

This effort is being led by Trout Unlimited, with participation of the Marin RCD, State Parks, NPS, RWQCB, and others. The effort will consider and implement LWD structures for habitat enhancement,

as described above (see Section 4.4.1). It will also consider streambed enhancement through gravel and cobble augmentation, also described above (see Section 4.3.5). MMWD will contribute staff time, LWD logs, and other resources to this effort.

4.4.3 Riparian Vegetation Enhancement

MMWD is leading a riparian habitat enhancement effort along the portion of Lagunitas Creek between Peters Dam and Shafter Bridge. The District will participate in riparian vegetation enhancement through the lower State Park and Tocaloma reaches. In addition, MMWD will continue to follow the guidance and practices for riparian management in the multi-agency, woody debris MOU, described below (see Section 4.9).

Riparian Enhancement through the Mt. Tamalpais Watershed Gateway Project

The District is implementing riparian enhancement in discrete sections of the Lagunitas Creek, between Peters Dam and Shafter Bridge. The work is part of MMWD's Mt. Tamalpais Watershed Gateway Project. It is being funded by grants from the California State Coastal Conservancy and the California Resources Agency (River Parkways Program). The District will maintain and enhance the riparian corridor along the remaining portions of Lagunitas Creek between Peters Dam and Shafter Bridge. This is the only section of Lagunitas Creek, below Peters Dam, that is owned by MMWD. We will control invasive weeds and install riparian revegetation along this entire section, for habitat enhancement.

MMWD is conducting habitat restoration activities at several sites situated between Peters Dam and Shafter Bridge. These sites are situated on the west side of Lagunitas Creek and include a former stream crossing where a footbridge was installed in early 2010, two decommissioned road sites, and sites along the streambank of Lagunitas Creek (Figure 18). The effort includes outreach and education activities with assistance from SPAWN for the revegetation plantings.

The purpose of this project is to improve recreational trails, public access and education; restore habitat; and protect endangered species along Lagunitas Creek on the Marin Municipal Water District's Mt. Tamalpais watershed lands. The project's goals are to:

- Restore natural conditions in the project area as much as possible;
- Protect endangered and threatened coho salmon and steelhead trout habitat and sensitive riparian areas from watershed users;
- Improve user access while simultaneously creating a safer and more sustainable trail; and
- Improve public understanding of human impacts to creek ecosystems.

A major feature of this project has been to improve access for fish viewing during spawning season at the Leo T. Cronin Fish Viewing Area, and increase public understanding of human impacts to creek ecosystems. This has entailed:

- Repaving the Leo T. Cronin Fish Viewing Area parking area, using permeable surfaces;
- Improving the parking area by designate parking slots, install log parking barriers, and repositioning a new entry gate; and
- Installing approximately 300 linear feet of split-rail exclusionary fencing around the perimeter of the parking area, at the top of bank.

Other work for this project entails the following tasks:

- Removal of invasive plant species such as vinca, broom, and cape ivy along the banks of Lagunitas Creek;
- Decommissioning 950 feet of informal or redundant trails;
- Constructing improvements to 950 feet of existing hiking trails;
- Constructing a 30-foot by 5-foot wooden footbridge across a seasonal tributary;
- Installation of up to 20,000 native plants at restoration sites;
- Installation of a temporary irrigation system, or irrigation supplement (e.g., DriWater) for the plantings;
- Installation of new educational signs at an information kiosk with interpretive material; and
- Regular inspections and maintenance (on an as-needed basis) of the revegetation sites.

Riparian Enhancement in the Lower State Park and Tocaloma Reaches

MMWD will participate in efforts to install native plants along the edge of the stream channel, to enhance habitat for the California freshwater shrimp, at various locations through the lower State Park and Tocaloma reaches of Lagunitas Creek. The intent will be to have vegetation growing along pools

and for those plants to extent fine roots into the pool, thus improving habitat in the pool for shrimp. The criteria for site selection and vegetation plantings will be as follows:

- Install only native plants; specifically plants that produce fine roots extending into the water column (e.g., dogwood, willow, blackberry, ash, alder);
- Select pools for vegetation plantings that have at least one foot of water depth along the shoreline and that are lacking in riparian vegetation;
- Install plantings by hand; and
- Provide supplemental irrigation with DriWater (or equivalent product).

4.5 Biotechnical Bank Stabilization

MMWD will lead efforts for biotechnical bank stabilization at sites on District-owned property. We will participate in bank stabilization projects at other locations.

For any stream bank stabilization project completed by MMWD, within the Lagunitas Creek watershed, MMWD will employ a biotechnical approach to the bank stabilization project. MMWD will implement biotechnical bank stabilization projects at three sites (Figure 19):

- Lagunitas Booster Station Site on San Geronimo Creek (Figure 20);
- Below Peters Dam Site on Lagunitas Creek (Figure 21); and
- Samuel P. Taylor State Park Site on Lagunitas Creek (Figure 22).

Biotechnical bank stabilization utilizes native riparian vegetation, logs, woody debris and/or native soils and incorporates these materials into the bank stabilization structure. Some biotechnical bank stabilization projects relay entirely on these materials for the structure while other projects include them as an element of the structure. In some cases, native plants or wood can serve to provide a habitat feature to the structure.

4.5.1 Lagunitas Booster Station Site

The Lagunitas Booster Station is an MMWD pumping facility located along Sir Frances Drake Boulevard, in the town of Lagunitas. The facility pumps raw (untreated) water en route from Kent Lake or Nicasio Reservoir to the San Geronimo Treatment Plant, in Woodacre. The site is located between

Castro Avenue and Mountain View Road and across from Cintura Avenue. This site is also the location of one of MMWD's annual juvenile salmonid survey sample sites (sample site SG-2; see Section 4.10).

San Geronimo Creek flows behind the booster station and through the parcel of land owned by MMWD (MMWD owns the land on both sides of the creek). The habitat through this section of the creek consists of a fairly large riffle between two pools, in a pool-riffle-pool habitat complex. The riffle has been documented to be a very active salmonid spawning site, often with multiple redds being developed on the riffle (particularly at the riffle head/pool tail area). Both pools have been found to support numerous juvenile coho and steelhead, in most years.

The roughly 200 foot section of streambank directly in front of the Lagunitas Booster Station is badly eroded and most of it is a sheer wall of exposed soil (see Figure 20). MMWD will stabilize this section of streambank, incorporating biotechnical methods into the repair. Along the 200 foot section of stream bank, there are a few bay and box elder trees at the upper end with dense blackberry hanging over most of the rest of the bank, and exposed soils underneath the blackberry.

A complicating aspect of this project is that there are several pipes extending out of this stream bank that are part of the booster station facility. The booster station contains pressure relief valves in order to relieve pressure surges to prevent pipeline ruptures. The facility was configured such that the relief values shunt water to discharge pipes that exit the facility and run to the stream bank of San Geronimo Creek, discharging the water into the creek. When the pressure surges occur, there can be discharges of raw water into San Geronimo Creek. These are usually very short-duration discharges (in the order of a few seconds) but can be relatively high velocity that cause scouring of the stream bed of San Geronimo Creek. While the pressure relief valves are necessary, the discharges directly into San Geronimo creek is not an ideal configuration, because of potential impacts to habitat through bed scour. Therefore, in addition to this project being a streambank stabilization project, it will also address the water discharges with the aim of reducing potential impacts to the habitat of San Geronimo Creek.

This site is fairly well shaded and it may be difficult to get willows to grow into the soils here. The most highly eroded portion of the stream bank is along the riffle habitat at this site. The bank stabilization project has to be designed and implemented to reduce the potential for this active spawning area to be altered. Somewhat fortunately, the riffle habitat up against the toe of the stream bank is usually dry during the summer months, with the water flowing along the opposite bank. Assuming that dewatering

of the work area for a bank stabilization project is needed during construction, it would most likely not have to entail relocating fish or disturbing the wetted channel.

The available work area for a bank stabilization structure is extremely constrained at this site. There is a very narrow strip of land, which is only about 6 feet wide, from the edge of the booster station facility out to the top of bank.

MMWD staff are evaluating options to dissipate the water discharges from the booster station into San Geronimo Creek and to stabilize the eroded stream bank. The preferred approach is to install a log and rock crib wall up against the eroded stream bank, and have the pressure relief discharge pipes discharge onto the top of this crib wall. Riparian vegetation can be incorporated as plantings into the crib wall.

On the opposite side of the creek, a roughly 30 foot section of the bank was carved into by erosive flows and has eroded. MMWD will stabilize these sections of streambank, incorporating biotechnical methods into the repairs. Periwinkle covers most of the 30 foot section of bank on the opposite side of the creek. This area will be stabilized with plantings of native riparian trees (box elder, bay, big-leaf maple, and/or buckeye).

4.5.2 Below Peters Dam Retaining Wall Site

This site is at the location of a drilled-pier retaining wall structure, immediately downstream from the Peters Dam plunge pool. The retaining wall was constructed to protect the 27-inch pipeline that conveys water from Kent Lake to the San Geronimo Treatment Plant. During the New Years Eve storm of 2005, extremely high flow over the Peters Dam spillway and down Lagunitas Creek caused a landslide of a 160 foot section of the stream bank and a portion of the access road to the base of Peters Dam. The retaining wall successfully protected the pipeline and access road but the stream bank between the retaining wall and channel of Lagunitas Creek remains slumping and largely unvegetated (see Figure 21).

The streambank stabilization project will entail plantings of native trees and shrubs on the eroded stream bank. This will require importing soil amendments to provide a planting medium. The area is fairly open and exposed to sunlight so willows should grow at this site, given sufficient irrigation. Other plantings can include redwood and alder saplings. It should be possible to install a temporary

irrigation system, given a water supply and power is available nearby at the stream release structure, just upstream.

4.5.3 Nicasio Transmission Line Retaining Wall Site in SP Taylor Park

This site is another drilled-pier retaining wall structure, constructed by MMWD to protect the Nicasio Transmission Pipeline. It is located along a nearly 400 foot section of Lagunitas Creek in Samuel P. Taylor Park. The heavy rains and severe flood of late December and early January 2005/06 caused a slope failure of the stream bank and eroded a portion of the State Park service road. The 36-inch Nicasio Transmission Line runs under the service road and became partially exposed. The retaining wall successfully protected the transmission line and service road. However, the stream bank between the retaining wall and channel of Lagunitas Creek has remained an exposed and eroded slope with continued cutting into the toe of slope and additional slope failure (see Figure 22). Some portions of this section of stream bank no longer support any vegetation and other portions are lose, slumping soils with some vegetation. This section of the creek has several discrete landslides separated by seemingly intact sections of stream bank, however, the entire 400-foot section is considered unstable.

The streambank stabilization project at this site will entail toe protection that incorporates large wood into it, fabric reinforced soil lifts to reestablish the stream bank, native riparian plantings to revegetate the slope, and erosion control materials. Supplemental irrigation of any plantings will need to utilize DriWater (or equivalent) since there is no opportunity for a temporary irrigation system at this site. The design for this project will need a detailed topographic survey and hydrologic analysis.

A large woody debris log jam spans Lagunitas Creek at the upstream end of this section of the creek. That debris jam will be left in place and will not be disturbed. The jam was caused when large trees on the streambank fell into the creek during the slope failure (it is not an MMWD-constructed LWD structure).

4.6 California Freshwater Shrimp Habitat Enhancement

The District will take the lead to conduct an assessment of habitat enhancement opportunities for California freshwater shrimp. Following the assessment, MMWD will participate in efforts to construct

or install site specific freshwater shrimp habitat enhancement projects in the main stem of Lagunitas Creek.

MMWD will convene a panel of experts on California freshwater shrimp to conduct an assessment on the shrimp's habitat needs and enhancement opportunities. The group will include members from the Lagunitas TAC. This group will review population data and develop habitat parameters most suitable to freshwater shrimp. The assessment will also describe habitat enhancement measures specifically designed to benefit the shrimp and we will .identify site through the main stem of Lagunitas Creek where these measures can be implemented.

MMWD will incorporate habitat enhancement for California freshwater shrimp into the winter habitat enhancement actions (see Section 4.2) instream and riparian habitat enhancement actions (see Section 4.4). This will include:

- Installations of woody debris structures designed specifically to enhance shrimp habitat; and
- Installations of native riparian vegetation plantings along pool margins in the lower State Park and Tocaloma reaches.

The installations of woody debris structures, to enhance freshwater shrimp habitat, will be designed and implemented to provide winter flow refuge habitat for the shrimp. While the specific design criteria will be determined as part of the winter habitat assessment, the following guidelines are expected to be followed:

- Flow refuge habitat for shrimp should be focused within the base flow channel of Lagunitas Creek, not necessarily in floodplain areas;
- Woody debris structures will be of a smaller scale than LWDs for salmonids;
- Woody debris structures will be positioned near the water surface and at the margins of deep pools;
- Woody debris structures will be designed to provide slow, backwater eddies as flow refuge for the shrimp; and
- Native riparian vegetation, along the shoreline, will be incorporated into the woody debris structures.

4.7 Monitoring

The District will take the lead to implement the monitoring surveys described for this Stewardship Plan. The monitoring effort will be implemented in collaboration with the Lagunitas Creek TAC.

Surveys for coho salmon and steelhead trout have been conducted in Lagunitas Creek since the 1970s. These surveys were initially conducted cooperatively between MMWD and CDFG and more recently have been a collaboration of MMWD, NPS, SPAWN, and U.C. Berkeley. Electrofishing for juvenile salmonids began in 1970, when CDFG established index sites for surveying. The electrofishing surveys at the index sites and other locations were performed in 1970, 1980, 1982 through 1988, 1990, and 1993 through 2010. In recent years MMWD has also conducted snorkel surveys for juvenile salmonids. This represents one of the longest data sets for juvenile salmonids in the coastal streams of California. Systematic coho spawner surveys were conducted during the 1982-83 and 1983-84 spawning seasons, and from the 1995-96 spawning season through the 2009-10 spawning season. California freshwater shrimp surveys were conducted in 1981, 1991, 1994, and annually between 1996 and 2009. Habitat typing surveys have been conducted in 1992, 1995, 1997, 1998/99, 2003, and 2006. Stream flows in Lagunitas Creek have been monitored daily since the early 1980s. Water quality monitoring of temperature, dissolved oxygen, and turbidity has been performed on a monthly basis since the early 1990s. Smolt outmigration monitoring began in 2006 and has been conducted each year since. The data collected through smolt monitoring have provided compelling evidence that winter habitat is currently limiting the coho population of Lagunitas Creek.

The purpose of the scientific monitoring in Lagunitas Creek is to answer the following questions:

- What are the trends in coho salmon, steelhead, and California freshwater shrimp abundance at multiple life stages?
- Is there a relationship between the population trends and MMWD management efforts?
- What salmonid and shrimp life stages suffer the lowest survival and should be the focus of future management practices?

The monitoring will include the studies and methods listed below. The methods for most of the studies are further described in Appendix D and Appendix E.

4.7.1 Survey & Monitoring Workgroup

MMWD will collaborate with other entities conducting monitoring surveys in the watershed. MMWD will help to form a monitoring workgroup to coordinate monitoring surveys and develop protocols for consistent methodologies and data sharing. The Lagunitas TAC has already formed the Lagunitas TAC Monitoring Subcommittee, which will be the venue for the workgroup.

4.7.2 Stream Flow and Water Temperature Monitoring

MMWD will ensure that there is continuous monitoring of stream flow at two gages: Point Reyes Station, on Lagunitas Creek (operated by USGS); and at Lagunitas Rd. on San Geronimo Creek (operated by MMWD) (see Figure 2). We may also conduct water temperature monitoring at these stream gages. Monitoring of stream flow and water temperature at the SP Taylor Park stream gage (operated by USGS) is a mandatory requirement of Order WR95-17 and so is described and included as an action for continued compliance with the Order (see Section 4.1 above).

4.7.3 Juvenile Salmonids Surveys

MMWD will conduct annual juvenile salmonid surveys. This is a summer/fall juvenile salmonid population abundance and salmonid habitat monitoring study. Sampling will occur at multiple survey sites during August, September and October. Backpack electrofishing, including multiple pass sample-depletion survey techniques, will be used to capture juvenile salmonids. Salmonids will be anesthetized, handled (identified to species, measured and weighed), sampled (by collection of fin clips or scales) and released back into the habitat unit from which they were taken. Habitat type and quality will be assessed at each survey site.

The surveys will be conducted at the 13 previously established sample sites in main stem Lagunitas Creek, main stem San Geronimo Creek, and Devil's Gulch (Figure 23). The methodology for the juvenile monitoring and other surveys is presented in Appendix D.

4.7.4 Salmon Spawner Surveys

MMWD will conduct annual salmon spawner surveys for a salmonid spawner abundance and population genetics study (see Appendix D). The surveys will be conducted through the main stem

Lagunitas Creek, the main stem San Geronimo Creek, and Devil's Gulch. The Lagunitas Creek section will be focused between Peters Dam and Tocaloma with less frequent surveys between Tocaloma and Nicasio Creek and occasionally downstream of Nicasio Creek (see Figure 23). Surveys through each stream section will be conducted weekly during the spawning season of late October through February. Surveys may be extended into March in some years. Teams will survey stream reaches to observe and record the number, species, location, and behavior of spawning adult salmonids. Redds will be located and measured. Carcasses of salmonids that are encountered during spawner surveys will be measured, sex recorded, evaluated for spawning condition, tissue sampled, marked to avoid double counting, and returned to the location where they were found. Tissue samples collected from carcasses will include opercular clips and otoliths. The opercular clips will be sent to the NMFS Santa Cruz lab (Dr. Carlos Garza) for genetic analysis. The otoliths will be sent to U.C. Berkeley (Dr. Stephanie Carlson) for analysis. In recent years, incidents of river otters taking adult salmonids have been reported. We will collaborate with NPS to record and track any such incidents observed or reported to evaluate if this appears to be prevalent but we will not propose managing the otter population.

4.7.5 Salmon Smolt Surveys

MMWD will conduct an annual salmon smolt outmigration monitoring study, utilizing a rotary screw trap (see Appendix D). The sample location will be at the Gallagher Ranch, on the main stem of Lagunitas Creek (Figure 24). A second trap may be employed at an upstream location to quantify the proportion of smolts originating between the upstream and Gallagher Ranch trap locations. The survey will be conducted from March into June. Coho salmon smolts and young-of-the-year (YOY), steelhead smolts and YOY, and Chinook salmon smolts will be captured in the rotary screw trap, anesthetized and handled to determine species, length and weight. After sampling, the majority of juvenile salmonids will be released downstream of the trap. A subset of juvenile salmonids will be marked using fin clips or PIT tags, released upstream of the rotary screw trap, and may be subsequently recaptured. Scales will be collected from up to ten coho and ten steelhead per day and provided to U.C. Berkeley (Dr. Stephanie Carlson) to be analyzed as part of an investigation into salmonid growth and survival in the watershed.

4.7.6 Coho Winter Habitat Survey

This is a juvenile coho winter habitat utilization study in Lagunitas Creek. Juvenile coho use of off-channel habitat enhancement areas will be investigated by capturing fish using a combination of

backpack electrofishing and seining. Sampling will occur prior to the smolt outmigration period, in January and February. Fish will be PIT tagged to compare growth rates of fish in off-channel versus in-stream areas. The movement of PIT tagged fish will be monitored from January through June by hand-held and stationary PIT tag readers.

4.7.7 Salmonid Fry Emergence

As part of the *Lagunitas Limiting Factors Analysis* (Stillwater 2008), a coho fry emergence study was conducted. The purpose of the study was to investigation if entombment (infiltration of fines into redds that impedes the emergence of fry) is a potential source of mortality for coho salmon. The study, conducted in 2005, did not reveal entombment or fry emergence to be particular problem but it was done during an anomalous year of particularly high spring flows and several traps had to be removed during a portion of the emergence period. MMWD will explore conducting another emergence study to further investigate the question of juvenile mortality during the emergence stage, as a potential limiting factor. An emergence study will only be conducted if collaborators and funding can be arranged.

4.7.8 California Freshwater Shrimp Surveys

MMWD will conduct an annual California freshwater shrimp survey (see Appendix D). The survey will be conducted at six sample sites in the main stem of Lagunitas Creek (Figure 25) with sampling being conducted in the late summer to early fall period. The survey will entail using a hand held insect net, vigorously sweeping the net through the underwater vegetation along the edges of the habitat, which in the process will capture shrimp in the net. The contents of the net bag will be emptied into a plastic tray and any obscuring detritus will be carefully removed and placed into an aerated black bucket partially filled with stream water. The remaining contents of the pan will be inspected for any shrimp, which often give away their presence by movement. The number, sex and age of any shrimp collected will be recorded. The collected shrimp and any remaining detritus will be returned to the habitat from which they were collected once the sampling event is completed. The habitat condition along the edge of each sample site will be subjectively rated as excellent, good, fair, or poor for shrimp and the lengths measured and then tallied for each site.

4.7.9 Habitat Typing Surveys

MMWD will conduct a habitat typing surveys every five years, or more frequently following channel-forming storm events. The habitat typing surveys will be conducted through Lagunitas Creek (Highway 1 Bridge to Peters Dam), San Geronimo Creek (mouth to Woodacre Creek), and Devil's Gulch. The surveys will follow DFG habitat typing survey protocols (see Appendix D).

4.7.10 Sediment & Streambed Monitoring

MMWD will conduct sediment and streambed monitoring surveys with sampling in Lagunitas Creek, San Geronimo Creek, and Devil's Gulch. Monitoring parameters will include: bed elevation; surface & subsurface grain sizes; fine sediment deposits; spawning gravels; and characteristics of large woody debris. The surveys will be conducted every other year, during the summer months. This monitoring program is presented in Appendix E. The monitoring effort will be developed and refined in collaboration with the RWQCB, to be consistent and have utility to their sediment TMDL for Lagunitas Creek.

4.7.11 Water Quality Monitoring

MMWD will continue with a water quality monitoring program for Lagunitas Creek. The monitoring effort will consist of monthly grab samples collected from four sample sites:

- Lagunitas Creek at Kent (between Peters Dam/Kent Lake and Shafter Bridge);
- Lagunitas Creek at Nicasio Creek (downstream of the Nicasio Creek confluence);
- Nicasio Creek (downstream of Seeger Dam/Nicasio Reservoir); and
- San Geronimo Creek (upstream of the mouth, at the Inkwells)

Samples will be analyzed for the following parameters:

- Temperature;
- pH;
- Turbidity;
- Alkalinity;
- Hardness;

- Copper;
- Total Suspended Solids; and
- Settleable Solids

4.7.12 Project Site Monitoring

MMWD will conduct an annual inspection site visit at all project implementation sites constructed in the previous year. The sites will be evaluated to determine if the sites are stable and if any repairs or maintenance are needed. We will also develop and conduct an effectiveness monitoring assessment to evaluate if these enhancement projects, as a whole or individually, are having a beneficial effect on the habitat conditions for the aquatic resources of Lagunitas Creek.

4.8 Aquatic Invasive Species (AIS) Management

The District will participate in a collaborative, regional effort to prevent or reduce the potential for infestations of AIS into the Lagunitas Creek watershed and water bodies throughout the North Bay. An important partner for this effort will be the North Bay Watershed Association. MMWD will also participate in a collaborative effort to manage invasive plants in the Lagunitas Creek watershed.

4.8.1 Early Detection/Rapid Response

The District will conduct baseline AIS surveys and conduct monitoring within District reservoirs for detection of New Zealand mud snail, quagga & zebra mussels. We will also seek to facilitate these studies being conducted periodically in Lagunitas Creek. The District will develop and implement response procedures, should any AIS be detected in District reservoirs, and coordinate with others for a response to any detection within Lagunitas Creek. These efforts will be conducted in collaboration with DFG and USFWS.

4.8.2 Protocols for Inspections and Disinfection of AIS

The District will develop and put into practice protocols for AIS controls through cleaning, storage, and inspections of field gear and equipment that will enter any water body within the watershed, related to District activities. The protocols will be incorporated into contract requirements for any contractors providing services to the District.

4.8.3 AIS Education

The District will develop and provide educational materials about AIS; disseminate to all stakeholders and the general public visiting the watershed. These efforts will be conducted in collaboration with DFG and USFWS.

4.8.4 Invasive Plant Control

MMWD will participate in efforts to remove invasive plants from the riparian corridor and manage populations of invasive plant species in the Lagunitas Creek watershed. The target species include: Cape ivy, French and Scotch broom, and yellow starthistle. Removing invasive plants will take a systematic, site-specific approach to minimize impacts to existing native habitat. The District's efforts will be focused along the main stem of Lagunitas Creek between Peters Dam and Shafter Bridge and on District-owned property along San Geronimo Creek. We will collaborate with State Parks, NPS, Marin County, and SPAWN to remove and management invasive plant populations from other locations within the watershed.

4.9 Programs and Policies

The District will take the lead on the approach described below in regards to each of the four programs and policies relevant to this Stewardship Plan.

4.9.1 Roads MOU

MMWD will continue to follow the guidelines and practices included in the MOU for Maintenance and Management of Unpaved Roads in the Lagunitas Creek Watershed.

4.9.2 Woody Debris MOU

MMWD will continue to follow the guidelines and practices included in the MOU for Woody Debris Management in Riparian Areas of the Lagunitas Creek Watershed.

4.9.3 Mt. Tamalpais Watershed Management Policy

MMWD will continue to follow MMWD Board Policy No. 7 - Mt. Tamalpais Watershed Management Policy.

4.9.4 Wells and Private Water Sources Policy

The District will review and may revise MMWD Board Policy No. 3 - Wells and Other Private Sources Policy (see Appendix C), to consider incorporating protection of stream flows into the policy. In reviewing the policy, the District will seek to retain the water conservation emphasis of the policy, for which it is intended, and ensure backflow prevention devices are installed with all wells. We will evaluate and may make modifications to the policy that will specify protection of instream flows and groundwater recharge to streams.

4.10 Collaboration and Outreach

MMWD will take the lead to pursue and maintain partnerships, collaboration, and outreach for watershed management and aquatic resource protection and enhancement for Lagunitas Creek.

4.10.1 Lagunitas Creek Technical Advisory Committee (TAC)

The main forum for collaboration, sharing of information, and dialogue regarding aquatic resource management in the Lagunitas Creek watershed has been the TAC. The District will remain an active participating entity of the TAC. We will continue to facilitate the TAC meetings, in lieu of another participating entity doing so, and we will continue to encourage other TAC members to also remain active participants.

4.10.2 Partnerships and Collaboration with Other Entities

The District will continue to seek ways to partner and coordinate with other entities involved and interested in the Lagunitas Creek watershed. The District will remain an active member of the following associations and other efforts collaborating on aquatic resource protection and enhancement:

- Tomales Bay Watershed Council (TBWC):
- North Bay Watershed Association (NBWA);
- Bay Area Integrated Regional Water Management Program (IRWMP) Coordinating Committee; and
- State & Federal coho & steelhead recovery efforts

4.10.3 Public Involvement and Education

The District will continue its public involvement and outreach through public meetings, volunteer events, participation in Trout-in-the-Classroom program, and other educational opportunities.

5.0 Schedule

This Stewardship Plan is intended to cover the ten-year period 2011 – 2020. A schedule for the actions identified in the Plan is presented in Table 4. The actions will be implemented over the ten-year time period. Some of the actions will be implemented on an on-going, continuous basis; some will be implemented within the first five years; and still others will be implemented at some point within the ten-year period but likely during years five through ten. Site specific project work will be implemented as funding allows and thus will be prioritized for grant funding opportunities and within District budgetary constraints. Our experience with the Sediment and Riparian Management Plan is that some project work takes years to implement, due in part to funding but also because of environmental review and permitting and coordination with other entities.

This final Stewardship Plan has been developed following consideration of comments received on the public review draft plan that was released on December 15, 2010. The District received three written comments on the public review draft plan: the California Department of Fish and Game, the San Francisco Bay Regional Water Quality Control Board, and Mervyn Zimmerman. In addition, the Lagunitas Technical Advisory Committee (TAC) provided comments during the TAC meeting on March 11, 2011. The comments are provided in Appendix F. The District has considered all of the comments and modified the draft plan in response to those comments.

6.0 Consistency with Other Plans & Programs

There are a number of existing management plans and programs that address watershed resource issues, particularly aquatic and fisheries resource issues, for the Lagunitas Creek watershed. Some of these existing plans and programs are specific to Lagunitas Creek while others are more regional. In developing this Stewardship Plan, we have strived to identify goals and actions that are consistent with the other resource management plans and programs that already exist. In some cases, the actions identified in other plans were developed based upon the same background information that this Stewardship Plan is based upon, thus logically arriving at the same conclusions for the future management actions needed.

The plans and programs that this Stewardship Plan are intended to be consistent with include:

- Tomales Bay Watershed Stewardship Plan (TBWC 2003);
- Tomales Bay Integrated Coastal Watershed Management Plan (TBWC 2007);
- San Geronimo Valley Salmon Enhancement Plan (PCI/Marin County 2010);
- Federal Coho Salmon Recovery Plan – Draft (NMFS 2010);
- State Recovery Strategy for California Coho Salmon (DFG 2004);
- State TMDL's for Lagunitas Creek (SWRCB; pending, not published); and
- National Park Service Program for Lagunitas Creek.

Specifically, in developing the goals for this Stewardship Plan (see Section 3) we have incorporated many of the goals and objectives described in these other plans and programs.

Appendix G presents an analysis of District actions and consistency with the Lagunitas HSA tasks specified in the State coho recovery strategy (DFG 2004).

7.0 Costs & Funding Opportunities

A cost estimate for all of the actions described in the Stewardship Plan is presented in Table 5, organized under the three implementation categories described in the plan (see Section 4.0). The cost estimate for all of the actions in the Plan, over the full ten years, is $7.8 million. The cost estimate is meant to be inclusive of District staff time that will be committed to implementation of the plan, as well as program and construction costs for the various actions. The cost estimate for the entire ten-year period has assumed all costs in 2011 dollars and is not adjusted for inflation. While there are no costs assigned to programs & policies or to collaboration & outreach, there is still staff time associated with these actions but those costs have not been estimated.

In Table 5, the actions and costs are organized and subtotaled by the priority they have been placed into. The ten-year costs are:

1.	Mandatory Requirements of SWRCB Order WR95-17	=	$ 215,500
2.	Actions MMWD will lead	=	$5,746,445
3.	Actions MMWD will participate in but may not lead	=	$1,832,500
	TOTAL	=	$7,794,445

The District is not intending to commit $7.8 million in District operational funds to the implementation of this Stewardship Plan. Rather, we have laid out actions the District will pursue and participate in and we will seek grant funding and partnerships with other entities to help support these efforts. MMWD will have significant staff commitments dedicated to the implementation of the plan and the District will also make financial commitments on an annual basis, for specific projects. MMWD has successfully secured grant funds through several State and Federal grant programs and we hope to remain competitive for grant funding in the future. Potential grant funding sources may include California State bond funding, the DFG Fisheries Restoration Grant Program, NMFS Restoration Center funding, USFWS species recovery funding, and other federal sources through the U.S. EPA, National Fish and Wildlife Foundation, and other agencies.

8.0 References

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U. S. National Park Service (http://www.nps.gov/archive/redw/pampas.htm)

Whirling Disease Initiative (http://whirlingdisease.montana.edu/)

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FIGURES

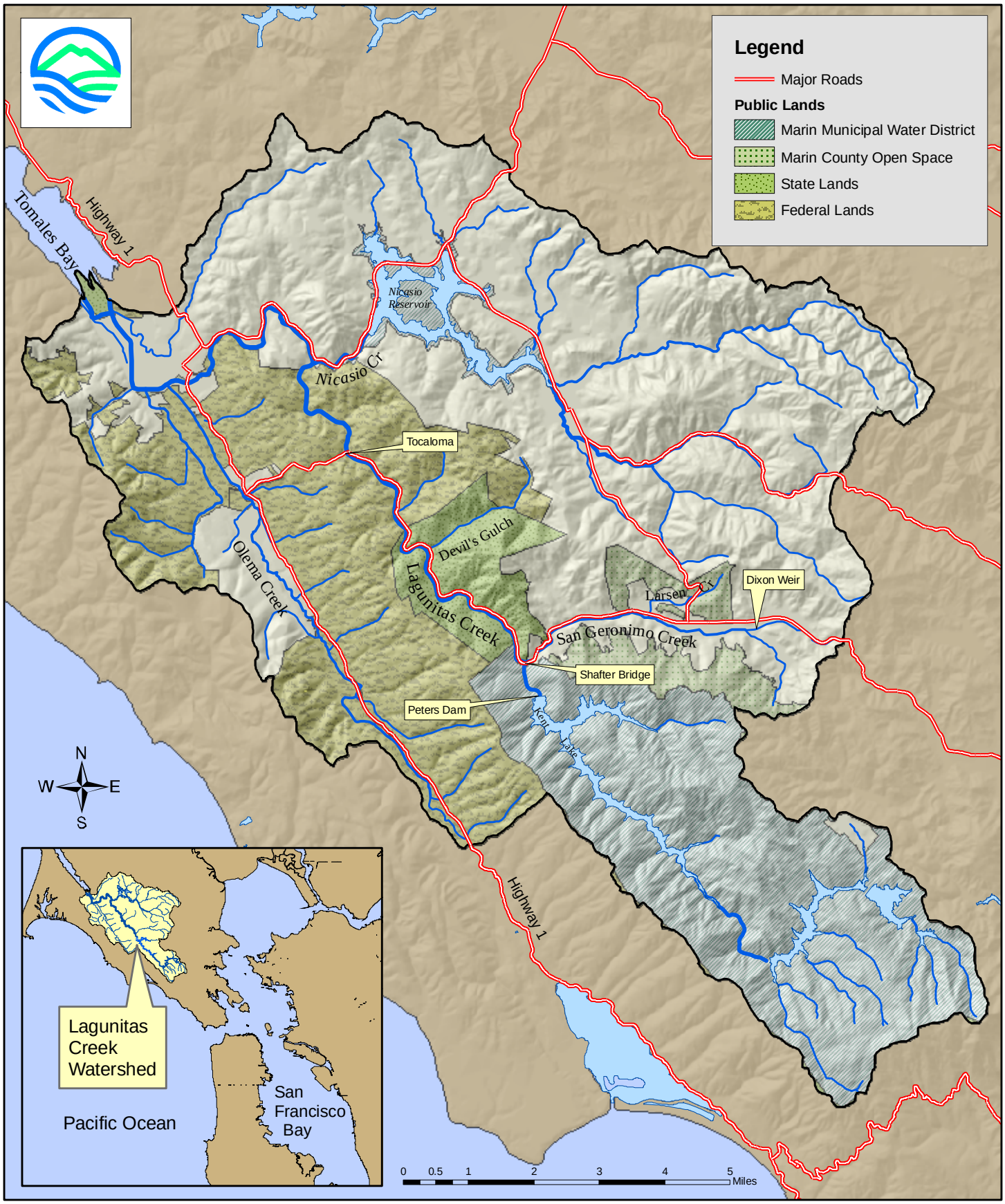

Figure 1. Map of the Lagunitas Creek Watershed

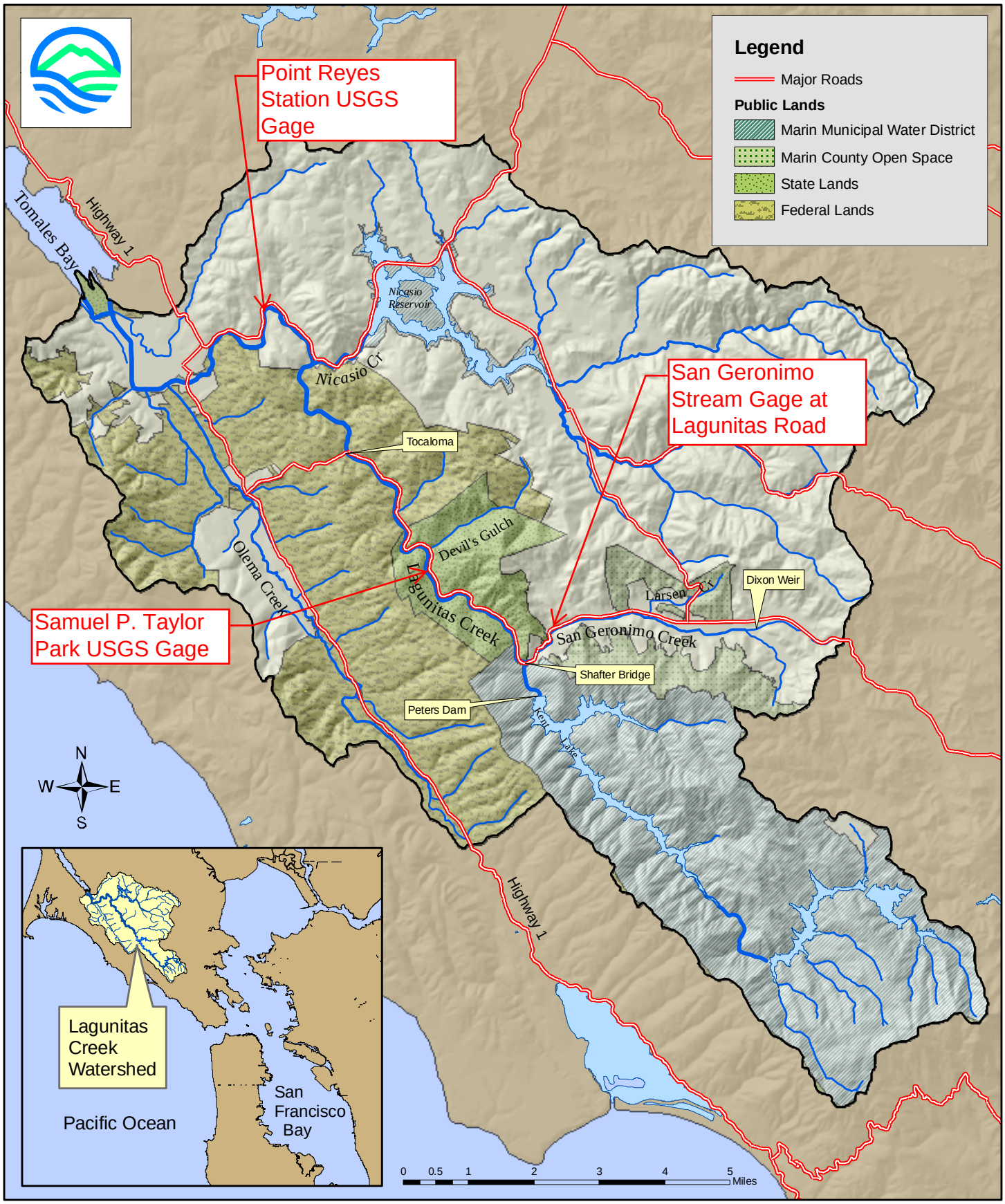

Figure 2. Stream gages on Lagunitas Creek and San Geronimo Creek.

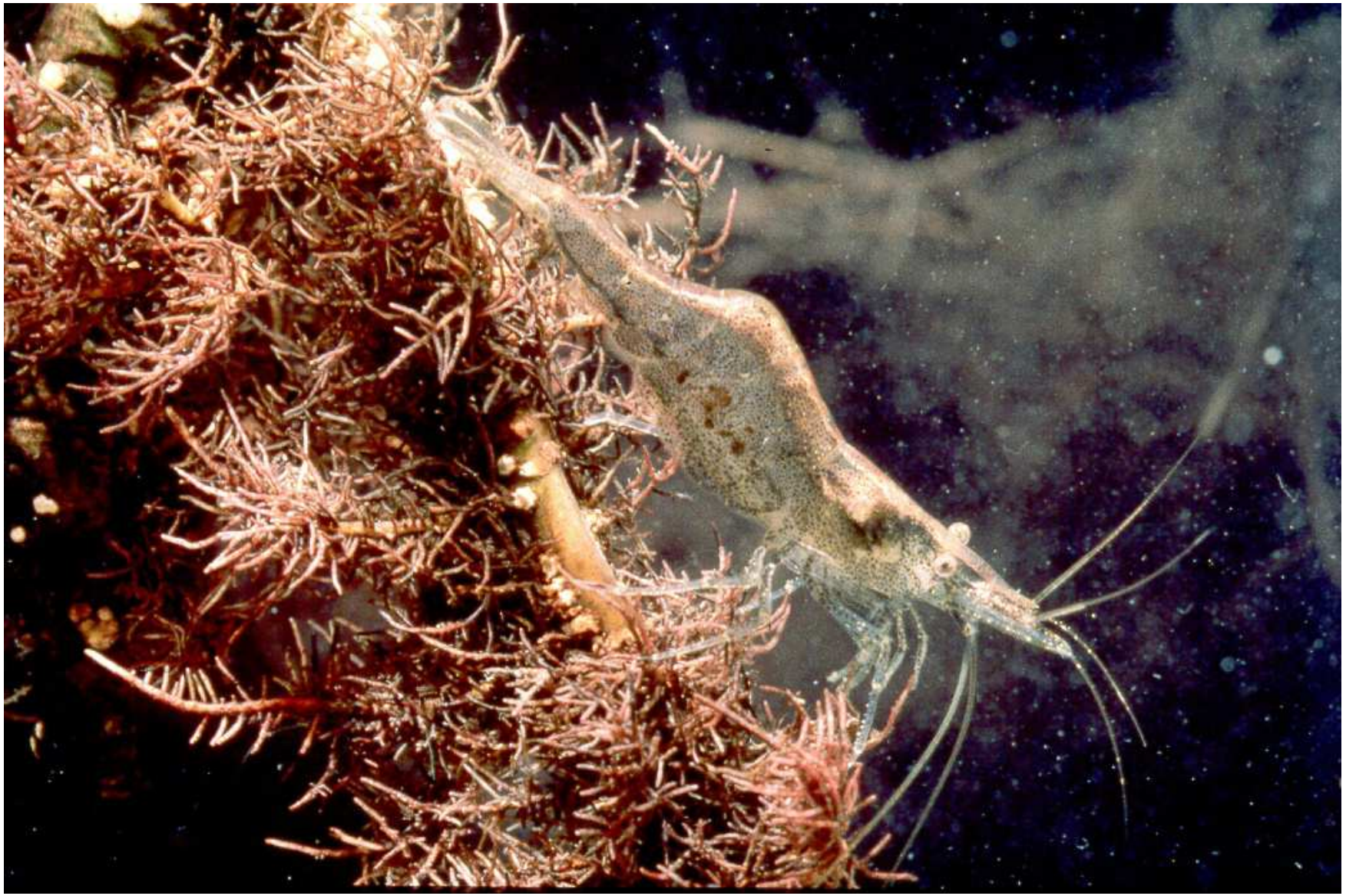

Figure 3. California freshwater shrimp; photograph by Larry Serpa (Source USFWS 2007).

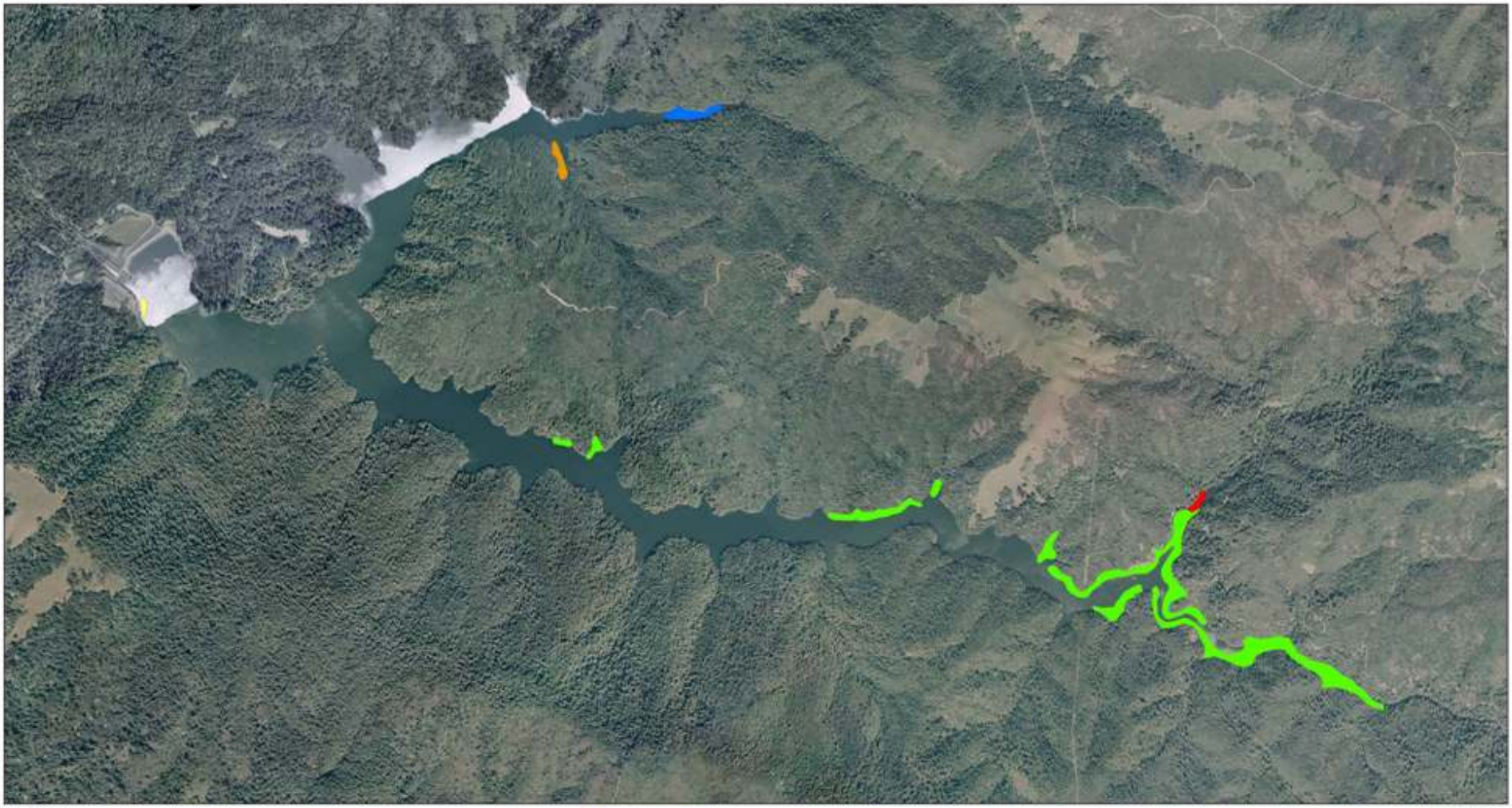

Figure 4. Kent Lake aquatic plant mapping, 2006.

Source: Aquatic Environments, Inc. 2007

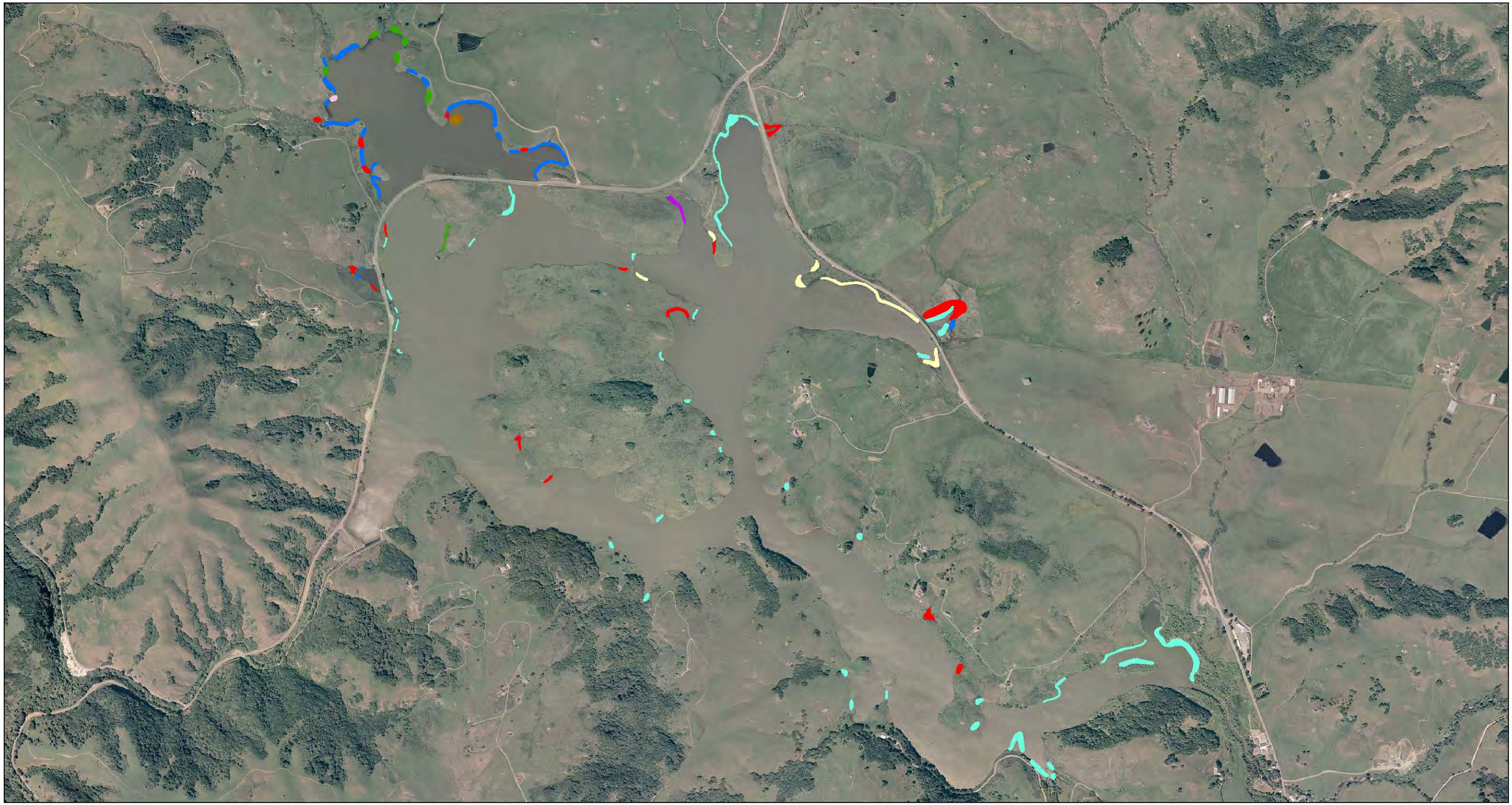

FIGURE A-6

Marin Municipal Water District

Nicasio Reservoir

Figure 5. Nicasio reservoir aquatic plants mapping, 2006.

Source: Aquatic Environments, Inc. 2007

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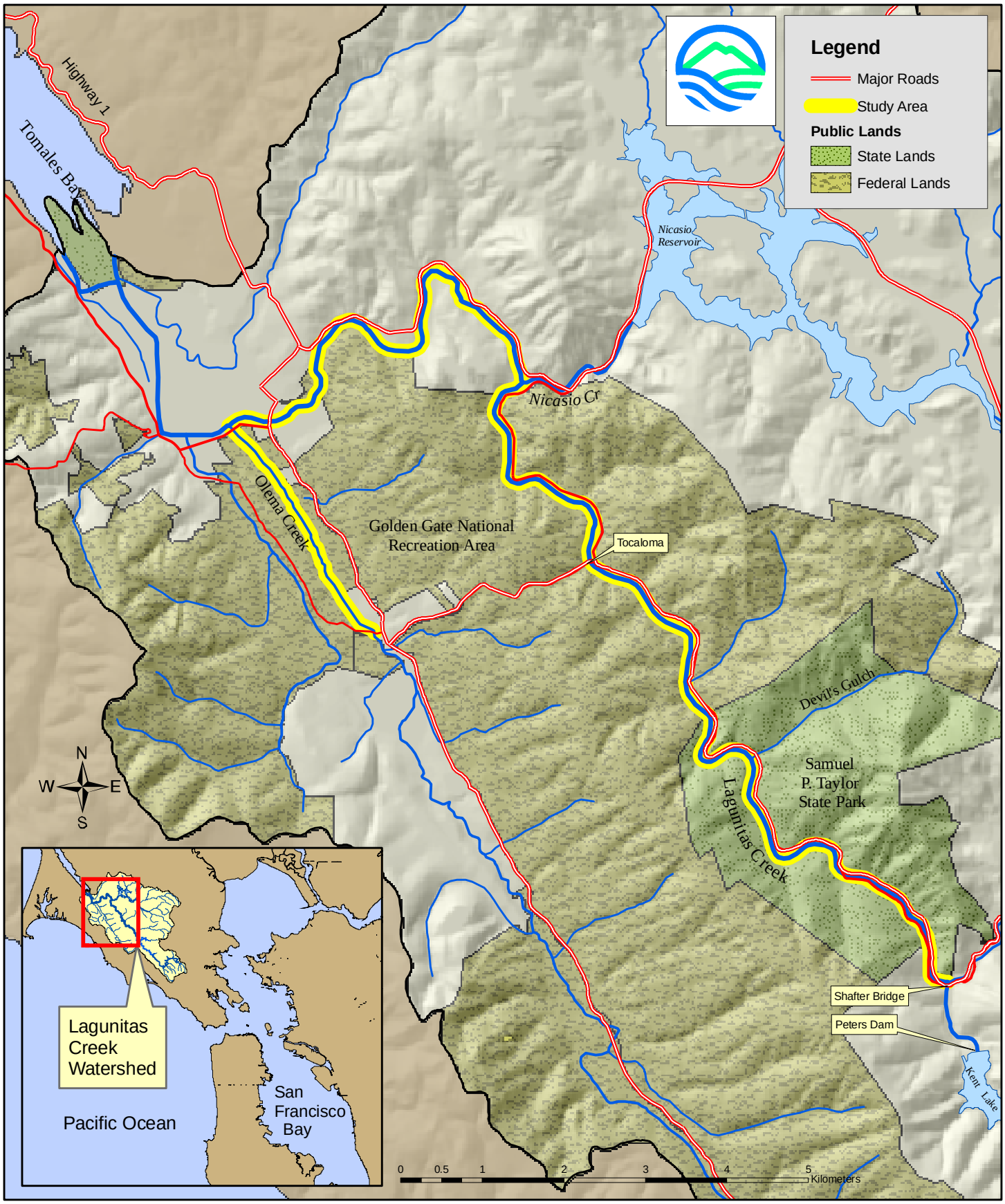


Figure 6. Lagunitas Creek Winter Habitat Enhancement Assessment Project study area.

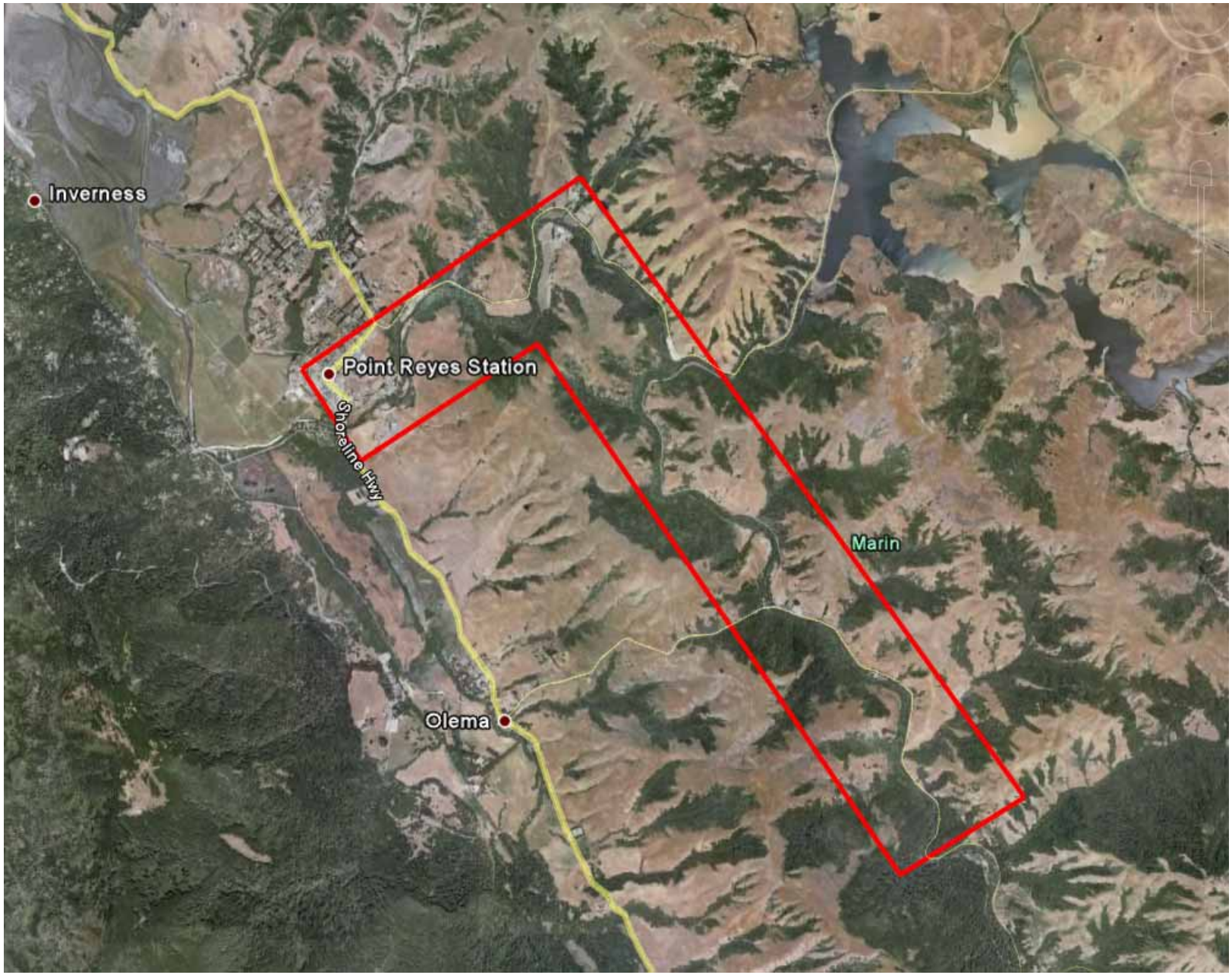


Figure 7. LIDAR survey boundary for the Lagunitas Creek Winter Habitat Enhancement Assessment (Highway 1 Bridge to Big Bend in SP Taylor State Park).

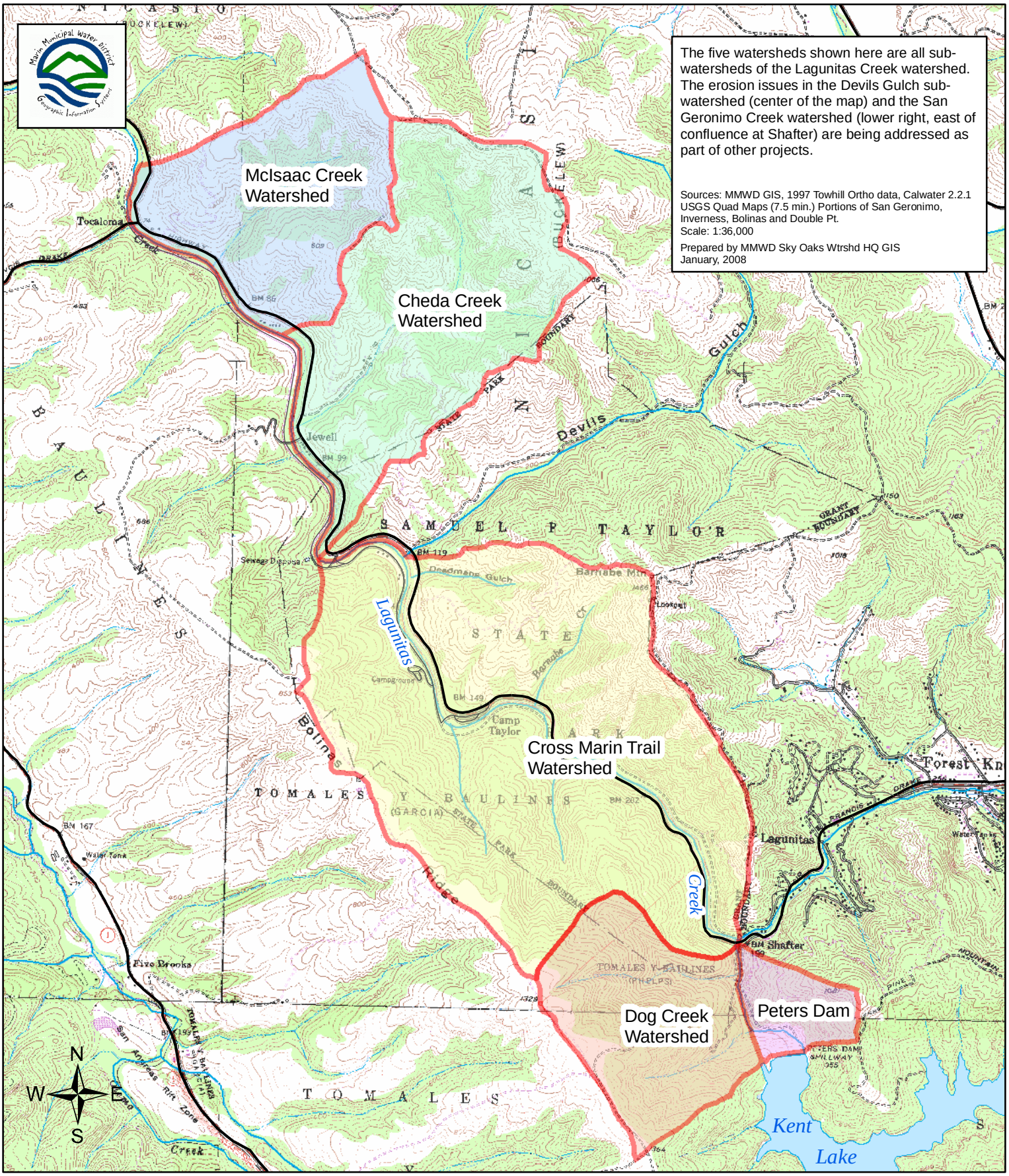


Figure 8. Habitat Improvement Project sub-watersheds.

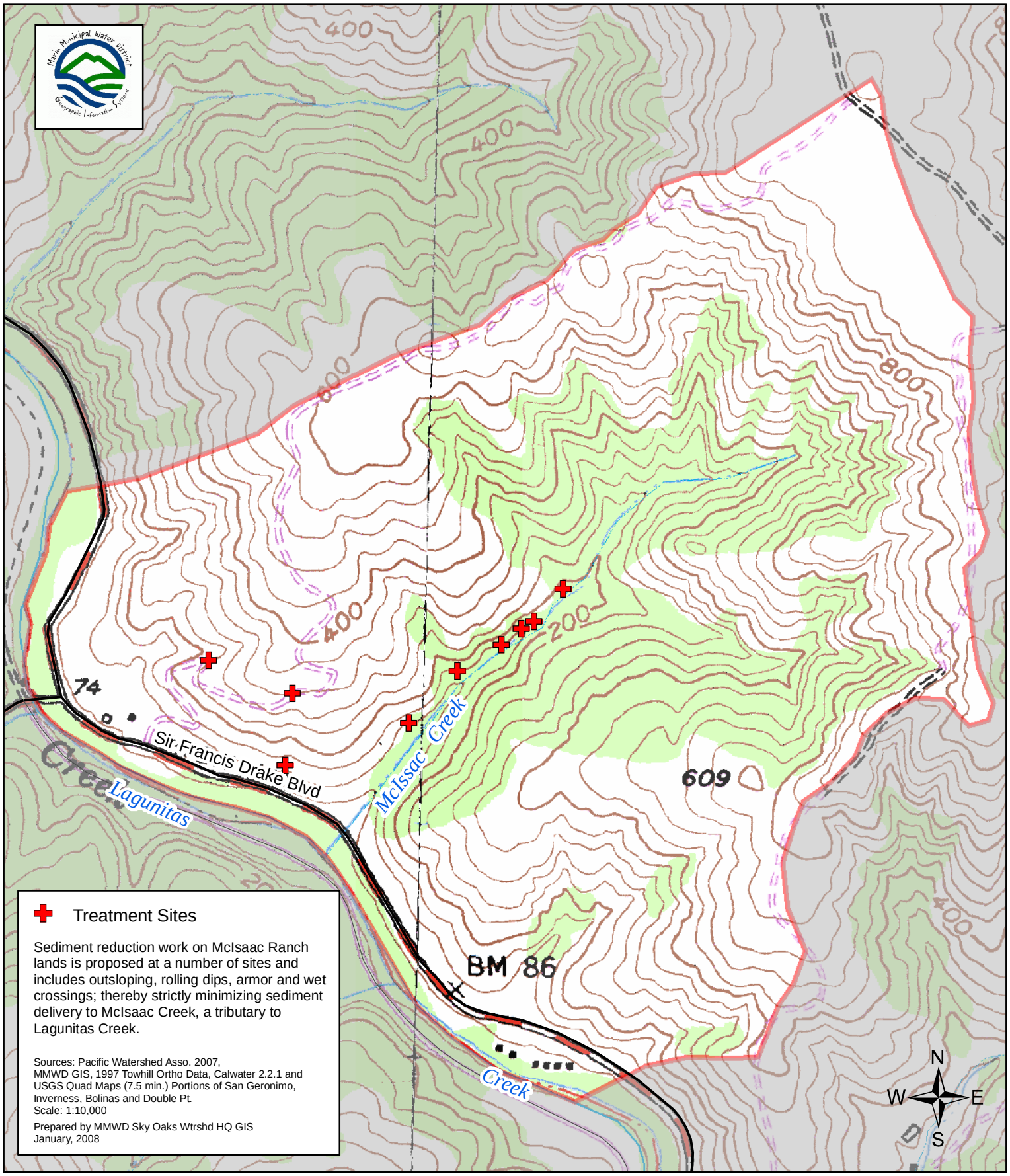


Figure 9. McIsaac Creek sub-watershed treatment sites.

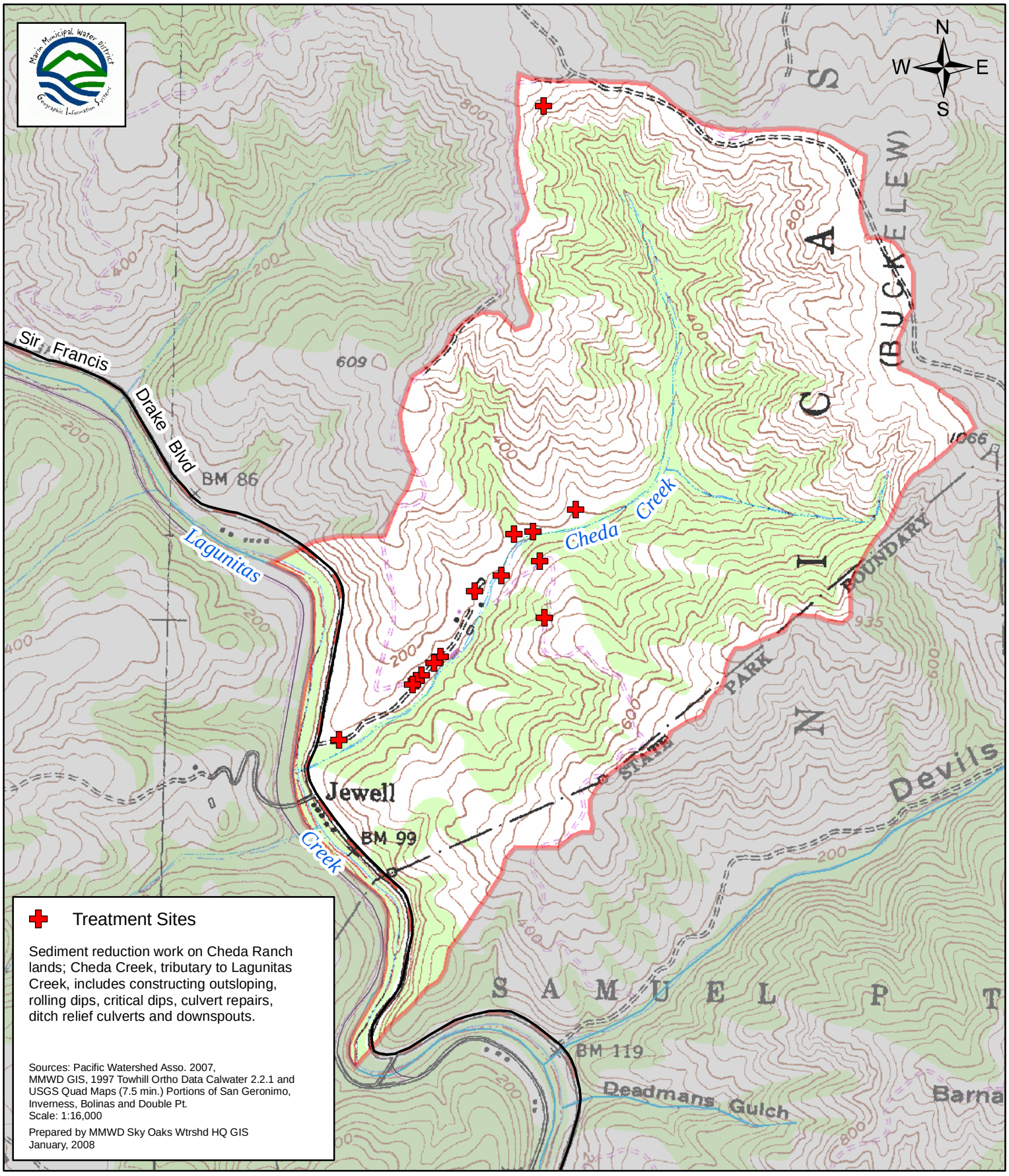


Figure 10. Cheda Creek sub-watershed treatment sites.

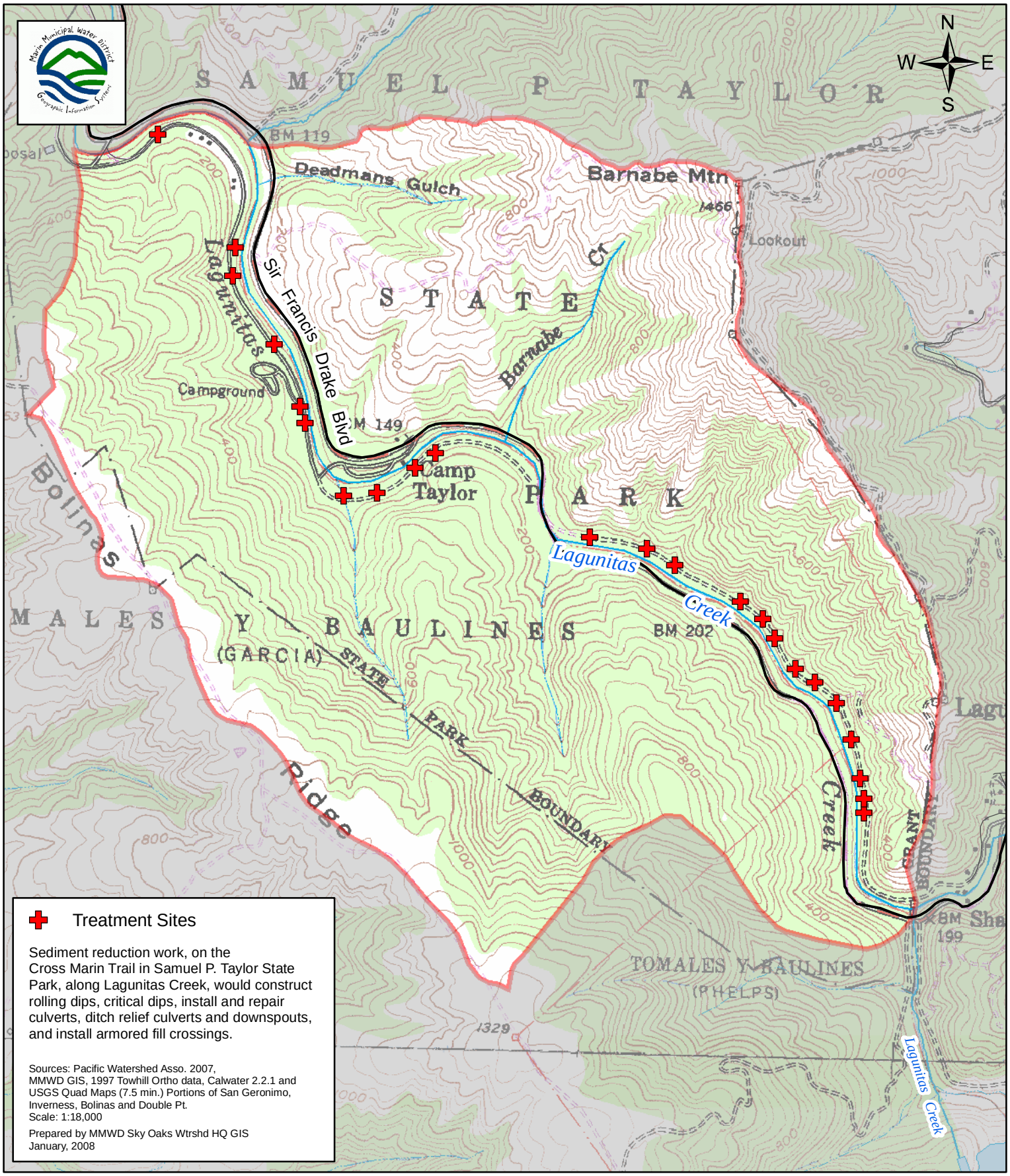


Figure 11. Cross Marin Trail sub-watershed treatment sites.

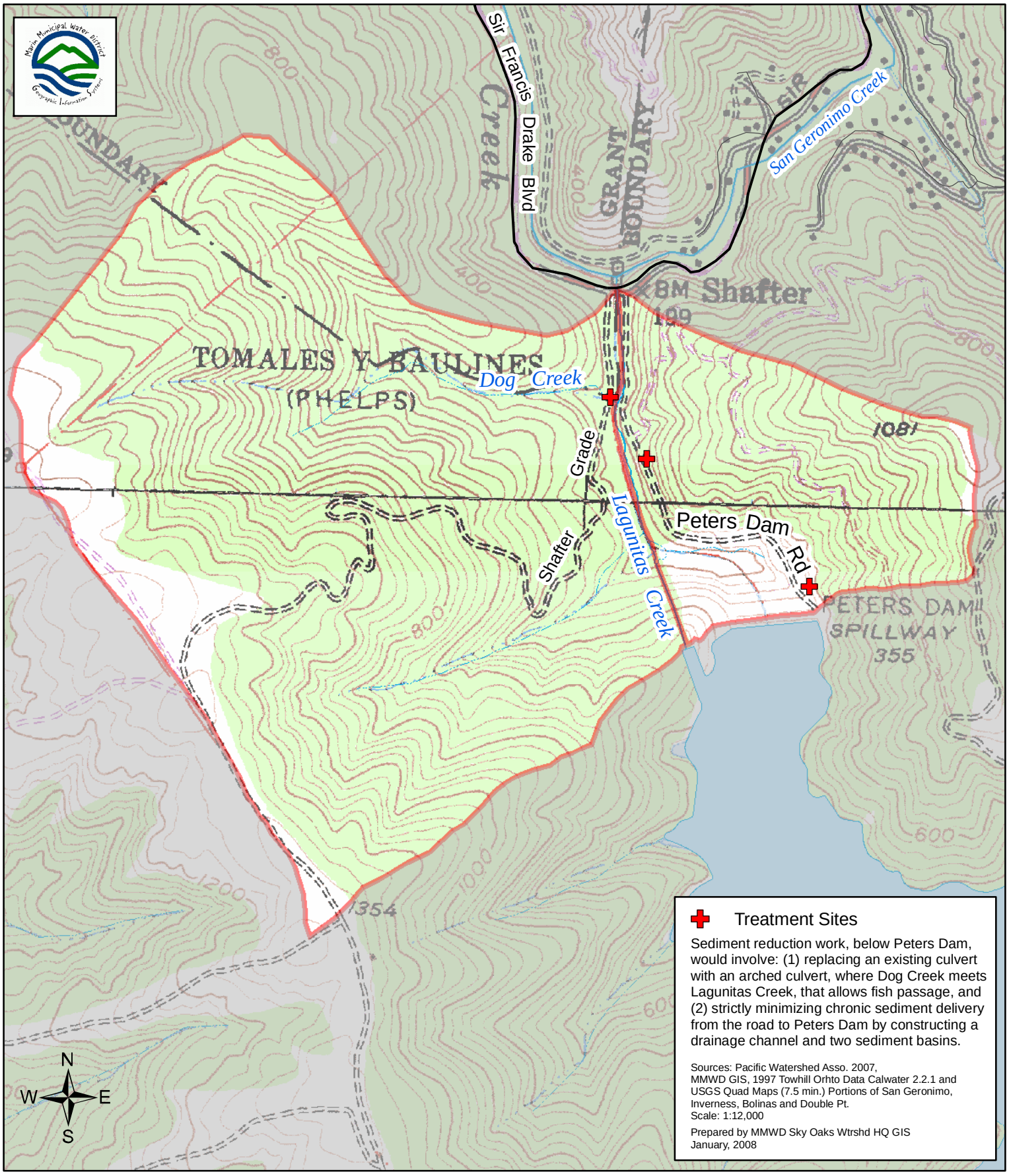
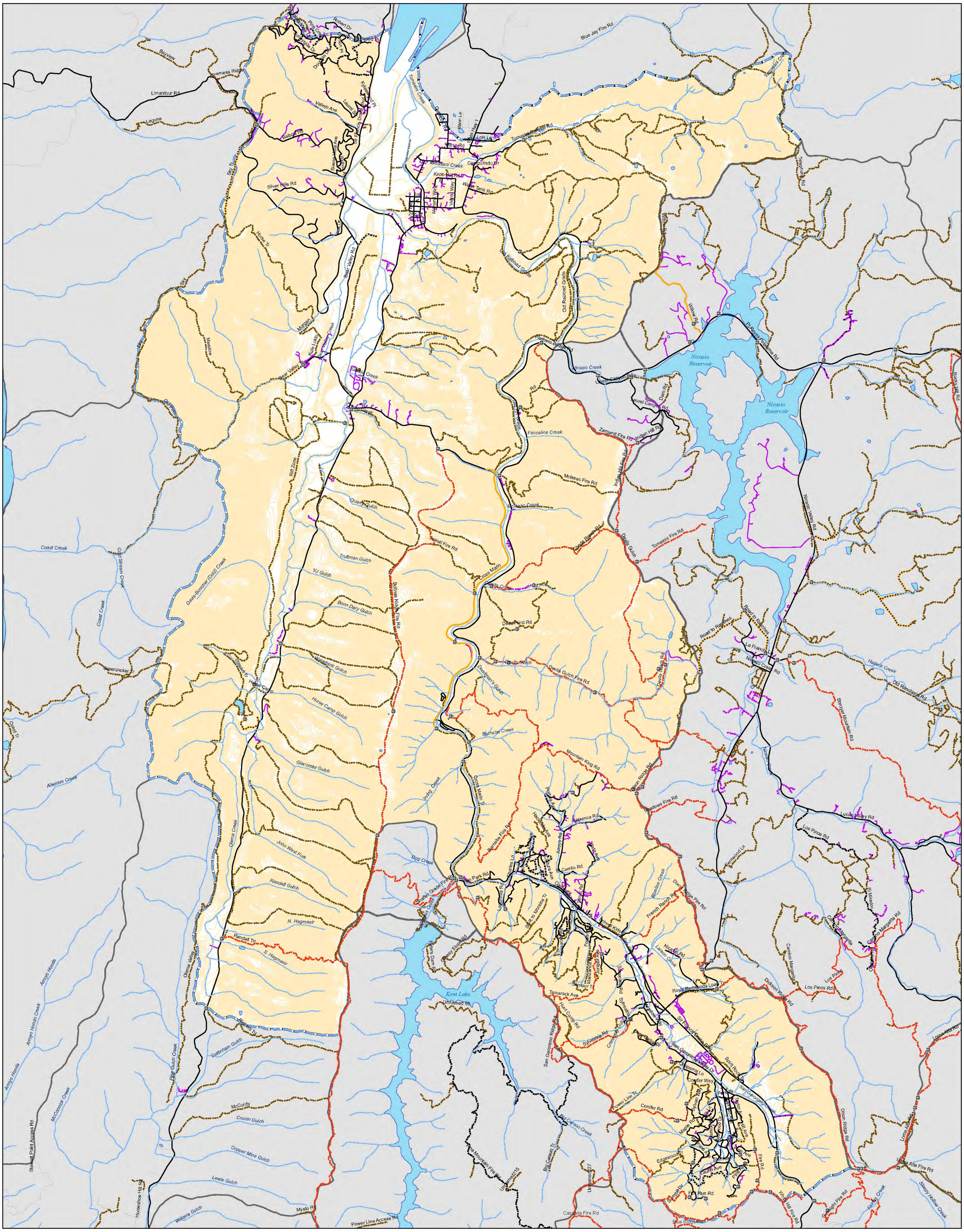


Figure 12. Dog Creek sub-watershed treatment site.

Figure 13. Resource areas for dirt road maintenance.

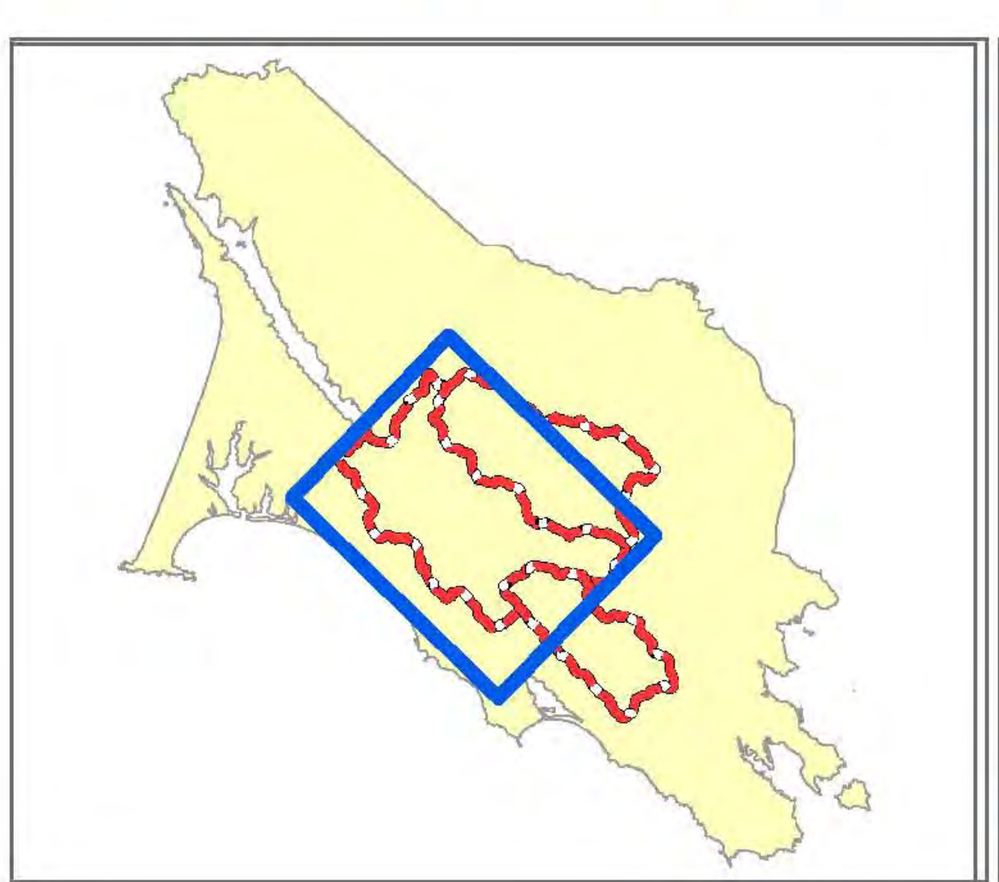


Roads Within The Lower Lagunitas Creek Basin Primary Management Area

Marin Municipal Water District

FIGURE 14

Map Sheet: 4



Legend

Primary Road	Secondary Road	Fire Road	Driveway
Dirt (2.91)	Dirt (113.23)	Dirt (31.08)	Dirt (5.05)
Gravel (3.18)	Gravel (2.58)	Gravel (0)	Gravel (1.36)
Paved (83.68)	Paved (3.70)	Paved (0.98)	Paved (20.06)
Bridge (0.03)	Bridge (0.10)		

Gates

Other Basins

Lower Lagunitas Creek

0 2,000 4,000 Feet

Prepared: March 13, 2007

Lynx Technologies

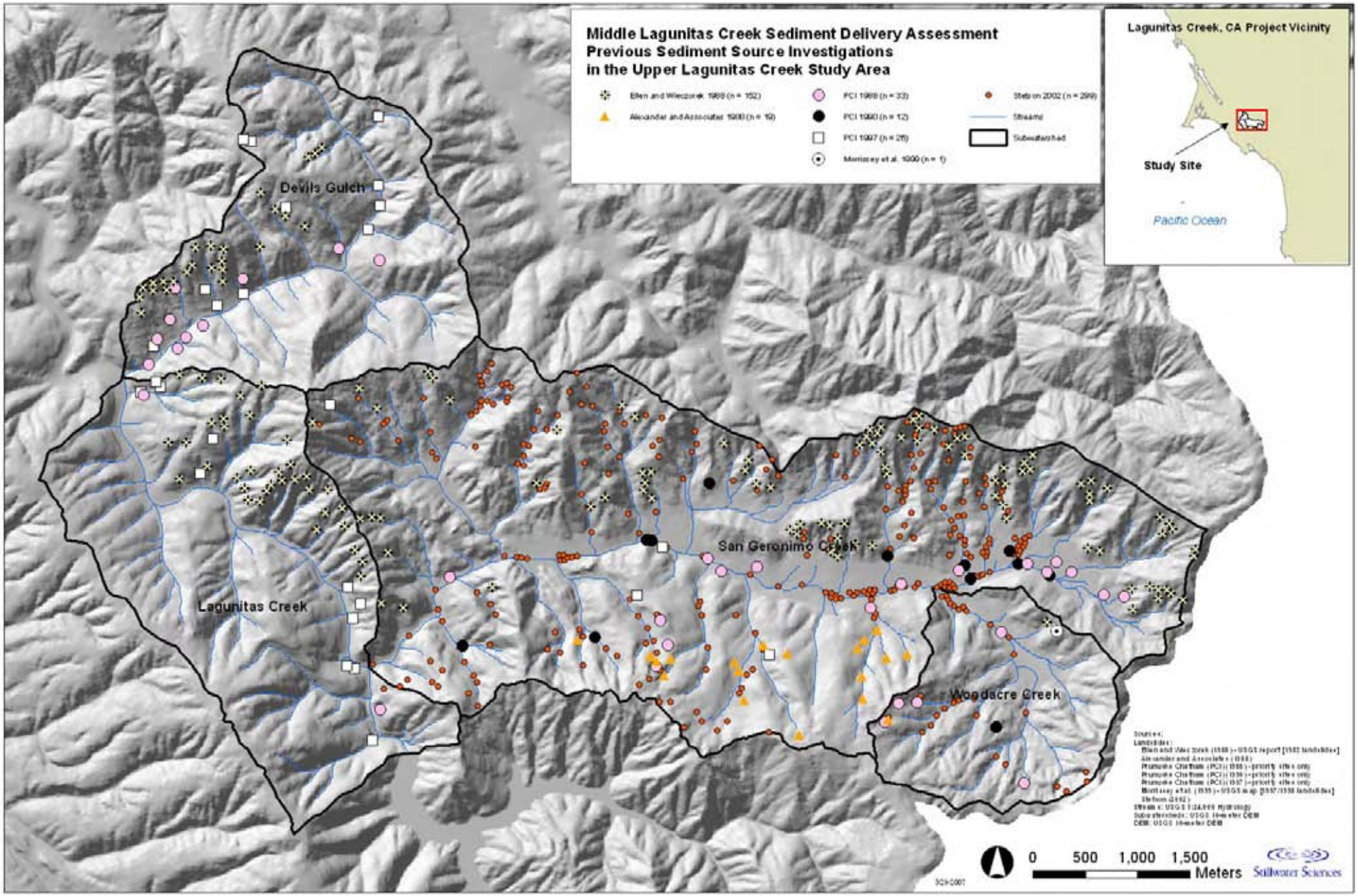


Figure 15. Sediment source sites identified in source assessment studies conducted 1988 - 2002.

(Source: Stillwater Sciences 2007)

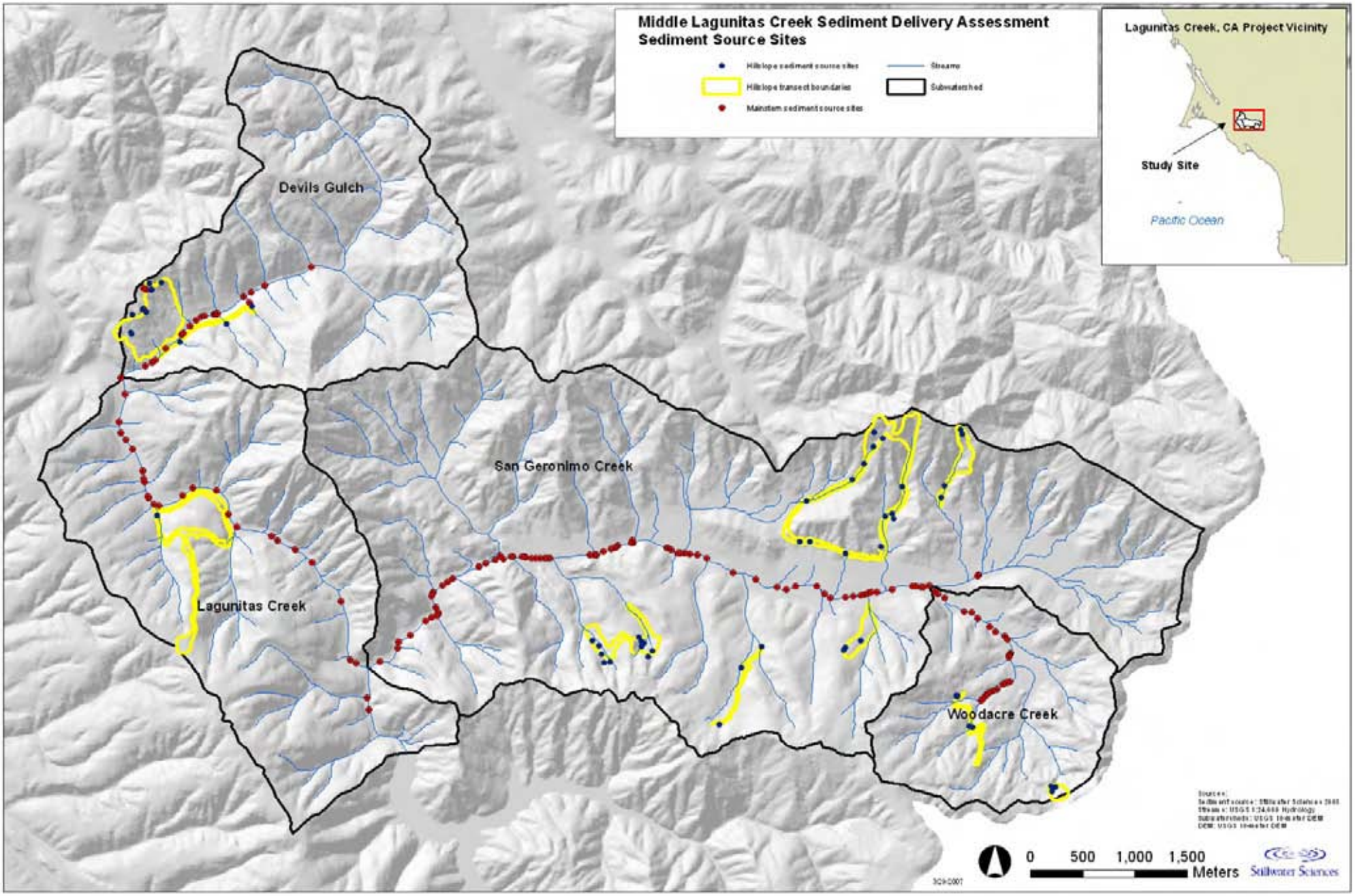


Figure 16. Sediment source sites identified in prior source assessment study from 2006.

(Source: Stillwater Sciences 2007)

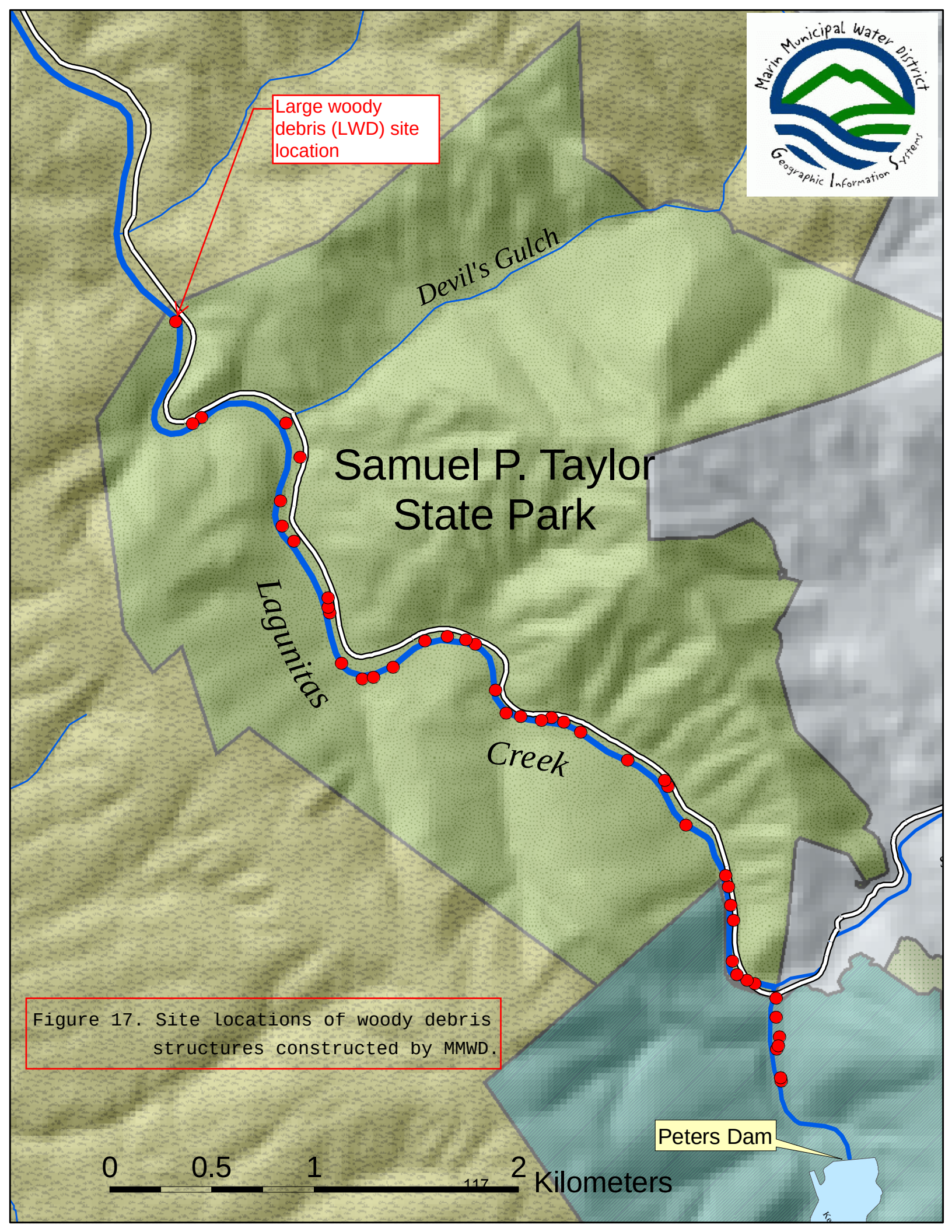


Figure 17. Site locations of woody debris structures constructed by MMWD.

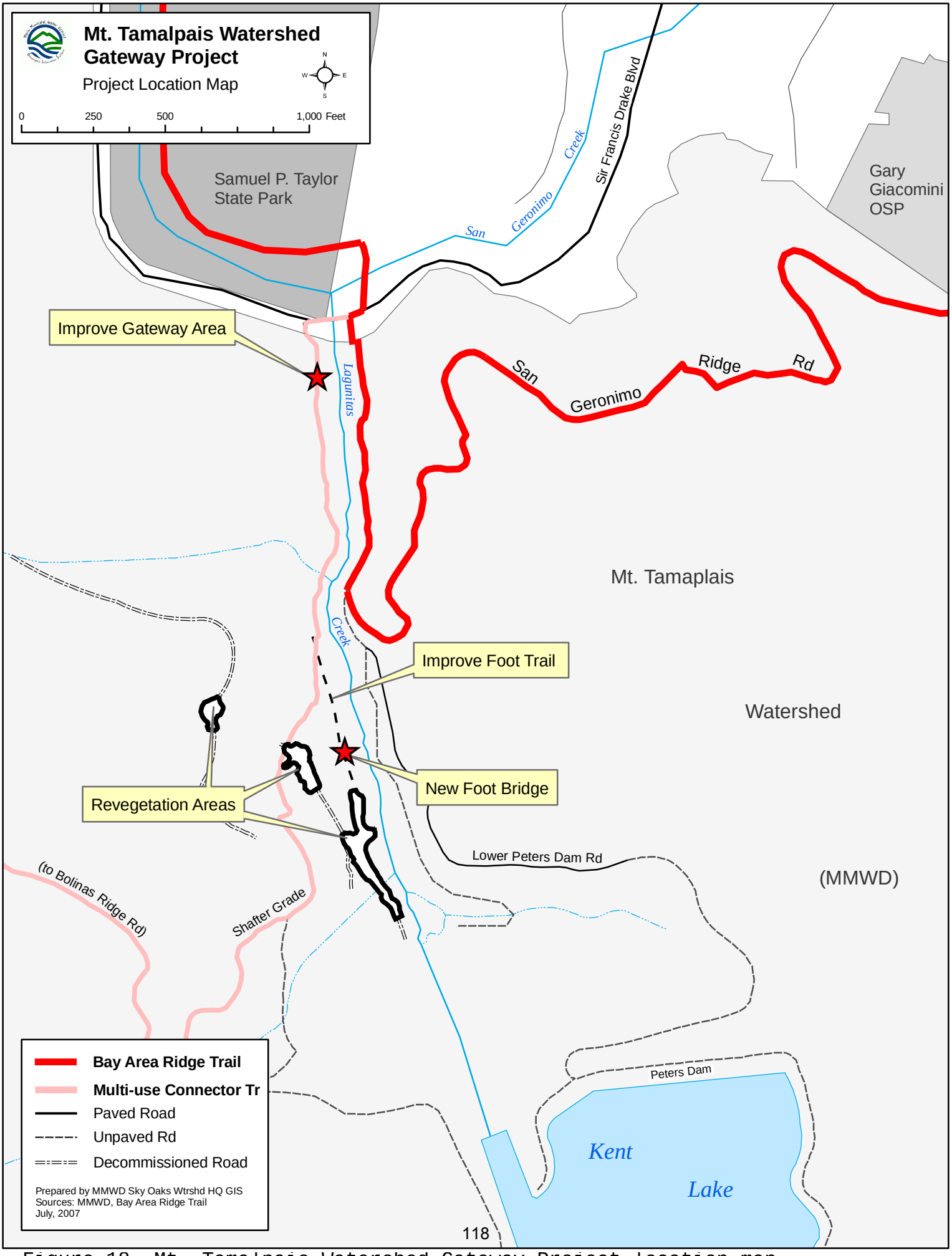


Figure 18. Mt. Tamalpais Watershed Gateway Project location map.

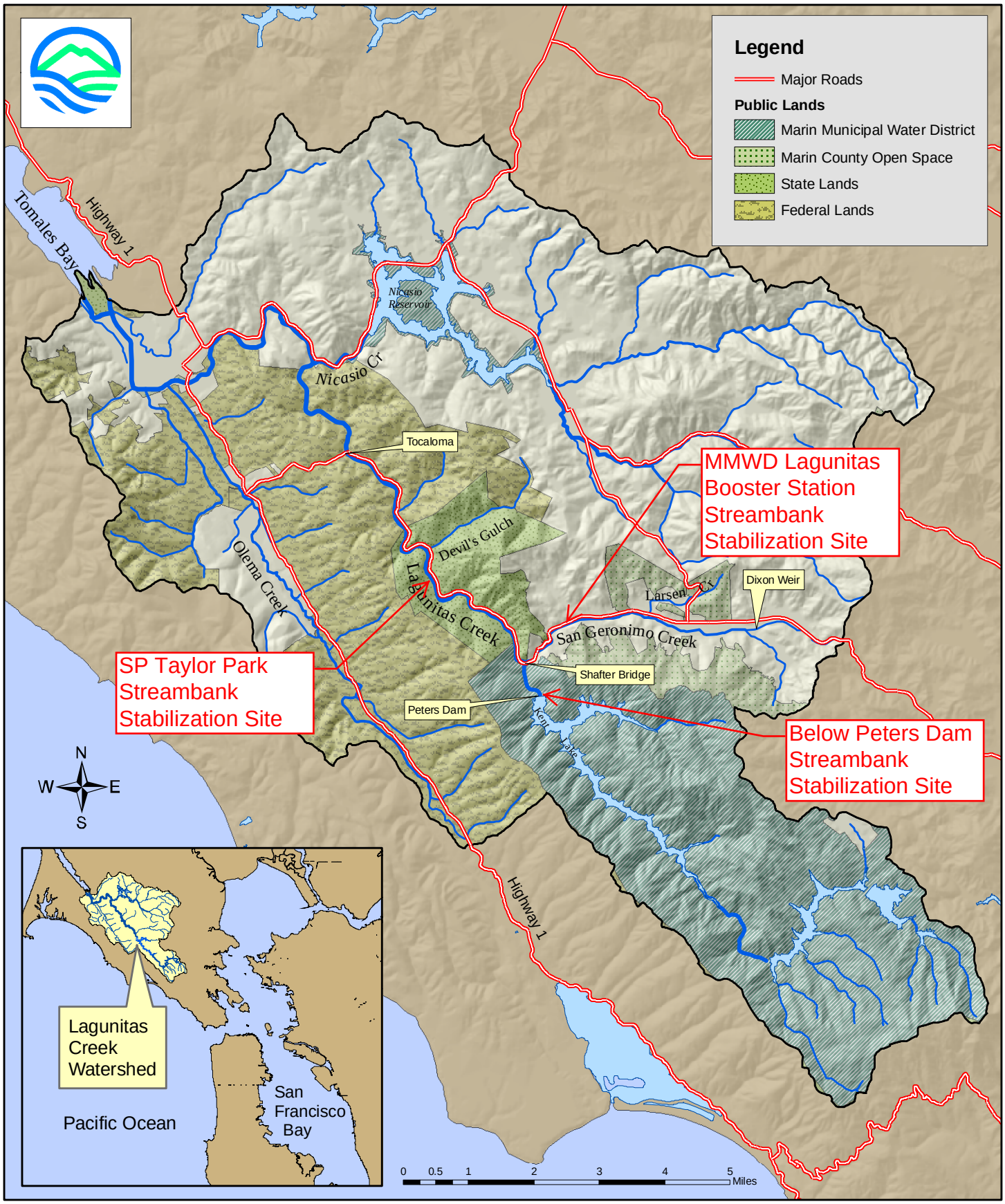


Figure 19. Streambank stabilization project sites for the Lagunitas Creek Stewardship Plan.

Figure 20. Lagunitas Booster Station streambank stabilization site, on San Geronimo Creek (eroded streambank and discharge pipe), looking upstream (top) and downstream.

Figure 21. Below Peters Dam streambank stabilization site; top view looking upstream towards Peters Dam, bottom view looking downstream.

Figure 22. Nicasio Transmission Line retaining wall bank stabilization site in Samuel P. Taylor State Park (view looking upstream).

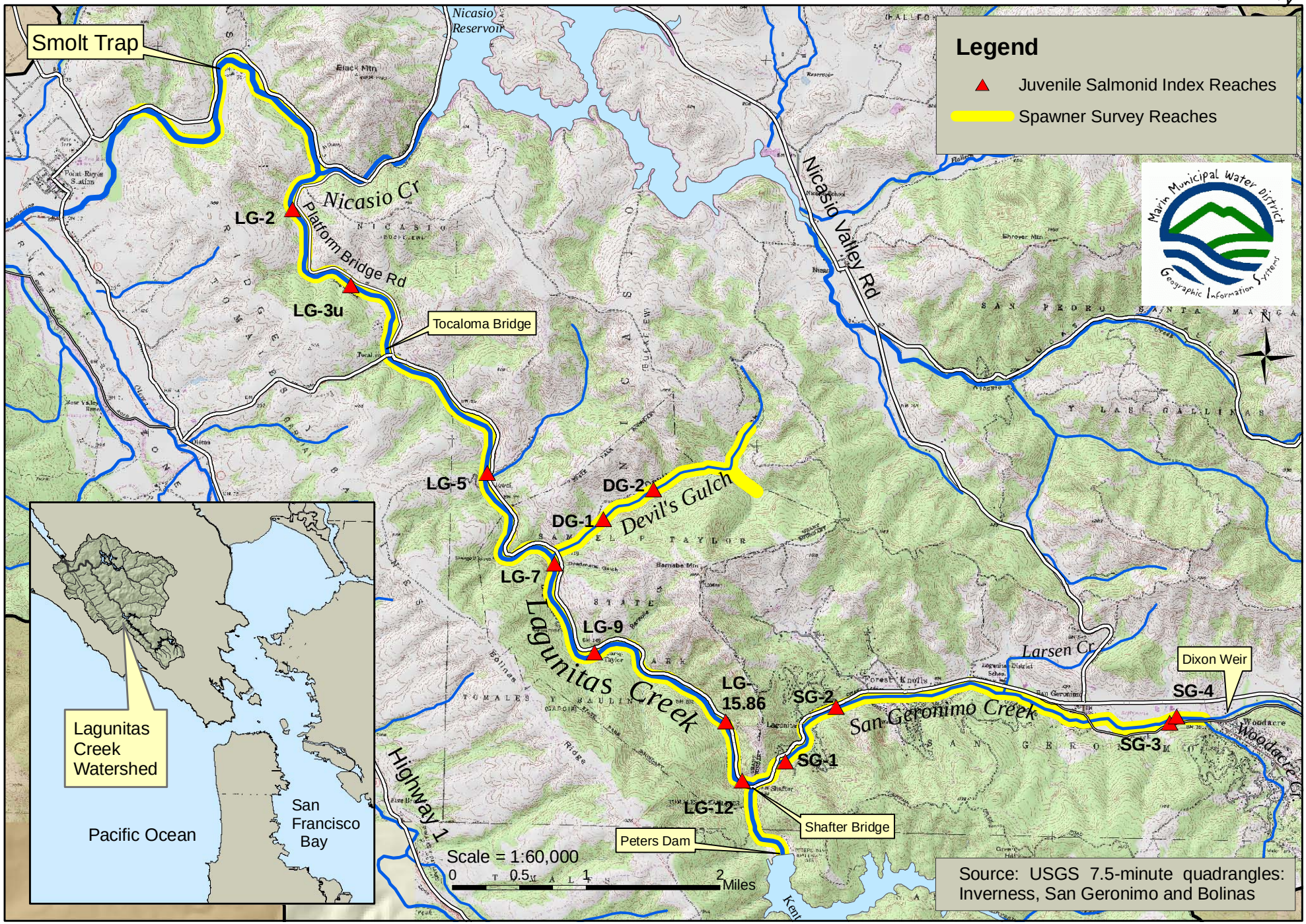


Figure 23. Juvenile salmonid survey sample sites and spawner survey reaches.

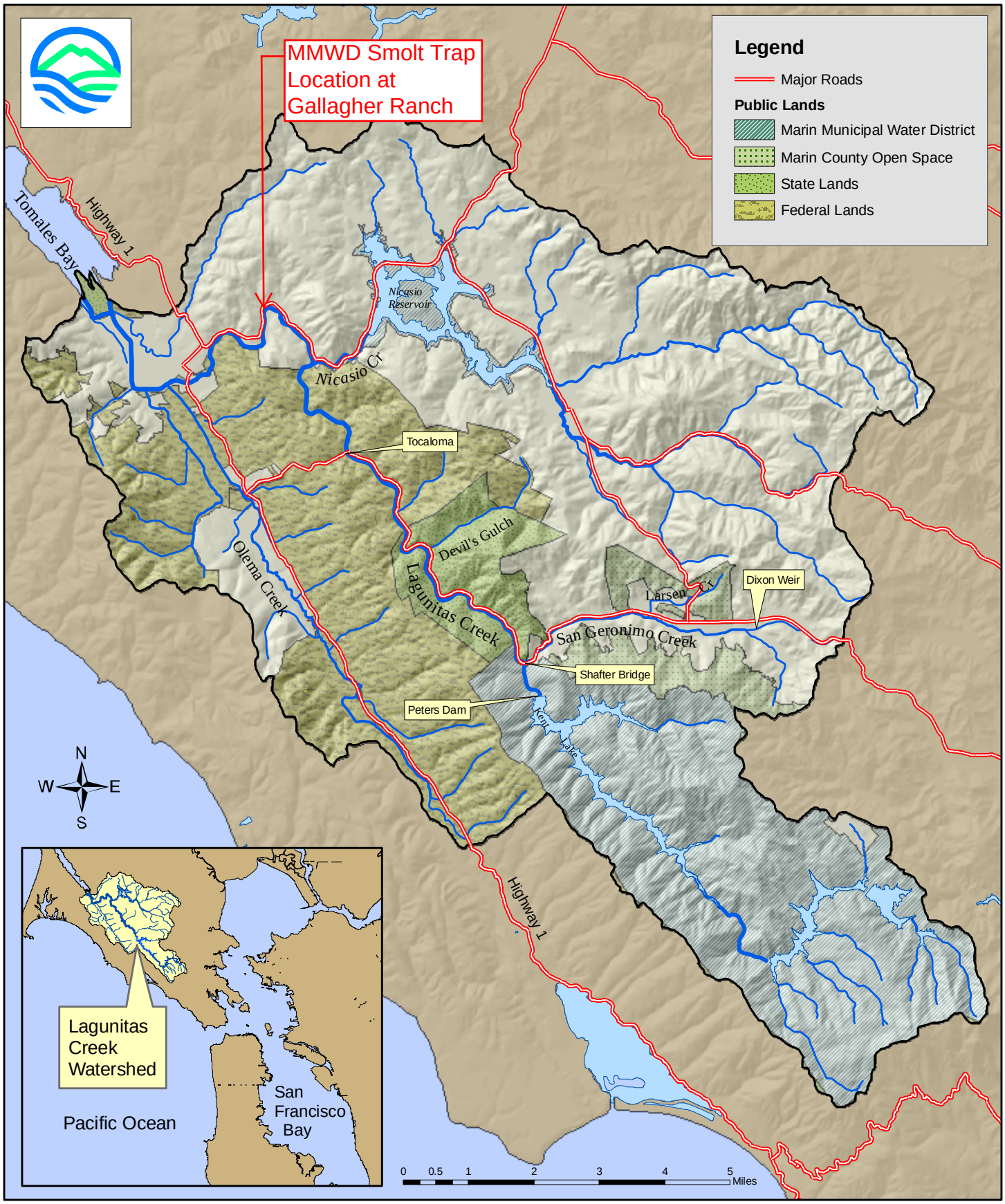


Figure 24. MMWD smolt trap location on Lagunitas Creek.

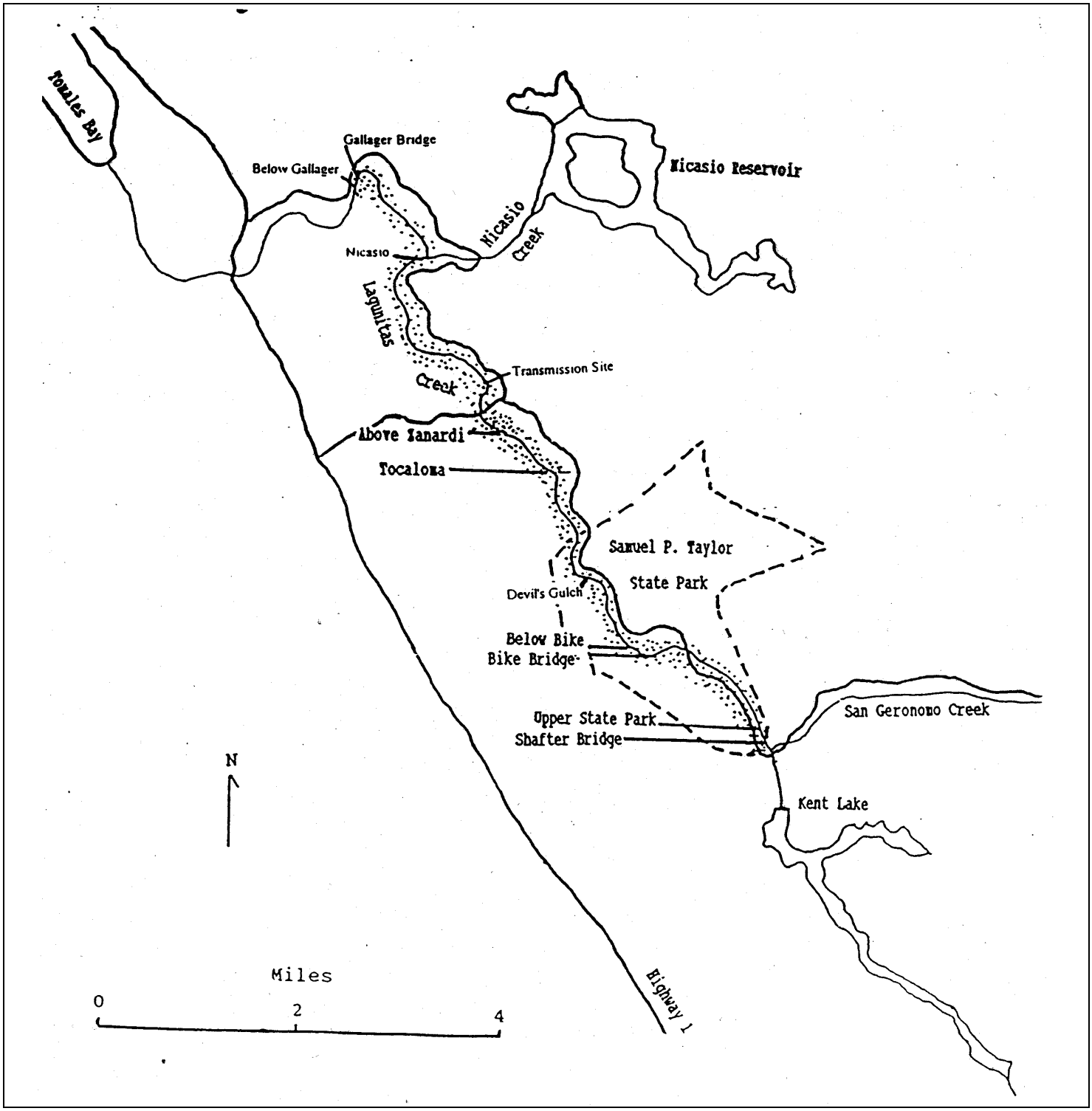


Figure 25. Location of study reaches for California freshwater shrimp surveys in Lagunitas Creek. (Source: Serpa 2008).

Lagunitas Creek Stewardship Plan
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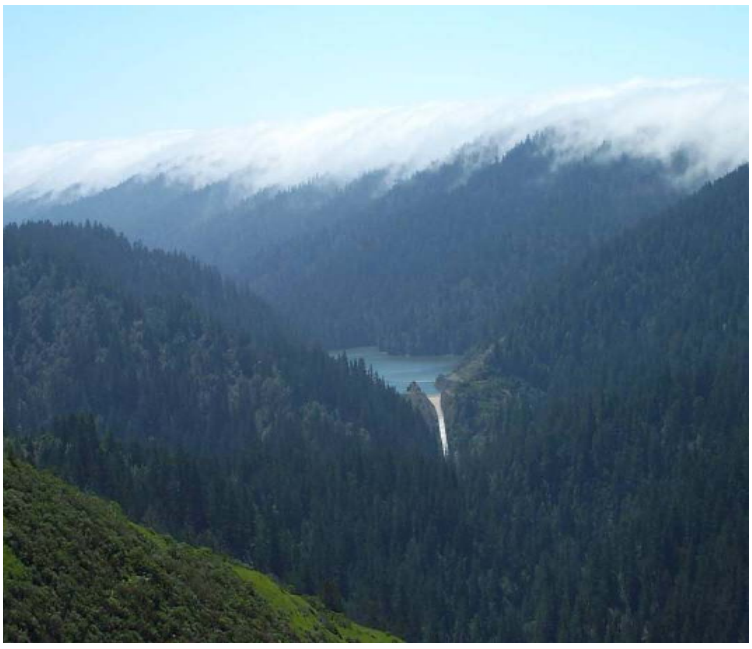
TABLES

Table 1: Chronology of events for the Marin Municipal Water District and Lagunitas Creek.

1953	MMWD completes construction of Peters Dam on Lagunitas Creek to form Kent Lake.
1970s	First fishery monitoring studies conducted by Fish & Game, establishing electrofishing sampling sites.
1976&1977	Two-year drought.
1982	MMWD completes construction to raise Peters Dam; the dam is raised by 45 feet, doubling the capacity of Kent Lake, with a new spillway.
1995	SWRCB concludes water rights hearings and issues Order WR95-17.
1997	MMWD & SWRCB approve the *Lagunitas Creek Sediment and Riparian Management Plan*.
2007	Milestone for the ten-year period of the *Lagunitas Creek Sediment and Riparian Management Plan*.
2008	*Lagunitas Creek Limiting Factors Analysis* completed.
2009	MMWD develops new fishery management plan for Lagunitas Creek.



Peters Dam and Kent Lake, Lagunitas Creek Watershed

Table 2: Requirements of the Marin Municipal Water District stipulated in State Water Board Order WR95-17 for Lagunitas Creek.

No.	Heading	Requirement
1	Instream Flow Requirement	A schedule of minimum flows must be maintained at the U.S. Geological Survey (USGS) stream gage located in Samuel P. Taylor State Park (see below). During a normal water year, the minimum flow ranges from 8 cubic feet per second (cfs) to 25 cfs, depending on the time of year. During a dry water year, the minimum flow ranges between 6 cfs and 20 cfs. In addition, a metered release of at least 1 cfs must be made from Kent Lake into Lagunitas Creek, directly below Peters Dam, at all times.
2	Upstream Migration Flows	Four upstream migration flows must occur, between November and February of each year, to provide for the upstream migration of anadromous fish. An upstream migration flow is at least 35 cfs for three consecutive days, at the USGS gage in SP Taylor Park.
3	Water Year Classification	A water year classification must be made and determine if there is a normal or dry water year and if the normal year or dry year minimum flow schedule shall be maintained. A normal year consists of a January 1st, 15-month index of 48 inches of precipitation and an April 1st, 6-month index of 28 inches of precipitation. Rainfall amounts less than these indices are a dry year classification.
4	Water Temperature	– Mean daily water temperature, at the USGS gage in SP Taylor Park must be at or less than 58 degree Fahrenheit during the summer months (May – October) and at or less than 56 degree during the winter months (November – April).
5	Special Circumstances	In the event the District determines that it cannot meet the flow and/or water temperature conditions, a process must be followed to notify and consult with the following agencies to attempt to develop an alternative operational plan: SWRCB, DFG, U.S. Fish & Wildlife Service (USFWS), and National Marine Fisheries Service (NMFS).
6	Ramping	Water releases into Lagunitas Creek, from Kent Lake, must be controlled and minimize rapid changes in flow in Lagunitas Creek (i.e., reduce the potential for rapid increases or decreases in flow).
7	Control of Sediment	Prepare and implement a sediment control plan to reduce sedimentation in the Lagunitas Creek, watershed. A draft and final plan must be developed in coordination with public agencies and allow for public review and input.
8	Riparian Management Plan	Prepare and implement a riparian management plan to improve riparian vegetation and woody debris within the Lagunitas Creek watershed. A draft and final plan must be developed in coordination with public agencies and allow for public review and input.

Table 2: Requirements of the Marin Municipal Water District stipulated in State Water Board Order WR95-17 for Lagunitas Creek.

9	Monitoring Fishery Resources	Prepare and implement a workplan for monitoring the coho salmon, steelhead, and California freshwater shrimp populations of Lagunitas Creek. The plan must be developed in consultation with DFG, USFWS, and NMFS.
10	Gages	Ensure that a continuous record of daily stream flow and water temperature is maintained at the USGS gage in SP Taylor Park.
11	Reporting	Prepare and submit an annual report to the SWRCB that verifies the District's compliance with Order WR95-17, over the previous water year. The water year runs from October 1st through September 30th.

Lagunitas Creek Minimum Instream Flow Requirements

Normal Water Year Requirements

Time Period	Flow (cfs)*
November 1/15** December 31	20
January 1 – March 15	25
March 14 – March 31	20
April 1 – April 30	16
May 1 – June 15	12
June 16 – November 1/15	8

Dry Water Year Requirements

Time Period	Flow (cfs)*
November 1/15** March 31	20
April 1 – April 30	14
May 1 – June 15	10
June 16 – November 1/15	6

***** cfs = cubic foot per second.
Flow as measured at the USGS gage at S.P. Taylor State Park.

****** The minimum flow of 20 cfs in November shall begin following the first storm that produces a "trigger " flow of 25 cfs at the USGS State Park gage; in absence of a trigger flow, the 20 cfs requirement shall become effective on November 15th of each year.

Notes:

- Order WR95-17 amended Water Right Permits 5633, 9390, and 18546.
- Order WR95-17 further amended Permit 12800 with the condition that MMWD shall not release water from Nicasio Reservoir directly into Lagunitas Creek, or its tributaries, between the base of Peters Dam and the confluence with Nicasio Creek.

LAGUNITAS CREEK STEWARDSHIP PLAN - Marin Municipal Water District (MMWD)

- MMWD will pursue these activities under the Lagunitas Creek Stewardship Plan.
- MMWD will pursue these actions in collaboration with other entities involved with Lagunitas Creek.
- MMWD will seek grants and other funding sources for these actions, along with commitments of staff time and finacial contributions.

ELEMENT	ACTION	DESCRIPTION	Collaborators
Category 1: On-Going Mandatory Requirements of SWRCB Order WR95-17.			
Compliance with Ongoing Requirements of WR95-17	Instream Flows	Maintain the minimum flows at the SP Taylor stream gage, per the schedule specified in Order WR95-17.	SWRCB
"	Upstream Migration Flows	Ensure that four upstream migration flows are provided between Nov. 1st and Feb. 3rd each year, as stipulated in Order WR95-17	SWRCB
"	Water Year Classification	Determine the water year classification, as a normal or dry year, and maintain stream flows under the normal or dry year requirements of Order WR95-17.	SWRCB
"	Water Temperature	Ensure sufficient water releases are made from Kent Lake, into Lagunitas Creek, to meet and maintain the minimum stream flows at the SP Taylor gage and that mean daily water temperatures at the gage are being recorded and reported.	SWRCB
"	Special Circumstances	Follow the Special Circumstance reporting procedures of Order WR95-17 if the stream flow and/or water temperature conditions of the Order cannot be met.	SWRCB, DFG, NMFS, USFWS
"	Ramping	Control releases from Kent Lake in order to minimize rapid changes in flow in Lagunitas Creek.	SWRCB
"	Gages	Ensure that the USGS stream gage at SP Taylor Park remains in operation and that the mean daily stream flow and temperature of Lagunitas Creek are recorded through continuous monitoring.	SWRCB, USGS, State Parks
"	Reporting	Compile and submit an annual report to the SWRCB, describing MMWD's activities and compliance with Order WR95-17.	SWRCB

Table 3. Summary of actions for the Lagunitas Creek Stewardship Plan.

ELEMENT	ACTION	DESCRIPTION	Collaborators
Category 2: Actions MMWD Will Lead.			
Winter Habitat Enhancement	Winter Habitat Enhancement - Assessment	Conduct a two-phase concept & design assessment of Lagunitas Creek and lower Olema Creek to enhance overwinter habitat for salmonids.	Fish & Game, USFWS, NPS, State Parks, NOAA
Sediment Reduction and Management	Sediment Source Treatments in the Watershed	Implements prescribed sediment reduction treatments at priority road-related sites in Lagunitas Creek watershed, under the 319(h) Lagunitas Cr. Water Quality & Habitat Improvement Project - Cheda Cr., McIsaac Cr., Cross-Marin Trail, and Dog Creek.	SWRCB, RWQCB, State Parks, NPS
"	Sediment Source Roads Assessment	Complete a comprehensive assessment of unpaved roads in the Lagunitas Creek Watershed, including a site inventory and prioritizing sediment source repair sites on about 105 miles of unpaved roads, under the Lagunitas Cr. Roads Assessment Project.	DFG, NOAA, State Parks, NPS, RCD
"	Sediment Source Management Roads GIS	Update the GIS of roads in the Lagunitas Creek watershed, completed in 2007, with new information on road assessments, treatments, and maintenance.	Marin County, NPS, State Parks, RCD, SPAWN
"	Sediment Source Treatments in the Watershed	Implement repairs at some of the sediment source sites identified in previous watershed assessments; focus on roads and other human-induced erosion sites, on public lands in the mainstem Lagunitas Creek watershed between Peters Dam and Nicasio Creek.	State Parks, NPS
"	Streambed Gravel Management	Evaluate goals and opportunities for gravel augmentation and enhancement in Lagunitas Creek and tributaries; implement a gravel management strategy in mainsteam Laguntias Creek.	TAC
Instream & Riparian Habitat Enhancement	Rearing Habitat Enhancement with Large Woody Debris (LWD)	Install and maintain LWD structures in mainstem Lagunitas Creek, downstream of Peters Dam and through S.P. Tayor State Park and on MMWD lands along San Geronimo Creek.	State Parks
"	Riparian Vegetation Enhancement	Plant and maitain native riparian vegetation between Peters Dam and Shafter Bridge, under the Mt. Tamalpais Watershed Gateway Project and future efforts.	Coast Conservancy, Resources Agency, SPAWN
Biotechnical Bank Stabilization	Biotechnical Bank Stabilization - Lagunitas Booster Station	Develop and implement biotechnical bank stabilization on San Geronimo Creek at MMWDs Lagunitas Booster Station site; coupled with water discharge dissipation from the site.	n/a
"	Biotechnical Bank Stabilization - Below Peters Dam	Develop and implement biotechnical bank stabilization and riparian revegetation at Below Peters Dam site.	n/a
Ca. Freshwater Shrimp Habitat Enhancement	Freshwater Shrimp Habitat Enhancement - Assessment	Data review and evaluation to develop habitat enhancement measures specifically designed to benefit freshwater shrimp.	USFWS, USGS, NPS, State Parks
Survey & Monitoring	Survey & Monitoring Workgroup	Coordinate monitoring surveys and protocols for consistent methodologies and data sharing.	TAC, TBWC
"	Stream Flow Monitoring	Conduct continous monitoring of stream flow at two gages: the USGS gage at Point Reyes Station, on Lagunitas Creek; and the MMWD gage Lagunitas Rd. on San Geronimo Creek.	USGS, NPS, County, North Marin Water District
"	Juvenile Salmonid Surveys	Annual juvenile salmonid survey; mainstem Lagunitas Creek, mainstem San Geronimo Creek, and Devil's Gulch.	NPS
"	Salmon Spawner Surveys	Annual salmon spawner survey; mainstem Lagunitas Creek, mainstem San Geronimo Creek, and Devil's Gulch.	NPS, SPAWN

Table 3. Summary of actions for the Lagunitas Creek Stewardship Plan.

ELEMENT	ACTION	DESCRIPTION	Collaborators
Survey & Monitoring	Salmon Smolt Surveys	Annual salmon smolt survey; mainstem Lagunitas Creek.	NPS, SPAWN
"	Salmon Winter Survey	Conduct a juvenile coho winter habitat utilization study in Lagunitas Creek, including track movement of PIT tagged fish.	State Parks, NPS, TAC
"	Salmon Fry Emergence Survey	Investigate conducting another emergence study to further investigate the question of juvenile mortality during the emergence stage, as a potential limiting factor.	State Parks, NPS, TAC
"	California Freshwater Shrimp Surveys	Annual Ca. freshwater shrimp survey; mainstem Lagunitas Creek.	USFWS
"	Habitat Typing Surveys	Habitat typing surveys every 5 years through Lagunitas Creek, San Geronimo Creek, and Devil's Gulch.	Fish & Game, AmeriCorps/WSP
"	Sediment & Streambed Monitoring	Sampling in Lagunitas Creek, San Geronimo Creek, and Devil's Gulch for: bed elevation; grain sizes; fine sediments; gravels; and characteristics of large woody debris.	RWQCB
"	Water Quality Monitoring	Monthly grab samples at 4 sites in Lagunitas, Nicasio, and San Geronimo Creek for: Temperature; pH; Turbidity; Alkalinity; Hardness; Copper; Total Suspended Solids; and Settleable Solids	TBWC
"	Project Site Monitoring	Annual inspections of project sites.	TAC
Programs and Policies	Roads MOU	Follow the guidelines and practices included in the MOU for Maintenance and Management of Unpaved Roads in the Lagunitas Creek Watershed.	County. MCOSD, State Parks, NPS, RCD, TAC
"	Woody Debris MOU	Follow the guidelines and practices included in the MOU for Woody Debris Management in Riparian Areas of the Lagunitas Creek Watershed.	County. MCOSD, State Parks, NPS, RCD, TAC
	Mt. Tamalpais Watershed Management Policy	Follow MMWD Board Policy No. 7 - Mt. Tamalpais Watershed Management Policy.	n/a
"	Wells Policy	Revised MMWD Board Policy No. 3 - Wells and other Private Sources Policy; incorporate protection of stream flows into the policy.	TAC
Collaboration and Outreach	Lagunitas TAC	Remain an active participating entity of the TAC; continue to facilitate the TAC meetings, in lieu of another participating entity; encourage other TAC members to remain active participants.	TAC
"	Partnerships & Collaboration	Partnerships and Coordination with other agencies through the TBWC, North Bay Watershed Association, State & Federal coho & steelhead recovery efforts, and the Bay Area IRWMP Coordinating Committee.	TAC, TBWC, NBWA, and others
"	Public Involvement & Education	Public involvement and outreach through public meetings, volunteer events, participation in Trout-in-the-Classroom, and other educational opportunities	Public, TAC

Table 3. Summary of actions for the Lagunitas Creek Stewardship Plan.

ELEMENT	ACTION	DESCRIPTION	Collaborators
Category 3: Actions MMWD Will Participate In But Not Necessarily Lead.			
Winter Habitat Enhancement	Winter Habitat Enhancement - Construction	Construct the winter habitat enhancement features, as designed, in Lagunitas Creek and lower Olema Creek.	Fish & Game, NOAA, NPS, State Parks, RCD
Sediment Reduction and Management	Sediment Source Treatments in the Watershed	Implement repairs at some of the sediment source sites identified in previous watershed assessments, focus on roads and other human-induced erosion sites, in the San Geronimo Valley and Olema Creek.	County. MCOSD, State Parks, NPS, RCD
"	Streambed Gravel Management	Implement a gravel management strategy in the tributaries to Laguitas Creek.	TAC
Instream & Riparian Habitat Enhancement	Rearing Habitat Enhancement with Large Woody Debris (LWD)	Install and maintain LWD structures in mainstem Lagunitas Creek, downstream of S.P. Taylor State Park, and in Devil's Gulch.	State Parks, NPS, TU
"	Devil's Gulch Habitat Enhancement	Evaluate, develop, and implement habitat enhancement strategies for Devil's Gulch.	TU, State Parks, NPS, RCD
"	Riparian Vegetation Enhancement	Install native plants along the edge of the stream channel, to enhance habitat for the California freshwater shrimp, at various locations through the lower State Park and Tocaloma reaches of Lagunitas Creek.	USFWS, NPS, State Parks
Biotechnical Bank Stabilization	Biotechnical Bank Stabilization - S.P. Taylor Park	Develop and implement biotechnical bank stabilization and riparian revegetation at Nicasio Transmission Line retaining wall site in S.P. Taylor Park.	State Parks
Ca. Freshwater Shrimp Habitat Enhancement	Freshwater Shrimp Habitat Enhancement - Construction	Installation of habtat enhancement projects, identified in prior assessment, for shrimp habitat enhancement; may include woody debris structures and riparian vegetation plantings along the lower State Park and Tocaloma reaches.	USFWS, USGS, NPS, State Parks
Aquatic Invasive Species (AIS) Management	Early Dectection/Rapid Response	Conduct baseline surveys of AIS and conduct monitoring for detection of New Zealand mud snail, quagga & zebra mussels.	TAC, TBWC
"	Protocols for cleaning, storage, and inspections of field equipment and gear	Develop and put into practice protocols for AIS controls through cleaning, storage, and inspections of field gear and equipment that will enter any water body within the watershed.	TAC, TBWC
"	Education	Develop and provide educational material about AIS; disseminate to all stakeholders and the general public visiting the watershed.	TAC, TBWC
"	Invasive Plant Control	Remove invasive plants from the riparian corridor; target species: cape ivy; take a systematic, piece-meal approach to minimize impacts to existing habitat.	NPS, State Parks, County, SPAWN

Table 3. Summary of actions for the Lagunitas Creek Stewardship Plan.

LAGUNITAS CREEK STEWARDSHIP PLAN - Marin Municipal Water District (MMWD)

- MMWD will pursue implementation of these actions under the Lagunitas Creek Stewardship Plan, under the schedule, duration,and frequency listed.
- MMWD will pursue these actions in collaboration with other entities involved with Lagunitas Creek.
- MMWD will seek grants and other funding sources for these actions, along with commitments of staff time and finacial contributions.

ELEMENT	Section in Report	ACTION	DESCRIPTION	SCHEDULE	Duration (No. of Years)	Frequency
Continued Compliance with the Requirements of Order WR95-17	**4.1**	Instream Flows	Maintain the minimum flows at the SP Taylor stream gage, per the schedule specified in Order WR95-17.	2011 - 2020	10	Continuous
		Upstream Migration Flows	Ensure that four upstream migration flows are provided between Nov. 1st and Feb. 3rd each year, as stipulated in Order WR95-17	2011 - 2020	10	Annual
		Water Year Classification	Determine the water year classification, as a normal or dry year, and maintain stream flows under the normal or dry year requirements of Order WR95-17.	2011 - 2020	10	Annual
		Water Temperature	Ensure sufficient water releases are made from Kent Lake, into Lagunitas Creek, to meet and maintain the minimum stream flows at the SP Taylor gage and that mean daily water temperatures at the gage are being recorded and reported.	2011 - 2020	10	Continuous
		Special Circumstances	Follow the Special Circumstance reporting procedures of Order WR95-17 if the stream flow and/or water temperature conditions of the Order cannot be met.	2011 - 2020	10	As Needed
		Ramping	Control releases from Kent Lake in order to minimize rapid changes in flow in Lagunitas Creek.	2011 - 2020	10	Continuous
		Gages	Ensure that the USGS stream gage at SP Taylor Park remains in operation and that the mean daily stream flow and temperature of Lagunitas Creek are recorded through continuous monitoring.	2011 - 2020	10	Continuous
		Reporting	Compile and submit an annual report to the SWRCB, describing MMWD's activities and compliance with Order WR95-17.	2011 - 2020	10	Annual

Table 4. Schedule for implementation of actions under the Lagunitas Creek Stewardship Plan.

ELEMENT	Section in Report	ACTION	DESCRIPTION	SCHEDULE	Duration (No. of Years)	Frequency
Winter Habitat Enhancement	**4.2**	Winter Habitat Enhancement - Assessment	Conduct a two-phase concept & design assessment of Lagunitas Creek and lower Olema Creek to enhance overwinter habitat for salmonids.	2011 - 2013	3	Project Site Specific
		Winter Habitat Enhancement - Construction	Construct the winter habitat enhancement features, as designed, in Lagunitas Creek and lower Olema Creek.	2011 - 2015	5	Project Site Specific
Sediment Reduction and Management	**4.3**	Sediment Source Treatments in the Watershed	Implements prescribed sediment reduction treatments at priority road-related sites in Lagunitas Creek watershed, under the 319(h) Lagunitas Cr. Water Quality & Habitat Improvement Project - Cheda Cr., McIsaac Cr., Cross-Marin Trail, and Dog Creek.	2011 - 2013	2	Project Site Specific
		Sediment Source Roads Assessment	Complete a comprehensive assessment of unpaved roads in the Lagunitas Creek Watershed, including a site inventory and prioritizing sediment source repair sites on about 105 miles of unpaved roads, under the Lagunitas Cr. Roads Assessment Project.	2011 - 2013	2	Project Site Specific
		Sediment Source Management Roads GIS	Update the GIS of roads in the Lagunitas Creek watershed, completed in 2007, with new information on road assessments, treatments, and maintenance.	2011 - 2020	10	Project Site Specific
		Sediment Source Treatments in the Watershed	Implement repairs at some of the sediment source sites identified in previous watershed assessments, focus on roads and other human-induced erosion sites.	2011 - 2020	10	Project Site Specific
		Streambed Gravel Management	Evaluate goals and opportunities for gravel augmentation and enhancement in Lagunitas Creek and tributaries; develop and implement a gravel management strategy.	2011 - 2015	5	Project Site Specific

Table 4. Schedule for implementation of actions under the Lagunitas Creek Stewardship Plan.

ELEMENT	Section in Report	ACTION	DESCRIPTION	SCHEDULE	Duration (No. of Years)	Frequency
Instream & Riparian Habitat Enhancement	**4.4**	Rearing Habitat Enhancement with Large Woody Debris (LWD)	Install and maintain LWD structures in mainstem Lagunitas Creek, Devil's Gulch, and on MMWD lands along San Geronimo Creek.	2011 - 2020	10	Project Site Specific
		Devil's Gulch Habitat Enhancement	Evaluate, develop, and implement habitat enhancement strategies for Devil's Gulch.	2011 - 2015	5	Project Site Specific
		Riparian Vegetation Enhancement	Plant and maitain native riparian vegetation at sites between Peters Dam and Shafter Bridge; install native plants to enhance habitat for Ca. freshwater shrimp through lower State Parks and Tocaloma.	2011 - 2020	10	Project Site Specific
Biotechnical Bank Stabilization	**4.5**	Biotechnical Bank Stabilization - Lagunitas Booster Station	Develop and implement biotechnical bank stabilization on San Geronimo Creek at MMWDs Lagunitas Booster Station site; coupled with water discharge dissipation from the site.	2011 - 2013	3	Project Site Specific
		Biotechnical Bank Stabilization - Below Peters Dam	Develop and implement biotechnical bank stabilization and riparian revegetation at Below Peters Dam site.	2011 - 2013	3	Project Site Specific
		Biotechnical Bank Stabilization - S.P. Taylor Park	Develop and implement biotechnical bank stabilization and riparian revegetation at Nicasio Transmission Line retaining wall site in S.P. Taylor Park.	2011 - 2015	5	Project Site Specific

Table 4. Schedule for implementation of actions under the Lagunitas Creek Stewardship Plan.

ELEMENT	Section in Report	ACTION	DESCRIPTION	SCHEDULE	Duration (No. of Years)	Frequency
California Freshwater Shrimp Habitat Enhancement	**4.6**	Freshwater Shrimp Habitat Enhancement - Assessment	Data review and evaluation to develop habitat enhancement measures specifically designed to benefit freshwater shrimp.	2011 - 2013	3	Project Site Specific
		Freshwater Shrimp Habitat Enhancement - Construction	Installation of habtat enhancement projects, identified in prior assessment, for shrimp habitat enhancement; may include woody debris structures and riparian vegetation plantings along the lower State Park and Tocaloma reaches.	2011 - 2015	5	Project Site Specific
Survey & Monitoring	**4.7**	Survey & Monitoring Workgroup	Coordinate monitoring surveys and protocols for consistent methodologies and data sharing.	2011 - 2020	10	Continuous
		Stream Flow and Water Temperature Monitoring	Conduct continous monitoring of stream flow at two gages: the USGS gage at Point Reyes Station, on Lagunitas Creek; and the MMWD gage Lagunitas Rd. on San Geronimo Creek.	2011 - 2020	10	Continuous
		Juvenile Salmonid Surveys	Annual juvenile salmonid survey; mainstem Lagunitas Creek, mainstem San Geronimo Creek, and Devil's Gulch.	2011 - 2020	10	Annual
		Salmon Spawner Surveys	Annual salmon spawner survey; mainstem Lagunitas Creek, mainstem San Geronimo Creek, and Devil's Gulch.	2011 - 2020	10	Annual
		Salmon Smolt Surveys	Annual salmon smolt survey; mainstem Lagunitas Creek.	2011 - 2020	10	Annual
		California Freshwater Shrimp Surveys	Annual Ca. freshwater shrimp survey; mainstem Lagunitas Creek.	2011 - 2020	10	Annual

Table 4. Schedule for implementation of actions under the Lagunitas Creek Stewardship Plan.

ELEMENT	Section in Report	ACTION	DESCRIPTION	SCHEDULE	Duration (No. of Years)	Frequency
Survey & Monitoring	**4.7**	Habitat Typing Surveys	Habitat typing surveys every 5 years through Lagunitas Creek, San Geronimo Creek, and Devil's Gulch.	2011 & 2016	2	Every 5 years
		Sediment & Streambed Monitoring	Sampling in Lagunitas Creek, San Geronimo Creek, and Devil's Gulch for: bed elevation; grain sizes; fine sediments; gravels; and characteristics of large woody debris.	2011 - 2020	5	Bi-Annual (on average); TTS sampling continuous
		Water Quality Monitoring	Monthly grab samples at 4 sites in Lagunitas, Nicasio, and San Geronimo Creek for: Temperature; pH; Turbidity; Alkalinity; Hardness; Copper; Total Suspended Solids; and Settleable Solids	2011 - 2020	10	Monthly
		Project Site Monitoring	Annual inspections of project sites.	2011 - 2020	10	Annual
Aquatic Invasive Species (AIS) Management	**4.8**	Early Dectection/Rapid Response	Conduct baseline surveys of AIS and conduct monitoring for detection of New Zealand mud snail, quagga & zebra mussels.	2011 - 2020	5	Bi-Annual
		Protocols for cleaning, storage, and inspections of field equipment and gear	Develop and put into practice protocols for AIS controls through cleaning, storage, and inspections of field gear and equipment that will enter any water body within the watershed.	2011 - 2020	10	Continuous
		Education	Develop and provide educational material about AIS; disseminate to all stakeholders and the general public visiting the watershed.	2011 - 2020	10	Continuous
		Invasive Plant Control	Remove invasive plants from the riparian corridor; target species: cape ivy; take a systematic, piece-meal approach to minimize impacts to existing habitat.	2011 - 2020	10	Project Site Specific

Table 4. Schedule for implementation of actions under the Lagunitas Creek Stewardship Plan.

ELEMENT	Section in Report	ACTION	DESCRIPTION	SCHEDULE	Duration (No. of Years)	Frequency
Programs and Policies	**4.9**	Roads MOU	Follow the guidelines and practices included in the MOU for Maintenance and Management of Unpaved Roads in the Lagunitas Creek Watershed.	2011 - 2020	10	Continuous
		Woody Debris MOU	Follow the guidelines and practices included in the MOU for Woody Debris Management in Riparian Areas of the Lagunitas Creek Watershed.	2011 - 2020	10	Continuous
		Mt. Tamalpais Watershed Management Policy	Follow MMWD Board Policy No. 7 - Mt. Tamalpais Watershed Management Policy.	2011 - 2020	10	Continuous
		Wells Policy	Revised MMWD Board Policy No. 3 - Wells and other Private Sources Policy; incorporate protection of stream flows into the policy.	2011 - 2012	1	Project Site Specific
Collaboration and Outreach	**4.10**	Lagunitas TAC	Remain an active participating entity of the TAC; continue to facilitate the TAC meetings, in lieu of another participating entity; encourage other TAC members to remain active participants.	2011 - 2020	10	Continuous
		Partnerships & Collaboration	Partnerships and Coordination with other agencies through active participation in the TBWC, North Bay Watershed Association, State & Federal coho & steelhead recovery efforts, and the Bay Area IRWMP Coordinating Committee.	2011 - 2020	10	Continuous
		Public Involvement & Education	Public involvement and outreach through public meetings, volunteer events, participation in Trout-in-the-Classroom, and other educational opportunities	2011 - 2020	10	Continuous

Table 4. Schedule for implementation of actions under the Lagunitas Creek Stewardship Plan.

LAGUNITAS CREEK STEWARDSHIP PLAN - Marin Municipal Water District (MMWD)

- MMWD will pursue the actions in the Lagunitas Creek Stewardship Plan in priority.
- MMWD will pursue the actions in collaboration with other entities involved with Lagunitas Creek.
- MMWD will seek grants and other funding sources for the actions, along with commitments of staff time and other finacial contributions.

CATEGORY	DESCRIPTION	TOTAL COST
Category 1	On-Going Mandatory Requirements of SWRCB Order WR95-17.	$215,500
Category 2	Actions MMWD Will Lead.	$5,746,445
Category 3	Actions MMWD Will Participate In But Not Necessarily Lead.	$1,832,500
	TOTAL	$7,794,445

Table 5. Summary of costs to implement actions in the Lagunitas Creek Stewardship Plan.

Lagunitas Creek Stewardship Plan
Marin Municipal Water District
Final – June 2011

APPENDICES

APPENDIX A

State Water Resourced Control Board
Order WR95-17

APPENDIX A

State Water Resources Control Board Order WR 95-17

Order: Marin Municipal Water District
Pages 109-118

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ORDER: WR 95-17

LAGUNITAS CREEK

Order Amending Water Rights and Requiring Changes in Water Diversion Practices to Protect Fishing Resources and to Prevent Unauthorized Diversion and Use of Water

October 26, 1995

STATE WATER RESOURCES CONTROL BOARD
CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

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below. The order deletes specified permit and license terms which are inconsistent with the newly established requirements.

ORDER

Based on the evidence in the record and the findings set forth in this order, the diversion of water from Lagunitas Creek by Marin Municipal Water District, North Marin Water District, and Waldo Giacomini shall be subject to the provisions below:

MARIN MUNICIPAL WATER DISTRICT

IT IS HEREBY ORDERED that Water Right Permits 5633, 9390, and 18546 (Applications 9892, 14278, 26242) are amended to include the following conditions:

1. **Instream Flow Requirement:** Permittee shall make a metered release of at least one cubic foot per second (cfs) directly below Peters Dam at all times and shall bypass or release sufficient water from Kent Lake to maintain the following minimum instream flow requirements, as measured in cfs at the U.S. Geologic Service gage at Taylor State Park.

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LAGUNITAS CREEK
MINIMUM INSTREAM FLOW REQUIREMENTS

Normal Year Requirements			
Time Period			*Flow (cfs)*
November 1/15*	-	December 31	20
January 1	-	March 15	25
March 16	-	March 31	20
April 1	-	April 30	16
May 1	-	June 15	12
June 16	-	November 1/15*	8

Dry Year Requirements			
Time Period			*Flow (cfs)*
November 1/15*	-	March 31	20
April 1	-	April 30	14
May 1	-	June 15	10
June 16	-	November 1/15*	6

** The minimum flow of 20 cfs in November shall begin following the first storm that produces a "trigger" flow of 25 cfs as measured at the USGS gage at Taylor State Park. In the absence of a storm causing a "trigger" flow, the 20 cfs flow requirement shall become effective on November 15 of each year.*

2. **Upstream Migration Flows**: To provide for the upstream migration of anadromous fish, Permittee shall ensure that four upstream migration flows are provided between November 1 and February 3, as described below. An "upstream migration flow" is defined as a continuous flow of at least 35 cfs that exists for 3 days as measured at the USGS gage at Taylor State Park. A "trigger" flow is defined as a flow of 25 cfs between November 1 and December 31, or a flow of 30 cfs between January 1 and January 31, as measured at the USGS gage at Taylor State Park. Permittee shall attempt to provide upstream migration flows that coincide with natural runoff from storm events.

   a. The first upstream migration flow shall be provided in conjunction with the first storm that occurs after

November 1 that produces a trigger flow of 25 cfs at the park gage. The minimum spawning flow of 20 cfs shall then be maintained for the rest of the month. If no storm produces a trigger flow before November 15, Permittee shall release sufficient water from Kent Lake to provide an upstream migration flow beginning on November 15.

b. A second upstream migration flow shall be provided in conjunction with a storm that occurs after November 4 that produces a trigger flow of 25 cfs at the park gage. If a second trigger flow of 25 cfs does not occur before December 1, Permittee shall release sufficient water from Kent Lake to provide an upstream migration flow beginning on December 1.

c. A third upstream migration flow shall be provided in conjunction with a storm that occurs after December 4 that produces a trigger flow of 25 cfs at the park gage. If a trigger flow of 25 cfs does not occur before January 1, Permittee shall release sufficient water from Kent Lake to provide an upstream migration flow beginning on January 1.

d. A fourth upstream migration flow shall be provided in conjunction with a storm that occurs after January 4 that produces a trigger flow of 30 cfs at the park gage. If a trigger flow of 30 cfs does not occur before February 1, Permittee shall release sufficient water from Kent Lake to provide an upstream migration flow beginning on February 1.

3. **Water Year Classification**: The water year classification shall be determined on January 1 and April 1 of each year, based on precipitation as measured at the Kent rain gage.

111.

The January 1 water year classification shall be based on the total precipitation measured during the preceding 15 month period. If the total precipitation during this 15 month period is less than 48 inches, Permittee shall maintain the dry-year flow requirements from January 1 through March 31. If the total precipitation during this 15 month period is 48 inches or greater, Permittee shall maintain the normal year flow requirements from January 1 through March 31. The April 1 water year classification shall be based on the total precipitation during the preceding 6 month period. If the total precipitation during this 6 month period is less than 28 inches, Permittee shall maintain the dry year flow requirements from April 1 to the first upstream migration flow in November. If the total precipitation during this six-month period is 28 inches or greater, Permittee shall maintain the normal year flow standard from April 1 to the first upstream migration flow in November.

4. **Water Temperature**: Permittee shall bypass or release sufficient water from Kent Lake to maintain a mean daily water temperature of 58 degrees Fahrenheit, or less, between May 1 and October 31, as measured at the USGS gage at Taylor State Park. From November 1 through April 30, permittee shall bypass or release sufficient water from Kent Lake to maintain a mean daily water temperature of 56 degrees Fahrenheit, or less, as measured at the USGS gage at Taylor State Park.

5. **Special Circumstances**: In the event Permittee determines that it cannot meet the flow and/or water temperature conditions described above, Permittee shall immediately notify the Department of Fish and Game (DFG), the U.S. Fish and Wildlife Service (USFWS), the National Marine Fisheries Service (NMFS) and the Chief of the Division of Water Rights. The notification shall include specific information

explaining the condition that cannot be met, the reason the condition cannot be met, and the length of time that the condition cannot be met. Permittee shall consult with DFG, USFWS and NMFS in an attempt to develop a plan of operation that is acceptable to DFG, USFWS, NMFS and the Permittee. If a plan acceptable to Permittee, DFG, USFWS, and NMFS is developed, the plan should be submitted for review by the Chief of the Division of Water Rights. If DFG, USFWS, NMFS and Permittee cannot reach agreement within a reasonable period of time, Permittee shall submit a proposed plan of operation for review by the Chief of the Division of Water Rights, to include:

a. The reasons or justification for the modification of the flow or temperature requirements;

b. A specific plan of operation, including the proposed release schedule from Kent Lake;

c. A description of other measures to be taken by the Permittee to deal with any deficiencies in water supply, including whether the Permittee will declare a water supply emergency and impose mandatory water conservation measures; and

d. Measures to be taken by Permittee to mitigate any potential adverse impacts to the fishery resources in Lagunitas Creek due to the Permittee's inability to meet the flow or temperature requirements specified in this permit.

Permittee shall be responsible for complying with requirements of the California Environmental Quality Act.

The Chief of the Division of Water Rights shall review the District's proposed plan of operation, and if acceptable, shall approve the proposed plan.

6. **Ramping**: Permittee shall make every reasonable effort to control releases from Kent Lake in order to minimize rapid changes in flow in Lagunitas Creek, except as necessary to provide the upstream migration flows required under this permit.

7. **Control of Sediment**: Permittee shall prepare a Sediment Management Plan that describes measures that should be taken to reduce sedimentation and to provide an appreciable improvement in the fishery habitat within the Lagunitas Creek watershed. During the development of the plan, Permittee shall coordinate with appropriate public agencies, and provide an opportunity for input by local environmental groups, property owners in the area, and the general public. Within one year from the date of this order, Permittee shall submit a draft Sedimentation Management Plan to the State Water Resources Control Board for review by the Chief of the Division of Water Rights that describes:

   a. Specific sediment management programs and projects.

   b. Agency responsible for each program or project.

   c. Estimated costs for each program or project.

   d. Time schedule for implementation of each program or project.

   e. Public participation process.

   f. Monitoring program.

g. Reporting procedures.

Permittee shall also submit a copy of the draft Sedimentation Management Plan to the Regional Water Quality Control Board (Regional Board), DFG, USFWS and NMFS at the time the draft plan is submitted to the State Water Resources Control Board. The Regional Board, DFG, USFWS, and NMFS shall have the opportunity to review and comment on the draft plan.

Following consideration of any comments provided by the Regional Board, DFG, USFWS, NMFS and the Chief of the Division of Water Rights, Permittee shall prepare and submit a final Sedimentation Management Plan to the State Water Resources Control Board for approval by the Chief of the Division of Water Rights. Permittee shall provide copies of the final Sedimentation Management Plan to the Regional Board, DFG, USFWS, and NMFS at the time it submits the plan to the State Water Resources Control Board. The Regional Board, DFG, USFWS, and NMFS shall have the opportunity to review and comment upon the final plan prior to approval by the Chief of the Division of Water Rights. The Chief of the Division of Water Rights shall notify the SWRCB Board Members if the final Sedimentation Management Plan submitted by Permittee is not acceptable. Following approval of an acceptable Sedimentation Management Plan, Permittee shall provide the appropriate level of funding and resources to ensure effective implementation of the measures described in the plan.

8. **Riparian Management Plan**: Permittee shall prepare a Riparian Management Plan that describes measures to be taken to improve the riparian vegetation and woody debris within the Lagunitas Creek watershed in order to improve habitat for fishery resources. During the development of the plan, Permittee shall coordinate with appropriate public agencies,

and provide an opportunity for input by local environmental groups, property owners in the area, and the general public. Within one year of the date of this order, Permittee shall submit a draft Riparian Management Plan to the State Water Resources Control Board for review by the Chief of the Division of Water Rights that describes:

a. Specific riparian management programs and projects

b. Party responsible for each program or project.

c. Estimated costs for each program or project.

d. Time schedule for implementation of each program or project.

e. Public participation process.

f. Monitoring program.

g. Reporting procedures.

Permittee shall also submit a copy of the draft Riparian Management Plan to DFG, USFWS and NMFS at the time the draft plan is submitted to the State Water Resources Control Board. The DFG, USFWS, and NMFS shall have the opportunity to review and comment on the draft plan.

Following consideration of any comments provided by the DFG, USFWS, NMFS and the Chief of the Division of Water Rights, Permittee shall prepare and submit a final Riparian Management Plan to the State Water Resources Control Board for approval by the Chief of the Division of Water Rights. Permittee shall provide copies of the final Riparian Management Plan to DFG, USFWS, and NMFS at the time it

submits the plan to the State Water Resources Control Board. The DFG, USFWS, and NMFS shall have the opportunity to review and comment upon the final plan prior to approval by the Chief of the Division of Water Rights. The Chief of the Division of Water Rights shall notify the SWRCB Board Members if the final Riparian Management Plan submitted by Permittee is not acceptable. Following approval of an acceptable Riparian Management Plan, Permittee shall provide the appropriate level of funding and resources to ensure effective implementation of the measures described in the plan.

9. **Monitoring of Fishery Resources**: Permittee shall be responsible for monitoring the coho salmon, steelhead and freshwater shrimp populations in Lagunitas Creek. Within six months, Permittee shall submit to the State Water Resources Control Board, for the approval of the Chief of Division of Water Rights, a workplan that describes the scope of the monitoring studies to be conducted. During the development of the workplan, Permittee shall consult with the DFG, USFWS and NMFS regarding the scope and duration of the monitoring studies. Following the approval of a plan that is acceptable to the Chief of the Division of Water Rights, the monitoring studies shall be conducted in accordance with the scope of work and time schedule described in the work plan. Permittee shall provide sufficient funding and resources to assure satisfactory completion of the monitoring studies. Annual reports shall be submitted to the Chief of the Division of Water Rights, by December 31 of each year, until the monitoring studies are completed.

10. **Gages**: In order to document compliance with the terms of this permit, Permittee shall ensure that a continuous record is maintained of the daily flow and temperature at the USGS gage at Taylor State Park. That data shall be made available

to the State Water Resources Control Board upon request, in a format acceptable to the Chief of the Division of Water Rights.

11. **Reporting:** Permittee shall submit a report to the State Water Resources Control Board by December 31 of each year that verifies Permittee's compliance with permit conditions for the previous water year ending September 30. The report shall be submitted to the Division of Water Rights in a format designated by the Chief of the Division of Water Rights.

IT IS FURTHER ORDERED that:

1. Conditions 19, 20, 21, 22, 23, 24, 25, 26, and 27 are deleted from amended Permit 5633 issued on May 20, 1982. (Application 9892).

2. Conditions 19, 21, 22, 23, 24, 25, 26, 27, 28 and 29 are deleted from amended Permit 9390 issued on May 20, 1982 (Application 14278).

3. Conditions 21, 23, 24, 25, 26, 27, 28, 29, 30 and 31 are deleted from Permit 18546 (Application 26242).

4. Amended Permit 12800 issued on May 20, 1982 (Application 17317) is amended to include the following condition:

   > Permittee shall not release water from Nicasio Reservoir directly into Lagunitas Creek, or its tributaries, between the base of Peters Dam and the confluence of Nicasio Creek and Lagunitas Creek.

5. Conditions 12, 18, 19, 20, 21, 22, 23, 24, 25, and 26 are deleted from amended Permit 12800 issued on May 20, 1982 (Application 17317).

APPENDIX B

Public Trust Doctrine Overview

APPENDIX B

Public Trust Doctrine

Overview By
Amanda Morrison, MMWD Fishery Watershed Aide

History

In 528 AD Roman Emperor Justinian gathered and condensed all the published rules and edicts handed down by his predecessors into a unified, coherent code of imperial law, the *Codex Justinianus*. It used both the *Codex Theodosianus* and private collections such as the *Codex Gregorianus* and *Codex Hermogenianus*.

Codex Justinianus, Book II- Of Things

> *By the law of nature these things are common to mankind---the air, running water, the sea, and consequently the shores of the sea. No one, therefore, is forbidden to approach the seashore, provided that he respects habitationes, monuments, and buildings which are not, like the sea, subject only to the law of nations.*

- *All rivers and ports are public; hence the right of fishing in a port, or in rivers, is common to all men.*
- *The seashore extends as far as the greatest winter flood runs up.*
- *The public use of the banks of a river is part of the law of nations, just as is that of the river itself. All persons, therefore, are as much at liberty to bring their vessels to the bank, to fasten ropes to the trees growing there, and to place any part of their cargo there, as to navigate the river itself But the banks of a river are the property of those whose land they adjoin; and consequently the trees growing on them are also the property of the same persons.*
- *The public use of the seashore, too, is part of the law of nations, as is that of the sea itself; and, therefore, any person is at liberty to place on it a cottage, to which he may retreat, or to dry his nets there, and haul them from the sea; for the shores may be said to be the property of no man, but are subject to the same law as the sea itself, and the sand or ground beneath it.*

Current Law

Justinian Law was adopted by the French, Spanish, and the English, inevitably being carried over into American Colonial common law without argument.

Upon signing the Declaration of Independence the US adopted the “doctrine of the public trust” from English common law where consistent with the Constitution of the U.S.

California the Public Trust Doctrine

In California the Public Trust Doctrine has taken various forms. The California Constitution Article 10, 2- "reasonable and beneficial use" and 4- regarding navigation; the California Endangered Species Act, California Fish and Game Code, California Water Code; the PTD also stands alone as common law principle.

Landmark Court Cases

1892 Illinois Central Railroad v. Illinois:

The U.S. Supreme Court held that state legislature could not grant ownership of land under navigable waters to a private party, in this case the railroad, which had in effect been handed, fee simple, one thousand acres of Lake Michigan shoreline and underwater land – at the time, the entire waterfront of Chicago.

1983 Mono Lake case: Audubon Society v, the LA Department of Water

The Department of Water and Power was drawing substantial amount of water from the feeder streams supplying Mono Lake, causing the lake to recede at a rate that threatened the entire surrounding ecosystem. The California Supreme Court, invoking the Public Trust Doctrine, ruled against LA and for the lake, extending the state's public trust authority to the control of water diversions from non-navigable tributaries of a navigable lake.

Summary

The Public Trust Doctrine is not a legal construct but rather an underlying principle of politics looking after the general welfare of a state's water and its entities to benefit public interest. Furthermore, the philosophy of public trust doctrine can be extended into protection of ecological integrity if there was a governing body to see it through. A district court in Long Island once declared that "the entire ecological system supporting the waterways is an integral part of them and must necessarily be included within the purview of the public trust."

The following sections of California law are examples of declarations influenced by the Public Trust Doctrine:

California Constitution

Article 10

> SEC. 2. It is hereby declared that because of the conditions prevailing in this State the general welfare requires that the water resources of the State be put to beneficial use to the fullest extent of which they are capable, and that the waste or unreasonable use or unreasonable method of use of water be prevented, and that the conservation of such waters is to be exercised with a view to the reasonable and beneficial use thereof in

the interest of the people and for the public welfare. The right to water or to the use or flow of water in or from any natural stream or water course in this State is and shall be limited to such water as shall be reasonably required for the beneficial use to be served, and such right does not and shall not extend to the waste or unreasonable use or unreasonable method of use or unreasonable method of diversion of water. Riparian rights in a stream or water course attach to, but to no more than so much of the flow thereof as may be required or used consistently with this section, for the purposes for which such lands are, or may be made adaptable, in view of such reasonable and beneficial uses; provided, however, that nothing herein contained shall be construed as depriving any riparian owner of the reasonable use of water of the stream to which the owner's land is riparian under reasonable methods of diversion and use, or as depriving any appropriator of water to which the appropriator is lawfully entitled.

This section shall be self-executing, and the Legislature may also enact laws in the furtherance of the policy in this section contained.

SEC. 4. No individual, partnership, or corporation, claiming or possessing the frontage or tidal lands of a harbor, bay, inlet, estuary, or other navigable water in this State, shall be permitted to exclude the right of way to such water whenever it is required for any public purpose, nor to destroy or obstruct the free navigation of such water; and the Legislature shall enact such laws as will give the most liberal construction to this provision, so that access to the navigable waters of this State shall be always attainable for the people thereof.

California Water Codes

11910. There shall be incorporated in the planning and construction of each project those features (including, but not limited to, additional storage capacity) that the department, after giving full consideration to any recommendations which may be made by the Department of Fish and Game, the Department of Parks and Recreation, the Department of Boating and Waterways, any federal agency, and any local governmental agency with jurisdiction over the area involved, determines necessary or desirable for the preservation of fish and wildlife, and necessary or desirable to permit, on a year-round basis, full utilization of the project for the enhancement of fish and wildlife and for recreational purposes to the extent that those features are consistent with other uses of the project, if any.

11912. The department, in fixing and establishing prices, rates, and charges for water and power, shall include as a reimbursable cost of any state water project an amount sufficient to repay all costs incurred by the

department, directly or by contract with other agencies, for the preservation of fish and wildlife and determined to be allocable to the costs of the project works constructed for the development of that water and power, or either.

11913. (a) The Legislature hereby declares its intent that, except as funds are provided pursuant to Section 11915, there shall be included in the budget for the department for each fiscal year, and in the Budget Act for each fiscal year, an appropriation from the General Fund of the funds necessary for enhancement of fish and wildlife and for recreation in connection with state water projects as provided in this chapter.

11900. The Legislature finds and declares it to be necessary for the general public health and welfare that preservation of fish and wildlife be provided for in connection with the construction of state water projects.

The Legislature further finds and declares it to be necessary for the general public health and welfare that facilities for the storage, conservation or regulation of water be constructed in a manner consistent with the full utilization of their potential for the enhancement of fish and wildlife and to meet recreational needs; and further finds and declares that the providing for the enhancement of fish and wildlife and for recreation in connection with water storage, conservation, or regulation facilities benefits all of the people of California and that the project construction costs attributable to such enhancement of fish and wildlife and recreation features should be borne by them.

1725. A permittee or licensee may temporarily change the point of diversion, place of use, or purpose of use due to a transfer or exchange of water or water rights if the transfer would only involve the amount of water that would have been consumptively used or stored by the permittee or licensee in the absence of the proposed temporary change, would not injure any legal user of the water, and would not unreasonably affect fish, wildlife, or other instream beneficial uses. For purposes of this article, "consumptively used" means the amount of water which has been consumed through use by evapotranspiration, has percolated underground, or has been otherwise removed from use in the downstream water supply as a result of direct diversion.

8608. The board shall establish and enforce standards for the maintenance and operation of levees, channels, and other flood control works of an authorized project or an adopted plan, including but not limited to standards for encroachment, construction, vegetation and erosion control measures. In adopting such standards, the board shall give full consideration to fish and wildlife, recreation and environmental factors. Any violation of such adopted standards without the permission of the

board is a public nuisance, and the board may commence and maintain suit in the name of the people of the state for the prevention or abatement of the nuisance.

Fish and Game Code

1600. The Legislature finds and declares that the protection and conservation of the fish and wildlife resources of this state are of utmost public interest. Fish and wildlife are the property of the people and provide a major contribution to the economy of the state, as well as providing a significant part of the people's food supply; therefore their conservation is a proper responsibility of the state.

APPENDIX C

MMWD Board Policy No. 3
Wells and Other Private Water Sources
Revised 1992

MARIN MUNICIPAL WATER DISTRICT

BOARD POLICY

No.: 3

Date: 2/22/78

Revised: 3/22/78, 9/13/89 and 9/23/92

Reviewed 2/23/94

Subject: WELLS AND OTHER PRIVATE WATER SOURCES

The District is charged with supplying water within its boundaries. The District has determined it is in the best interest of its consumers, both existing and future, to allow the use of wells or other private water sources only for non-potable use, and only to supplement District service. As a water conservation measure, the District wishes to encourage the use of wells for irrigation purposes; and, has developed this policy in response to planning needs of the Cities and County.

The District requests that the Cities and County require new multi-unit development to have water service from the District as the potable water source and require review by the District of any such development wishing to supplement such service. The District's review as a condition for development shall include, but not be limited to:

1. Impact of total water requirements on District's facilities in the event of well failure.
2. Need for well system to provide fire protection.
3. Need to install backflow prevention devices to protect District's system.

It is not the intent of this policy to limit or prevent the use of a private well or other private water source for irrigation of landscaping or for non-potable uses, but said private water supply shall not serve as the potable water source for two or more units. Water supply shall be located on the same property for which the water supply serves.

In the event of failure of the private water source, an application for change in the character of service shall be submitted to District and will be processed in accordance with the District's rules and regulations in effect at the time of such application. District does not assume any commitment to provide additional potable water services in the event of the failure of any private system.

The use of a private water source for a single-residential unit does not require a meter from the District but a proposal for such use should be reviewed by District prior to building permit approval.

A supplemental water system which is installed for a single-residential unit already connected to the District shall require District review and approval, and shall require installation of appropriate backflow protection.

We suggest the following section as a guide for the department or departments responsible for the issuance of well permits for single-residential units.

A. Adequate Water, Vertical Wells

Adequate Water (Vertical Wells) is defined as a well or wells which will produce a minimum of one gallon per minute for a sustained pumping test of 8 hours after the pumping level has been established or the well is pumped to the bottom. This minimum shall be accompanied at the time of residential construction, with a minimum of 1,000 gallons of storage capacity.

B. Adequate Testing Requirements

In addition to the 8-hour yield test described above, testing to meet the above yield requirements must be conducted from June 1 to November 15 and must be done by a licensed drilling or pump contractor or a registered geologist. In the case of prolonged dry weather, the time period may be extended or certification be required by a registered geologist as to the well's productivity.

C. Adequate Storage Requirements

Minimum storage facility shall be a 1,000 gallon tank. This allows 2 to 3 days of storage for consumption during periods where well is out of service for maintenance reasons or for pump repair.

D. Potable Water

Water intended for domestic use must meet all standards and conditions as the health officer deems necessary for the protection of the public health, safety, and welfare.

E. Hold Harmless Agreement

A Hold Harmless Agreement between the issuing authority and the applicant (property owner) relieving the issuing authority of any liability must be entered into prior to the issuance of a permit. This should be recorded with the Marin County Recorder.

F. Abandoned Wells, Test Wells, or Holes and Destruction of Wells

No person should abandon, construct, destruct, remodel, or reconstruct any well, test well, or hole without first submitting an application to and receiving a permit from the local jurisdiction for such construction or abandonment. Such permit should be subject to conditions necessary to comply with State laws and the rules and regulations issued thereunder that will promote the protection of public health.

G. Review by Water District

Any applicant for a well permit should submit the proposed well application to the Marin Municipal Water District for review. Well applications should include:

- Plot plan of property showing buildings, roads, sewer lines, septic systems, storage facilities, etc.
- Description of intended use (potable, irrigation, fire protection, etc.).
- Any other information pertinent to the well development.

A letter from the Water District attesting to the review should be required prior to issuance of a well permit. The letter from the District will advise the applicant that the District cannot assume in advance any commitment to provide additional potable water service to the property in the event of the failure of the well unless the applicant applies and pays for the amount of water which the District calculates is needed to serve the property without benefit of the well. The District will not reduce its calculation of the amount of District water needed by such an application because of the proposed utilization of a well due to the impossibility of determining with any certainty how long the well is likely to be productive and at what level of yield.

APPENDIX D

Aquatic Resource Survey and Monitoring Methodologies
Lagunitas Creek Stewardship Plan
Marin Municipal Water District

Final – June 2011

Appendix D
Aquatic Resource Survey and Monitoring Methodologies
Lagunitas Creek Stewardship Plan
Marin Municipal Water District

Final – June 2011

Juvenile Salmonid Surveys

The goal of this monitoring effort is to produce long-term trends in juvenile salmonid populations for the Lagunitas Creek study area. Population estimates will be produced by estimating the numbers of fish, using a combination of electrofishing and snorkeling, at established sample sites in Lagunitas Creek and two of its tributaries, San Geronimo Creek and Devil's Gulch. Fish abundance estimates will be then extrapolated to estimate the total populations of fish in the study area.

The Lagunitas Creek study area includes 13.3 km of Lagunitas Creek, 7.5 km of San Geronimo Creek, and 3.4 km of Devil's Gulch. In Lagunitas Creek, the habitats downstream of the confluence with Nicasio Creek (5.9 km) will not be included in our analyses because the juvenile sample sites are not intended to represent this section of creek. For San Geronimo Creek and Devil's Gulch, salmonid populations will be estimated for the main stem reaches for which habitat data are available. Habitat typing of Lagunitas Creek, San Geronimo Creek, and Devil's Gulch will also be completed (see below). The habitat typing surveys classify habitats as pool, glide, run, riffle, cascade, and dry (any dry habitats have only occurred in a few sections of San Geronimo Creek or Devil's Gulch, not in mainstem Lagunitas Creek). Cascades and dry habitats have represented approximately 1.0% of the study area and have typically been excluded from our population extrapolations because these habitat types have not been included within our sample sites and/or do not provide salmonid habitat. Side channel habitats have also been excluded because the sample sites did not adequately represent these habitats.

Seven sites in Lagunitas Creek, four in San Geronimo Creek, and two in Devil's Gulch will be sampled between August and October each year (see Figure 23). Sample sites typically consist of one or more riffle, run, glide, or pool habitat units. The sample sites in Lagunitas Creek are (in a downstream to upstream listing): LG-2, LG-3u, LG-5, LG-7, LG-9, LG-15.86, and LG-12. The sites in San Geronimo Creek are: SG-1, SG-2, SG-3, and SG-4. Sites in Devil's Gulch are DG-1 and DG-2. These sites have been sampled annually for juvenile salmonids since 1993, with the exception of LG-15.86 (added in 1994), SG-1 (added in 1998), and LG-2 (added in 2002). SG-1 and LG-15.86 were added to better represent salmonid distribution throughout San Geronimo Creek and Lagunitas Creek, respectively. In 2002, LG-2 was added to replace LG-1, which was abandoned due to problems gaining access onto the property containing this site. In 2004, bank stabilization work at site LG-3 necessitated relocating the site immediately upstream. The new site was designated LG-3u and has been sampled each year since 2004.

Most sample sites in Lagunitas Creek that are electrofished will also be snorkeled to compare these sampling methods. Devil's Gulch is typically too shallow to snorkel and San Geronimo Creek will not be snorkeled due to water quality concerns related to septic inputs. For the habitats in mainstem Lagunitas Creek that are snorkeled, block nets will not erected to isolate habitat units during snorkeling, as is done during electrofishing. Two or three divers swim from the downstream end to the upstream end of each habitat unit, counting juvenile coho and steelhead. Tallies will be written on plastic tablets during the survey. Two or three passes will be made through each habitat and the highest count will be used as the population estimate. Steelhead age classes will be differentiated visually at LG-2, LG-5 and the glide habitat. We expect to snorkel but not electrofish site LG-2 due to the depth of the site (up to 1.4 m) and because electrofishing has not previously been conducted at this site. We also may not electrofish the upper pool of site LG-5 because in recent years the pool has become too long, wide and deep to electrofish effectively.

Sample sites LG-3u and LG-5 will first be surveyed by a qualified biologist for the presence of California freshwater shrimp (*Syncaris pacifica*) prior to electrofishing. All shrimp captured will be removed from the sample area and placed in appropriate habitat immediately upstream or downstream of the sample site.

Electrofishing will be conducted in compliance with guidelines set by NOAA Fisheries (NMFS 2000). Prior to electrofishing a sample site, block nets will be erected at the downstream and upstream end of each habitat unit to prevent fish migration during sampling. Smith-Root Type 12 back pack electrofishers will be used to make a minimum of three passes through each habitat. Electrofishers will typically be set to voltages of 200-300 volts, frequencies of 50-70 Hz and pulse durations of four milliseconds. The electrofisher voltage and output wave will initially be set based on water conductivity (expressed as microSiemens/cm, μS), measured prior to electrofishing, and water depth. One or two electrofishers will be used at each of the sample habitats (depending on the width of the site) with at least one person following each electrofisher using dip-nets to capture stunned fish. As fish are stunned and netted they will be placed into buckets containing fresh stream water, carried by a survey team member.

Habitat units will be sampled from the downstream net to the upstream net and then back down stream again to complete one pass. After each pass, captured fish will be anesthetized using alka-seltzer or clove oil to reduce stress in handling. The captured fish will be identified to species, except for sculpin (*Cottus spp*.), which will be identified only to genus. The fork lengths (FL) of coho salmon and steelhead trout will be measured in millimeters (mm). Other species such as Tomales roach (*Lavinia symmetricus symmetricus*), Pacific lamprey (*Entosphenus tridentata*), Sacramento sucker (*Catostomus occidentalis*), sculpin, threespine stickleback (*Gasterosteus aculeatus*), Pacific giant salamander (*Dicamptodon ensatus*) and California freshwater shrimp (*Syncaris pacifica*) will be recorded for a total catch. Juvenile lampreys will be classified as smolts (if they have eyes, well-developed sucking mouths and silver coloring) or ammocoetes (if they lack smolt features).

Weights will be collected from a broad length range of coho and steelhead. At least five juvenile salmonids of each species will be weighed for each ten-millimeter length group (e.g. 50-59mm, 60-69 mm, etc.) for each creek, except when fewer than five fish are caught in a

length group. Fish will be placed on a hollow sponge to remove excess water before being weighed on a digital scale.

During the electrofishing surveys, steelhead will be grouped into age classes of 0+ (young-of-the-year; <1 year old) or 1+ (one to three years old) based upon length and appearance of the fish at time of capture. In the field, steelhead captured in Lagunitas Creek that have been longer than 110-115 mm FL, depending on site, have generally been considered to be 1+ steelhead and those smaller have been considered to be 0+ steelhead. Steelhead captured in San Geronimo Creek and Devil's Gulch that have been 90 mm FL or larger have been considered to be in the 1+ age class. Scale samples will be taken from several representative steelhead ranging from 85 to 120 mm FL in order to determine a more accurate size break between 0+ and 1+ steelhead. Scales will be obtained by scraping the side of the fish above the lateral line and behind the dorsal fin. We will be able to definitively determine the ages of most of the steelhead by viewing the scales under a microscope and counting their annuli (yearly rings). When annuli were indistinct and age class can not be determined, we use size breaks (natural gaps in the size range) to determine age class. At any sites that are just snorkeled but not electrofished (i.e., LG-2 and upper LG-5), steelhead age classes will be determined by visual inspection only during the snorkel passes.

After handling, fish will first be transferred into a black recovery bucket and then transferred to live cars (holding pens consisting of a basket lined with netting) placed in the stream, outside of the block netted sample unit. Large sculpin will be held in separate recovery buckets and live cars to avoid predation of salmonids. Once sampling of the habitat unit is completed, captured fish will be released back into the unit from which they were captured.

Incidental juvenile salmonid and smolt mortalities will be provided to U.C. Berkeley (Dr. Stephanie Carlson), who is studying salmonid otoliths to investigate life history variations and salmonid survival. Fin clips from these incidental mortalities will be sent to the NOAA research lab (Dr. Carlos Garza) in Santa Cruz, CA.

In addition to fish data, we will collect habitat data at each sample site, including depth, substrate composition, shelter ratings, and bank vegetation. Water temperature will be measured at each sample site using hand held digital thermometers. Water temperatures will also be being recorded, independently, at the USGS stream gage at Samuel P. Taylor State Park (upstream of the mouth of Devil's Gulch and sample site LG-7).

Coho and steelhead capture data will be entered into a population estimation program designed for use with depletion data (e.g., Microfish by Van Deventer & Platts 1989). Output from this program will be used to calculate population estimates of coho, 0+ steelhead, and 1+ steelhead for the habitat unit. Population estimates of coho, 0+ steelhead, and 1+ steelhead will be made for individual habitat units and for each sample site. The population estimates for each sample site will then be extrapolated for entire stream segments, using the habitat typing survey data (see below).

Prior to 1995, juvenile salmonid population estimates relied on the assumption that sample sites were representative of streams or stream reaches. The estimating method used since 1995 has been based on fish densities within habitat types so more accurate estimates of coho and steelhead populations can be made. Habitat typing completed throughout the

Lagunitas Creek study area will allow for a comparison of the habitat composition of the sample sites to the habitat composition of the streams or stream reaches. Total fish population sizes will be estimated by extrapolating fish densities in individual habitats to entire streams based on the proportions of habitat types within those streams. Salmonid densities in each habitat type will be multiplied by the linear length of the same habitat type in the applicable stream. The extrapolated population estimates can be compared to the annual juvenile salmonid surveys conducted since 1995, when we began estimating salmonid populations using habitat proportions.

Fish abundance can also expressed as the density of coho or steelhead per 30 meters of stream. Fish densities for individual streams can be compared to surveys conducted as early as 1970. Fish densities can be compiled from data presented in previous MMWD juvenile salmonid surveys. Fish densities in individual streams can also multiplied by the lengths of those creeks, and those estimates summed to produce population estimates comparable with pre-1995 survey data. Set creek lengths will be used so that estimates are comparable across all years.

Salmon Spawner Surveys

Annual salmon spawner surveys will be conducted to assess spawner abundance. The surveys will be conducted through the mainstem Lagunitas Creek, the mainstem San Geronimo Creek, and Devil's Gulch (see Figures 1 and 23). Surveys will be conducted on a weekly basis during the spawning season of late October into through February and may be extended into March in some years.

Spawner surveys will be conducted through up to nine stream sections.

The mainstem of Lagunitas Creek will be divided into five sections:

1) Nicasio Creek confluence to Tocaloma Bridge;
2) Tocaloma Bridge to Devil's Gulch (approximately 2.5 miles);
3) Devil's Gulch to Shafter Bridge (approximately 3.0 miles);
4) Shafter Bridge to Peters Dam (approximately 0.5 miles); and
5) Downstream of Nicasio Creek to Point Reyes Station.

The section downstream of Nicasio Creek may only be surveyed occasionally.

San Geronimo Creek will be surveyed in two sections:

6) Lagunitas Creek confluence to Meadow Way Bridge (2.4 miles); and
7) Meadow Way Bridge to Woodacre Creek (2.1 miles).

Devil's Gulch will be surveyed:

8) Lagunitas Creek confluence to a bedrock cascade (2 miles); and
9) An unnamed tributary ("The Fork) near the upstream end (1/4 mile).

In Devil's Gulch, the cascade at the upstream end of the survey is impassable to coho.

The Lagunitas Creek spawner surveys will be focused between Tocaloma and Peters Dam with less frequent surveys between Nicasio Creek and Tocaloma. In most sections, the surveys will be conducted moving from downstream to upstream. The Nicasio to Tocaloma section will actually be conducted moving downstream (from the Tocaloma Bridge down to the confluence with Nicasio Creek) as will any surveys conducted downstream of Nicasio Creek

The spawner surveys will be coordinated with Salmon Protection and Watershed Network (SPAWN) and the National Park Service (NPS). SPAWN may continue to survey five tributaries to San Geronimo Creek. These tributary streams have included: Arroyo Creek, Evans Canyon, Larsen Creek, Montezuma Creek, and Woodacre Creek. In addition, SPAWN may continue to survey the headwater section of San Geronimo Creek, upstream of Woodacre Creek. The NPS may continue to survey Cheda Creek, a tributary of Lagunitas Creek, as well as Olema Creek and its tributary, the John West Fork.

During all surveys we will record observations of redds, live adult salmonids, salmonid carcasses, and diggings (i.e. test pits that are not complete redds). Live fish will be identified to species, whenever possible, and recorded as male, female, jack, or unknown. Their behavior, condition (color, wear marks, hooked jaw, etc.), and their location in relation to landmarks such as tributaries, bridges, or habitat enhancement structures will be noted. Any observed spawning activity will also be recorded (females digging, males quivering, release

of milt, etc.). We will record the sex and length of recovered carcasses and collect tissue samples off of them for subsequent genetic analyses by NOAA's Santa Cruz lab (Dr. Garza). We may also collect the otoliths from carcasses for analysis by U.C. Berkeley (Dr. Carlson), for the studying of salmonid life history variations and survival. We will attempt to determine if female salmonids had spawned by inspecting for retained eggs. Other information recorded during each survey will include the survey start and stop times, air and water temperatures, weather conditions, and qualitative observations of stream flow, water clarity, and water visibility.

Redds will be classified as having been constructed by coho, steelhead, Chinook, chum, lamprey or "unknown." Redds will be considered to have been conclusively built by one of these species when an identified fish was observed on the redd, or when only one species was present in the creek (e.g., steelhead after January 21st). When fish were not present, redds will be classified based on their area, shape, depth, substrate, location and/or time of year. When coho are present in the creek, large redds with wide pits will generally be classified as coho redds. Smaller redds with deep pits and sharp margins will generally classified as steelhead redds after the first live steelhead are observed. Unoccupied redds observed at a time when multiple salmonid species are in the creek and not displaying obvious distinguishing characteristics will have to be classified as "unknown." Redd classification will be corroborated at the end of the season by comparing "conclusively identified" redds (those with fish present or built on a date when no other species were in the creek) with "confidently identified" redds (based on redd size, shape, substrate and date). Redd sizes will be compared for redds in Lagunitas and San Geronimo Creeks when size data is available. Devil's Gulch data may have to be excluded from this analysis because coho redds in that narrow stream are often much smaller (and more similar to steelhead redds) than in Lagunitas and San Geronimo Creeks.

We will assign a unique number to each redd and mark its location in the field by hanging colored tape on adjacent vegetation. Redds will be marked this way so no redd will be double-counted during subsequent surveys and so any additional redds near that site can be distinguished. We will label each flag with the date, the redd number, redd dimensions and the position of the redd with respect to the channel (i.e. mid-channel, left- or right-bank, etc). The flag will be hung in line with the upstream end of the redd pit, so further enlargement of the redd will be conspicuous during subsequent surveys. If it is determined that a female made a small "test" pit and not a redd, the site will be recorded as a "digging" and flagged with a different color flagging. We will also mark redd and digging locations on a map of the creek, using a new map for each survey date, and we will take a GPS coordinate reading at each redd. We will measure the maximum length, width, and depth of all redds and the depth of the undisturbed substrate adjacent to the redds, unless fish are present. To avoid disturbing fish we will add a second colored flagging, next to occupied redds, as a reminder to measure the redd at a later date. We will attempt to identify when redds appear to have been built on or overlapping older redds to evaluate superimposition of an existing redd by other spawning salmonids.

We are not likely to have a way of positively determining if we recount the same fish during subsequent surveys or miss fish during the intervals between surveys. By surveying upstream stream sections before or concurrent with downstream sections, we will be able to reduce the possibility of recounting the same fish as they move upstream, particularly when

stream flows facilitated upstream migration. For example, we will survey San Geronimo Creek first, Lagunitas Creek from Devil's Gulch to Peters Dam next, and then Tocaloma Bridge to Devil's Gulch. Most surveys on each section will be conducted between five and nine days apart. In addition, an attempt will be made to quantify double-counted fish after the survey season has ended. Observations of fish on redds over multiple surveys will be subtracted from the total, as will schools of fish observed holding in the same pool over multiple surveys. Even with these efforts, some fish may end up being counted multiple times.

Salmon Smolt Surveys

An annual salmon smolt survey will be conducted between March and June, to evaluate salmonid outmigration from Lagunitas Creek. The study will utilize a rotary screw trap at the Gallagher Ranch, on the mainstem of Lagunitas Creek (see Figure 24). A second trap may be employed at an upstream location, in the vicinity of Tocaloma, to quantify the proportion of smolts originating between the upstream and downstream trap locations.

A rotary screw trap (RST) with a 5-foot diameter drum will be installed in lower Lagunitas Creek, at the Gallagher Ranch, approximately 2.1 miles above the Highway 1 Bridge crossing in Point Reyes Station. The trap is situated in a pool directly downstream of a small bedrock cascade and is the same location that has been used since 2006. The bedrock cascade concentrates enough flow to operate the RST in the relatively low gradient of the creek. The trap will be installed in early to mid-March 2009 and removed in early to mid-June, depending on stream flow conditions and the extent of outmigration activity. This will ensure sampling during the roughly three-month migration period and include the period of peak emigration for coho salmon that typically occurs from late April to early May, in Lagunitas Creek.

During the sampling period, the trap will be checked every day. Trap function will be visually inspected each day to ensure proper operation. The number of revolutions per minute of the trap drum will be recorded daily. Typically, stream flows will generally decrease throughout the monitoring period. Towards the end of the sampling period, decreased streamflows may necessitate the installation of plywood baffles or other structures to direct flow into the drum to assist in proper trap function. During any very high flow periods, during storm events, the drum may need to be raised and trapping ceased until flows subside again.

Each day, captured fish will be removed from the trap and identified to species. Salmonids will be checked for marks such as fin clips, visually inspected for signs of smoltification, allowed to recover, and released downstream of the point of capture. Lengths and weights of salmonid smolts and parr will be recorded. Downstream migrating fry will be tallied into five-millimeter (mm) length bins and not weighed. Scales will be collected from a subsample of coho and steelhead smolts in order to determine the age-class of downstream migrants. Scales will also be provided to U.C. Berkeley (Dr. Carlson) for the investigation into salmonid growth and survival in the watershed. During the smolt survey season, adult steelhead may be in Lagunitas Creek and some may inadvertently swim into the rotary screw trap(s), where they will remain until released. If any adult steelhead are found in the trap(s), they will be removed from the live box with nets and immediately released back into the creek.

Efficiency of the trap(s) will be determined from the recapture of a known amount of previously marked fish. Each day, up to ten smolts per species will be given a fin clip unique to that week and trap location, and then transported approximately 500 m upstream and released back into the creek. Some percentage of the marked fish will be expected to be recaptured. Marking of fish will be coordinated with a simultaneous trapping effort conducted by SPAWN on San Geronimo Creek, upstream of the MMWD trap location(s). Each monitoring effort will be assigned a distinct fin clip to avoid duplicate marks from the trapping locations. All marks on recaptured fish will be recorded, but only those marked at the MMWD trap will be used to estimate trap efficiency.

California Freshwater Shrimp Surveys

MMWD will conduct an annual California freshwater shrimp survey. The survey will be conducted at six sample sites in the mainstem of Lagunitas Creek with sampling being conducted in the late summer to early fall period.

Study Area

The surveys will primarily focus on the same six sections of the stream surveyed during the 1991, 1994, and 1996 through 2009 studies (Serpa 2010). The sample areas are referred to as: Shafter Bridge; Upper State Park; Bike Bridge; Below Bike; Tocaloma; Above Zanardi (see Figure 25). These areas were originally selected because of differences recorded in shrimp densities during Li's 1981 study, in order to better determine the vigor of the shrimp population in Lagunitas Creek. Shafter Bridge and Upper State Park were selected because they were low density shrimp areas, Bike Bridge and Below Bike because they were high density areas still within the upper portion of the stream, and Tocaloma and Above Zanardi because they were higher density areas in the lower part of the stream. Four or five additional pools will be sampled, in order to obtain additional information on the lower portions of the stream These pools are referred to as: the Devil's Gulch pool, in Samuel P. Taylor State Park where the Devil's Gulch tributary joins Lagunitas Creek; the Transmission pool, immediately upstream of the MMWD's Tocaloma pump station, downstream of the Tocaloma Bridge; Nicasio pool, just upstream from where the Nicasio Creek tributary enters Lagunitas Creek; a fourth pool immediately upstream of Gallager's Bridge (if access can be arranged); and the Below Gallager pool, about 0.2 mile further downstream.

Habitat and Stream Reach Classification

The different types of habitat around the perimeter of the pools will be separately rated as "poor", "fair", "good" or "excellent", and measured to the nearest foot. Most "fair", and all "good", and "excellent" sections will be sampled for shrimp. No "poor" areas will be sampled for shrimp; shrimp are almost never found in such areas in any stream, and have never been found in them in Lagunitas Creek. Due to the complex and subtle nature of the habitat, fine root structure and undercuts can not always be ascertained until after the habitat has been disturbed during sampling. This means that the ranking may not occur immediately before sampling, because some of the frightened shrimp will take refuge in more inaccessible areas, lowering the sampling counts. However, if the ranking is done immediately after sampling, it could be biased by knowledge of shrimp abundance in the various microhabitats of the pool. In order to avoid this possibility, the ranking will not be done on the same day the shrimp are sampled. The linear length of undercut banks in the pools will also be recorded, wherever the undercut extends at least one foot under the bank and is mostly underwater at the time of sampling. Although the shrimp would have access to undercut areas above the sampling water level during higher winter flows, these areas would not be as good habitat, since they would lack the root development that occurs in undercuts that are beneath the water throughout the year.

Habitat quality will be rated by a combination of features known to be important to the shrimp, including water depth, presence or absence of undercut banks, current speed, and the quality and quantity of tree roots and herbaceous vegetation hanging into the water. Although this is

somewhat subjective, it is actually a relatively consistent method of habitat evaluation. The following criteria will be used to make a determination for each of the four categories.

Poor Habitat:
1. Water usually less than six inches deep, but could be much deeper if there is a sheer bank of earth or rock.
2. Very little or no roots, twigs, branches, or vegetation hanging into the water.

Fair Habitat:
1. Water usually more than six inches deep, but could be shallower if the habitat was otherwise very well developed.
2. At least one of the following features also present - some herbaceous vegetation, hair-like fine roots, coarse roots (>.5cm diameter), twigs or branches in the water, or an undercut bank extending inward away from the stream for more than six inches.

Good Habitat:
1. Water one to four feet deep.
2. Usually at least two of the following features also need to be present - hair-like fine roots, coarse roots (>.5cm diameter), blackberries or dogwood or shrubs or ferns with roots in water, grass on the water, undercut banks (>six inches away from stream) or abundant herbaceous vegetation. A well developed section of fine roots, or blackberries with adventitious roots, would qualify for good habitat by itself, even without the complementary presence of one of the other features noted.

Excellent Habitat:
1. Water one to three feet deep.
2. Usually at least two of the following features are also required to be present, better developed than above - hair-like fine roots, coarse roots (>.5cm diameter), blackberries or dogwood or shrubs or ferns with roots in water, grass on the water, undercut banks that extend >six inches away from the stream. Only one of the above would be needed if it was exceptionally well developed.

If the current is excessive, or there is too much silt or algae, the habitat quality will be reduced by a rank. In these situations, an otherwise "excellent" habitat will instead be rated as "good" habitat.

In addition to the habitat classification, some of the other characteristics of the stream reaches will also be quantified. The length of each pool, its maximum width, and the length of the adjacent riffles will be directly measured with a 200 foot long measuring tape.

Field Collection Methods

Sampling Techniques:
During the sampling process, a submerged fifteen inch diameter insect net will be used to vigorously disturb the underwater vegetation along the edges of the pools. The long bag of the aerial net reduces the amount of force to which shrimp within it are subjected during the sampling process. It also insures that shrimp are not able to leave once captured, a potential problem with dip nets. Immediately after disturbing the vegetation, the net will be moved back

through the sampled area to collect any shrimp that might have moved out a few centimeters into the open water when they were dislodged by the passage of the net. This covers a much greater volume of habitat than the simple push-pull process, since the net can be moved repeatedly through the entire habitat and adjacent water column. If shrimp are abundant within a section of stream habitat, the area will be re-sampled one or more times, until the number of shrimp captured during a sweeping event drops off substantially. This will usually mean less than five shrimp captured in the final pass through the section of habitat. However, sampling will always be discontinued before there is any significant habitat damage.

Following each of the sampling events described above, the contents of the net bag will be emptied into a plastic pan located at a convenient level location along the side of the pool. The pan will be partially filled with water, and rested on a white sheet (approximately 3 feet by 2 feet), so any shrimp that flip out of the pan will be immediately noticed and can be returned to a safe environment. Any obscuring detritus will then be carefully removed and placed on top of the insect net bag. The remaining contents of the pan will be inspected for any shrimp, which often give away their presence by movement. The debris on the net will be examined several times before it and the remaining contents of the pan are put back into the pool.

Shrimp Data Recorded

Any shrimp found will be counted, and determined to be male, female or juvenile. It will also be noted if eggs could be seen through the body walls of the females. Shrimp will be moved with a small aquarium net from the pan to a covered plastic container or an aerated black bucket partially filled with stream. The shrimp will be temporarily retained in captivity until the next section of the pool has been sampled. After enough of the pool had been sampled to prevent the possible recapture of the same animals, the shrimp will be released as close as possible to the sites where they had been netted.

Habitat Typing Surveys

MMWD will conduct a habitat typing surveys every 5 years, or more frequently following channel-forming storm events. The habitat typing surveys will be conducted through Lagunitas Creek (Highway 1 Bridge to Peters Dam), San Geronimo Creek (mouth to Woodacre Creek), and Devil's Gulch (See Figures 1 and 23). The surveys will follow California Department of Fish and Game (DFG) habitat typing survey protocols.

Habitat typing protocols and methodology will follow guidelines from the DFG's *California Salmonid Stream Habitat Restoration Manual* (Flossi et al. 2002). A "Level II" survey, which classifies habitats as either "pool," "riffle" or "flatwater," will be performed. Past surveys have modified the Level II classifications: "flatwater" habitats were distinguished as either "run" or "glide"; and "riffle" habitats were identified as either "riffle" or "cascade." Habitat unit classifications used in these surveys were, therefore, identified as either "pool," "run," "riffle," "glide" or "cascade." Units encountered that did not definitively fall into one of these classifications were classified as "other" and measurements were taken where possible.

The habitat survey will be conducted during the summer and early fall period, prior to any significant rainfall or scheduled increase in stream flows. Flows in the mainstem of Lagunitas Creek are regulated and are typically between eight and ten cubic feet per second (cfs) at this time of year, in each year since the 1995 State Water Board Order. This consistency allows for comparisons between surveys conducted since 1995, without having any variations in flow conditions.

Surveys will be conducted by a two-person team, walking from the confluence of the stream upstream to a designated landmark at the upstream end of that stream (Peters Dam for Lagunitas Creek; the mouth of Woodacre Creek for San Geronimo Creek, and the cascade in Devil's Gulch). Parameters collected for each habitat will be consistent with DFG protocols. Habitats shorter than the stream width (typically short riffles) will be lumped with the upstream unit and not identified as separate habitat units. Measurements will be taken using a measuring tape and measuring rod but some measurements will be made by ocular estimates. Data will be recorded in feet on standard DFG data sheets copied to write-in-the-rain paper. Data collection and rating criteria will follow guidelines set forth by the *California Salmonid Stream Habitat Restoration Manual* (Flossi et al. 2002), using the "ten percent methodology." Habitat dimensions and a count of large woody pieces will be collected for every habitat unit. Substrates, bank vegetation, bank composition and in-stream shelter will be quantified for every pool, as well as for one in ten randomly selected habitats. Habitats will be randomly selected by using the last digit of the most recent GPS coordinate reading. GPS coordinates as well as air and water temperatures (in degrees centigrade) will be recorded at the start of every tenth habitat or new datasheet.

Analysis of Parameters

Habitat typing data collected from each new survey will be compared to data collected in prior surveys (i.e., 1992, 1995, 1997, 1998/1999), 2003, 2006, etc.). For all years, data from side channel habitats has not been analyzed. In some instances data were recorded differently during different surveys and so this will likely require some assumptions when the data are

compared to new survey data. Any assumptions and difficulties arising from different survey methodologies will be discussed in the survey reports.

Habitat composition will be determined by totaling the lengths of each habitat type (pool, riffle, run, etc.) and dividing by the total length of stream. Most other habitat comparisons will be based on habitat surface area, but habitat composition will be calculated by length in order to compare with past surveys when only habitat lengths were collected. Mean pool depths will be calculated by totaling the pool volumes (mean length x mean width x mean depth) and dividing by the total pool surface area. Average maximum pool depths will be determined by averaging the maximum depths of individual pools. Mean creek widths will be calculated by dividing the total surface area of all habitats in a reach by the length of that reach.

In 2003 and 2006, fish cover was recorded in the field as the percentage of the habitat covered, plus an estimate of the contribution of each cover type (woody debris, terrestrial vegetation, etc.). In earlier years, shelter ratings were assigned to each cover type, which corresponded to a general level of contribution (16-25%, for example). To compare years, earlier shelter ratings will be converted to a percentage using the midpoint of the contribution range while ensuring that the total of all cover types equals 100%. An area will then be calculated for each cover type for each habitat, and the total area of all cover types will always equal the area of cover estimated in the field.

During the 2003 and 2006 surveys, substrates were recorded as either dominant or sub-dominant, as opposed to estimating the contribution of each substrate type, as was done in 1997 and 1998/99. Comparing these datasets means only comparing the areas dominated by each substrate. Sub-dominant substrates may not be analyzed due to the uncertainty of their contribution in each habitat. Habitats will be grouped by their most-abundant substrates and their surface areas totaled. These totals can be compared with the total surface area of each reach and with data from previous years. Substrate data will be collected for every pool and for 10% of other habitat types (as part of the 10% methodology), which will likely over represent pool substrates in the dataset. To analyze this data, in previous analyses, the area of pool substrates has been multiplied by 10% before totaling the areas of dominant substrates. Sand was identified separately from silt/clay in 2003, but was lumped in 2006 as well as in earlier surveys. Large cobble was identified separately from small cobble in 2003 and 2006, unlike earlier surveys.

Bank vegetation data will be collected similarly in all years, with the exception that data from the right and left banks will be recorded separately (as was done in 2003 and 2006). The dominant vegetation type will be recorded along with the percentage of the banks vegetated. The proportions of banks covered by each vegetation type will be calculated by multiplying habitat lengths by two (two banks), and then by the percentage of the banks vegetated by each type. When multiple vegetation types are recorded for a single habitat they will likely be assumed to be equally abundant. Total lengths of vegetated bank will be divided by reach lengths to produce the proportion of the reach vegetated by each vegetation type.

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APPENDIX E

Preliminary Sediment Monitoring Plan
O'Connor Environmental
April 2010

Appendix E

DRAFT SEDIMENT AND STREAMBED MONITORING PLAN LAGUNITAS CREEK

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Contents

Introduction

This draft final version of the Sediment and Streambed Monitoring Plan (the Plan) is intended for review by Marin Municipal Water District (the District) and for distribution as appropriate. The draft final Plan describes the goals of the monitoring plan and how they relate to District fisheries and riparian management plans. Prior monitoring methods are reviewed in relation to proposed future monitoring. The draft final Plan also describes monitoring parameters and methods with substantial details pertaining to sampling methods, sample size and analytical methods.

Monitoring Goals

The Plan is intended to provide data and analytical methods that can achieve the following goals.

- Document sediment and streambed conditions in Lagunitas Creek, including its major tributaries San Geronimo Creek and Devils Gulch.
- Provide a means to evaluate the efficacy of sediment management efforts implemented within the Lagunitas Creek watershed.
- Integrate hydrologic and geomorphologic characteristics of Lagunitas Creek with its biological components in an attempt to reveal how stream flow, sediment and streambed conditions influence fish and shrimp populations.

The monitoring goals above are related to District fisheries management goals in Lagunitas Creek:

- Reduce the quantity of fine sediment that enters Lagunitas Creek and enhance the streambed habitat conditions of the creek, for the benefit of coho, steelhead, and California freshwater shrimp.
- Improve and enhance rearing habitat for salmonids and enhance the condition of the riparian corridor to benefit all fishery resources of the Lagunitas Creek watershed.

Monitoring Plan Overview

The Plan includes several discrete monitoring parameters distributed among broadly defined stream reaches in the Lagunitas Creek watershed as summarized below. The Plan is designed to evaluate trends in sediment conditions over time using sampling methods and analytical techniques that can distinguish between statistically-verified trends and random variation. In support of fish habitat monitoring by District biologists, the Plan will also provide quantitative and qualitative data relevant to the quality and quantity of aquatic habitat.

Channel Reach Framework for Monitoring Sites

Monitoring sites will be distributed within distinct reaches of the Lagunitas Creek mainstem and its tributaries. Three mainstem reaches have been identified based on data from prior studies pertaining to sediment size, geomorphology and channel slope:

- Hwy 1 to Tocaloma Bridge (reach M1),
- Tocaloma Bridge to Devils Gulch (reach M2), and
- Devils Gulch to Shafter Bridge (reach M3).

Two tributaries will be monitored:

- Devils Gulch (reach T1) and
- San Geronimo Creek (reach T2).

Monitoring data will be collected and analyzed within each of these five reaches as they represent distinctive portions of Lagunitas Creek that have significantly different characteristics such as channel slope and width (Table 1), as well as differences in stream flow and sediment supply controlled by both natural conditions and the effects of Kent Lake[1]. Time trend analysis of channel conditions will be made more effective by collecting and analyzing monitoring data in this spatial framework because inherent variability between reaches will not be confused with change over time.

Monitoring Using Systematic Sampling

Systematic streambed sampling will be used to determine the streambed surface sediment size distribution and other characteristics of interest. A systematic random grid will be established within the lateral limits of the bankfull channel to conduct this sampling procedure. Transverse transects spaced at intervals of one-half bankfull width will be sampled at ten equally-spaced points across the transect over a portion of channel twenty bankfull widths in length. This sampling grid will yield 400 data points from forty transects; this design

[1] O'Connor Environmental, Inc. 2006. Lagunitas Creek Fine Sediment Investigation. p 14-15.

provides relatively high accuracy while limiting the extent (and cost) of sampling. Data to be collected using the systematic sampling grid include:

- the size distribution of sediment on the surface of the streambed,
- the proportion of the channel bed occupied by fine sediment including characteristic sediment mixtures distributed in "patches" (sediment facies),
- proportions of habitat types (pool, run, glide, riffle and cascade)
- depth and size distribution of fine sediment deposits (this data may be sub-sampled to improve efficiency based on analysis of preliminary data), and
- volume and characteristics of large woody debris (measured on grid transects)

Systematic sampling of sediment deposits in spawning habitat (**McNeil sampling**) will be collected and analyzed to determine the size distribution of spawning gravel. Sample locations will be randomly determined in the sampling grid established for surface sampling described above; relatively few McNeil samples will be collected. The McNeil data used to quantitatively characterize aspects of spawning habitat quality will simultaneously be used to calculate a geomorphic index representing the relationship between sediment transport capacity and sediment supply (q_*).

Table 1. Summary of reach characteristics and sampled area.

Reach	Length[a] (miles)	Mean Slope (ft/ft)	Typical Bankfull Width (ft)	Estimated Total Sample Length[e] with 4 Sites (ft)	Estimated % of Reach Sampled
M1: Tocaloma Bridge to Hwy 1	5.8	0.002[c]	40	3,200	10
M2: Devils Gl. to Tocaloma Br.	2.7	0.003[c]	50	4,000	28
M3: Shafter Bridge to Devils Gl.	3.1	0.004[b]	60	4,800	29
T1: Devils Gulch	1.4	0.02[d]	20	1,600	22
T2: San Geronimo Creek	4.6	0.007[b]	30	2,400	10

Notes:
a. Reach lengths from MMWD (2008) Lagunitas Creek Habitat Typing Survey 2006 Analysis, Table 2.
b. Slope estimated from longitudinal profile surveyed by SFBRWQCB.
c. Slope estimated from preliminary analysis of 2009 LiDAR data.
d. Slope estimated from USGS topographic data.
e. Sample length refers to the systematic sampling reaches.

Streambed Elevation and Topography

Topographic surveys will be conducted periodically at two monitoring sites each in the reaches M1, M2 and M3. The primary product of the survey will be a digital elevation model from which topographic maps and cross-sections can be produced. Elevation data from a systematic sampling grid will also be produced to test for changes in mean bed elevation over time. This type of monitoring will produce quantitative data and analyses, along with process observations and quantitative analysis of trends that will provide continuity with monitoring that began in 1992. Monitoring sites will coincide with prior established monitoring reaches KB (reach M3), KC (reach M3), KD (reach M2) and KF (reach M2). Two new monitoring sites will be established in reach M1. It is intended that these monitoring sites will coincide with monitoring sites used for systematic sampling of sediment described above, including q_* sites. In addition to measures of bed topography, mapping of woody debris accumulations and the distribution of distinctive sediment patches in relation to wood and other morphologic features will be developed. These observations and maps are intended to provide descriptive monitoring data in a three-dimensional map context distinct from the numerical two-dimensional data obtained in systematic sampling.

Turbidity Threshold Sampling

An effective method of quantifying fine sediment delivery from management activities dispersed over a group of sites or an entire watershed is to measure suspended sediment loads (SSL) at key locations. Turbidity Threshold Sampling (TTS) is an accurate and cost effective SSL monitoring system that estimates loads by sampling suspended sediment (SS) in conjunction with continuous turbidity (an optical property of water) and streamflow measurements. [2] Determination of SSL for individual storm events will provide highly accurate estimates of sediment flux at locations of interest over a variety of time intervals for trend analysis.

TTS monitoring sites are proposed at three locations: San Geronimo Creek gauge site (existing station operated by Balance Hydrologics), Samuel P. Taylor State Park gauge site (existing station operated by USGS), and Devils Gulch (gauging station to be established). These monitoring data will provide the District with direct measures of sediment yield that can be used to evaluate the effectiveness of the District's erosion control management efforts as well as trends over time. This data set will be particularly valuable in that it provides direct continuous

[2] Lewis J and Eads R (2009). Implementation guide for turbidity threshold sampling: principles, procedures, and analysis. Gen. Tech. Rep. PSW-GTR-212. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 87 p.

measurements of sediment yield that will complement indirect measures of erosion and sedimentation from streambed monitoring.

Limitations

Proposed methods may require modification for the Tocaloma to Hwy. 1 reach owing to the prevailing depth of water and the prevalence of finer-grained channel substrate. The final monitoring plan for the reach downstream of Tocaloma will be determined following a pilot study to test the applicability of Plan methods in this reach. Feasible alternative methods would be selected as appropriate.

The recommended approach to monitoring depth and size distribution of fine sediment deposits is similar to methodology using the metric v_* to systematically monitor the volume of pools occupied by fine sediment.[3] The proposed adaptation of the method for use in Lagunitas Creek is feasible but has not been tested to evaluate the expected precision of sampling. The proposed approach is expected to provide quantitative estimates of the volume of fine sediment stored on the channel bed that will be useful for evaluating sedimentation impacts on fish habitat as well as trend analysis related to effectiveness of watershed management to control erosion.

Frequency of Monitoring

Frequency of monitoring in the Plan is variable. Annual sampling of all monitoring sites for all parameters is not recommended. Rather, a fixed minimum sampling frequency is proposed that may be modified by high magnitude flow events in Lagunitas Creek. Sampling at the full complement of systematic streambed monitoring sites would occur at a maximum interval of three years. Sampling would also occur during the summer following a peak flow event exceeding 3,000 cfs at Samuel P. Taylor State Park. Sampling would occur again the third summer following, assuming that no additional 3,000 cfs events occur. Based on the period of record 1980-2006, monitoring would have occurred in 13 of 27 years using these criteria. Sampling would have occurred in consecutive years during the intervals 1985 to 1986 (2 consecutive years) and 1995 to 1998 (4 consecutive years).

Annual monitoring would be conducted for a limited set of systematic streambed monitoring parameters (size distribution, proportion of fine sediment and patch type, and habitat type) from a sub-set of sites comprised of one monitoring site

[3] Lisle T and Hilton S (1999). Fine bed material in pools of natural gravel bed channels. Water Resources Research 35(4):1291-1304. and
Hilton, S. and Lisle, T.E. 1993. Measuring the fraction of pool volume filled with fine sediment. Research Note PSW-RN-414, 11 pp. USDA For. Serv., Albany, Calif.

in each of the five reaches of Lagunitas Creek. Fine sediment depth and woody debris would be excluded from annual monitoring. The TTS monitoring is a continuous program operated primarily in the winter months.

Number of Monitoring Sites

Methods for grid sampling of surface sediment size distributions and data sets available from OEI's 2006 study of fine sediment in Lagunitas Creek were used to design the systematic random sampling and McNeil sampling. Details of the monitoring design are described below.

Monitoring site reaches are designed to be twenty bankfull width units in length, so typical monitoring reaches in Lagunitas Creek would likely be on the order of 1,000 ft long (Table 1). Each site would be comprised of forty sampling transects perpendicular to flow and spaced at intervals of one-half bankfull width. Each transect would contain ten evenly spaced sample points; locations would be subject to a random start in each transect. The Plan proposes four monitoring site reaches within each of the five reaches of Lagunitas Creek and its tributaries identified above. Hence, the Plan proposes to establish twenty monitoring site reaches. McNeil sampling to monitor spawning habitat also comprises twenty sampling sites to be co-located with systematic streambed monitoring reaches.

Prior Monitoring Program

The prior monitoring program[4] measured streambed parameters of interest with respect to sediment conditions as they affect fish habitat. The Plan proposes substantial changes in the approach to monitoring relative to prior monitoring; however, these changes do not represent a radical departure from the prior monitoring program with respect to monitoring parameters. Continuity with selected elements of the prior monitoring program will be maintained. Prior monitoring analyses of monitoring data did not utilize formal hypothesis testing procedures. Following is a brief summary of the prior monitoring program including a description of how prior monitoring program elements will be handled under the Plan. *Elements of the prior monitoring program for which further consideration is recommended are emphasized with italics.*

Annual Reconnaissance Survey. This survey was conducted to provide geomorphic perspective on annual channel changes at a broader spatial scale within Lagunitas Creek. It provided insights regarding annual variation of in-

[4] Balance Hydrologics 2008. Lagunitas Creek Sediment and Riparian Management Plan, Marin County, California: Streambed Monitoring Report, 1995-2007.

stream processes and channel condition. The Plan will not continue this reconnaissance survey in its current form.

The Plan is expected to document significant changes at the scale of monitoring reaches (M1, M2, M3, T1 and T2). The proportion of channel to be sampled in four monitoring sites per reach is shown in Table 1. The Plan assumes that significant systemic changes would be detected in this framework. Local variations detected in the spatially comprehensive reconnaissance surveys may will not be individually represented in the Plan.

Systematic photo point monitoring within sampling reaches will be conducted to provide supplemental descriptive information. Successive photos can be compared to qualitatively evaluate change over time. Particular areas of interest that are not within the sampling reaches will be identified (e.g. the Big Bend area where sediment storage and bank erosion dynamics appear to be of greater significance), and comparable photo points established.

Bed Elevation and Channel Configuration. Topographic cross-sections of relatively short reaches containing representative riffles, pools and glides have been used to document changes in bed elevation and channel configuration over time. This prior monitoring established that channel patterns and bed elevations are relatively stable over a period of years with modest variability from year to year. *The Plan proposes to retain this fundamental approach, with substantial revisions to the methods of surveying and the frequency of data collection.*

The Plan proposes to produce three-dimensional maps of selected portions of monitoring reaches using a Total Station survey instrument to develop a digital elevation model (DEM) of the selected portion of the reach. DEM's will then be used to create topographic maps to document conditions and assess changes in the channel between surveys. Both qualitative and quantitative analyses will be performed. Bed elevation changes in relation to habitat units and prior cross-section locations from the prior monitoring program can continue to be observed.

Particle-size Distribution of Bed Surface. The prior monitoring program focused sampling intensity on relatively short monitoring reaches. The Plan utilizes a similar method (surface point counts on a systematic grid), but over a larger area and at wider intervals. Existing monitoring data and proposed monitoring data from the Plan would be generally comparable, but may not be directly comparable.

Embeddedness of Cobbles and Boulders. The Plan eliminates this monitoring parameter. Alternative methods are proposed to measure accumulations of fine sediment on the bed. *Embeddedness is primarily a fish habitat metric. We*

suggest that District fisheries staff consider including this measure of cover habitat be retained in fish habitat monitoring protocols.

Abundance of Cobbles and Boulders. The Plan will continue to provide data on the abundance of cobbles and boulders through the measurement of particle size distributions on the bed surface.

Percent of Bed Covered by Fine Sediment. The Plan will continue to provide data on the abundance of fine sediment through the measurement of particle size distributions on the bed surface.

Particle-size Distribution of Bed Sub-surface. The prior monitoring program obtained samples of subsurface sediment from pool tails. The Plan proposes an alternative method focusing on spawning habitat that will produce data on size distribution of subsurface sediment. McNeil samples of subsurface sediment in pool-tail and riffle crest transitions demonstrated in a prior study[5] provides comparable information regarding sediment conditions in addition to direct measures of habitat quality.

Lithology of Fine Sediment Deposits. Distinctive rock types found in different portions of the Lagunitas Creek watershed enabled utilization of this technique to provide information on the relative magnitude of sediment source areas in the watershed. More direct studies of sediment sources have been conducted and are proposed since the inception of this analysis. The Plan does not propose to continue routine measurement of this parameter.

San Geronimo Creek Stream Gauge. Hydrologic data from San Geronimo Creek are extremely useful. *It is recommended that stream gauging activity at this site should be continued.* Bedload sediment transport measurements are of considerable value. These data provide observations pertaining to bed sediment in San Geronimo Creek, a primary source area for sediment delivered to Lagunitas Creek. The utility of these data with respect to inferences that can be made regarding changes in transport rates over time is limited by the variability of the data. *Bedload transport data should be analyzed to determine the accuracy of the inferences that may be made.* The existing data are extremely useful in that they establish a relationship between stream discharge and bedload transport rate in San Geronimo Creek.

[5] O'Connor Environmental, Inc. 2006. Lagunitas Creek Fine Sediment Investigation.

Monitoring Plan Methods and Analysis Techniques

In this section, details regarding data collection and analytical techniques, along with study design considerations, are described in greater detail.

Systematic Streambed Sampling Study Design

A systematic random grid sampling procedure will be used to collect the following data:

- the size distribution of sediment on the surface of the streambed,
- the proportion of the channel bed occupied by fine sediment including characteristic sediment mixtures distributed in "patches" (sediment facies),
- proportions of habitat types (pool, run, glide, riffle and cascade)
- depth and size distribution of fine sediment deposits (this data may be sub-sampled to improve efficiency based on analysis of preliminary data), and
- volume and characteristics of large woody debris (measured on grid transects)

The design for systematic sampling was guided by sample data from prior studies that used a comparable design.[6] The primary monitoring parameter considered is the size distribution of sediment, and it is upon these parameters that the analysis of sampling design was based. Consideration was given both to sampling objectives and sampling efficiency. The recommended sampling grid for monitoring sites contains transverse transects (oriented perpendicular to flow), spaced at intervals of one-half bankfull width with sample points at ten equally-spaced locations across the transect over a portion of channel twenty bankfull widths in length. This sampling grid will yield 400 data points from forty transects.

Based on sampling data from 2005 streambed surveys of the bankfull channel width, sampling precision over a range of the number of transects was estimated assuming transects spaced at intervals of one bankfull width. Additional analyses were conducted to evaluate transect spacing greater than one bankfull width, however the efficiency of sampling declines (i.e. the cost of sampling increases) as transect spacing increases hence the analysis presented focuses on an interval of one bankfull width.

Sampling precision is evaluated in terms of the mean of the size distribution measured in "psi" units (sediment size classes based on $\log_2$ units, e.g. 1 mm = 0 , 2 mm =1, 4 mm = 2, 8 mm =3 an so on) and in terms of the proportion of the streambed sediment size distribution finer than 4 mm. Figures 1 and 2 on the following page summarize these relationships.

[6] O'Connor Environmental, Inc. 2006. Lagunitas Creek Fine Sediment Investigation.

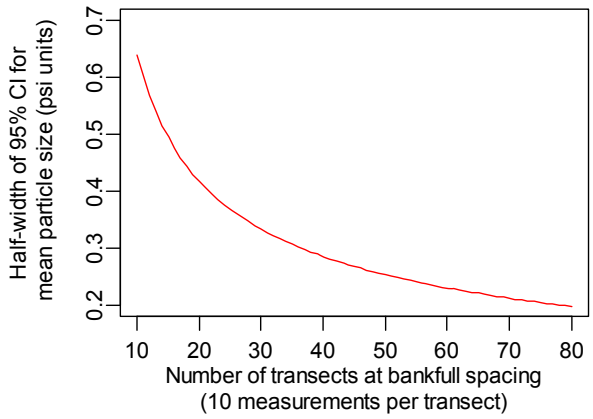


Figure 1. Relationship between number of transects at bankfull width spacing and sampling precision for an estimate of the mean of the sediment size distribution.

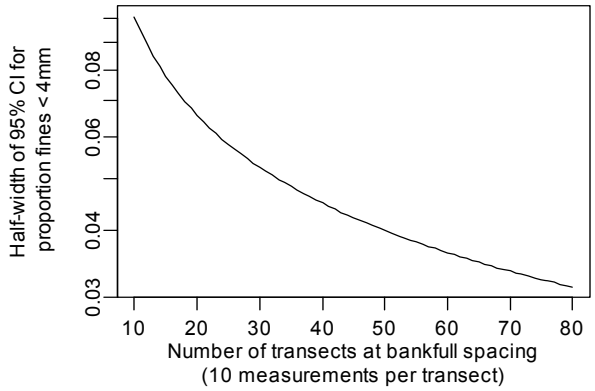


Figure 2. Relationship between number of transects at bankfull width spacing and sampling precision for an estimate of the proportion of the sediment size distribution finer than 4 mm.

The recommended monitoring approach will have a transect spacing of one-half bankfull width, a scenario that could not be evaluated with the available sample data. The closer spacing of transects is expected to provide improved sampling precision within monitoring sites owing to spatial autocorrelation of sediment sizes, hence the precision estimates portrayed in Figure 1 and 2 are conservative estimates.

The recommended monitoring approach specifies sampling of 40 transects at each monitoring site. Figure 1 indicates that the half width of the 95% confidence interval with 40 transects will be about 0.3 phi units. Table 2

provides the confidence interval converted to measurement units of mm over a range of likely values observed in Lagunitas Creek.

Table 2. Representative confidence intervals in measurement units for mean sediment diameter.

Sediment Diameter (phi units)	Sediment Diameter (mm)	Lower Bound 95% Confidence Interval (mm)	Upper Bound 95% Confidence Interval (mm)
2	8	6.5	9.8
3	16	13.0	19.7
4	32	26.0	39.4

With respect to proportion of sediment finer than 4 mm on the streambed, the recommended monitoring approach is expected to produce a 95% confidence interval of +/- 5%. In other words, for a mean estimate of 15% of the streambed occupied by sediment finer than 4 mm it is 95% certain that the true proportion lies between 10 and 20%.

Sampling precision with respect to the sediment size distribution may also be conveniently expressed in relation to percentiles of a cumulative size distribution such as that determined by simple random streambed sampling[7]. Such a relationship is displayed in Figure 3. The expected precision from the proposed sampling approach is expected to be greater because of spatial autocorrelation of sediment size data in systematic random sampling. Figure 3 therefore represents a conservative estimate of sampling precision.

The recommended sample grid within each monitoring site would contain 400 sample points. As shown in Figure 3, for n = 400 the 95% confidence interval around the 5th and 95th percentiles of the distribution would about +/- 2.2%. For the 16th and 84th percentiles, the confidence interval would be about +/- 4.2%, and for the 50th percentile (the median), the 95% confidence interval is +/- 5%. In other words, there would be 95% certain that the true median grain size would be between the 45th and 55th percentile of the sample distribution.

[7] Bunte K. and Abt S. 2001. Sampling surface and subsurface particle-size distributions in wadable gravel- and cobble-bed streams for analyses in sediment transport, hydraulics and streambed monitoring. Gen. Tech. Rep. RMRS-GTR-74. Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 428 p.

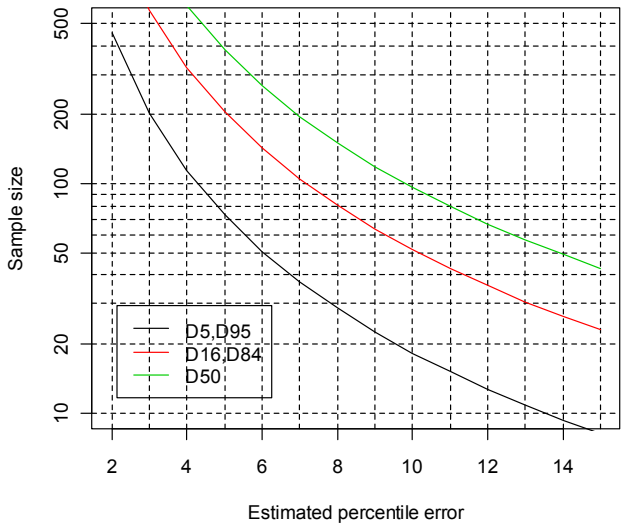


Figure 3. Estimated percentile error for specified percentiles of the cumulative sediment size distribution after Bunte and Abt (2001).

The relationship between sampling precision and the number of monitoring sites sampled in each monitoring reach of Lagunitas Creek (Table 1) was determined based on sample data from prior monitoring studies[8]. This analysis likely overestimates error because it is based on sample variance for sites extending from Shafter Bridge to Nicasio Creek, encompassing monitoring reaches M2, M3 and part of M1. Both surface sediment size distributions (2005 data) and subsurface sediment size distributions (pooled data from 2004 and 2005) were analyzed.

Figure 4 presents the estimated standard error for the mean value of various surface and subsurface sediment size parameters of interest. Figure 5 presents the estimated standard error of the mean value of percentage of cumulative sediment size distributions less than particular diameters of interest for both surface and subsurface sediment. The curves represent sampling precision as a function of the number of monitoring sites per reach. Four sites per reach were judged to provide the appropriate balance between sampling precision and sampling efficiency (cost).

[8] O'Connor Environmental, Inc. 2006. Lagunitas Creek Fine Sediment Investigation.

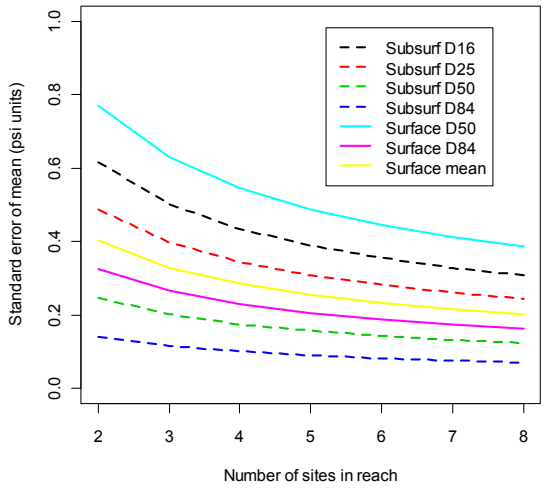


Figure 4. Relationship between number of monitoring sites per monitoring reach and sampling precision for an estimate of the mean of various percentiles and the mean of the sediment size distribution.

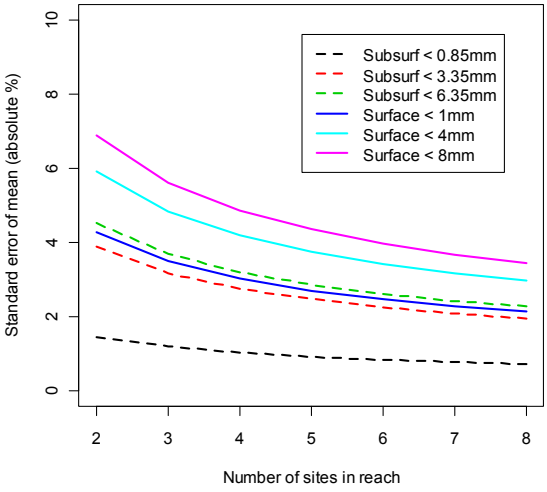


Figure 5. Relationship between number of monitoring sites per monitoring reach and sampling precision for an estimate of the mean percentage of cumulative sediment size distributions less than particular diameters of interest for both surface and subsurface sediment size distributions.

q_* Monitoring

The metric q_* is a theoretical fluvial geomorphologic index of the state of sediment supply in relation to sediment transport capacity[9]. This metric was analyzed in a prior study in Lagunitas Creek and showed considerable potential interpretative value. [10] It can potentially be computed at all sites where McNeil samples are collected, provided local channel slope and cross-section data are also collected. These data on channel geometry are needed to estimate bed shear stress at the sampling location. The channel geometry data can be obtained from topographic survey data collected to monitor bed form and elevation when and where available, otherwise specific local measurements will be necessary. In addition, local surface sediment median diameter should be measured by conducting a small scale systematic sample of the bed surface size in the immediate vicinity of the McNeil sample site. This additional surface sediment size data would be collected in conjunction with McNeil sample collection.

Depth and Size Distribution of Fine Sediment Deposits

Measurement of depth and size distribution of fine sediment deposits at points on the sampling grid has not been performed in prior studies of Lagunitas Creek, hence there are no estimates of sample size or precision for this portion of the monitoring plan. Number of pools or patches sampled to be determined using power analysis for two-sample t-test, (assuming spatial autocorrelation is not an issue between fine sediment patches). The sediment size range of particular interest is sediment < 4 mm diameter based on prior studies indicating that sediment between about 1 and 4 mm diameter is expected to be retained in temporary storage on the streambed.[11] This size fraction is transported in intermittent suspension, and may potentially be relatively responsive to variations in sediment supply and streamflow. These data will be evaluated regarding potential correlation with measures of streamflow and suspended sediment yield.

Field Methods

The sampling grid will be established at a random start point within a systematic framework to locate monitoring sites within monitoring reaches. The locations of the random start points will be established relative to a semi-permanent

[9] Dietrich WE, Kirchner JW, Ikeda H, and Iseya F. 1989. Sediment supply and the development of the coarse surface layer in gravel-bedded rivers. Nature 340:215-217.
[10] O'Connor Environmental, Inc. 2006. Lagunitas Creek Fine Sediment Investigation. pp 24-25, 51-52.
[11] IBID. pp 56-58.

monument established on the floodplain for each monitoring site. The monument will also be located using a GPS receiver. Once established, the random start points and transect locations are to be recorded so that future surveys are repeated allowing two-sample matched-pairs statistical analyses to be employed. During the initial survey, ten bankfull width measurements will be collected at intervals equivalent to twice the bankfull width to establish the nominal bankfull width for transect spacing. (The bankfull width in this context is that associated with flow conditions approximately equal to the 1.5 yr recurrence interval flow as demonstrated in prior studies.[12])

The start point in each transect will be randomly determined. The location of sample points on transects will be determined by dividing the bankfull width (w) at each transect by 10. A random number between 0 and w/10 will be chosen to establish the location of the first point, with successive points spaced at intervals of w/10.

Measurements at individual sample points will include observation of individual sediment grains on transect sample points. Transects will be temporarily located using a flexible fiberglass tape or equivalent. To select a sediment grain for measurement, a sharp-tipped object such as a pencil will be located adjacent to the appropriate point on the flexible tape and then lowered to touch the bed; the sediment grain touched will be picked up for measurement. A sediment measurement template may be used, or a ruler, to determine the width of the intermediate or b-axis of the sediment grain. The measured dimension is equivalent to the sieve mesh that the grain would catch on. Grain diameters are to be measured at half psi intervals (4, 5.6, 8, 11.2, 16, 22, 32, 45, 64, 90, 128, 180, 256 mm and so on). Sediment finer than 4 mm is classified as < 4 mm. Sediment size distributions are analyzed as the proportion of grain sizes finer than a given diameter. Touches on bedrock or organic material will be recorded as such and excluded from the sediment size analysis. Data are to be recorded so that the spatial relationship of sample points in the grid is preserved.

At each sample location on the transect, additional descriptors pertaining to the local sediment facies and channel morphology pertaining to fish habitat will be recorded. Sediment facies previously described include well sorted sand, fine gravel and sand, gravel with pockets of sand, gravel dominant and cobble dominant.[13] Fish habitat morphology at sample points in the wetted channel will be classified as pool, run, glide, riffle and cascade as used by District fisheries biologists.[14] Dry portions of the channel may be classified as either bar or bank as appropriate.

[12] O'Connor Environmental, Inc. 2006. Lagunitas Creek Fine Sediment Investigation. p 51.
[13] IBID, p. 21; also see photographic examples in Appendix A.
[14] MMWD 2008. Lagunitas Creek Habitat Typing Survey 2006 Analysis.

For sample locations with surface sediment diameter < 4 mm and sediment facies described as well sorted sand, fine gravel and sand, or gravel with pockets of sand, the depth of fine sediment deposit will be measured. A thin metal rod at least 3 ft long will placed on the bed at the sample location and pushed into the bed with consistent force until firm resistance is encountered. The depth of penetration will be observed and recorded as the depth of the fine deposit. The depth of the water column above the sample point will also be observed and recorded. In addition, a small volume subsample of the fine sediment is to be collected for a proportion of sample locations for analysis of grain size distribution. As noted previously, this procedure is similar to that used to measure v_*, but is intended here to be used in all wetted channel habitat types. As described for v_*, the ratio of sediment depth to the sum of sediment depth and water column depth provides a measure of potential habitat space occupied by fine sediment. This is a direct measure characterizing a relationship between fine sediment and aquatic habitat.

Sediment size distributions in spawning gravels will be evaluated using the McNeil sample technique. A modified version of this technique has been tested in Lagunitas Creek and is recommended.[15] Sample locations for this method are selected at likely spawning sites where pool tails interface with riffles. Such locations will be randomly selected for sampling by using the systematic grid to determine an approximate location. The actual location will be adjusted in the field by selecting the first appropriate site at or upstream of the randomly selected location. The sample site will be located within the sampling framework and the location will be recorded. Sample sites will be reused in successive surveys to permit analysis of paired samples. Additional data collection required for calculation of q_* include channel slope, channel cross-section, and local surface sediment median size as per the prior study.[16]

Analysis

Systematic streambed sampling is intended to quantitatively estimate various monitoring parameters pertaining to sediment and habitat and their interrelationships. Monitoring data will be used to produce particle size distributions with confidence bands for mean values and percentiles of the distribution. The streambed area occupied by different habitat types and sediment facies will be estimated, along with the proportion of the streambed influenced by LWD. The mean depth and volume of fines will be estimated with confidence intervals.

The interrelationships that may exist among streambed monitoring parameters will be evaluated by estimating parameter means or percentiles of

[15] O'Connor Environmental, Inc. 2006. Lagunitas Creek Fine Sediment Investigation. pp 21-23.
[16] IBID. pp 24-25.

subpopulations. Quantitative estimates will be developed for sample reaches (M1, M2, M3, T1 and T2) and individual monitoring sites (comprised of the systematic grid over twenty bankfull widths, forty transects and 400 sample points). Quantitative estimates will also be provided for subpopulations by habitat type and sediment facies type.

Data analyses will focus on comparisons of the proportions of fines and particle size percentiles between pairs of surveys. Particle size distributions will be tested for normality using chi-square or Kolmogorov-Smirnov tests. Shifts in distributions may be evaluated using a non-parametric quantile test. The proportion fines (or other size class) may be evaluated using a chi-square contingency table test.

Comparison of fines and particle size percentiles among multiple surveys will be conducted. For the proportion fines (or other size class), a chi-square contingency table test may be used. For analysis of trends, Spearman's rho and Kendall's tau statistics may be used.

Comparison of the areas of given habitat or sediment facies types among surveys will be conducted. For the proportion of points in each class, a chi-square contingency table test may be used.

For subsurface sediment (McNeil samples), the mass of sediment particles will be determined be sieve analysis. Geotechnical laboratories may perform this analysis using ASTM C-136 to produce the required sediment size distributions. The mass of particles will then be derived for half-psi classes. Particle size distributions with confidence bands, mean and percentiles will be produced for each monitoring reach (M1, M2, M3, T1 and T2).

Subsurface sediment analyses will compare percentiles of specified grain diameters of biological significance and particle size percentiles between pairs of surveys. Particle size distributions will be evaluated by chi-square or Kolmogorov-Smirnov tests. Comparisons will be made with paired t-tests. Non-parametric tests will use the Wilcoxon signed-rank test.

Comparison of the percentiles of specified grain diameters of biological significance and particle size percentiles among multiple survey sites will be conducted with 2-way repeated measures ANOVA. A comparable non-parametric test that can be used is Friedman's test. Trends will be evaluated using Spearman's rho and Kendall's tau tests.

Fine sediment depth will be quantified for each monitoring site and for each monitoring reach. Comparisons between surveys can be made with paired t-test. A comparable non-parametric test is the Wilcoxon signed-rank test.

Comparison of fine sediment depth or volume of fines among multiple surveys will be made using 2-way repeated measures ANOVA or using Friedman's test for non-parametric data. Trends will be determined using Spearman's rho and Kendall's tau.

The metric q_* will be quantified for each monitoring site and for each monitoring reach. Comparisons between surveys can be made with paired t-test. A comparable non-parametric test is the Wilcoxon signed-rank test.

Comparison of q_* among multiple surveys will be made using 2-way repeated measures ANOVA or using Friedman's test for non-parametric data. Trends will be determined using Spearman's rho and Kendall's tau.

Large Woody Debris Sampling and Study Design

Large woody debris (LWD) is an element of fish habitat that contributes cover and may interact with streamflow to create pools. Prior studies of Lagunitas Creek suggested that streambed sediment sizes tend to be finer in the vicinity of LWD[17]. Consequently, systematic streambed sampling will include measurements of LWD on transects in order that the effect of LWD on sediment size can be evaluated further.

Given this need for LWD observations, it is a relatively simple matter to collect additional data pertaining to LWD so that estimates of LWD volume and other characteristics of interest can be monitored. Prior sampling of LWD in mainstem Lagunitas Creek in 2005 provided sample data that could be used to estimate LWD volume based on measurements of the diameter of LWD pieces intersecting sample transects using line-transect sampling methods. This approach was used in a study of LWD ecology in a coastal stream in Mendocino County to determine the quantity of LWD, the mechanisms delivering it to streams and its relationship to stream hydraulics and fish habitat. [18]

Owing primarily to high natural variability of LWD distribution in streams, the sample data from 2005 produced estimated mean LWD volume with 95% confidence intervals of +/- 70 to 80% of the mean within monitoring reaches with three or four monitoring sites. Because of this high variability, monitoring data are not expected to detect small changes in LWD volume. Some advantage in statistical analysis can be gained by paired sampling where measurements are made on the same sample transects in successive sampling events. In any case,

[17] O'Connor Environmental, Inc. 2006. Lagunitas Creek Fine Sediment Investigation. p 49.
[18] O'Connor M. and Ziemer R. 1989. Coarse woody debris ecology in a second-growth *Sequoia sempervirens* forest stream. Gen. Tech. Rep. PSW-GTR-110. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. pp 165-171.

because the data will have low marginal cost and will provide quantitative data pertaining to a significant component of the aquatic system contributing to fish habitat, LWD measurement is recommended. The LWD survey data is expected to provide data on LWD accumulation rates and input processes, as well as details of LWD position and quality that will provide perspective regarding its role in sedimentation processes and fish habitat.

The frequency of LWD measurement should be relatively infrequent, but should average twice per ten year period.

Field Methods

The number of LWD pieces, characteristics of interest, and an estimate of the volume of LWD will be sampled at each monitoring site using the systematic transects set up for streambed sediment sampling.[19] LWD volume is determined as a function of the diameter of LWD pieces encountered on transect lines.

LWD characteristics of interest are not generally quantitative; hence much of the useful monitoring data will be nominal or categorical. These characteristics include tree species, source (e.g. bank erosion, wind throw, habitat enhancement), decay class (an index of LWD age), position in the channel (e.g. in the wetted channel, in the bankfull channel, spanning above the channel, proportion of channel cross-section affected, orientation to flow), habitat influence (e.g. pool cover, pool formation) sedimentation influence (bar development or sediment deposition associated with LWD), presence or absence of a root wad, and association with other LWD pieces (e.g. single piece, accumulation, debris jam).

Analysis

Quantitative LWD data will be limited to LWD counts and volume estimates. These data will be compared between pairs of surveys using paired t-tests for comparisons over time. The Wilcoxon signed-rank test is an alternative test for non-parametric data. Comparison of LWD counts or volume among multiple surveys will use 2-way repeated measures ANOVA. For non-parametric data, the Friedman test will be used.

Streambed Elevation and Topography

Patterns of channel change documented by cross-section monitoring pertain primarily to the movement of coarser sediment transported on the streambed as bed load. Cross-sections in pools may record transient deposition of finer sediment transported intermittently in suspension. Monitoring to-date has been

[19] IBID.

quantitative, but trend analysis to-date has not incorporated analysis of sampling error or appropriate statistical tests that differentiate between random variation and true trends that are proposed here.

Prior monitoring provided an annual record of repeated cross-section surveys over the period 1993-2007. This long-term monitoring indicated patterns of channel incision of about 1 ft in Lagunitas Creek at station KB below the confluence of San Geronimo Creek and channel aggradation of about 1 ft in Lagunitas Creek near Tocaloma at station KF. At the six intervening monitoring sites in Lagunitas Creek, patterns of elevation change were variable.[20]

Long-term changes in bed elevation are of interest to the District in relation to overall status of watershed erosion and sedimentation conditions. Given the evidence from monitoring to date and the generally long residence time of bed load sediment in gravel bed streams (decades), it is not necessary to monitor channel bed elevations on an annual basis. The necessary perspective on channel response to variable bed load sediment transport and sediment supply can be maintained with less frequent monitoring. Greater confidence in the interpretation of these monitoring data will be achieved through appropriate statistical analysis of topographic survey data.

Topographic surveys will be conducted periodically at two monitoring sites each in the reaches M1, M2 and M3. Monitoring sites will coincide with prior established monitoring reaches KB (reach M3), KC (reach M3), KD (reach M2) and KF (reach M2). Two new monitoring sites will be established in reach M1. It is intended that these monitoring sites will coincide with monitoring sites used for systematic sampling of sediment described above, including q_* sites. This preference for monitoring sites will deviate from random sampling procedure in monitoring site selection in reaches M2 and M3. Acknowledging this imposition on standard sampling procedure has the benefit of maintaining continuity of the prior monitoring record while simultaneously implementing a new monitoring protocol.

Woody debris accumulations and the distribution of sediment deposits and facies in relation to wood and other morphologic features will be mapped. These observations and maps will provide descriptive monitoring data in a three-dimensional context supplementing the numerical two-dimensional data obtained in systematic sampling.

[20] Balance Hydrologics 2008. Lagunitas Creek Sediment and Riparian Management Plan, Marin County, California: Streambed Monitoring Report, 1995-2007. Figure 13a.

Field Methods

The length of individual topographic monitoring sites will be comparable to the length of systematic streambed sample sites. Topographic monitoring sites may be extended to incorporate portions of prior monitoring sites KB, KC, KD and KF as necessary.

Systematic sampling of elevation will be conducted in a systematic pattern within the boundaries of the bankfull channel using a Total Station survey instrument. Survey elevation datums from prior surveys will be incorporated to allow comparison with prior survey data. Systematic sampling will conform with transect locations used for systematic streambed sampling to the extent possible to produce a reproducible gridded data set for channel bed elevation. Data collection is sometimes constrained by sight lines required between survey instrument positions and sample locations, and it is not always practical to clear obstructions or reposition the survey instrument. Additional survey points at morphologically significant locations such as edges of stream banks, bar tops and edges, edge of water, thalweg position, and LWD positions will also be collected. Data points from the gridded sample and from other points of interest will all be used for mapping purposes. The primary product of the survey will be a digital elevation model from which topographic maps and cross-sections can be produced using GIS software. Gridded elevation data will also be generated for analyses of changes in mean bed elevation. Appropriate slope data will also be collected in relation to McNeil sample locations for calculation of q_*.

Sample data from prior surveys could be used to determine variance and sample size requirements; however it is recommended that initial survey data collected in the new plan be used for this purpose. Subsequent data sets could be modified to achieve the desired degree of sampling precision and efficiency.

Bed elevation data collected in a systematic pattern will exhibit strong spatial autocorrelation. Variance of the mean cannot be estimated without bias, but the method of local differences can be used to compensate.[21] This permits construction of conservative confidence intervals, and we can estimate sample sizes needed to achieve a given precision. Traditional hypothesis testing is not robust to lack of independence; if applied to grid-sampled, positively autocorrelated data, the error rate will be lower than the nominal alpha. For example, with alpha = 0.05 we will reject a true null hypothesis less than 5% of the time. When we do reject we will be very unlikely to be wrong. That's

[21] Heikkinen J. 2006. Assessment of uncertainty in spatially systematic sampling. Chap. 10, pp. 155-176 in: Kangas, A; Maltamo, M (eds.). Forest Inventory – Methodology and Applications. Springer, Netherlands.

because the true variance of the mean is less than that given by formulae for simple random sampling.

Analysis

Data will be summarized and estimates of mean bed elevation will be produced for each monitoring site and each monitoring reach (M1, M2, and M3). Mean bed elevation will be compared between pairs of successive surveys focusing on estimating changes with confidence intervals, using a local difference approximation to estimate variance. Over the long term, plots of means with confidence intervals are expected to reveal trends.

Comparisons between surveys may also be accomplished by a paired t-test for a reproducible sampling grid; a two-sample t-test may be used if the grid is not reproducible. These tests will be conservative and will likely underestimate sampling precision because of spatial autocorrelation in the systematically sampled data. Permutation tests may be used as an alternative approach for comparing surveys that does not require spatially uncorrelated data.[22]

Turbidity Threshold Sampling Study Design

An effective method of quantifying fine sediment delivery from management activities dispersed over a group of sites or an entire watershed is to measure suspended sediment loads (SSL) at key locations. Turbidity Threshold Sampling (TTS) is an accurate and cost effective SSL monitoring system that estimates loads by sampling suspended sediment (SS) in conjunction with continuous turbidity (an optical property) and streamflow measurements[23] (Lewis and Eads, 2008). The system uses an automatic pumping sampler to collect SS samples for later lab analysis of mass concentration. The timing of the samples is determined in real time based on changes in turbidity; samples are collected when specified turbidity thresholds are crossed. After the concentrations are gravimetrically determined, they can be related to the corresponding discrete turbidity measurements for any period of interest. Then the continuous record of turbidity can be converted to a continuous record of concentration that, combined with the streamflow data, facilitates computation of SSL for any period of record. TTS is an advance over previous methods in that (1) samples are automatically collected based on turbidity conditions during each significant sediment transport

[22] Moore, D. S.; G. McCabe, G; Duckworth, W; Sclove, S. 2003: Bootstrap Methods and Permutation Tests. Supplemental Chap. 18 in: The Practice of Business Statistics: Using Data for Decisions. W. H. Freeman, New York.

[23] Lewis J and Eads R (2009). Implementation guide for turbidity threshold sampling: principles, procedures, and analysis. Gen. Tech. Rep. PSW-GTR-212. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station. 87 p.

event, (2) the resulting samples and recorded data permit reliable estimation of sediment loads for each significant sediment transport event.

Benefits of a TTS monitoring program are several:

1. Provides the most direct available measure of fine sediment inputs from dispersed areas in the watershed.
2. Provides a means for comparing trends in fine sediment transport at different locations (see the following two paragraphs).
3. Advances our understanding of fine sediment routing by providing quantitative inputs to a fine sediment budget
4. Fine sediment transport can be computed for different size fractions
5. Could accurately establish the quantity of fine sediments entering the system from Peters Dam.

Event-wise load estimates provide much better statistical power than annual loads for comparing the long-term sediment transport response at two or more monitoring locations. An unpublished statistical power analysis for the South Fork of Caspar Creek showed that, having collected 11 years (60-70 events) of pretreatment data, a 40% increase in sediment load would be detectable with at least 80% probability within 2 years after harvest in most subwatersheds. Failure to detect such an increase in sediment loads could be interpreted as evidence that fine sediment inputs have been no greater than 40%. In an environment such as Lagunitas there might be ongoing disturbances in watersheds being compared. Rather than testing for a discrete shift, the analysis would focus on identifying trends in the residuals from an average relationship (see example in next subsection). If disturbances can be limited or excluded from one watershed, then it can serve as a control and any detected changes can be more reliably attributed to the other watersheds being compared.

Monitoring Designs

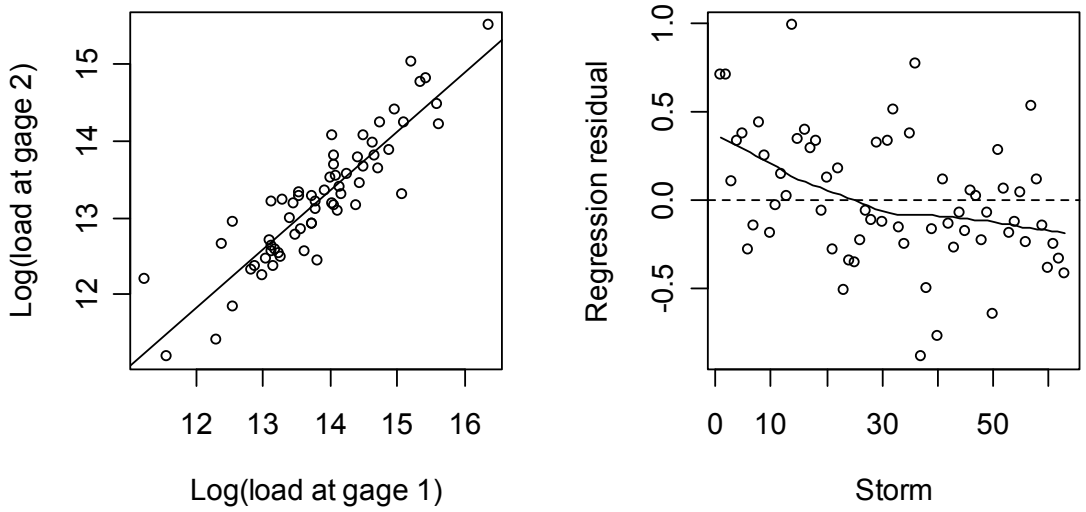
Four configurations are typical of studies designed to detect management-related sediment inputs:

1. above and below a confluence of the tributary of concern (e.g. Lagunitas Creek above and below Devil's Gulch)
2. above the confluence on both the tributary and the stream that it flows into (e.g. Devil's Gulch and Lagunitas Creek, above their confluence)
3. on streams draining a watershed of concern and a similar nearby watershed (e.g. San Geronimo Creek and Devil's Gulch).
4. on a single stream channel above and below the terrain draining activities of concern

The first two are essentially equivalent designs and the choice between the two depends mainly on whether the tributary or the receiving stream is more suitable and convenient for installing the equipment. Although the relationship between

the two responses in the second design will have lower variance than the first, the expected change is smaller because the tributary output is diluted by that of the upper station. The third design is preferable to the second when there is another stream available that is very similar to the tributary of concern. The fourth design is appropriate where activities of concern occur on "face" watersheds drained primarily by subsurface flow or low-order channels into a larger stream. The fourth design is used for studying localized sites of activity, while the others are used for assessing entire watersheds. All four designs are best when one of the streams is relatively stable in terms of management and sediment delivery, and all four designs are most effective when monitoring is begun before the activities of concern are implemented.

Even without before and after monitoring these designs can be effective for assessing relative performance of two watersheds over time. The analysis focuses on shifts in the relationship between responses over time, either by analysis of covariance (in the case of temporally discrete disturbances) or by plotting regression residuals through time. For example, the first frame of the figure below shows the logarithms of the suspended sediment storm loads at 2 stream gaging stations. The second frame shows the residuals plotted as a function of storm sequence. (The data are real but the trend was added artificially for illustration.) The non-linear trend in the residuals depicts a declining trend with time in the response of gauge 2 relative to gauge 1. Trends of arbitrary shape can be tested statistically for significance using generalized additive models[24] (Hastie and Tibshirani, 1990).



[24] Hastie, T. J. and Tibshirani, R. J. 1990. Generalized Additive Models. Chapman & Hall/CRC.

Site Selection

A complicating factor when assessing a TTS program in the Lagunitas Creek watershed is the effect of dam releases. Key to the designs discussed is a strong relationship between responses at the two monitored locations. Geographic proximity usually ensures that streamflow is well-related between watersheds draining similar terrain. But if streamflow is decoupled by artificial flow controls, turbidity, concentrations and loads also may not be well-related. A comparison of San Geronimo Creek and Devil's Gulch would not be subject to that difficulty, but above and below measurements of Devil's Gulch would be affected by releases from Peters Dam that would likely reduce the sensivity of the design.

Some advantages can be gained by implementing TTS at existing stream gaging stations. Existing stations already have established discharge rating equations and, in some cases, existing infrastructure may be utilizable for TTS. Finally, adding suspended sediment measurements to sites with longer discharge records may permit certain analyses, such as estimation of historical loads, that would be more difficult at previously ungauged sites.

Considering the above discussion, we recommend implementation of TTS at the following locations.

1. San Geronimo Creek at Lagunitas Road bridge. This is an existing stream gauge operated since 1980 by Balance Hydrologics. This gauge is approximately one mile above the confluence of San Geronimo Creek with Lagunitas Creek, capturing runoff from about 90% of the 9.3 mi^2 San Geronimo watershed. The San Geronimo Creek watershed is considered to be a major source of sediment in Lagunitas Creek.
2. USGS gauge 11460400 on Lagunitas Creek at Samuel P. Taylor State Park. This gauge has been operated by the USGS since 1982. The watershed area of 35.9 mi^2 includes 21.5 mi^2 from Peters Dam, and 5.1 mi^2 draining to Lagunitas Creek below the dam, plus all of San Geronimo Creek. This gauge is ideal for integrating all sediment inputs from the basin. Sediment transport at sites further downstream would be more difficult to interpret as management-related because of the large amounts of stored alluvial sediment that are episodically transported in the lower reaches of Lagunitas Creek.
3. Devil's Gulch near the confluence with Lagunitas Creek. This would be a new gaging location. Sediment from Devil's Gulch is not measured at USGS gauge 11460400, which is just upstream of the Devil's Gulch confluence. Since Devil's Gulch flows are unregulated, this site provides one of the best comparisons with San Geronimo Creek within the Lagunitas watershed below Peter's dam. Because the watershed is largely contained in the State Park, management activities are limited and it

might serve well as a control for evaluating trends in San Geronimo Creek. In addition this gauge will provide a reading on the effectiveness of several erosion control projects located within Devil's Gulch.

If a fourth station were to be included, it could be at Lagunitas Creek above Shafter Bridge. This would be another new gauging site. Located about 0.6 mi downstream from Peters Dam, the drainage area includes 2 small tributaries below the dam. Because of the regulated flows, it would not be informative in relation to San Geronimo Creek, but would provide a nearly direct measure of the sediment being released from Peters Dam. Such sediment, however, is expected to consist only of very fine sediments and will be minimal except during spills over the dam, which are of concern primarily for their scouring effect rather than their sediment content.

Final site selection will require a field reconnaissance to determine the precise location of instrumentation and site specific equipment needs. Primary considerations will be the type and location of the equipment shelter and configuration of the boom from which the turbidity sensor and pumping sampler intake are deployed.

Implementation

Details of general TTS implementation can be found in the "Implementation Guide for Turbidity Threshold Sampling: Principles, Procedures, and Analysis" (Lewis and Eads 2009). Once a station is established, the basic components of implementation at MMWD stations would be

1. Field data collection
    a. Visual inspection and maintenance of gauge site
    b. Reading staff plates and taking field notes
    c. Interacting with the data logger and software
    d. Downloading and plotting TTS data
    e. Retrieving pumped samples and replacing bottles
    f. Collecting simultaneous depth-integrated and pump sample pairs
    g. Current-meter discharge measurements
    h. Equipment troubleshooting
2. Laboratory processing of pumped and depth-integrated samples
    a. Filtration and weighing of samples
    b. Separation of sand fractions on a subset of pumped samples and all simultaneous pumped and depth-integrated samples
    c. Determination of sand fractions and concentrations
3. Data processing and analysis
    a. Calculate discharge from current meter measurements
    b. Establish and/or update stage:discharge ratings

c. Collate staff plate readings for comparison with stage data
d. Correct and finalize electronic stage and turbidity data
e. Apply discharge rating equation to finalized stage data
f. Establish relationship between simultaneous pumped and depth-integrated sample concentration
g. Define storm events and calculate loads
h. Calculate annual loads of fine sediment and sand
i. Re-evaluate TTS sampling parameters

Current meter measurements will be required at Devil's Gulch and possibly at San Geronimo Creek, depending on Balance Hydrologics' stream gauging program. We assume that the USGS gauging station has an ongoing program of discharge measurements and rating curve maintenance.

Paired depth-integrated and pump samples are needed to determine whether the pump samples adequately represent the cross-sectional mean concentrations of suspended sediment and sand. If a bias is detected, a correction can be developed from the paired sample concentrations.

The collection of discharge measurements and paired depth-integrated and pump samples should be most intense the first year of monitoring (15 or more samples well-distributed with respect to flow). These programs can be continued at a lesser intensity during subsequent monitoring years (5-10 measurements per year).

TTS sampling parameters will initially be estimated from existing data records at the San Geronimo and Lagunitas Creek gaging stations. Ideal sampling parameters will yield at least 4-12 samples per storm event (depending on the maximum level and smoothness of turbidity), with scattered samples between events, resulting in about 100-150 pumped samples per station per year. In order to quantify annual sand transport, sand fractions will be analyzed on about one-third of all pumped samples, including all those associated with simultaneous depth-integrated samples.

Electronic stage and turbidity data will be corrected in conjunction with field notes using the TTS Adjuster program, which facilitates corrections by displaying staff plate readings and scatterplots of turbidity and SSC. The program will also calculate discharge if a rating equation is supplied. If necessary USGS discharge data will be merged with the TTS data using customized scripts.

Resource Requirements

Installation of three gauging sites is assumed. Instrumentation costs will vary somewhat depending on unknown factors such as required cable lengths.

Optimally, 4 x 6 ft walk-in shelters will be constructed at each gauge site. Such shelters are highly desirable for servicing and protecting instrumentation during inclement weather, especially at long-term gauging sites. However, if existing structures can be utilized, or if new structures of that size are impractical alternative instrument shelters can be used.

Laboratory resources to analyze 150 pumped samples and 15 depth-integrated samples during the first year for each station, with sand fractions on 50 pumped samples and all depth-integrated samples. In subsequent years the number of pumped samples and depth-integrated samples would likely be reduced by 5 each and the number of sand fractions is correspondingly reduced by 10, at each station.

Trained field staff would be required to conduct 15 site visits during storm events the first year and 10 site visits during storm events the second year, as well as 10 non-storm maintenance visits each year.

APPENDIX F

Comments on the Public Review Draft Stewardship Plan (12/15/10)

1 – S.F. Regional Water Quality Control Board
2 – California Department of Fish and Game
3 – Lagunitas Technical Advisory Committee
4 – Mervyn Zimmerman

California Regional Water Quality Control Board
San Francisco Bay Region

Linda S. Adams
Acting Secretary for
Environmental Protection

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(510) 622-2300 • Fax (510) 622-2460
http://www.waterboards.ca.gov/sanfranciscobay

Edmund G. Brown, Jr.
Governor

April 1, 2011
File No. 1185.03 (LCF)

Greg Andrew
Marin Municipal Water District
220 Nellen Avenue
Corte Madera, CA 94925

Dear Mr. Andrew:

Thank you for the opportunity to comment on Marin Municipal Water District (District)'s draft *Lagunitas Creek Stewardship Plan* (Stewardship Plan). This Stewardship Plan is a follow up to the District's 1997 *Lagunitas Creek Sediment and Riparian Management Plan* (Sediment Plan), pursuant to State Water Board Order WR95-17 (Order), which was adopted to regulate dam operations and set mitigation measures for raising Peters Dam. San Francisco Bay Water Board (Water Board) staff have been involved through the hearing process and with the Lagunitas Creek Technical Advisory Committee (TAC) for over 18 years.

The District deserves commendation for their implementation of the Sediment Plan. Your sediment management, large woody debris (LWD) addition, and fishery monitoring programs have been exemplary, with some exceptions, as described below. Additionally, in areas of sediment management, winter refuge, and fishery monitoring, the District has pursued grants and collaboration that go well beyond the Order. We strongly support the ongoing implementation of these District programs, with suggestions for adaptive management as described below.

In general, we support the elements of the Stewardship Plan and find it well written and clearly described. If these elements were consistently implemented, we believe there would be substantial improvement in fisheries habitat and stream ecosystem functioning. However, because the Stewardship Plan places most actions in the voluntary priority category, we are concerned that it represents significant backsliding from the District's commitment to mitigate for ongoing impacts of the dams on fishery resources and other aquatic species. These impacts are severe and ongoing and affect critical stream elements necessary to maintain viable salmonid and shrimp populations. This mitigation for the impacts of the dam must be guaranteed through committed actions and not left to voluntary efforts that may or may not materialize.

As described in more detail below, we are also concerned that the District has not complied with all elements of the Order, including conditions related to temperature (Section 5, Special Circumstances) and has not demonstrated, "appreciable improvement in the fishery habitat within the Lagunitas Creek watershed" (Section 7). In fact, the Order requirement for "appreciable improvement..." is not evaluated or included in the Stewardship Plan, and there are no substitute criteria for effecting improvement in streambed conditions. We are also concerned that the District has not complied with the gravel augmentation component of the Sediment Plan. At this time, it is necessary for the District to proceed in an adaptive management framework, to scientifically evaluate those elements of the program that have not resulted in the required outcomes of appreciable improvement and maintaining temperature standards. Based on this evaluation, the District should propose additional measures to achieve compliance.

General Comments

We have the following general overall comments on the Stewardship Plan:

1. The Stewardship Plan's goals are overly broad in many areas and frequently do not include specific measurable objectives. For example, the winter habitat enhancement goal (4.2) aims to "reduce or eliminate a limiting factor for coho and steelhead populations" but does not include specific targets. The work done by NOAA Fisheries in the Draft Central California Coast ESU Coho Recovery Plan (Coho Recovery Plan) does provide data from which these targets can be developed (It should be noted that one of the most significant difficulties encountered in evaluating performance of habitat components of the Order has been the lack of specific targets.).

2. The Order states:

   > Much fishery habitat in the Lagunitas Creek Watershed has been lost due to construction of dams and other development. In order to protect and improve the remaining habitat, this Order requires a package of measures including minimum instream flow requirements, maximum water temperature requirements, measures to protect water quality, a sedimentation control plan, a riparian vegetation management plan [*including LWD*]... (Section 9, Summary).

   The Stewardship Plan contains these components as required by the Order; however, unlike the previous efforts based on the Order, which were mandatory, the District has organized the components in the Stewardship Plan into three priority tiers: 1) mandatory requirements, 2) high priority actions the District will lead, and 3) important actions that the District will participate in but may not lead. The District has placed the majority of the proposed actions in Tiers 2 and 3, which are contingent upon many factors, including grant funds and voluntary collaboration by other partners. In requiring this "package of measures", the State Water Board recognized the complex interplay among flow, sediment, LWD, riparian vegetation, temperature, water quality, and fish habitat. These components are not separable; all of these components are mitigation for the dams and should not be prioritized as "voluntary" but should be placed in Tier 1. Please see the Appendix to this letter for a list of these actions.

3. The Order required the District to develop fisheries, habitat, sediment and other monitoring programs to determine order compliance. In the past decade, the need for baseline and effectiveness monitoring has become even more firmly established. The list of Action Items in the Appendix that indicates which Stewardship Plan elements should be shifted to Tier 1 priorities includes almost all of the monitoring programs listed under Tier 2 "Surveys and monitoring." These monitoring programs are essential for allowing the District to determine the status of coho, steelhead and shrimp populations in the watershed, and the impact of District programs on streambed conditions and fisheries habitat, as required in the Order.

Specific Comments

Sediment

The Order, Section 6.5.1, states:

> Erosion and sedimentation have resulted in large quantities of sand and fine gravel filling pools and glide habitat areas, and filling the spaces around cobbles, boulders and undercut banks. The result is to reduce habitat available for juvenile fish, freshwater shrimp, and other aquatic organisms.

This finding was the basis for requiring the District to implement sediment reduction actions. The District's monitoring program was designed to measure the effectiveness of these actions in making appreciable improvement. The District's 10-year monitoring report, "*Lagunitas Creek Sediment and Riparian*

Management Plan, Streambed Monitoring Report 1995-2007" (Streambed 10-Year Monitoring Report) on streambed conditions indicates that there has not been an appreciable improvement in bed conditions[1].

Lagunitas Creek is listed as a 303(d)-impaired waterbody for sediment, and a Total Maximum Daily Load (TMDL) is under development by the Water Board. Our TMDL analysis indicates that streambed conditions have degraded when compared to the 1980s and further suggests that critical elements for reducing sediment impairment include: reduction in fine sediment delivery to the creek, beneficial substrate addition (cobble and gravel), enhancement of LWD, and floodplain restoration. The Order required the majority of these elements, and these elements should continue as mandatory and committed components of the Stewardship Plan. It should be noted that over the past ten years, the District has developed considerable expertise in designing and implementing cost-effective fine sediment reduction projects. The work of this land stewardship team is outstanding and should continue. The Stewardship Plan should incorporate the following Tier 1 components upon consultation with State and Regional Water Board staff and the TAC sediment sub-committee:

- Development and implementation of a fine sediment reduction plan;
- Assessment and implementation, if appropriate, of gravel/cobble addition actions; and
- Development and implementation of a modified stream-bed monitoring program that is integrated with biological and physical habitat monitoring. The currently proposed monitoring plan (Appendix E, Stewardship Plan) is not integrated with the other monitoring programs as necessary to address the Order requirements.

Large Woody Debris (LWD)
Sections 4.2 Winter Habitat Enhancement and 4.4 Instream and Riparian Habitat Enhancement of the Stewardship Plan incorporate LWD addition. Our comments are the following:

One of the most critical elements of the District's program to improve streambed conditions and fisheries habitat is the LWD enhancement component. An LWD enhancement component was required in the Order because the dam captures and thereby removes LWD from the creek system. LWD is a critical geomorphic and ecosystem component, providing the functions of pool and bar (riffle) formation, creating complex summer and winter salmonid habitat, and promoting beneficial sediment metering and sorting. Currently, the District has an exemplary program using trained District staff to design and implement in-stream LWD construction projects, incorporating LWD from the Lagunitas Creek watershed. Monitoring has demonstrated that there is a significant increase in pool cover, pool depth, and coho densities in habitat where LWD structures are placed. We believe that one reason the beneficial effects of LWD have not created an overall improvement in streambed conditions and fisheries habitat is that the scale of LWD addition has been too small. Significantly more LWD is necessary to meet NOAA-recommended performance thresholds. The District followed the previous Sediment Plan diligently; however, adaptive management is necessary at this time. Therefore, rather than scaling back the District's LWD enhancement program, the annual amount of LWD added needs to be increased, and the program should be shifted to a Tier 1 priority.

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[1] The Streambed Monitoring Report, 1995-2007 states, "Table 7 catalogs the individual metrics monitored and comments on whether they individually are indicative of appreciable improvement in bed condition. In a few areas of inquiry, we do see some movement in the directions deemed favorable for anadromous salmonids, and/or freshwater shrimp. In many areas, improvement does not clearly appear or there are confounding factors suggesting interpretation is not as simple as originally envisioned." (pg 46, Analysis, section 5.4, Is there an Appreciable Improvement in Bed Conditions?)

Water Temperature
The Order requires the District to maintain a mean daily water temperature of 58° F or less from May 1 to October 31 to protect rearing juvenile steelhead and coho from chronic and lethal effects. The District's *Lagunitas Creek Sediment and Riparian Management Plan Review and Evaluation Report 1997-2009* (Review and Evaluation Report) states that the District violates this requirement during the summer months on hot summer days. In 2006 this standard was violated on 59 days. With large exceedances such as 59 days, chronic impacts are likely.

The Order additionally requires a temperature standard of 56°F from November 1 to April 30 to protect steelhead and coho incubation and fry emergence. This standard is reported to have been violated for "relatively short periods of time" in March and April ranging from 2-9 days. The summary data in the Review and Evaluation Report is inadequate to permit a determination of the significance of these violations.

The Stewardship Plan indicates that the District will continue to "seek and pursue reasonable approaches to maintain water temperatures under the 58°F standard." However, we are not aware of any measures that have been pursued over the past ten years to maintain temperatures, and none have been reported. We are particularly concerned because the District is allowed to reduce flows to 6 cfs in the summer during droughts. There were no droughts during the past ten years, and therefore the flows were not reduced. As there is a direct relationship between flow and temperature, reduced flows during a drought will likely cause increased temperatures, potentially to levels where disease or other chronic effects may become prevalent, as has occurred in the Klamath River.

Based on the above comments, we believe the following actions are necessary:

1. Since the District has violated the Order's April-October temperature standard during numerous years and for significant amounts of time in hot summers, the District should follow the reporting procedures laid out in the Special Circumstances Section of the Order regarding failure to meet temperature standards. Among other measures, these procedures require consultation with numerous agencies and an operations plan to rectify the situation. The Water Board should be included in this dialogue as we have responsibility for 303(d)-listed impaired water bodies and development of TMDLs to restore beneficial uses of such water bodies. At the time of the Order, these Water Board initiatives were not well developed and thus not considered.

2. Since the District has violated the Order for November to April, a more detailed analysis is necessary to determine if these violations could have harmed incubating or emerging fry. Summary tables of all violations (summer and winter), the timing of these violations and the lifestages they may affect, should be incorporated as an appendix to the Stewardship Plan.

3. The District should clearly describe, in the Stewardship Plan background, the measures it has previously taken to reduce temperature violations and what future measures, including riparian enhancement (see comments below) will be undertaken.

Specific Comments on Plan Sections

Section 4.2 Winter Habitat Enhancement
We are very supportive of the District's efforts to create winter refuge, including off-channel and floodplain habitat. In addition to benefits, these actions have the potential to cause deleterious water quality impacts (low dissolved oxygen, fish stranding, increased fish predation risk, and creation of habitat for invasive species). Proposed studies and design work must include consideration of these potential impacts. Actions must be accompanied by adequate fish and water quality monitoring efforts to determine project success.

Section 4.4.1 Rearing Habitat Enhancement with LWD

The Stewardship Plan does not include a specific discussion of **spring** refuge for emerging salmonid fry. District staff has presented data to the Lagunitas TAC suggesting that in many years the lack of spring refuge (high velocity refuge) is responsible for high observed mortality rates. The LWD designs that are specific to this function may be different from other designs, and the District should propose actions specific to LWD designs in the Stewardship Plan.

Section 4.4.3 Riparian Vegetation Enhancement
Riparian vegetation plays a critical function in almost all aspects of the stream ecosystem. As it pertains to the Order, riparian vegetation plays the following important roles: 1) providing shade and thereby mediating water temperatures, 2) providing a source for future LWD recruitment, and 3) mitigating the effects of fine sediment accretion along the stream edges, which provide critical salmonid habitat (i.e., low hanging terrestrial vegetation provides cover from predators for juvenile fish in exposed shallow areas). The Stewardship Plan addresses the need for riparian vegetation as a Tier 2 measure; this should be a Tier 1 measure, particularly as it relates to shade and amelioration of water temperature and LWD recruitment.

Sections 4.8.1 and 4.8.2 Roads and LWD MOUs
These sections state that the District will continue to follow the guidelines and practices of the MOUs. The District's leadership in these programs is an integral part of these programs, and they should be a Tier 1 commitment.

Section 4.10.10 Sediment and Streambed Monitoring
The District's current streambed monitoring program is not well-integrated with the biological, habitat and water quality monitoring programs. This has made it difficult for the District to evaluate the impact of its actions on fish habitat, as required by the Order. The Stewardship Plan Appendix E includes a preliminary sediment monitoring plan. While this plan contains many important elements, we believe it should be vetted through the Lagunitas TAC Sediment Subcommittee, in combination with consultation with Water Board TMDL staff, to ensure that the monitoring program will achieve its intended goals. In addition, the monitoring program should be considered a Tier 1 Priority Action.

The District's Streambed 10-Year Monitoring Report has stated that a longer data record is necessary to evaluate streambed conditions. We concur and believe that an important and immediate action item is to rectify the 1980s and 1990s streambed cross-section datums. Marin County has imminent plans to resurface Sir Francis Drake Road. It is likely that the information needed to rectify the cross-sections is contained in surveying monuments within the road's right-of-way, and they may be destroyed during the repaving. Therefore, the District should immediately collect this information.

Thank you again for the opportunity to comment on the Stewardship Plan. We look forward to continuing to work collaboratively with you on the ongoing efforts to protect Lagunitas Creek. Additionally, we would be willing to meet with the District to discuss our comments. If you have any questions, please contact Leslie Ferguson at (510) 622-2344 or lferguson@waterboards.ca.gov or Dale Hopkins at (510) 622-2362 or dhopkins@waterboards.ca.gov.

Sincerely,

Digitally signed by
Bruce Wolfe
Date: 2011.04.01
19:21:02 -07'00'

Bruce H. Wolfe
Executive Officer

Cc: Lagunitas TAC

APPENDIX

Actions that should be shifted to Priority 1 [1]

1. Winter habitat enhancement: Winter habitat enhancement assessment and implementation
2. Survey and Monitoring:
   - Stream Flow Monitoring
   - Juvenile Salmonid Surveys
   - Salmon Spawner Surveys
   - Salmon Smolt Surveys
   - California Freshwater Shrimp Surveys
   - Habitat Typing Surveys
   - Sediment and Streambed Monitoring
   - Project Site Monitoring
3. Instream and Riparian Enhancement: Riparian Vegetation Enhancement (From Peter's Dam through Tocoloma)
4. Collaboration and Outreach: Partnerships and Collaboration (Lagunitas TAC)
5. Programs and Policies:
   - Road MOU
   - Woody Debris MOU
6. Sediment Reduction and Management: Sediment Source Treatments in the Watershed
7. Instream and Riparian Habitat Enhancement: Rearing Habitat Enhancement with Large Woody Debris
8. Sediment Reduction and Management
9. Streambed Gravel Management
10. Survey and Monitoring: water quality monitoring

[1] Note: this list is taken from the Stewardship Plan Table ES-1 and therefore does not include the changes that we have recommended making. Therefore, a final Stewardship Plan table should include both the changes in priorities and the additional elements as discussed in the text of our letter.

April 1, 2011

Greg Andrew
Marin Municipal Water District
220 Nellen Avenue
Corte Madera, CA 94925

Dear Greg:

The California Department of Fish and Game (DFG) appreciates the opportunity to review Marin Municipal Water District's (MMWD) draft *Lagunitas Creek Stewardship Plan* (Plan). The Plan supports objectives of the *Recovery Strategy for California Coho Salmon* (DFG 2004) and the recent start-up of the California Central Coast ESU coho recovery effort. Elements of the Plan include State and Federal high priority recovery actions, including assessment and enhancement of over-wintering habitat, installation of large and small wood structures, recruitment of spawning gravels, riparian corridor restoration, and invasive species eradication. Over the past 15+ years, MMWD has implemented many of these actions and has made significant progress in salmonid population monitoring, habitat restoration, public outreach, and multi-agency/multi-organizational collaboration through the Lagunitas TAC. Importantly, MMWD recognizes that these actions must continue with even greater urgency. The current predicament demands that every possible agency, organization, and community choose to make protection of public trust resources a requirement. Discretionary approaches will not save the species.

DFG looks forward to working directly with MMWD and collaborating organizations in implementing the actions in the Plan. I expect that MMWD will fine-tune the Plan over time and incorporate specific details, milestones, and deliverables for each action so that grant proposals can be submitted to the Fisheries Restoration Grant Program, NOAA Restoration Center and other funders. My staff and I will be available to assist.

I can be reached at (707) 299-9299, gseymour@dfg.ca.gov.

Thank you.

Sincerely,

Gail Seymour
Senior Environmental Scientist, Supervisor
Bay Delta Region

Lagunitas Creek Stewardship Plan – Public Review Draft
Marin Municipal Water District
December 2010

Review by CA Department of Fish and Game
Gail Seymour, Senior Environmental Scientist, Supervisor
April 2011

This review is specific to Table ES 1, *MMWD Prioritized Actions* in the Lagunitas Creek Stewardship Plan (Plan). The priorities are set in three separate priority tables segregated by, 1) mandated actions, 2) projects where MMWD proposes to be the Lead, and, 3) projects where MMWD proposes to not take the lead but may be involved.

Perhaps all of the listed actions should be prioritized within one inclusive table. Prioritizing actions based, in part, on MMWD's proposed responsibility for the actions, creates a list where high priority actions are listed as lower priorities. Priority actions should be based on keystone limiting factors and recovery urgencies for coho salmon, steelhead trout, and California freshwater shrimp.

The following includes DFG's comments on the Table ES 1:

Page #	Action	DFG Comments
4	Conduct a two phase concept and design assessment…enhance over-winter habitat for salmonids.	After the two phases, there should be 100% designs ready for on-the-ground implementation. Add NOAA Restoration to collaborators
4	Stream Flow Monitoring	Should be in Priority 1; Is this mandated by SWRCB? Is streamflow monitoring only required at the gages?
4	Salmonid, CFWS, and Habitat Surveys	All should be a priority 2 within the group
4	Habitat typing surveys every 5 yrs	Add Americorps/Watershed Stewards Project to collaborators ?

Page #	Action	DFG Comments
4	Annual inspections of project sites	Add, Marin Co Open Space District, SPAWN, Marin County RCD to collaborators or will inspected projects only be MMWD's, State Park?s, and NPS's?
5	Plant and maintain native riparian… between Peter's Dam and Shafter Bridge	Why not continue downstream through SP Taylor and Tocaloma? Add DFG, NOAA Restoration Center, State Parks, NPS, SPAWN to collaborators. In what capacity is the Natural Resources Agency a collaborator?
5	Partnerships and Collaboration	Add Climate Change Adaptation Strategies for Marin County Committe to collaborators
5	Public Involvement and Education	Add interpretive signage and MMWD website, both of which are effective outreach tools.
5	Roads MOU	Add SPAWN to collaborators
5	Woody Debris MOU	Add SPAWN to collaborators
6	Construct the winter hab enhancement features as designed in Lagunitas and lower Olema	This should be in Priority #2 Table and the same priority (#1) as Winter Habitat Enhancement Assessment. MMWD should be co-lead with NPS or at least a primary collaborator. If an all inclusive priority list is developed, this action should be a high priority on that list.
6	Install and maintain LWD structures in mainstem Lagunitas Cr, (Peter's Dam to SP Taylor State Park) and Devil's Gulch.	This should be in the Priority #1 Table as Peter's Dam is directly preventing natural recruitment of LWD in the Lagunitas System. MMWD has a successful history of driving and implementing LWD installation and DFG encourages MMWD to continue that effort. Include DFG, SFRWQCB and NOAA Restoration Center as collaborators
6	Evaluate goals and opportunities for gravel augmentation and enhancement in Lagunitas Creek and tributaries; develop and implement a gravel management strategy.	This should be in the Priority #1 Table as Peter's Dam is directly preventing natural recruitment of gravel and cobble into the Lagunitas System. DFG encourages that MMWD lead this effort. Collaborators should include, SFRWQCB and TAC.

Page #	Action	DFG Comments
6	Evaluate, develop and implement habitat enhancement for Devil's Gulch	This should be in the Priority #2 Table
6	Installation of habitat enhancement projects identified in prior assessment for shrimp habitat enhancement…	This should be in the Priority #2 Table.
6	Develop and implement biotechnical bank stabilization and riparian revegetation at Nicasio Transmission line retaining wall – SP Taylor Park.	This should be in the Priority #2 Table
6	Implement repairs at some of the sediment sources sites identified in previous watershed assessments; focus on roads and other huan-induced erosion sites.	This should be in the Priority #2 Table.
6	Remove invasive plants from riparian corridor…	Consider SPAWN as the lead?
6	Aquatic Invasive Species	Add DFG as collaborator; DFG has a regional AIS staff person to assist.
6	Monthly grab samples for WQ	Especially for water temperature, this should be in the Priority #1 Table or is the necessary temperature monitoring fulfilled under "Gages" in the Priority #1 Table ?

Lagunitas Creek Technical Advisory Committee

March 9, 2011

NOTICE OF MEETING OF THE
LAGUNITAS CREEK TECHNICAL ADVISORY COMMITTEE (TAC)

Notice is hereby given that a meeting of the Lagunitas Creek Technical Advisory Committee will be held as follows:

DATE: Friday, March 11, 2011
TIME: 9:00 AM - 11:00 AM
PLACE: MMWD BOARD ROOM
220 NELLEN AVENUE, CORTE MADERA, CA.

See Item #2

AGENDA

Call to Order & Introduction of TAC members
Adopt agenda

1. Approve minutes of November 18, 2010 (Action).
2. TAC Comments on MMWD's Lagunitas Creek Stewardship Plan (Information/Discussion; see Attachment 1 and web site link below). http://www.marinwater.org/controller?action=menuclick&id=442
3. TAC Chair and Vice Chair for 2011 and New Participating Entities (Action).
4. Fecal Coliform Monitoring in the Watershed; presentation by Rob Carlson, TBWC (Information).
5. Grants & Grants Database (Information).
6. Updates (Information):
    a. 2010/11 Spawner Survey (draft results);
    b. Marin County's San Geronimo Valley Salmon Enhancement Plan (Marin County and San Geronimo Valley Stewards update); and
    c. Marin County's Sir Francis Drake Boulevard Rehabilitation Project (Marin County update).
7. Reports by TAC Members (Information).
8. Future Agenda Items: Broodstock genetics & Coho Recovery Working Group; Pacific Salmon Recovery Fund; Nicasio pipeline to Kent Lake.
9. Public Comment.

ADA NOTICE - In accordance with the Americans With Disabilities Act and California Law, it is the policy of the Marin Municipal Water District to offer its public programs, services and meetings in a manner that is readily accessible to everyone, including those with disabilities. If you have a disability and require a copy of a public hearing notice, or an agenda and/or agenda packet in an appropriate alternative format; or if you require other accommodation, please contact Stephanie Eichner-Gross at (415) 945-1448, at least two days in advance of the meeting. Advance notification within this guideline will enable the District to make reasonable arrangements to ensure accessibility.

LAGUNITAS CREEK TECHNICAL ADVISORY COMMITTEE
MINUTES OF March 13, 2011 Meeting

Chair and Vice-Chair Present: Brannon Ketcham and Liza Crosse

Secretary Present: Laurie Offenbach

Committee Members Present: Gregory Andrew, Jean Berensmeier, Chuck Shultz, David Behar, Michael Snyder, Leslie Ferguson, Dale Hopkins, Bill Cox, Richard Plant, Terence Carroll, Gordon Bennett, and Liz Lewis

Other Attendees: Michael Reichmuth, Liz Lewis, Rob Carson, Eric Ettlinger, Darci Rosenblat, Tom Cronin, Dain Anderson and Mike Swezy

Call to Order: 9:12 am
Introduction of TAC members
Agenda adopted: Adopted with a modification to item 8b adding the San Geronimo Valley Planning Group.

1. **Approved minutes of November 18, 2010 meeting.**
Modifications to item 8b naming the San Geronimo Valley Planning Group. Brannon Ketcham asked for item 5 to read, he "could not continue" rather than he "did not want to continue."

2. TAC Comments on MMWD's Lagunitas Creek Stewardship Plan
Gregory Andrew gave a brief overview of the Lagunitas Creek Stewardship Plan. The plan identifies actions for the District to follow such as mandatory requirements, high priority actions and important actions. Greg stated the mandatory requirements are on-going State mandates, most notably for maintaining stream flows in Lagunitas Creek. High priority actions are actions the District will take the lead on, including monitoring and habitat enhancement evaluations. Important actions include implementation of projects to enhancement salmon habitat in the creek. Goals include the protection of coho, steelhead and fresh water shrimp. This plan is intended be used as direction for the District staff over the next ten years. Gregory reviewed many elements of the plan and identified some of the actions that the District and other entities have implemented and are still ongoing under existing grants and other funding. Greg commended the many agencies for their funding, collaboration and outreach and for their efforts to protect and enhance the watershed. Greg asked for comments regarding the plan.

Gordon Bennett mentioned his concerns regarding wells and the drawing of water out of the creeks. He felt that the District's policy on wells should be reversed and revoked and Marin Municipal Water District (MMWD) should take affirmative action to oppose wells. He offered a suggestion of looking at alternatives for off stream high flow catchment basins.

Leslie Ferguson stated this plan is a significant set back from the previous plan (Lagunitas Sediment and Riparian Management Plan) in terms of commitment and

the required actions. She commented that as long as dam (Peters Dam) is in operation, impacts have to be mitigated in an ongoing manner which includes installation of woody debris and monitoring sediment in the creek. She said the flows have been addressed very well. She would like to see goals and objectives incorporated into the plan, felt the ranking of categories were confusing, had concerns about temperature evaluations in the creek, and felt there should be reasonable assessments to develop a more aggressive riparian plan. She would like to see the committee reconvene and review the stream bed monitoring part of the plan. Leslie said a letter would be mailed from the Executive Officer of the Regional Water Quality Control Board (RWQCB), including all the concerns the RWQCB has regarding the plan.

Michael Snyder stated he agreed with Gordon regarding the wells policy and said that drilling wells should be discouraged.

Liza Crosse questioned the RWQCB role as it relates to this plan and as it relates to the original water rights order. Leslie explained the board may or may not pursue regulatory actions under the State Water Board Order. She stated the dam continues to have impacts on the creek which have been recognized by the State Water Board and there should be mitigation. Liza complimented the woody debris program, saying it was “the jewel in the crown” that is enormously valuable and would like to see this program fostered more into the plan. She asked if the District will still have an ongoing commitment to the TAC and would like to see this addressed.

Leslie complimented the sediment reduction program and said the RWQCB would like to continue to try to find grant funding for this project, but the RWQCB is not in a position to find funding for the large woody debris work. She mentioned that the dam is holding back the wood and it is a Districts’ responsibility, but the RWCQB would write letters of support.

David Behar commented on the dire financial situation of MMWD and if cuts were needed this may affect the plan.

Brannon Ketcham said lower priority items may be vulnerable to budget cuts and suggested collaboration among the agencies to help supplement parts of the plan. A brief discussion ensued regarding budget cuts and implementing the plan.

Liza complimented Greg on how well the plan was written.

Bill Cox appreciated the way that freshwater shrimp were addressed in the plan.

Jean Berensmeier enjoyed reading the plan and agreed with Leslie that goals and objectives were needed to have something to be measured against; she also supports the concern about the wells policy.

Greg offered a timeline to finalize the plan, bringing it to the board for approval, but this may depend on the CEQA process.

Leslie would like to have the sediment TMDL completed before the RWQCB can

comment on the sediment monitoring plan and suggested keeping the sediment monitoring plan in draft form.

Liza suggested following up on resident rainbow trout in the tributaries.

Jean asked about a slope repair on Sir Francis Drake Blvd. Greg said it was a job being done by the County.

Greg said the wording in the policy does not address the impacts of wells on the streams and felt it probably should. He stated that the way the plan is written, it is structured by actions and with each action starting out with a goals statement.

3. TAC Chair and Vice Chair for 2011 and New Participation Entities (Action)
David Behar nominated Liza Crosse to the Chair due to her knowledge of the TAC and felt she is a strong leader. Liza said she has struggled with the functions and accomplishments of the TAC and stated there is always a lot of discussion, but no action. She asked if the TAC serves a value above and beyond those processes that already exist elsewhere and if the TAC feels satisfied by the outcomes and agrees it could be more action orientated. A brief comment session of the members stated they would like to be more action orientated and felt that the TAC is very valuable to the group. Liza said she would be willing to serve and her first action would be to bring back the coho recovery program as an important agenda item at the next meeting.

Liza Crosse was nominated and accepted to the Chair and would like a gavel!

Bill Cox was nominated and accepted as the Vice-Chair.

A list of participating entities was updated. Gordon Bennett now represents Save Our Seashore. Sierra Club position would stay open until filled. Marin County Open Space has shown interest in the TAC. Unrepresented entities will be changed to At Large.

A motion was made and approved to add Save Our Seashore to the TAC and change the designation of Bill Cox and Laurel Collins to “At Large.”

4. Fecal Coliform Monitoring in the Watershed; presentation by Rob Carlson, TBWC (Information)
Rob Carlson from the Tomales Bay Watershed Counsel (TBWC) updated the TAC on information about the fecal coliform monitoring on the Lagunitas Creek Watershed. He outlined the data collection and state regulation parameters. Five sites are being monitored for fecal coliform. Monitoring is conducted weekly during the wet season and twice a month during the dry season. Other sites are monitored by the County, CA Department of Public Health and the Regional Board. Information and advisories are being disseminated via signs at the various public access sites and on web sites. Rob gave a PowerPoint presentation from data collected around the watershed, summarizing: fecal coliform results and standards, high winter run-off, single samples, mean daily discharges and other related information. More information can be found at www.**tomalesbaywatershed**.org

5. Grants and Grants Database (Information)
See item 7.

6. Updates (Information)
a) 2010-11 Spawner Survey (draft results) Eric Ettlinger stated this year, the spawner survey was better than the last two seasons. There was not as large a decline as in the past two seasons. The survey saw very little steelhead spawning activity.

b) Marin County's San Geronimo Valley Salmon Enhancement Plan (Marin County and San Geronimo Valley Planning Group) Liz Lewis stated the San Geromino Land Owner Assistance Program developed with the San Geronimo Planning Group and the UC Cooperative Extension has received funding from the State Coastal Conservancies and some funding from the Department of Fish and Game. The request for proposals is out and need to be in by March 25, 2011; the request for bids can be found on the County's website: www.marinwatersheds.org

c) Marin County's Sir Francis Drake BLVD. Rehabilitation Project (Marin County Update) Liz Lewis said the EIR approval for paving, drainage and slide repair on Sir Francis Drake Blvd. does not have a Board of Supervisors date yet, but may be ready on April 5, 2011.

7. Reports by TAC members (Information)
Gregory received email from Gail Seymour regarding stating that NOAA and DFG have come to an agreement regarding coho recovery and they will be moving forward with the coho recovery effort, with Fish and Game taking the lead. Greg suggested this be the primary agenda item for the next TAC meeting. Greg also stated MMWD is moving forward with grant applications to the Department of Fish and Game for woody debris and monitoring on Lagunitas Creek.

Jean Berensmeier mentioned that the Arroyo Creek Passage celebration was a "super event" and is on YouTube to view. Jean mentioned that the Marin County Open Space District has completed two major projects in Woodacre and San Geronimo, working on trails and fire roads for sediment prevention. She also mentioned a two day community group project that harvested and replanted plants along two trails.

Richard Plant said the Marin Resource Conservation District is still working on Pine Gulch Creek to allow organic ranches to store water in the winter so they don't have to having take water from the creek in the summer. He stated it's been a complicated project due to permitting, but the project is making steady progress.

Liz Lewis aid Kallie Kull said the County is working on a grant for repairing or replacing a box culvert on San Geronimo Creek at Railroad Avenue, in Woodacre.

Liza Crosse said the San Geronimo Land Trust was successful in receiving one parcel in Woodacre and another one on San Geronimo Creek opposite the Lagunitas pump station, funded by the Department of Fish and Game as well as a small grant from the County and that the property owner contributed a portion of the value of the parcel. Liza contacted Eric to see if the creek site is an appropriate site

for a woody debris structure. Liza also said the Woodacre Flats Septic Remediation Projects' feasibility study should be out shortly and a community meeting in association with the project is planned in the next few weeks. Liza will update the TAC at a later date for a report on the project and may ask for TAC support.

The Tomales Bay Watershed Counsel has started negotiations with Trout Unlimited to do some baseline water quality surveys in Devils Gulch.

8. Future Agenda Items
Department of Fish and Game Coho Recovery Program

Meeting Adjourned.

Dear Sirs

Until you people do something to keep the fresh water river otters out of the creeks no matter how much money you spend the Coho salmon will never come back in any large numbers because the otters eat all the fish in the creeks all year around.

Sincerely yours

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APPENDIX G

MMWD Consistency with the DFG (2004) Coho Recovery Strategy

APPENDIX G

Consistency with the DFG Coho Recovery Strategy

By
Katherine Pofahl, MMWD Fishery Watershed Aide

Since implementing the 1997 *Lagunitas Creek Sediment and Riparian Management Plan* and the *Aquatic Resources Monitoring Workplan for the Lagunitas Creek Drainage* Marin Municipal Water District has worked to protect and improve Lagunitas Creek and its tributaries for the betterment of the coho salmon population. These plans have focused on implementing and monitoring technical improvements, performing annual population surveys, and working with other local stakeholders to improve the condition of and decrease threats to the Lagunitas Creek drainage. Other agencies have prepared publications that are designed to benefit the Lagunitas Creek drainage. In creating a new fisheries plan, MMWD has sought to be consistent with the goals and recommendations of these other plans.

***The Recovery Strategy for California Coho Salmon*, California Department of Fish and Game, 2004**

This document gives recommendations for all Evolutionarily Significant Units (ESUs) in California under "Range-Wide Recommendations" as well as suggestions for the Bodega and Marin Coastal Hydrologic Units, which contains specific recommendations for the Lagunitas Creek drainage, referred to as the Lagunitas Creek Hydrologic Subareas (HSA). The attached table provides a complete list of the tasks which refer specifically to the tasks identified for the Lagunitas Creek HSA and describes MMWD's consistency with each task.

The majority of the recommendations that are most readily applicable to MMWD's activities are the habitat improvement tasks. MMWD is already consistent with many of the tasks pertinent to the Lagunitas Creek drainage through compliance with the Sediment and Riparian Management Plan. Particularly, MMWD has addressed issues relating to fish passage, water quality, sediment management, water temperature, large woody debris habitat, and ecological refugia. However, some tasks identify ways to build on existing restoration activities. In addition, the DFG recovery strategy addresses the threat of habitat competition by way of invasive species. Lagunitas Creek so far has avoided invasions from species that directly affect the coho population but, as this document addresses, the threat remains and a formal response plan could reduce threats of infestations and improve chances of managing species that may be detrimental to coho salmon populations. The CDFG recovery strategy contains a number of recommendations that can not be evaluated for consistency with MMWD's actions because their viability in the Lagunitas Creek drainage has not been adequately researched or other entities are leading the effort to implement those tasks.

Task Number	Task Description	Identified Action Entities	MMWD Consistency
LAGUNITAS CREEK HSA			
BM-LA-01	Use recommendations of existing sediment source surveys to restore habitat of coho salmon.	Potential Lead: CDFG, NOAA Fisheries, Marin County/**MMWD** Others: NPS, DPR, **Landowners**, Marin RCD	MMWD is improving unpaved roads in Cheda Cr. McIsaac Cr., Cross-Marin Trail, and at Dog Creek to prevent chronic and catastrophic sediment loading; improvements at the Cronin Fish Viewing Area increase water infiltration and prevent use trails; conducting an assessment of all unpaved roads in the watershed, that have not already been surveyed. Also, sediment source sites identified in the1997 Lagunitas Creek Sediment and Riparian Management Plan have been stabilized.
BM-LA-02	Expand inventories as needed for a comprehensive watershed approach for coho salmon passage.	Potential Lead: CDFG, NOAA Fisheries, Marin County/**MMWD** Others: NPS, DPR, **Landowners**, Marin RCD	MMWD provided funding to SPAWN to conduct an assessment of fish passage on private roads in the San Geronimo Valley.
BM-LA-03	Coordinate with appropriate agencies to restore coho salmon passage at barriers identified by Ross Taylor, SPAWN, and others.	Potential Lead: CDFG, NOAA Fisheries, Marin County/**MMWD** Others: **Landowners**, Marin RCD, SPAWN, NPS, DPR, Caltrans	MMWD has facilitated Marin Count's fish passage projects by relocating water mains; notably at Castro Road, Evans Canyon, and Woodacre Improvement Club culverts.
BM-LA-04	Complete any needed surveys of migration barriers that were not Identified by Ross Taylor, SPAWN, and others.	Potential Lead: CDFG, NOAA Fisheries, Marin County/**MMWD** Others: **Landowners**, Marin RCD, SPAWN, NPS, DPR, Caltrans	See BM-LA-02.
BM-LA-05	Investigate opportunities for restoring historic runs of coho salmon.	Potential Lead: CDFG, NOAA Fisheries	MMWD salmonid survey monitoring data is provided to DFG & NOAA to assist their assessments.
BM-LA-06	Continue ongoing efforts and support of stewardship in the basin to include riparian enhancement and protection, sediment source reduction, habitat typing and surveying, coho salmon surveys and counts, water conservation, outreach and education, effectiveness monitoring of projects, and planning and assessment of potential restoration projects to benefit coho salmon.	Potential Lead: CDFG, SWRCB Others: **MMWD**	MMWD performs extensive monitoring of salmonid populations and habitat condicitons, including juvenile, spawner, and smolt surveys, habitat typing, and streambed monitoring
BM-LA-07	Provide incentives for septic inspection, repair, and replacement to reduce aquatic pollution.	Potential Lead: Marin County, NCRWQCB Others: **Landowners**, CDFG	Marin County, TBWC, and the San Geronimo Planning Group is leading this effort.
BM-LA-08	Assess and evaluate habitat restoration actions in Nicasio Creek.	Potential Lead: CDFG, SWRCB, Marin County/**MMWD** Others: **Landowners**, Marin RCD	MMWD has initiated water temperature monitoring in Nicasio Creek, downstream of Seeger Dam.
BM-LA-09	Implement habitat restoration actions in Nicasio Creek.	Potential Lead: CDFG, SWRCB, Marin County/**MMWD** Others: **Landowners**, Marin RCD	No restoration actions have been identified yet.
BM-LA-10	Develop a monitoring and assessment program for the estuarine reaches of Lagunitas Creek and inter-tidal reaches of Tomales Bay, looking at impacts to coho salmon rearing and emigration.	Potential Lead: CDFG, NOAA Fisheries Others: **Landowners**, NPS, DPR, Academia	MMWD collaborating and coordinating smolt outmigration monitoring surveys with NPS.
BM-LA-11	Restore Olema Marsh, Bear Valley Creek, and the mouth of Olema Creek, to benefit coho salmon. The restoration should provide rearing habitat refuge during high flows, habitat protection, and hydrologic connectivity between marshes.	Potential Lead: NPS, CDFG Others: **Landowners**, Marin RCD	MMWD is performing an assessment of winter habitat in Olema Creek, and will develop site specific plans for floodplain and/or base flow channel enhancement, in collaboration with NPS and DFG.

Task Number	Task Description	Identified Action Entities	MMWD Consistency
LAGUNITAS CREEK HSA			
BM-LA-12	Work with private landowners to encourage biotechnical bank stabilization, riparian protections, woody debris retention, and timing of water withdrawals to help protect coho salmon.	Potential Lead: Marin RCD, Marin County, CDFG Others: **Landowners**, NPS, DPR	MMWD's biotechnical bank stabilization, large woody debris, and riparian vegetation management efforts, provides educational opportunities for private landowners to observe; MMWD has issued a letter to landowners along San Geronimo Creek about water pumping or other diversions from the creek, in relation to MMWD water rights.
BM-LA-13	In the San Geronimo Creek sub-watershed, continue public outreach and education for private landowners, residents, commercial, public utility and county workers regarding best management practices to control erosion, protect riparian vegetation, retain LWD, and minimize disturbance to coho salmon from domestic animals.	Potential Lead: Marin RCD, Marin County, Watershed Groups Others: SPAWN, **Landowners**	Marin County is the lead on this effort, in collaboration with the San Geronimo Valley Planning Group, Marin RCD, SPAWN, the San Geronimo Valley Stewards. MMWD has produced an educational pamphlet on creek care, for distriction to landowners.
BM-LA-14	In the San Geronimo Creek sub-watershed, work with stock pond owners to remove non-native fish species where they are a threat to coho.	Potential Lead: Watershed Groups, CDFG, Marin RCD	SPAWN has taken the lead on this effort.
BM-LA-15	Marin County should develop a policy for reviewing the impacts of new development projects and how new well construction effects the streams. The County should consider adopting recommendations for well developments from the local coastal plan.	Potential Lead: Marin County Others: **Landowners**, CDFG, SWRCB	Marin County is the lead on this effort.
BM-LA-16	Recommend the NPS continue practices to benefit coho salmon, which include restoration projects, sediment control projects, locating fences out of riparian zones, repairing headcut gullies as possible, and implementing rotational grazing in locations to minimize erosion and impacts to the creek.	Potential Lead: NOAA Fisheries Others: CDFG, NPS	NPS is the lead on this effort.
BM-LA-17	Continue to implement and coordinate the the Watershed Protection Agreement Program for additional water hook-ups in Nicasio and San Geronimo creek watersheds.	Potential Lead: Marin **MMWD**, County Others: NOAA Fisheries, CDFG	MMWD exercises Watershed Protection Agreement for all new water hook-ups, in the San Geronimo Valley and Nicasio Creek watershed.
BM-LA-18	Look for opportunities to restore natural channel form and function in the upper watershed to protect summer flows into San Geronimo Creek.	Potential Lead: Marin County, CDFG Others: **Landowners**, NPS, DPR, NOAA Fisheries, USFWS	Marin County has taken the lead in this effort.
BM-LA-19	Continue riparian protection and sediment control projects with a focus on working with landowners to manage livestock to protect riparian areas, and to implement erosion control projects on State and Federal park and private lands (e.g., Devil's Gulch).	Potential Lead: DPR, NPS Others: **Landowners**, CDFG, NOAA Fisheries	MMWD has implemented sediment source control projects in the Cheda, McIsaac, and Devil's Gulch drainages, which has included installilng fencing to protect erosion control sites; this has been in collaboration with ranchers with grazing agreements in these basins.
BM-LA-20	Continue public outreach and education for private landowners, residents, commercial, public utility and county workers regarding best management practices to control erosion, protect riparian vegetation, retain woody debris, and minimize disturbance to coho from pets.	Potential Lead: CDFG, Watershed Groups Others: County	Marin RCD and MCSTOPPP have taken the lead in this effort.
BM-LA-21	Determine policy for reviewing new development projects and well construction. Consider adopting recommendations for well developments from the Coastal Plan.	Potential Lead: CDFG, County, Watershed Groups	MMWD reviews proposals for new wells under its policy on Wells and Other Private Water Sources; MMWD will evaluate to ensure that they will not impact the flow of Lagunitas Creek.