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

Andrew, Gregory, E. Ettlinger, E. Childress, M. Piovarcsik, D. Morrell, and A. Wolf. 2011. Lagunitas Creek Sediment and Riparian Management Plan Review and Evaluation Report. Marin Municipal Water District, June 2011.

Aquatic Environments, Inc. 2007. Aquatic weed assessment for the Marin Municipal Water District's seven reservoirs. Prepared by Aquatic Environments, Inc. July 31, 2007. 32 pp. plus appendices.

Bean, Caitlin and Mary J. Russo. 1988. Element Stewardship Abstract for *Vinca major* (Periwinkle). The Nature Conservancy.

California Department of Fish and Game (DFG). 2004. Recovery Strategy for California Coho Salmon. Report to the California Fish and Game Commission. Species Recovery Strategy 2004-1; February 2004.

California Fish and Game Website (http://www.dfg.ca.gov/)

Eng, L.L. 1981. Distribution, life history, and status of the California freshwater shrimp, *Syncaris pacifica* (Holmes). California Department of Fish and Game. Inland Fisheries Endangered Species Program Special Publication 81-1. 27 pp.

Fidenci, Pierre. 2003. Mt. Tamalpais Watershed Western Pond Turtle Study.

Leblanc, John W. 2001. Getting a Handle on Broom: Scotch, French, Spanish, and Portuguese Brooms in California. ANR Publication 8049. (http://anrcatalog.ucdavis.edu/)

Marin Municipal Water District. 1997. Lagunitas Creek Sediment and Riparian Management Plan: Final. Prepared for MMWD by Prunuske Chatham, Inc. June 1997.

Martin, Barbara A., M. K. Saiki, and Darren Fong. 2009. Habitat Requirements of the Endangered California Freshwater Shrimp (*Syncaris pacifica*) in Lagunitas and Olema Creeks, Marin County, California, USA. Journal of Crustacean Biology, 29(4): 595-604, 2009.

National Marine Fisheries Service (NMFS). 2010. Public Draft Recovery Plan for Central California Coast coho salmon (*Oncorhynchus kisutch)* Evolutionarily Significant Unit. National Marine Fisheries Service, Southwest Region, Santa Rosa, California.

Piovarcsik, Marisa and G. Andrew. 2008. Summary of water quality monitoring data for the Lagunitas Creek watershed (1995-2006); report for the Marin Municipal Water District. 16 pp. plus appendix.

Prunuske Chatham, Inc. (PCI). 2010. San Geronimo Valley Salmon Enhancement Plan: A Guidance Document. Prepared for Marin County Dept. of Public Works. Prepared by Prunuske Chatham, Inc. with assistance from Stillwater Sciences. February 9, 2010. 143 pp. plus appendices.

Reichmuth, Michael. 2007. Personal communication. Email from Michael Reichmuth (Fishery Biologist, National Park Service, Point Reyes National Seashore), July 10, 2007.

Serpa, Larry. 1991. California freshwater shrimp (*Syncaris pacifica*) survey for the U.S. Fish and Wildlife Service. Fish and Wildlife Enhancement, Sacramento Field Office. 44 pp.

Serpa, Larry. 2010. 2009 Survey of the California freshwater shrimp, *Syncaris pacifica* in Lagunitas Creek, Marin County, California. Prepared for the Marin Municipal Water District, Corte Madera, California; prepared by Larry Serpa; June 2010. 26 pp.

Smith, Ronald. 2009. Personal communication/presentation: Biological invasion of aquatic resources (Ron Smith, U.S. Fish & Wildlife Service); presented at Stop Aquatic Invasive Species Workshop, Bay Model, Sausalito, September 2009.

State Water Resources Control Board (SWRCB). 1995. 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. 120 pp.

Stillwater Sciences. 2007. Middle Lagunitas Creek watershed sediment delivery analysis. Prepared for Department of Public Works, County of Marin; prepared by Stillwater Sciences; May 2007. 53 pp. plus figures and appendices.

Stillwater Sciences. 2008. Lagunitas limiting factors analysis: limiting factors for coho salmon and steelhead. Prepared for Marin Resource Conservation District; prepared by Stillwater Sciences; March 2008. 72 pp. plus appendices.

Strzelec, M. 2005. Impact of the introduced *Potamopyrgus antipodarum* (Gastropods) on the snail fauna in post–industrial ponds in Poland. Biologia (Bratislava) 60(2):159–163.

Tomales Bay Watershed Council (TBWC). 2003 Tomales Bay Watershed Stewardship Plan: A Framework for Action. TBWC, July 2003. 137 pp.

Tomales Bay Watershed Council (TBWC). 2007. Tomales Bay Integrated Coastal Watershed Management Plan. Submitted to State of California, State Water Resource Control Board; submitted by TBWC; July 2007.

University of California, Davis (http://wric.ucdavis.edu/yst/)

U. S. Fish and Wildlife Service. 1998. Recovery Plan for the California freshwater shrimp (*Syncaris pacifica* Holmes 1895). Portland, Oregon. 96 pp.

U. S. Fish and Wildlife Service. 2007. California Freshwater Shrimp (*Syncaris pacifica*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service Sacramento Fish and Wildlife Office, Sacramento, California. 20 pp.

U. S. Fish and Wildlife Service (http://www.fws.gov/invasives/)

U. S. Forest Service (http://www.na.fs.fed.us/fhp/invasive_plants/)

U. S. Geological Survey (http://www.usgs.gov/)

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

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