San Francisco Estuary Watersheds Evaluation

Identifying Promising Locations for Steelhead Restoration in Tributaries of the San Francisco Estuary

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By

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TABLE OF CONTENTS

Executive summary

This report summarizes the results of a novel, region-wide analysis that for the first time provides planners and resource agency staff a thoroughly documented, transparent guide to prioritizing expenditures on steelhead restoration in the watersheds tributary to the San Francisco Estuary. All readily available documentation about steelhead was gathered, and local experts interviewed, to establish the most comprehensive record currently available on the distribution of the species and its habitat. This document was vetted with members of academia, agency staff, and others with expertise, and provides a systematic and transparent basis for recommending Bay Area locations with the greatest promise to achieve steelhead conservation and restoration.

The method used in this study assumes that watersheds containing the greatest amount of functioning steelhead rearing habitat are most likely to contribute to smolt production and therefore to the strength of the regional spawning run. Identifying functioning habitat routinely is confounded by various factors, however, including temporal variation in habitat quality, existence of passage barriers, migration-limiting flows, and the quality of available data. Despite these challenges, this study was undertaken as an attempt to advance Bay Area steelhead restoration planning due to the current perilous condition of the species. We propose that steelhead populations of the Bay Area should receive attention as they typically have relatively short migration distances to spawning areas (with lower accociated mortality risk), may serve as a disturbance-resistant, regional "metapopulation," and occupy streams with high potential for maintaining or establishing long-term instream flow provisions.

Bay Area watersheds were assessed using two criteria: the existence of reproducing steelhead populations and the amount of rearing habitat available. Of the 58 watersheds tributary to the estuary, 24 support steelhead and/or resident rainbow trout reproduction. We estimate there are about 360 stream miles of habitat suitable for rearing in these 24 watersheds collectively. However, the existence of many total migration barriers, particularly large dams where fish ladders are unlikely to be constructed, means that only 230 miles of this habitat can be made available to steelhead.

Eight of our region's watersheds account for about 75 percent (i.e., 175 stream miles) of the regional habitat resources, and we call these "anchor watersheds" to reflect their importance. They include Alameda, Coyote, San Francisquito, Corte Madera, Sonoma and Suisun creeks and the Guadalupe and Napa rivers. Within these watersheds, we examined 54 mainstem streams and tributaries for the amount of habitat in each in order to identify a set of "essential streams" that may be used to focus restoration efforts further. Our analysis indicates that one third (18) of these streams collectively contain about 73 percent of the anchor watershed rearing habitat, and we recommend these streams form the basis of a regional effort to restore steelhead trout.

We assessed past and on-going collaborative restoration planning efforts in the anchor watersheds as well, since multi-stakeholder collaboration is essential for watershed-scale restoration. In general, excellent collaboration has produced many high quality analyses in the anchor watersheds, with the exception of Suisun Creek. Additional collaborative habitat analysis and planning is recommended for successful restoration in this watershed. We also examined the amount of open space present in the anchor watersheds and the degree to which open space is protected through ownership or management policies. This analysis was required given the ecological value of securing the best habitat areas prior to investing in major restoration efforts (since lack of land use controls can create problems such as inadequate instream flow provision or high sedimentation rates). The most urbanized anchor watershed is Corte Madera Creek, where open space constitutes about 42 percent of the total watershed area. However, 90 percent of the Corte Madera Creek watershed open space is protected. While Suisun Creek's watershed is 90 percent open space, only 11 percent is protected, suggesting the need for landowners in this watershed to be engaged in any future restoration programs to ensure success.

This report also identifies projects, studies, and other actions recommended for each anchor watershed. While the resulting recommendations may serve to guide restoration expenditures, it should be noted that significant additional work remains before a restora-

tion "road map" exists. In particular, several watersheds need habitat and passage barrier inventories, and important erosion control and instream flow studies have not been completed in most of the study area. Finally, the process of prioritizing projects within individual watersheds according to reasonable criteria is not well developed in the region.

Despite the on-going and admirable efforts of the many members of the Bay Area restoration community, the state of the steelhead resource in streams of the San Francisco Estuary remains dire, and economic and environmental factors will continue to threaten existing habitat. We suggest that the current study be used to focus restoration activities, bringing the best land use practices, monitoring, stakeholder collaboration efforts, and watershed analyses to bear as quickly as possible. We hope also that agreement on regional restoration priorities will help attract available funding to this important program. Restored steelhead runs in Bay Area streams will inspire the public to protect our waterways, and will provide a valuable mechanism for ecosystem-scale planning and management.

Introduction

In 2005, researchers published a comprehensive review of the distribution of steelhead/rainbow trout (*Oncorhynchus mykiss*) in streams tributary to the San Francisco Estuary. This analysis (Leidy *et al.* 2005) documented several important factors concerning regional steelhead resources. First, *O. mykiss* remains in a large percentage of the watersheds (approximately 81 percent) and streams (approximately 69 percent) it occupied historically, although the ability to complete the anadromous life cycle has been impacted substantially. Second, population declines have occurred in most if not all of the Bay Area's steelhead streams. Also, the study suggested there is a paucity of information, particularly quantitative information, regarding the steelhead resource.

Activities that benefit steelhead such as modifying fish passage barriers, reducing sedimentation, and providing instream flows for habitat are being undertaken throughout the region. A variety of stakeholders including water and flood control districts, parks, cities, counties and regional resource agencies, watershed groups, the Department of Fish and Game (DFG), and others are pursuing many important studies and projects through a set of diverse funding sources. The California State Coastal Conservancy (hereafter, Conservancy) receives a large number of requests for support of such stream restoration-related efforts, and the potential benefit to steelhead is cited regularly as a rationale for funding. With limited funds available for restoration, Conservancy staff determined that an analysis of steelhead restoration opportunities in the Bay region was likely to allow for more efficient expenditures toward the goal of steelhead conservation and restoration.

It is in this context that the present study, the San Francisco Estuary Watersheds Evaluation, was conceived. In consultation with staff from DFG and the Conservancy, the Center for Ecosystem Management and Restoration (CEMAR) developed an intuitive, information-based approach to identifying critical steelhead resources in the region. Our approach involves "screening" Bay Area watersheds using two criteria to identify and characterize steelhead resources (*i.e.*, populations and habitat) in the region. We then propose groupings of watersheds based on the estimated habitat, measured in stream miles, they offer anadromous life history *O. mykiss* populations. Watersheds containing the most extensive habitat resources are deemed "anchor watersheds," and are described further in terms of on-going restoration activities and planning, involved stakeholders, watershed protection and provision of instream flows. Our analysis also lends itself to enumerating a number of "essential streams" within the anchor watersheds, or streams that stand out for their significant potential contribution to the regional steelhead population. In addition, this report seeks to direct attention to a set of projects, policies, and future investigations we consider critical elements of a regional restoration strategy aimed at conserving and expanding steelhead resources in the anchor watersheds and in a second group of other notable watersheds.

The approach used in this study stresses the importance of conserving and restoring watersheds with larger amounts of habitat based on our understanding that they offer the greatest potential for producing juvenile steelhead. It may be argued that stream restoration actions in watersheds with lesser steelhead resources merit priority based on cost efficiency, public education value, the presence of other target species or assemblages, or other factors (Grossinger pers. comm.). While we support stream restoration in general, we seek to identify the set of watersheds in which restoration actions are mostly likely to secure and/or increase steelhead production in the near term. This goal appears to correspond with the basis for recovery planning efforts being made by staff at the National Marine Fisheries Service (NMFS). As part of the basis for recovery planning, NMFS recently produced an analysis of the historical population structure of steelhead in Bay Area stream systems (Bjorkstedt *et al.* 2005). The analysis found five "functionally independent populations" amongst the Bay Area tributaries as well as ten "potentially independent populations." Watersheds in these categories are typically larger and are deemed to have a high likelihood of persisting over 100-year time scales. (Presumably, these watersheds will be emphasized in the recovery plan for the region.) The NMFS report notes that "dependent" populations (usually located in smaller watersheds) "are not themselves dominant sources of dispersers," yet serve other roles in maintaining the regional population. Just as NMFS' steelhead recovery planning places a lesser but important role on "dependent" populations for achieving long-term population viability, the current study de-emphasizes immediate steelhead restoration related expenditures in non-anchor, typically smaller watersheds while acknowledging the important functions these systems serve, including providing buffer against catastrophic disturbance and as pathways for incremental dispersal. We encourage restoration of such systems, particularly when conducted as part of a regional, prioritized action plan. A recent publication regarding native fishes of San Francisco Estuary tributaries by Dr. Robert Leidy of the U.S. EPA could serve as the basis for an assemblage-based restoration strategy (Leidy 2007).

A draft of this watersheds evaluation was produced in March 2007 and circulated to various reviewers. We received approximately 25 comment letters that were used to revise the report in various ways. Most importantly, recently developed information was provided that improved the characterization of steelhead habitat in San Francisco Estuary tributaries. Also, the method was altered to make the analysis clearer, and additional assumptions were stated. Finally, changes have been made throughout the report that better reflect the knowledge of agency staff, academics, watershed group members, and others regarding steelhead resources in the region.

This report is intended in part to stimulate discussion leading to consensus on a science based, proactive program of steelhead related stream restoration activities with the highest possible degree of return on investment. Focused work in anchor and other watersheds during the next decade has the potential to prevent further decline of the threatened steelhead in our region, thus avoiding the fate of coho salmon. The extirpation of coho from S.F. Estuary streams was due in part to the lack of documentation of coho habitat resources and a well-reasoned plan to protect them. It is critical that steelhead not be similarly lost due to inadequate planning.

Methods

We used two criteria to identify the Bay Area watersheds with the greatest potential contribution to steelhead conservation and restoration: 1) presence of reproducing *O. mykiss* populations; and 2) existence of substantial available steelhead rearing habitat. Since our study area incorporated a large number of watersheds (58), we applied a sequential evaluation approach rather than rank all watersheds for both criteria. Thus, watersheds had to satisfy the first criterion to be analyzed under the second. Definitions for the criteria and discussion of the method of application are provided below. A detailed description of the information sources, assumptions, and evaluation process associated with each criterion is included as Appendix A of this report.

1. Reproducing *O. mykiss* populations

This characteristic indicates the presence of functioning spawning and rearing habitat in a watershed over time. Evaluation under this criterion was based largely on information contained in Leidy *et al.* (2005). In some instances, we made additional inquiries to supplement the record concerning the location of reproducing *O. mykiss* populations. For a watershed to "move on" in the evaluation, it had to have evidence of *O. mykiss* occurring during the last ten years.

2. Available *O. mykiss* rearing habitat

We reviewed information in Leidy *et al.* (2005), its source materials, and a substantial number of additional sources to determine the stream reaches with suitable *O. mykiss* rearing habitat. We did not attempt to differentiate between habitat used exclusively by resident rainbow trout or by anadromous steelhead, as information regarding the life history form of *O. mykiss* populations in San Francisco Estuary tributaries is not well understood. Rather, habitat is considered suitable if sufficient observational or other information exists to indicate that it supports or could support rearing given reasonably anticipated management changes.

The amount of information available and its quality varied considerably amongst watersheds, and we made every effort short of conducting additional field work to complete the record regarding this criterion. It should be noted that habitat estimates do not include weighting for the quality of the habitat and resulting variable juvenile salmonid growth rates. Also, we have not attempted to estimate habitat available in different water year types. Our approach provides screening level estimates of rearing habitat in average water years as data do not exist on which to base more elaborate evaluations. In some cases, we used professional judgment to "standardize" information. (For example, various habitat assessment methods relied on various qualitative and quantitative ranking systems, and we attempted to include habitat most closely associated with the descriptor "good" in our data set.)

Habitat was mapped and stream miles were measured using ArcGIS. We then identified total barriers to fish passage using published information and, in some cases, interviews and professional judgment. Habitat upstream from barriers with a high likelihood of modification was retained in our calculations as "available," while habitat upstream from barriers with little likelihood of modification was removed. We determined the likelihood of barrier modification by evaluating factors such as the existence of plans for modification, statements made by representatives of barrier-owning institutions, and fiscal and institutional hurdles. For example, large, functioning water supply dams were considered unlikely to be modifiied. This step resulted in estimates of habitat available to anadromous steelhead.

It should be noted that this step discounts the value of streams with reproducing resident rainbow trout and substantial rearing habitat upstream from total barriers unlikely to be modified for passage. (Our approach should be viewed as reflecting current agency guidance that discourages long-term trap and haul programs or similar efforts to use habitat upstream from total barriers toward steelhead recovery rather than an endorsement of this policy.) Further, available rearing habitat may be overestimated in some instances due to the presence of partial barriers that prevent access under some conditions. Our analysis assumes that such barriers will be mitigated eventually in important steelhead streams. It should be noted also that some rearing habitat counted in our analysis may not contribute to steelhead production due to lack of outmigration flows. We do not exclude these areas on the basis that flows may be provided in the future (through re-operation of water supply facilities, channel modification, or other method) and because we find insufficient evidence regarding outmigration success to discriminate between rearing areas in the region for their relative contribution to the steelhead population. These issues are further described below, and in Appendix B.

Finally, we used the statistical technique of cluster analysis (*i.e.*, Ward's minimum variance method) to establish a threshold value for our anchor watershed category. Reviewers of the draft of this report noted that cluster analysis typically is applied to multi-variate statistics. In our application, it is used as a hierarchical method designed to indicate clusters based on minimum variance without introducing observer bias. Additional discussion of the method's application and implications is provided in Appendix A. The statistical analysis was applied to the set of values for our metric (*i.e.*, miles of rearing habitat) to produce clusters of most closely related values. Watersheds in the cluster with the highest median habitat value were deemed to be anchor watersheds. The watersheds in the lower ranking clusters were not deemed anchor watersheds and were not analyzed for collaborative restoration planning or open space protection. Watersheds with available habitat values in the highest group (*i.e.*, anchor watersheds) were reviewed regarding collaborative restoration planning and open space protection as described below.

Our understanding of watershed restoration suggests that stream restoration projects, particularly expensive projects or those involving changes in land or resource uses, are unlikely to be implemented without powerful driving forces. Therefore, we reviewed candidate anchor watersheds for the presence of effective, collaborative restoration planning processes. Watersheds where key stakeholders are engaged in advanced planning processes producing professional-quality assessments are considered better targets of restoration related funding.

We used land use analysis to discriminate between watersheds according to level of protection afforded the upstream areas. Previous studies have found the protection of headwaters to be a critical component of successful restoration. For example, the Pacific Rivers Council recommends "comprehensive protection of the remaining relatively healthy headwaters" and restoration "focused on securing the relatively healthy areas, followed by expanding these areas" (Doppelt *et al.* 1993 p. 33-34). For the purposes of this study, the discussion is used to link spending on steelhead restoration with additional plans, policies and projects that reduce threats to habitat from water supply projects and land uses, notably uses that affect riverine and riparian areas directly. We used ArcGIS to show open space within the anchor watersheds in relation to open space than can reasonably be considered "protected."

Within the anchor watersheds we identified "essential streams," or streams of particular importance for *O. mykiss* populations. This process relied on a statistical analysis of available habitat in the various anchor watershed mainstems and tributaries. In some cases, the values for stream habitat in tributaries were combined to reflect our understanding of the ecological function of the sub-basin. For example, habitat in Bear Creek is considered with Sonoma Creek habitat because we believe steelhead from the run of a given year are likely to visit both streams in seeking spawning sites. We again used cluster analysis to establish a threshold value within the data set of habitat available in anchor watershed streams. Those with lower habitat values than our threshold have not been flagged as essential streams for the purposes of this discussion. It should be noted that not all tributaries in the anchor watersheds have been considered in this step. We are aware of a small but not insignificant number of streams for which there is evidence of steelhead presence but little or no characterization of habitat. It is beyond the scope of this project to undertake habitat assessments, and therefore some streams have been "missed."

Lastly, watersheds with available habitat values lower than the threshold but of obvious regional importance were reviewed in terms of steelhead resources, limiting factors, and restoration planning. We wish to re-emphasize that our approach is not intended to discourage restoration activities in non-anchor watersheds or in streams not deemed essential. Rather, we intend to use the available information to focus attention on the relative value of restoration actions in a select number of streams.

Results

This section presents an overview of the watersheds screening process for the sake of brevity. In the following we summarize the results of applying the criteria to all Bay Area watersheds, identify the anchor watersheds, and briefly discuss the manner in which the anchor watersheds satisfied the criteria. The results of our investigation into the status of collaborative restoration planning processes and the level of protection of watershed lands also is presented. Lastly, we provide the results of the essential streams analysis and characterize some important non-anchor watersheds. Detailed screening results for both anchor and non-anchor watersheds is included as Appendix B.

Fifty eight watersheds tributary to the San Francisco Estuary were considered in this analysis (Map 1). Applying the first criterion screened out 34 watersheds because they did not contain reproducing *O. mykiss* populations (Table 1; Table B-1, Appendix B). The remaining 24 watersheds were screened for the amount of habitat they contained (Appendix B). Our estimates of the total amount of suitable *O. mykiss* habitat in each of the watersheds is shown in Table 2, and the geographical distribution is presented on Map 2. (See also Table B-2, Appendix B).

Our review of passage barriers indicated that numerous San Francisco Estuary tributaries contain total barriers that are unlikely to be modified for passage or removed in the near-term (*i.e.*, within about ten years)(Table B-3, Appendix B). We therefore subtracted the suitable *O. mykiss* habitat upstream from these total barriers to produce our estimates of total available habitat. These estimates are presented in Table 2 and Figure 1, and the geographic extent of the habitat is depicted on Map 2. (See also Table B-2, Appendix B). Our data analysis produced a threshold value of about seven stream miles that we suggest represents a regionally significant amount of habitat in a single watershed. Further description of the threshold value calculation is provided in Appendix B.

Our screening found that eight watersheds tributary to the San Francisco Estuary qualify as anchor watersheds, or areas where restoration actions likely will have the most powerful effect on conserving and restoring steelhead. These watersheds are Alameda Creek, Coyote Creek, the Guadalupe River, San Francisquito Creek, Corte Madera Creek, Sonoma Creek, the Napa River, and Suisun Creek (Map 3). In the following, we review some of the features of these watersheds and describe our understanding of the state of collaborative restoration planning in each, as well as the results of our analysis of the open space protection afforded. The amount of protected open space and the ratio of protected open space to total open space area vary widely amongst the eight watersheds as shown in Table 3.

Anchor watersheds

Alameda Creek. Reproducing *O. mykiss* populations occur in mainstem Alameda Creek, in Stonybrook Creek, and possibly in other tributaries. Suitable habitat exists in Arroyo Mocho, although the existing population appears to be of hatchery origin. The watershed's most extensive habitat resources and most abundant *O. mykiss* populations occur upstream from dams, however, and the so-called BART weir in the lower creek is a total barrier to upstream migration. Currently, Alameda Creek supports anadromous

map 1, p. 1

Map 1, p. 2

Table 1. San Francisco Estuary watersheds criterion 1 screening results (Key: Y = Yes, N = No)

County	Watershed	Criterion 1: Reproducing *O. mykiss* population?
Contra Costa	Marsh Creek	N
	Mt. Diablo Creek	N
	Walnut Creek	N
	Alhambra Creek	N*
	Rodeo Creek	N
	Refugio Creek	N
	Pinole Creek	Y
	Garrity Creek	N
	San Pablo Creek	Y
	Wildcat Creek	Y
	Cerrito Creek	N
Alameda	Codornices Creek	Y
	Strawberry Creek	N
	Temescal Creek	N
	Glen Echo Creek	N
	Sausal Creek	N
	Peralta Creek	N
	Lion Creek	N
	Arroyo Viejo Creek	N
	San Leandro Creek	Y
	San Lorenzo Creek	N*
	Alameda Creek	Y
	Laguna Creek	N
Santa Clara	Coyote Creek	Y
	Guadalupe River	Y
	San Tomas Aquino Creek	Y
	Calabazas Creek	N
	Stevens Creek	Y
	Permanente Creek	N
	Adobe Creek	N
	Barron / Matadero Creeks	N
San Mateo	San Francisquito Creek	Y
	Redwood Creek	N
	Cordilleras Creek	N
	Belmont Creek	N
	Laurel Creek	N
	San Mateo Creek	Y
	Sanchez Creek	N
	Easton Creek	N
	Mills Creek	N
	Colma Creek	N
Marin	Coyote Creek	N
	Arroyo Corte Madera del Presidio	Y
	Corte Madera Creek	Y
	Miller Creek	Y
	Pacheco Creek	N
	Arroyo San Jose	N
	Novato Creek	Y
Sonoma	Petaluma River	Y
	Sonoma Creek	Y
	Schell Creek	Y
Napa	Huichica Creek	Y
	Napa River	Y
	Fagan Creek	N
	American Canyon Creek	N
Solano	Unnamed to Cordelia Slough	Y
	Green Valley Creek	Y
	Suisun Creek	Y

* See discussion in Appendix B

Table 2. Suitable and available *O. mykiss* rearing habitat in SF Estuary watersheds.

Suitable habitat is all stream reaches capable of supporting juvenile rearing regardless of relationship to migration barriers; available habitat is both capable of supporting juvenile rearing and accessible to spawning steelhead (*i.e.,* downstream from total passage barriers). Watersheds are listed beginning in Contra Costa County clockwise around the San Francisco Estuary.

		Habitat (stream miles)	
County	Watershed	Suitable	Available
Contra Costa	Pinole Creek	5.8	5.8
	San Pablo Creek	4.8	4.3
	Wildcat Creek	5.1	5.1
Alameda	Codornices Creek	1.3	1.3
	San Leandro Creek	9.9	1.3
	Alameda Creek	63.3	12.7
Santa Clara	Coyote Creek	34.6	13.7
	Guadalupe River	26.4	16.7
	San Tomas Aquino/Saratoga	10.1	0.0
	Stevens Creek	8.1	3.7
San Mateo	San Francisquito Creek	18.1	18.1
	San Mateo Creek	3.3	2.8
Marin	Arroyo Corte Madera del Presidio	6.7	6.7
	Corte Madera Creek (Marin Co.)	12.3	11.6
	Miller Creek	5.0	5.0
	Novato Creek	4.8	4.8
Sonoma	Petaluma River	5.5	5.5
	Sonoma Creek	29.1	27.8
	Schell Creek	4.4	4.4
Napa	Huichica Creek	2.5	2.5
	Napa River	82.0	63.4
	Unnamed trib. to Cordelia Slough	1.7	1.7
Solano	Green Valley Creek	3.9	3.9
	Suisun Creek	9.6	9.6

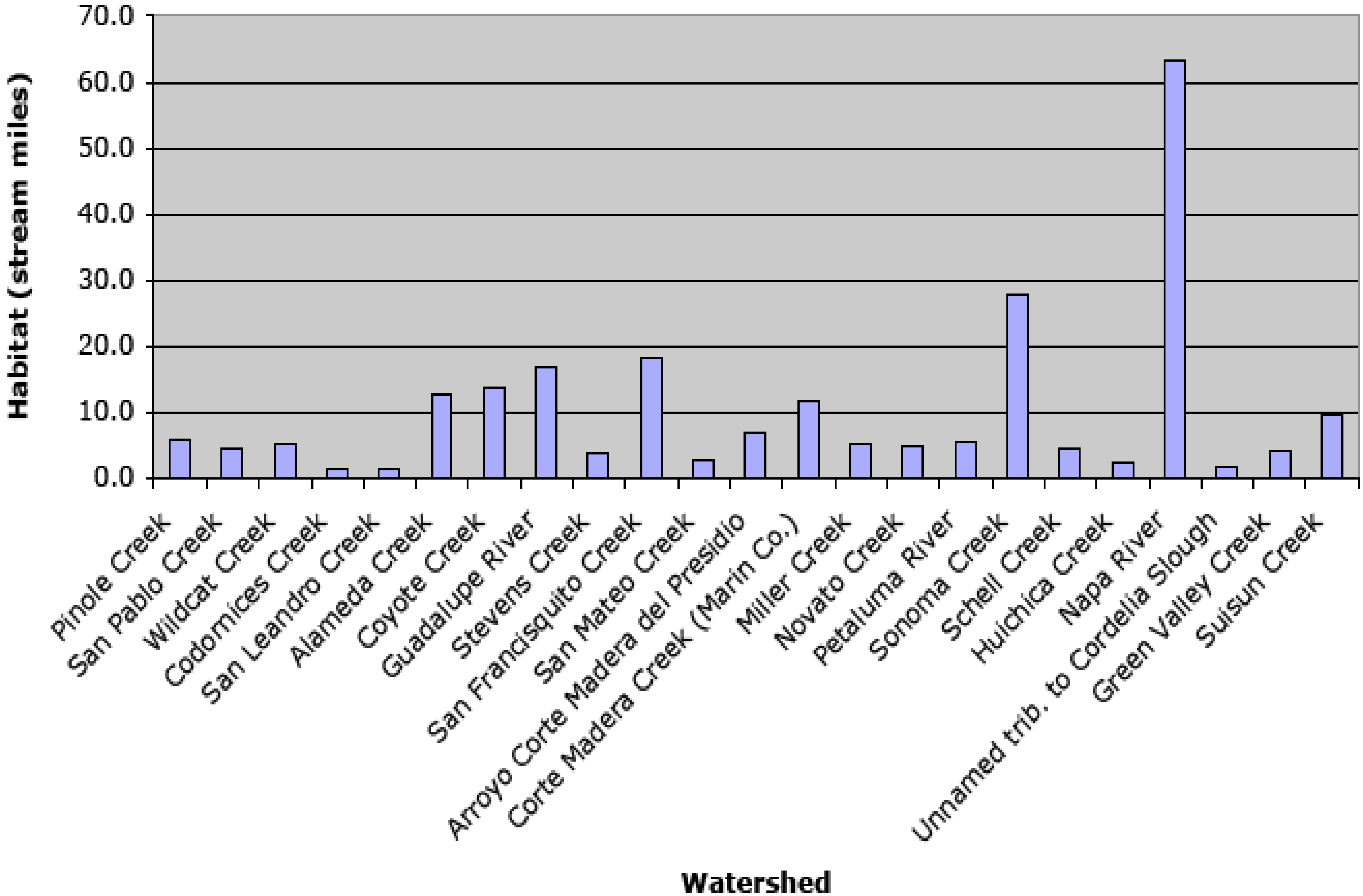
Table 3. Open space information for SF Estuary anchor watersheds
Please see appendix A for a description of open space analysis methods.

Watershed	Area (sq. mi.)	Open space (sq. mi.)	Protected open space (sq. mi.)	Open space/ Area (%)	Protected open space/ Area (%)	Protected open space/ Open space (%)
Alameda Creek	652	585	146	90	22	25
Coyote Creek	371	288	126	78	34	44
Guadalupe River	160	86	53	54	33	61
San Francisquito Creek	40	21	16	52	40	78
Corte Madera Creek	25	10	9	42	37	90
Sonoma Creek	155	125	35	80	22	28
Napa River	417	348	82	84	20	24
Suisun Creek	51	50	5	98	10	11

map 2, p. 1

Map 2, p. 2

Figure 1. Available *O. mykiss* habitat in SF Estuary watersheds



steelhead propagation only when in-migrating adults are detected, captured, and released upstream from total passage barriers in the flood control channel, access to suitable spawning habitat is available, and sufficient flow exists for rearing.

The existing steelhead run in Alameda Creek consists of a very small number of individuals. In-migrants appear to be wild fish, but their stream origin has not been determined. It also is unknown if the adfluvial populations of Calaveras and San Antonio reservoirs or resident rainbow trout in the watershed produce smolts that become the spawning steelhead observed in recent years. Since it appears feasible to build a fishway at the BART weir and other lower watershed barriers for fish passage (CH2M HILL 2001; Wood Rodgers 2006), we included areas upstream from the BART weir in our estimates of available habitat. Plans do not exist to modify Calaveras or San Antonio dams for fish passage, however, and we did not assume habitat upstream from these structures would be available to steelhead in the future.

The Alameda Creek Fisheries Restoration Workgroup includes all major stakeholders in the watershed and has been working collaboratively since 1999 to restore steelhead. A draft action plan has been prepared to guide restoration and several important passage projects have been completed, are underway, or are in advanced states of planning. A relatively small proportion (about 25 percent) of the watershed's open space may be considered protected. However, the area draining into upper Alameda Creek is owned largely by the San Francisco Public Utilities Commission (SFPUC), which considers steelhead habitat value in its management plans.

Coyote Creek. This watershed supports *O. mykiss* reproduction, although Smith (1998) and others note low abundance in the system. The majority of the historical steelhead habitat is upstream from the current location of Anderson Reservoir and therefore unavailable to in-migrating steelhead. Existing habitat resources consist of the Anderson Reservoir tailwater fishery (immediately downstream from the dam) and portions of the Upper Penitencia Creek sub-basin. A drop structure on Upper Penitencia Creek in Alum Rock Park presents a severe partial barrier to fish passage, but an engineering analysis to modify the barrier is underway (CEMAR in preparation).

A comprehensive settlement process involving water suppliers, local agencies, environmentalists, and other stakeholders (*i.e.*, the Fisheries and Aquatic Habitat Collaborative Effort, FAHCE) identified the Coyote Creek watershed as one of the three most important steelhead restoration opportunities in Santa Clara County. The Watershed Management Initiative (WMI) and subsequent monitoring and planning processes have introduced stream restoration strategies for the watershed. In particular, the City of San Jose and the Santa Clara Valley Water District (SCVWD) are principal sponsors of restoration projects. A number of local stakeholders are in the process of preparing a Habitat Conservation Plan (HCP) for the Santa Clara Valley (SCV) that will address steelhead habitat, including in the Coyote Creek watershed. A draft HCP was published in May 1997. More information is available on the SCVHCP website.

The Coyote Creek watershed produced a mid-range ranking for the proportion of open space that is protected to total open space (*i.e.,* ~44 percent). However, Alum Rock Park contains a substantial portion of the upper watershed of Upper Penitencia Creek and is managed pro-actively to conserve and restore natural resources.

Guadalupe River. This is an historical steelhead stream, although the amount of production may have been limited by such factors as migration distance and duration of migration season flows. Steelhead continue to use the Guadalupe River system and expanded their range in 1999 when a fishway on the mainstem river became functional. Habitat occurs in the Guadalupe Creek and Alamitos Creek sub-basins, where conditions are affected substantially by operation of water supply facilities. Resident rainbow trout populations also persist in upper portions of the watershed.

The Guadalupe River watershed was identified by FAHCE as offering one of the best steelhead restoration opportunities in Santa Clara County. Although the construction of dams on the river's tributaries reduced available habitat, the existence of water supply facilities now aids in management for steelhead. Much of the stream habitat in the watershed is managed by the SCVWD, which uses policies set forth in the WMI and other sources to determine strategy. A number of local stakeholders are in the process of preparing an HCP for the Santa Clara Valley that will address steelhead habitat, including in the Guadalupe River watershed. A draft HCP was published in May 1997. More information is available on the SCVHCP website. Stream mangement may be influenced in the future by the Natural Flood Control Program and the Watershed Protection Collaborative (Abel pers. comm.).

The Guadalupe River watershed had the third highest level of protection for open space in its watershed of the eight anchor watersheds (*i.e.*, about 61 percent protected). However, we determined that the areas adjacent to the essential streams in the watershed (*i.e.*, Guadalupe and Alamitos creeks) are not well protected. Further, the Guadalupe system contains a long migratory route through highly urbanized areas to high quality spawning and rearing habitat.

San Francisquito Creek. This watershed may have had a substantial historical steelhead run and appears to have supported coho salmon as well due to the presence of high quality habitat including cold, perennial streamflow and dense riparian canopy (Leidy, Becker, and Harvey 2005). Steelhead continue to utilize the creek, and *O. mykiss* populations occur in the mainstem and notably in Los Trancos, Bear, and West Union creeks. Searsville Dam prevents access to substantial habitat areas in the Corte Madera Creek sub-basin. The status of planning for dam removal indicated that upstream areas are not available habitat. Thus, providing passage at this site would make the San Francisquito Creek watershed still more important in terms of steelhead restoration opportunities in the San Francisco Bay Area.

The San Francisquito Watershed Council consists of various stakeholders and addresses steelhead restoration in the watershed. On-going passage barrier modification projects are being conducted that stemmed from the recommendations contained in a passage analysis commissioned by a steelhead task force. Extensive stream surveys have been conducted in recent years. Major project sponsors in the watershed include the San Francisquito Watershed Council, Stanford University, San Mateo County Parks Department, and the town of Portola Valley. According to staff at Stanford University, a habitat conservation plan under development will include "permanent dedication of all the Stanford portions of San Francisquito, Los Trancos, and Bear creeks" (Launer pers. comm.).

About 78 percent of the total open space in the San Francisquito Creek watershed is protected. This characteristic suggests that land uses in the upper watershed areas are likely to be consistent with actions to conserve and restore steelhead habitat. Providing fish passage into the Corte Madera Creek sub-basin would access valuable open space resources.

Corte Madera Creek (Marin County). Good natural rainbow trout propagation is occurring in the Corte Madera Creek watershed. The principal tributary in terms of steelhead production appears to be San Anselmo Creek, while Ross, Sleepy Hollow, and Cascade creeks are important habitat resource contributors. Fish passage problems exist in the lower portions of Corte Madera Creek but on-going efforts to mitigate these problems led us to include upstream habitat as available to steelhead in the future.

This watershed involves numerous jurisdictions and other stakeholders, presenting a challenge to coordinating watershed improvement actions. However, the not-for-profit group Friends of Corte Madera Creek Watershed has commissioned comprehensive, advanced studies to inform restoration including habitat characterization, examination of watershed geomorphology, and fish passage assessment. An extensive hydrology study presently is being conducted by the Marin County Flood Control and Water Conservation District (with funding from the Conservancy) to evaluate flooding impacts of potential restoration activities.

The Corte Madera Creek watershed had the highest level of open space protection of the anchor watersheds (*i.e.*, about 90 percent). In particular, the headwaters of Corte Madera Creek in the Cascade Canyon Open Space Preserve may be considered an important regional steelhead resource.

Sonoma Creek. Research suggests that the Sonoma Creek watershed probably supported the second largest steelhead run among Bay Area streams historically. Currently, relatively high densities of rainbow trout are found in the mainstem creek and in several important tributaries such as Agua Caliente, Calabazas, and Stuart creeks. A total barrier on Stuart Creek is being evaluated for removal; habitat upstream from this barrier therefore was considered available.

The Sonoma Ecology Center (SEC) has sponsored or conducted several focused and rigorous studies of the watershed including a steelhead census, habitat characterizations, and a limiting factors analysis. The group works with stakeholders including public agencies and private citizens to advance stream restoration processes and fund project implementation. As the Regional Water Quality Control Board has listed the creek as impaired by sediment, the watershed has an additional, potentially important restoration "driver."

A relatively small proportion of open space in the Sonoma Creek watershed is protected (*i.e.*, ~28 percent). However, open space comprises a large proportion of the Sonoma Creek watershed largely due to agricultural land use. Land ownership in relationship to steelhead restoration planning is explored further in the Discussion section of this report.

Napa River. Leidy *et al.* (2005) concluded that the Napa River historically supported the largest steelhead run in the Bay Area. Possibly the most thorough fish surveys ever performed in the Bay Area were sponsored by Friends of the Napa River (FONR) and led to identifying Dry, Redwood, Sulphur, and Soda creeks as important contributors to the steelhead fishery. Dams on several tributaries on the Napa Valley's east side removed upstream areas from consideration as available steelhead habitat in the future for the purposes of this study.

Major stakeholders in the watershed include municipalities, the county, agricultural interests, and others. Efforts by FONR and the Napa County Resource Conservation District (RCD) and various consultants have increased the understanding of steelhead resources dramatically in recent years. Sedimentation reduction plans and projects also are being developed due in part to the watershed's listing as impaired by the Regional Water Quality Control Board. Decreasing siltation is a key element of a comprehensive restoration program for the basin.

The Napa River watershed also has a relatively low proportion of open space that is protected (*i.e.*, ~24 percent) and a high ratio of open space to total watershed area. Similar to the Sonoma Creek watershed, open space comprises a large proportion of the Napa River watershed due to extensive agricultural land use.

Suisun Creek. The Suisun Creek steelhead run was substantially affected by the construction of Gordon Valley Dam in 1926. However, *O. mykiss* continue to use this watershed and adults and juveniles have been observed in the mainstem below Lake Curry and in Wooden Valley Creek in recent years (Leidy *et al.* 2005). The steelhead population and habitat resources of this watershed have the poorest documentation of the eight anchor watersheds.

The Suisun Creek Restoration Team was formed in 1999 to reflect the interests of various stakeholders and to advance restoration planning. A watershed assessment and enhancement plan for Suisun Creek was produced in 2004. This watershed appears to have the least developed stakeholder-driven restoration process of the eight anchor watersheds. Interestingly, the Suisun Creek watershed has both the highest open space/watershed area ratio of the anchor watersheds and the lowest level of open space protection of the anchor watersheds (*i.e.*, about ten percent of open land is protected). The implications of land ownership in the watershed are explored further in the Discussion section of this report.

Essential streams

The evaluation of essential streams involved screening the mainstems of the anchor watersheds and all of the tributaries for which we could find fisheries information (Table 4; Figure 2). More than 20 of these tributaries had values of "0" for available habitat and were removed from consideration in our statistical analysis. The data set of potential essential streams consisted of 51 mainstems and tributaries. As previously mentioned, habitat values were combined for some streams to form "systems."

Statiscal analysis of the variance between habitat values for the anchor watershed streams determined six major clusters (Figure B-2, Appendix B). The two clusters including streams with the greatest amount of habitat were associated closely and comprise a set of nine streams that should be considered essential steelhead resources of the San Francisco Estuary. These streams are Alameda Creek, Coyote Creek, Alamitos Creek, Bear Creek (San Francisquito Creek watershed), Sonoma Creek, mainstem Napa River, Redwood and Dry creeks in the Napa River watershed, and Suisun Creek (Map 3). The median habitat value for this group of streams is about 9.3 stream miles.

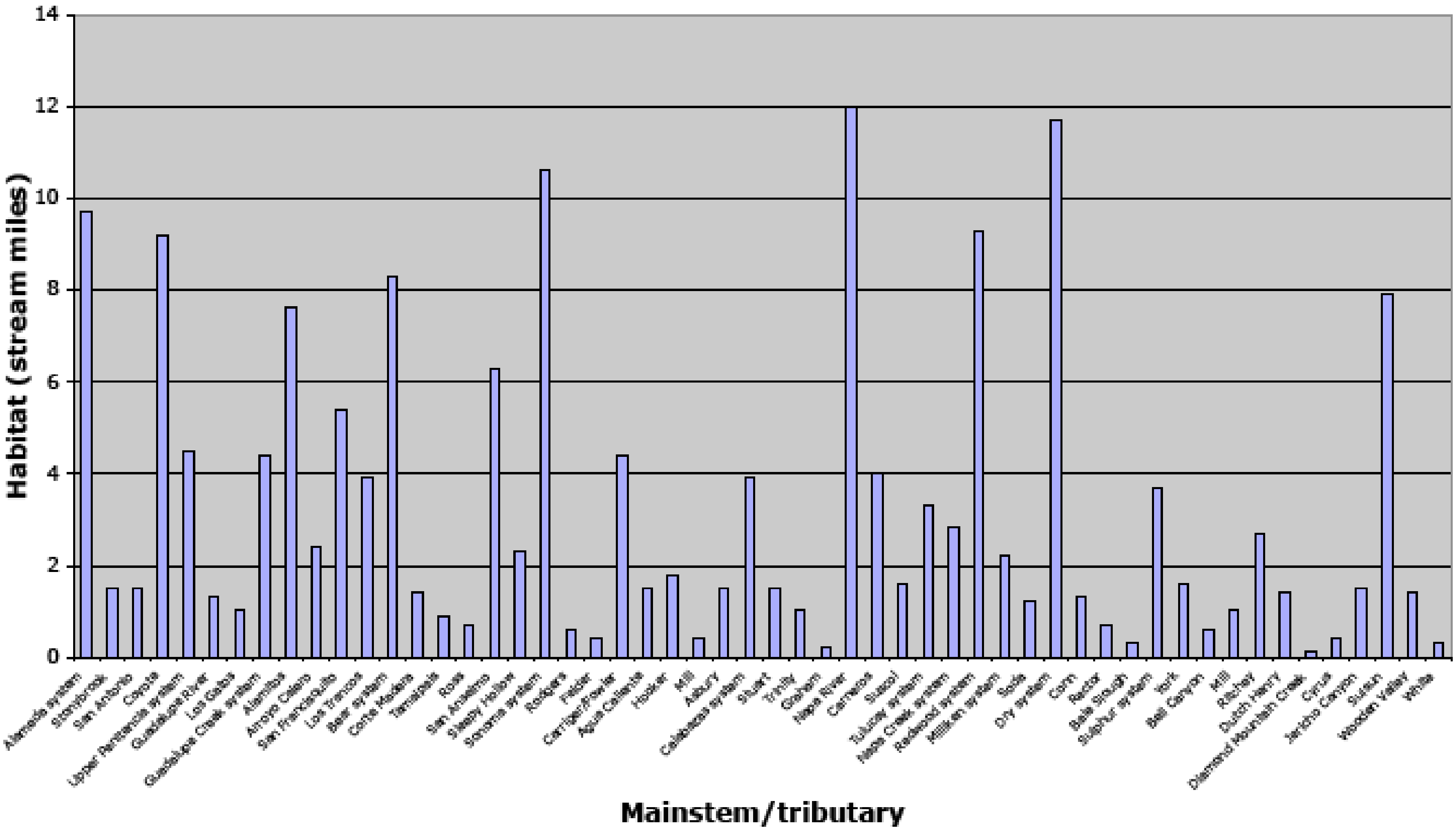
The analysis recognized a set of nine streams in the third ranked cluster with a median habitat value of 4.4 miles. The streams in this group are well-established as "steelhead streams" in historical references and current planning efforts, and therefore are included as essential streams for the purposes of this report. They include Upper Penitenica, Guadalupe, San Francisquito, Los Trancos, San Anselmo, Fowler/Carriger, Calabazas, Carneros and Sulphur creeks (Map 3).

Using fisheries information summarized in Leidy *et al.* (2005), we determined that the fourth ranked and lower cluster streams generally did not contain streams considered particularly important to the fishery of a watershed by previous researchers. Streams in the fourth ranked cluster had a median habitat value of 2.6 stream miles. Averaging the medians of the third and fourth ranked

Table 4. Available *O. mykiss* rearing habitat in SF Estuary anchor watershed streams
Additional habitat information is provided in Table B-2, Appendix B

Watershed	Mainstem/tributary	Habitat (stream miles)	Watershed	Mainstem/tributary	Habitat (stream miles)
Alameda	Alameda system	9.7	Sonoma (cont.)	Stuart	1.5
	Stonybrook	1.5		Trinity	1.0
	San Antonio	1.5		Graham	0.2
Coyote	Coyote	9.2	Napa River	Napa River	12.0
	Upper Penitencia system	4.5		Carneros	4.0
Guadalupe River	Guadalupe River	1.3		Suscol	1.6
	Los Gatos	1.0		Tulucay system	3.3
	Guadalupe Creek system	4.4		Napa Creek system	2.8
	Alamitos	7.6		Redwood system	9.3
	Arroyo Calero	2.4		Milliken system	2.2
San Francisquito	San Francisquito	5.4		Soda	1.2
	Los Trancos	3.9		Dry system	11.7
	Bear system	8.3		Conn	1.3
Corte Madera	Corte Madera	1.4		Rector	0.7
	Tamalpais	0.9		Bale Slough	0.3
	Ross	0.7		Sulphur system	3.7
	San Anselmo	6.3		York	1.6
	Sleepy Hollow	2.3		Bell Canyon	0.6
Sonoma	Sonoma system	10.6		Mill	1.0
	Rodgers	0.6		Ritchey	2.7
	Felder	0.4		Dutch Henry	1.4
	Carriger/Fowler	4.4		Diamond Mountain Creek	0.1
	Agua Caliente	1.5		Cyrus	0.4
	Hooker	1.8		Jericho Canyon	1.5
	Mill	0.4	Suisun	Suisun	7.9
	Asbury	1.5		Wooden Valley	1.4
	Calabazas system	3.9		White	0.3

Figure 2. Available *O. mykiss* habitat in SF Estuary anchor watershed streams



clusters produces a value of 3.5 stream miles of habitat that can be viewed as a threshold for essential stream status in the anchor watersheds. Additional information on our 18 essential streams is provided in the Discussion section of the report. We also note features of several streams with lesser amounts of habitat that nevertheless appear to have important function in the steelhead fishery of their respective watersheds. These steams include Los Gatos, Ritchie, and Sleepy Hollow creeks.

Discussion and recommendations

Steelhead trout populations have declined dramatically in the tributaries of the San Francisco Estuary. Recovering steelhead in Bay Area streams will require coordinated actions to mitigate the substantial loss of habitat that has resulted from human activities over the last 150 years. Given the relatively limited resources available for steelhead restoration, and the inherent political complexity of coordinating sustained political action at the watershed scale, it is essential that on a regional basis we identify priority watersheds in which to focus our efforts.

In this analysis, we have attempted to use available information and an intuitive analytical approach to screen the watersheds draining to the San Francisco Estuary for their relative importance to the regional steelhead fishery. Our analysis identified eight of the 58 Bay Area watersheds as being critical to steelhead conservation and restoration strategy. These watersheds contain 18 streams we deem essential in terms of their potential to support *O. mykiss* spawning and rearing.

We suggest that focusing restoration resources on these anchor watersheds will lead to a highly effective use of available funding. However, we re-state our support for stream restoration in general including in other, smaller Bay Area watersheds. Achieving viable steelhead populations in a large number of geographically dispersed creeks around the San Francisco Bay will produce the greatest resiliency for the Bay Area population as a whole.

The eight watersheds reviewed in this section contain stream reaches with the increasingly rare conditions that allow juvenile rainbow trout to survive during the extended dry season experienced in the region. Also, since ocean survival of steelhead smolts is directly related to their size at out-migration, streams that can produce high juvenile growth rates are arguably the most important for steelhead. We suggest, therefore, that the primary focus of restoration activities should be to protect and enhance existing stream reaches with cold water and adequate food supply.

The corresponding restoration strategy may be seen as essentially three-fold. First, analyses that produce quantitative estimates of adequate water supply for rearing habitat and processes that implement these instream flow provisions must be developed for the Bay Area's anchor watersheds. To date, our research finds no watershed where this step has been completed satisfactorily. The recently signed Memorandum of Understanding in the Alameda Creek watershed, under which joint flow studies will be designed and implemented, may become a model for addressing this critical component of restoration.

Second, limiting factors analyses should be completed for at least the key tributaries in the anchor watersheds and their recommendations should be implemented. Several such analyses have been completed or are on-going or planned that characterize and prioritize restoration activities. Implementing the projects proposed by these efforts will, in many instances, require a degree of political will and funding support previously unseen in the Bay Area. Specifically, it is likely that steelhead recovery will require protecting the riparian corridor of the important streams in the anchor watersheds, and securing water flows in the streams to support rearing and migration.

Finally, we recommend that a comprehensive, well-funded, regional program to re-connect the high quality spawning and rearing habitat to the Bay should be undertaken. The lower watershed areas of virtually all of the anchor watersheds have been severely modified, mainly for flood control purposes. In particular, Alameda Creek and Corte Madera Creek will require expensive lower watershed construction projects to allow for a reasonable degree of steelhead recovery. Several other major barrier modifications should be pursued in the tributaries of the eight anchor watersheds as well.

In the following, we review the status of restoration planning and project implementation in each of the anchor watersheds. Our goal is to identify key projects, studies, and policies necessary to advance steelhead restoration in these watersheds, and thus in the Bay Area as a whole.

Alameda Creek. Several factors lead us to conclude that this watershed presents one of the best long-term steelhead restoration opportunities among tributaries of the San Francisco Estuary. First, the large resident rainbow trout populations presently using reservoir tributaries for spawning and rearing suggest a relatively large historical run in the watershed. Also, suitable habitat exists in mainstem Alameda Creek and its tributaries that can be substantially augmented through re-operation of water supply facilities.

Important limiting factors to the Alameda Creek steelhead fishery include passage barriers, instream flows, and riparian condition. The San Francisco Public Utilities Commission completed the removal of Niles and Sunol dams in 2006, and the East Bay Regional Park District (EBRPD) removed a swim dam from the creek previously. The Fisheries Restoration Workgroup has improved fish migration conditions in the creek and is planning significant habitat improvements including providing instream flows. The Flood Control and Water Conservation District and the Alameda County Water District (ACWD) are pursuing funding to construct a fishway at the BART weir and middle inflatable dam. The water district also has obtained funds to modify its diversion facilities to be more compatible with steelhead migration, including installing a fish screen on a major diversion in summer 2007. A tributary, Stonybrook Creek, contains substantial habitat that may be made more available through a planned improvement to the culvert at the mouth of the creek by CalTrans. Conceptual designs also have been prepared to modify two upstream culverts to allow access to additional habitat (Winzler & Kelly *et al.* 2005).

The following list includes projects and studies for Alameda Creek that were identified either in the Draft Steelhead Restoration Action Plan for the Alameda Creek Watershed (CEMAR 2003) or in subsequent discussions with Workgroup members:

- Removal of the lower inflatable dam in the flood control channel
- Construction of a fishway at the BART weir and middle inflatable dam
- Construction of a fishway at the upper inflatable dam
- Determination of passage flows at new fishways
- Installation of fish screens on ACWD diversions
- Modification of the USGS gaging station weir in Niles Canyon for fish passage
- Modification of the culvert at the Stonybrook/Alameda Creek confluence
- Modification of the PG&E gas line crossing in the Sunol Valley

Determination of instream flows for reservoir-influenced Alameda Creek reaches
Riparian corridor improvements including excluding cattle from Alameda Creek

In addition, the draft restoration action plan recommends investigating a program to supplement the steelhead population using artificial propagation or by moving individuals from the adfluvial populations to areas downstream from San Antonio and Calaveras dams.

Coyote Creek. Steelhead restoration in this watershed is dependent largely on fish passage and habitat quality in mainstem Coyote Creek and the watershed's other essential stream, Upper Penitencia Creek. Water temperature and sediment have been identified as important water quality concerns, particularly in Coyote Creek. Multi-year studies associated with sediment impairment are underway by the Santa Clara Valley Urban Runoff Pollution Prevention Program.

Three reports were reviewed for information concerning restoration actions in the watershed: 1) Fisheries and Aquatic Habitat Collaborative Effort: Summary Report (FAHCE 2003); 2) Upper Penitencia Creek Limiting Factors Analysis (Stillwater Sciences 2006); and 3) Assessment of Stream Ecosystem Functions for the Coyote Creek Watershed (Buchan and Randall 2003). The following projects were identified as priority actions for addressing limiting factors:

Improve passage at an unscreened Santa Clara County water diversion on Upper Penitencia Creek
Remove or modify the grade control weir in Alum Rock Park on Upper Penitencia Creek
Remove the Ogier Road Quarry Pond Complex from the main channel and improve passage
Improve passage at the Singleton Road Low-Flow Crossing
Develop biologically-based release schedule for Cherry Flat Reservoir on Upper Penitencia Creek
Identify and re-vegetate areas of denuded riparian corridor
Implement fine sediment reduction measures

These actions and others that protect the migration corridor between the San Francisco Bay and the areas with high quality habitat are valuable contributions to the regional steelhead resource.

Guadalupe River. Key habitat areas in this watershed are located in the Guadalupe Creek and Alamitos Creek sub-basins. Releases from reservoirs largely control the quality and extent of steelhead rearing habitat on these creeks and on Los Gatos Creek. According to the FAHCE (2003) report, passage barriers, water temperatures, riparian cover, sediment, mercury contamination, and predatory warmwater fish species are limiting to the *O. mykiss* population in the Guadalupe River watershed. The following projects have been identified as priority actions for addressing these limiting factors (FAHCE 2003):

Determine optimal reservoir releases for fish habitat
Improve spawning and rearing habitat through gravel placement, tree planting, bank stabilization, and woody debris placement in three key areas: Guadalupe Creek between Guadalupe Dam and the Guadalupe River confluence, Los Gatos Creek from Camden Avenue to the Guadalupe River confluence, and Alamitos Creek/Arroyo Calero from Calero and Almaden dams to Lake Almaden

Also, continuing activities related to protecting and enhancing the riparian corridor of the Guadalupe River and its essential tributaries, as well as modifying partial passage barriers, will benefit the watershed's steelhead population. As substantial areas adjacent to Guadalupe and Alamitos creeks are not in public ownership, a riparian land acquisition program or a suitable alternative should be developed to protect water quality.

San Francisquito Creek. A recent limiting factors analysis for this watershed concluded that overwintering habitat limits steelhead production (J & S 2006). The analysis suggested that this factor may have been limiting historically as well but has been exacerbated by simplification of the channel and by hydraulic and direct removal of juvenile steelhead refuge materials such as larger bed material and large woody debris. Restoration projects directed at this factor likely will involve re-establishing channel complexity and creating stormwater detention facilities. Other limiting factors on San Francisquito Creek include sedimentation, maintenance of instream flows, and passage barriers (J & S 2006). Stanford University owns and operates a fish ladder at the Felt Lake diversion on Los Trancos Creek and is proposing to modify the ladder in order to improve fish passage. Also, the California Water Service Company is considering improvements to its dam on Bear Gulch Creek that would provide steelhead passage upstream from this barrier.

Information on restoration projects in this watershed was collected from the Lower San Francisquito Creek Watershed Aquatic Habitat Assessment and Limiting Factors Analysis (J & S 2006), the assessment entitled Adult Steelhead Passage in the Bear Creek Watershed (Smith and Harden 2001), the San Francisquito Creek Bank Stabilization and Revegetation Master Plan (Royston Hanamoto Alley & Abey *et al.* 2000), and from comment letters. The following projects to remove or modify instream barriers were identified by Smith and Harden (2001) and by the San Francisquito Watershed Council as needing attention:

Bonde weir (at El Camino Real) on mainstem San Francisquito Creek
Concrete dam upstream from Sand Hill Road and box culvert at Fox Hollow Road on Bear Creek
California Water Service Company diversion dam on Bear Gulch Creek
Concrete dam upstream from Old Alpine Road, Felt Lake diversion, and two box culverts along Los Trancos Road on Los Trancos Creek

While removal of Searsville Dam would provide steelhead access to as much as seven stream miles of habitat in the Corte Madera Creek sub-basin, planning does not appear to be advancing in a meaningful way. A group has been formed recently under the auspices of American Rivers, Beyond Searsville Dam, that is "...advocating for investigating the restoration of threatened steelhead trout and free flowing San Francisquito Creek through the removal of Searsville Dam in a safe manner that is consistent with protecting creekside communities and watershed resources" (Stoecker pers. comm.).

Additional restoration activities recommended in the watershed include improving habitat by allowing large woody debris recruitment, implementing re-vegetation and bank stabilization projects, carrying out the projects that implement the 2004 sediment reduction plan for the watershed, and outreach to engage stakeholders in steelhead restoration. Finally, it has been suggested that the frequency and extent of drying of portions of the Los Trancos and San Francisquito creek channels has increased in recent years, possibly due to groundwater pumping in headwaters areas (Launer pers. comm.). A water inventory could provide information useful in managing instream flow needs in these streams.

Corte Madera Creek (Marin County). The main factor controlling the long-term success of steelhead in the drainage appears to be the confinement of stream channels by urbanization. Unfortunately, steelhead restoration in the Corte Madera Creek watershed is perhaps the most challenging and complex in the Bay Area due to the multiple jurisdictions affected and the intense pressure to maintain or increase residential land uses adjacent to the creek. These areas could be used to create additional channel capacity consistent with habitat requirements for steelhead. Maintenance of instream flows, water temperature, and passage barriers also have been identified as limiting factors for steelhead.

Several barrier modification projects have been identified in Corte Madera Creek and its tributaries (Rich 2000; Ross Taylor & Associates 2003). Friends of Corte Madera Creek and consulting engineers are examining current fish passage conditions in the "Unit 3" portion of the lower creek in order to develop alternatives for improving steelhead passage. In particular, the study likely will result in a set of proposed modifications to resting pools within the unit, as well as other recommendations (Guldman pers. comm.). An engineering analysis, conceptual design, and cost estimate for modifying the so-called "Lansdale site" barrier on San Anselmo Creek is currently being conducted (CEMAR in preparation). Other important restoration actions in the Corte Madera Creek basin were identified in Fishery Resource Conditions of the Corte Madera Creek Watershed (Rich 2000) and Corte Madera Stream Crossing Inventory and Fish Passage Evaluation (Ross Taylor & Associates 2006):

Analyze instream flows downstream from Phoenix Lake on Ross Creek
Modify the barriers at Saunders Avenue and Pastori Avenue on San Anselmo Creek for fish passage
Modify barriers at the Taylor Street, Deer Hollow Road crossings, and at the Raven Dam on Sleepy Hollow Creek
Modify the crossing at Fairfax-Bolinas Road and the Olema Dam on Fairfax Creek
Modify the crossing at Park Drive/Branson School on Ross Creek
Replace obsolete fishway at the upstream end of the flood control channel

General restoration activities recommended for the watershed include re-vegetation along eroded banks and in riparian corridors, removing concrete slabs from creeks, and outreach programs to reduce water diversions, minimize pollution, and encourage clean-up projects.

Sonoma Creek. According to a recent analysis, passage barriers, sedimentation, water temperatures, and instream flows limit the *O. mykiss* population in Sonoma Creek (SEC 2006a). The study hypothesizes a "bottleneck" in steelhead production in the watershed consisting of limited rearing habitat (SEC 2006a). Therefore, the Sonoma Ecology Center (SEC) identified restoration measures that enhance rearing habitat along with a relatively small number of passage improvement projects as highest priority. Several programmatic goals were identified to address limiting factors in Sonoma Creek Watershed Limiting Factors Analysis including: installing in-stream habitat restoration structures made of boulders and logs; implementing stream and bank stabilization projects, developing instream flow guidance, and re-planting riparian areas. Projects that address the limiting factor of degraded summer and winter rearing habitat likely will involve re-establishing channel complexity and developing instream shelter through introduction of larger bed material and large woody debris. In addition, projects that counter hydrologic effects of development (*i.e.*, decreased lag time, increased peak hydrograph) through water detention or increasing flood plain area will benefit the steelhead resources of the Sonoma Creek watershed.

Also recently, a sediment source analysis was completed for Sonoma Creek which states, "Dramatic increases in loads [from pre-European settlement levels] are evident in many tributary watersheds and in most cases are attributable to intensified stream bed and bank erosion" (SEC *et al.* 2006b, p. 46). The report emphasized remediation efforts that off-set the "intensified, flashy runoff in steep, unattenuated hydrographs" during storms. Such efforts typically include detaining stormwater and reducing impervious surfaces. The report also notes, "Other focuses: protect landcover integrity, prevent slides and slumps through proper hillside protection, preserve riparian setbacks that filter fine sediment from runoff, and increase continuous monitoring..." (SEC *et al.* 2006b, p. 46).

The Sonoma Ecology Center has completed an inventory and ranking of the passage barriers in the Sonoma Creek watershed that lists 20 most important barriers in the watershed (Katopothis *et al.* 2005). The SEC has received funding to modify one of these, a total barrier at Dunbar Road on Calabazas Creek, and is participating in designing fixes at four additional locations. For example, an engineering analysis, conceptual design, and cost estimate for a total barrier on Stuart Creek is presently being conducted (CEMAR in preparation). Other barriers currently being examined include the Warms Springs Creek location on Yulupa Creek, and the Grove Street location and Grove Street "#1 DST" on Carriger Creek. The Glen Oaks Dam location on Stuart Creek appears on the list as an unaddressed important passage project (Katopothis *et al.* 2005).

The success of steelhead restoration in Sonoma Creek and its tributaries depends on the degree of cooperation of private landowners due to a low level of public land ownership in the watershed. Ultimately, land use changes and passage improvements will be effective only if they occur in conjunction with a program that protects riparian areas and identifies and secures adequate streamflow for steelhead rearing in Sonoma Creek streams. As riparian enhancement and provision of instream flows involve complex issues of property and resource rights, we recommend pilot projects for the essential streams of the Sonoma Creek watershed: mainstem Sonoma Creek, Carriger/Fowler Creek, and Calabazas Creek. These investigations should be advanced under the auspices of a stakeholder group for each sub-basin.

Napa River. A comprehensive study of limiting factors in the Napa River basin (Stillwater Sciences and Dietrich 2002) indicates that various factors including changes in physical habitat, fine sediment loading, increased water temperatures, creation of passage barriers, and reduced dry season flows likely contribute to decreased steelhead production from historical levels. The report recommends modifying a relatively small number of passage barriers to aid steelhead recovery. A project to develop the conceptual design for removing a culvert on Ritchie Creek is underway (CEMAR in preparation).

Continuing work by the Regional Water Quality Control Board, the Resource Conservation District, and others should allow researchers to reduce "scientific uncertainties" cited in the 2002 limiting factors analysis and develop watershed wide restoration priorities. Restoration of a 4.5 mile reach of the Napa River called the "Rutherford Reach" is being planned through a stakeholder process managed by the RCD. The Oakville to Oak Knoll Restoration Project also is funded and will benefit habitat in mainstem Napa River. Also, Similar to Sonoma Creek, restoration planning for the Napa River must address instream flow provisions (especially for rearing) in order to be successful. A recently completed study examined the relationship between flow, temperature, and seasonal steelhead growth in the Napa River basin. Also, the RCD has an on-going project to identify opportunities to coordinate agricultural diversion with habitat needs.

We reviewed two reports, the Napa River Basin Limiting Factors Analysis (Stillwater Sciences and Dietrich 2002) and Central Napa River Watershed Project (Koehler 2005), and interviewed staff from DFG for information on priority restoration projects in the Napa River watershed. These references recommend several important projects including:

Removal or modification of the concrete weir on Bell Creek

Modifying the concrete ford crossing on Rector Creek

Modifying the dirt road crossing and concrete/bedrock dam structure on Wing Canyon Creek

Modifying the barrier at the Zinfandel Lane bridge on the Napa River

Replacement of a poorly functioning fishway on Sulphur Creek

Instream sill removal, channel and bank stabilization, and riparian re-vegeation in Dry Creek

Additional work is needed to generate an updated list of the highest priority restoration sites in the most important steelhead streams in the Napa River system (Koehler pers. comm.). General, basin-wide restoration activities also were noted in the 2002 report such as allowing recruitment of large woody debris, increasing riparian cover, increasing summer baseflow, reducing fine sediment input from roads and bank erosion, and mitigating potential turbidity sources at sites of mass wasting and active gullies. Data exist that could be used to characterize problem erosion locations for this watershed and begin prioritizing treatments (Koehler pers. comm.). For example, an assessment of bank erosion in the Dry Creek basin has been performed (Seymour pers. comm.).

Steelhead restoration in the Napa River basin ultimately depends on the level of cooperation than is obtained from private landowners due to the high degree of private land ownership. Restoration actions should be implemented in concert with an overall program to identify and secure instream flows and provide for healthy riparian areas. Since land and water rights have proven to be "hot button" issues in north Bay Area counties, we recommend establishing stakeholder groups in the essential stream sub-basins in the Napa River watershed to plan for steelhead restoration. Groups are proposed for the mainstem Napa River and for Carneros, Dry, Redwood/Napa, and Sulphur creeks. Developing successful steelhead restoration programs in these areas would serve both to advance overall recovery in the watershed and to provide models for other sub-basins.

Suisun Creek. A fishery habitat study in Suisun Creek found that steelhead habitat is limited by a number of seasonal and partial passage barriers (including several beaver dams), high water temperatures during dry years, and limited spawning gravels (Hanson Environmental Inc. 2002). A subsequent watershed assessment for Suisun Creek added sedimentation and inadequate riparian cover to the list of primary factors limiting the steelhead population (Laurel Marcus & Associates 2004). These studies were reviewed for projects recommended to address the limiting factors. While several fish passage barriers are identified, they have not yet been assessed for removal priority. General recommendations included riparian corridor restoration (particularly on denuded areas of Wooden Valley and White creeks), developing a habitat-based flow schedule for Lake Curry releases, improving land management to reduce sedimentation associated with agricultural uses, and increasing habitat complexity by the placement of large woody debris.

The Suisun Creek watershed represents an "outlier" in our analysis of anchor watersheds. The remaining seven basins we have identified as most important for steelhead restoration have well-developed information and planning resources. Further, while the watershed is largely in open space, the ratio of protected open space to open space is low. We recommend that the Suisun Creek stakeholder group be expanded and funded sufficiently to produce rigorous analyses of steelhead resources and meaningful restoration strategies. Our experience suggests that cooperative planning and political will are necessary foundation elements for successful restoration projects. In particular, landowner agreements regarding maintaining minimum instream flows and intact riparian corridors will be critical to the success of an overall program of steelhead restoration. Removal of the dam forming Lake Curry appears to be politically feasible and can provide an opportunity for providing fish flows in Suisun Creek (Stern pers. comm.).

Other important watersheds

During the course of our research we determined that several watersheds that had too little habitat to qualify as anchor watersheds nevertheless were notable for their potential contribution to the steelhead fishery of the San Francisco Estuary. In particular, these watersheds have conditions related to management, stakeholder involvement and public educational value, or biological resources that distinguish them from other, non-anchor watersheds. These systems include Pinole and Stevens creeks, Arroyo Corte Madera del Presidio, Miller Creek, and the Petaluma River. The following briefly describes conditions in these watersheds.

Pinole Creek. Biologists from the East Bay Municipal Utilities District (EMBUD) have observed juvenile *O. mykiss* in the Pinole Creek watershed believed to be of anadromous ancestry as well as adult steelhead. Suitable habitat exists in mainstem Pinole Creek, although access to inmigrants may be limited by poor passage conditions at the culvert at the I-80 crossing. Large portions of the watershed are in open space, due in part to extensive EBMUD watershed lands holdings. Restoration related studies and planning have been conducted under the auspices of the local resource conservation district and The Watershed Institute and include a recent sediment source analysis (SFEI 2005). Groundwater extraction in the upper watershed may be leading to decreased duration and extent of wetted summer stream channel.

It may be argued that Pinole Creek represents Contra Costa County's best potential steelhead stream. Restoration of this system would involve erosion control projects, relatively minor passage barrier modifications, and studies and implementation measures to assure provision of dry season instream flows. A habitat conservation plan is being developed for EBMUD's watershed lands that will enumerate further conservation actions with the potential to benefit steelhead. A restored Pinole Creek watershed could serve to decrease the geographic increment between *O. mykiss* populations, thereby improving dispersal. The urbanized nature of the lower watershed and the presence of a secondary school adjacent to the creek make Pinole Creek's potential education value high.

Stevens Creek. Steelhead lost access to the majority of this watershed's habitat with the construction of Stevens Creek Reservoir. However, *O. mykiss* reproduce in the reach downstream from the dam and the population appears to produce smolts. The approximately four mile section of the creek between the Highway 280 crossing and the dam supports a cold water community, including steelhead (Tetra Tech Inc. 2006). As of 2001, the Santa Clara Valley Water District had identified multiple partial passage barriers on Stevens Creek. Five barriers were rated passable only under a small range of flow conditions and included: the gaging station between Central Avenue and Highway 85 (with its three associated drop structures), the Moffett fish ladder downstream of the gaging station; fish ladders at Evelyn and Fremont avenues; and a low-flow vehicle crossing at Blackberry Farm (Leidy *et al*. 2005.)

Stillwater Sciences completed a limiting factors analysis of Stevens Creek in 2004. Findings included:

Barriers, both partial and complete, limit access to a substantial amount of stream habitat; effects of barriers on smolt production depend on the ability of fish to pass barriers (upstream and downstream);

Seasonal low flows downstream of Fremont Ave may severely limit steelhead outmigration success in some years, especially if channel drying occurs before the end of the outmigration period (typically February-May);

Gravel permeability is low but not likely limiting smolt production;

Pool filling is low, indicating high sediment transport capacity relative to sediment supply;

Bed mobility (and therefore potential redd scour) is relatively low in upper reaches but increases downstream;

Overwintering habitat is likely the key limiting factor for steelhead prior to smolt outmigration; and

Water temperature is elevated but not likely to lethal levels and is not likely limiting fish growth, as evidenced by the size distributions of age 0+ and 1+ steelhead.

A 2003 project implementing the Fish and Aquatic Habitat Collaborative Effort (FAHCE) process removed the Central Avenue passage barriers by constructing a fishway. Pro-active stakeholder groups including Acterra and the Stevens and Permanente Creeks Watershed Council currently are planning modifications to three CalTrans-owned fish passage barriers in the creek that have the potential to improve access to good spawning and rearing habitat, particularly in the reach passing through Stevens Creek County Park. The City of Cupertino has proposed a creek restoration project in the McClellan Ranch/Black Berry Farm area. This project would remove or modify a number of barriers including several low flow crossings and water diversions. The project also includes realigning the stream channel and stabilizing an eroding hillside bordering the creek. The creek is the subject of management actions under the FAHCE process that may lead to long-term, biologically-based instream flow releases from the reservoir that benefit the steelhead run.

In the lower watershed area, the historical Stevens/Permanente creeks confluence has been re-aligned to flow through the Permanente Creek by-pass channel. A potential modification to this channel may allow fish passage to good habitat in upstream portions of Permanente Creek and the possible re-establishment of the anadromous life history form of the existing *O. mykiss* population (Moore pers. comm.).

Arroyo Corte Madera del Presidio. This system formerly provided habitat for coho salmon prior to its likely extirpation from San Francisco Estuary streams, and continues to support *O. mykiss* reproduction. In 2003, consultants inventoried fish passage barriers throughout Marin County, including Arroyo Corte Madera del Presidio. The subsequent report cites the presence of two culverts in the arroyo and three culverts in Old Mill Creek (Ross Taylor & Associates 2003). Mill Valley Stream Keepers commissioned a study of culvert modifications and flood assessment on Arroyo Corte Madera del Presidio and Old Mill Creek that was completed in 2004. It provides conceptual designs for several barrier projects and recommends additional hydraulic and passage analysis as well as flood modeling prior to completing final designs (FarWest 2004).

Mill Valley Stream Keepers is the primary group working in this watershed. Other stakeholders include Marin County and DFG. On-going challenges relate to development encroaching on the stream banks and channel throughout a significant portion of its length, although some headwaers areas, such as Old Mill Creek, remain in a relatively undeveloped state and include substantial, intact redwood forest areas that are uncommon in the Bay Area. Water supply assurance, riparian area protection, and passage improvements are necessary to improve conditions for steelhead in this watershed. Technical expertise and funding appear to be available to support restoration activities.

Miller Creek. Dr. Rob Leidy of the U.S. EPA previously identified this system as a regional priority for restoration. Multiple year classes of *O. mykiss* have been observed in several Miller Creek reaches in recent years, indicating the presence of suitable spawning and rearing habitat. In particular, the watershed is said to offer high quality connected riparian habitat (Lewis pers. comm.). The creek has minimal passage barriers and no major water supply features. One substantial barrier, known as the Grady bridge, is being examined for a replacement crossing, although a timeline for the project is not available. Staff from the Marin County Public Works agency and from DFG also have called attention to this creek for its restoration potential.

Petaluma River. Various tributaries of the river appear to offer suitable habitat, and observations of *O. mykiss* have been made in Adobe and Lichau creeks. Most steelhead resources information is anecdotal and comprehensive habitat assessment proposed for summer of 2007 should allow for a more thorough analysis of the watershed's regional importance. Specifically, San Antonio Creek may offer habitat that was not sufficiently documented for inclusion in the current study. A hatchery operated at Casagrande High School has brought substantial attention to salmonids in Adobe Creek and serves as an important educational tool. The watershed contains subtantial open space resources but appears to have a relatively low ratio of protected open space to total open space.

Staff from DFG indicates that NMFS will undertake a bridge replacement and wet crossing project to improve passage on Adobe Creek (Seymour pers. comm.). The City of Petaluma is planning to sponsor a project to relocate part of the Adobe Creek channel to its historical configuration. Also, Casagrande High School sponsors on-going assessments and re-vegetation of the riparian area along Adobe Creek, while Sonoma County was funded to retrofit a major culvert on Adobe Creek for fish passage in 2002.

Appendix A. Methods used for evaluating Bay Area watersheds

The following provides additional detail regarding the methods used to evaluate Bay Area watersheds for potential steelhead restoration potential. The two evaluation criteria are described, followed by discussion of our approach to evaluating collaborative stakeholder processes in the various watersheds and to analyzing the level of open space protection. More information regarding the analytical results may be found in Appendix B.

Criterion 1. Reproducing *O. mykiss* populations

Leidy *et al.* (2005) was used to identify the watersheds with existing populations of reproducing *O. mykiss*. This information was obtained from the county summary tables contained in the report. These tables assign a value of 0, 1, 2, or 3 under the category "Current Population Status" that correspond to the following definitions:

0-Population absent or unknown

1-Population present

2-Population reproducing, as evidenced by the presence of age 0+ and 1+ juveniles

3-Multiple age classes present

For the purpose of this analysis, any watershed with one or more streams that had been assigned a value of 2 or 3 in Leidy *et al.* (2005) was considered to have satisfied this criterion. Watersheds with streams that had been assigned a 0 or 1 in Leidy *et al.* (2005) were assumed not to have reproducing populations of *O. mykiss* and were not advanced to the next criterion. In several instances, interviews with local experts indicated updates to or errors in the information in Leidy *et al.* (2005). We used the most recent information where we could confirm its reliability.

Criterion 2. Available *O. mykiss* rearing habitat

This analysis focused on the amount and location of *O. mykiss* rearing habitat in Bay Area streams. Sufficient information either existed or was developed through this analysis to allow us to compare across the various watersheds and streams tributary to the San Francisco Estuary. Major data sources used in our analysis included:

-Leidy *et al.* 2005

-Reports and studies such as habitat assessments, fishery resource studies, restoration plans, stewardship plans, and limiting factors analyses

-Fish sampling data sheets for the surveys conducted by Dr. Robert Leidy and summarized in Leidy *et al.* (2005)

-Interviews by phone and e-mail with local experts

The specific data sources used for analysis pursuant to this criterion are noted in the text and tables in Appendix B.

Due to the lack of standardized data on *O. mykiss* habitat in the watersheds under consideration, several different types of data were used to identify the stream reaches containing suitable rearing habitat. While every attempt was made to be consistent in our interpretation of the available information, substantial uncertainty is inherent in this analysis due to the varying methods and descriptive approaches used by biologists to classify habitat. It should also be noted that the amount of habitat in a stream is variable over time based on streamflow and other factors. Our approach sought to characterize, at a screening level, the amount of "good" habitat available in a watershed for *O. mykiss* rearing in an average water year. Three principal types of information were considered in our analysis:

1. Descriptions of habitat. Relevant documents were collected and analyzed for descriptions of locations of suitable *O. mykiss* rearing habitat within Bay Area streams. Where we found references to "good" or "suitable" rearing habitat, we noted its location. We also noted statements indicating that stream reaches regularly support steelhead or rainbow trout. Reaches described as containing "marginal" or "poor" habitat were not included.

2. Information from maps. Maps compiled by other researchers often provided useful information for determining *O. mykiss* habitat. We included as rearing habitat stream reaches having medium to high steelhead density on maps indicating sampling results, the Coldwater Fish Management Zones designated in the FAHCE report (FAHCE 2003), and areas designated as "rearing habitat" or "nursery habitat" in other reliable sources.

3. Observations of *O. mykiss*. We also reviewed *O. mykiss* sampling results and other reports of observations, and used the presence of juvenile fish in a specific area to indicate the existence of rearing habitat. Many of these observations used were summarized in Leidy *et al.* (2005).

All of watersheds considered under this criterion are known to have existing reproducing populations of *O. mykiss*. However, recent habitat and *O. mykiss* distribution information was not available for some streams, where we relied on older information. Historical information was used in several instances to establish the extent of suitable rearing habitat in a given stream.

Steelhead habitat was mapped using ArcGIS, allowing us to estimate habitat quantities for the study area streams. Large variations in the quality of the data reviewed required us to apply professional judgment in many cases to produce reasonable estimates of the location and extent of habitat. Specifically, we employed the following techniques:

1. Where habitat was illustrated on a map or described in a supporting document, we transferred the upper and lower extents to our ArcGIS database to calculate habitat in stream miles.

2. In survey reports, two sample sites containing juvenile *O. mykiss* were said to bound a suitable habitat area when the distance was less than one mile and the intermediate reach was not highly urbanized.

3. Under certain circumstances, areas downstream from single sampling sites containing juvenile *O. mykiss* were considered to provide habitat. Specifically, non-urbanized areas downstream from known areas of suitable habitat were included unless information regarding passage barriers, land use, or stream features such as bed material suggested otherwise.

4. When we encountered *O. mykiss* presence information without corresponding habitat information we assumed a suitable habitat reach length of ½ mile centered on the observation location.

5. The presence of juvenile *O. mykiss* upstream from partial barriers was taken to indicate potentially available habitat even when the anadromous ancestry of these fish could not be established.

Upstream limits of anadromy were determined by reviewing information regarding total barriers and by the method described in Ross Taylor & Associates (2006). This approach considers the upper limit of anadromy to be where the channel slope exceeds eight percent slope for 300 feet.

Habitat mapping and length estimates relied on the 1:100000 scale stream-based routed hydrography shapefile produced by the California Department of Fish and Game (and available via the CalFish website and other sources). We sought estimates in stream miles, leading us to use this dataset (and not the NHD or other datasets), and to convert values from feet to miles. The "route identify" tool (in ArcGIS 9.1) was used to locate the points of upper and lower habitat extent. A route table was produced using these points wherein the lower measure was subtracted from the upper measure. Values were converted to stream miles and rounded to the nearest one tenth of a mile. The route table was used to create the linear referenced shapefile displayed on our maps.

After determining the distribution of suitable habitat, we used information regarding passage barriers to distinguish between available habitat and non-available habitat. We identified total passage barriers unlikely to be removed or mitigated in the near term, and downstram habitat was labeled "available" while upstream habitat was not considered "available". Barrier information for many watersheds was available from Leidy *et al.* (2005) and was supplemented with information in other reports and the Passage Assessment Database (PAD), published on the CalFish website. This dataset helped us define the geographic extent of habitat in streams where other information was lacking and to locate barriers which were inadequately described in our other refereneces.

Based on our review of the available information and on conversations with individuals with expertise concerning specific streams and watersheds, we deemed various barriers such as water supply dams to be permanent for purposes of this report. These barriers are listed in Appendix B. Our estimates of available habitat would be changed if an unexpected dam removal were accomplished, if a trap and truck program were instituted, or if a barrier was re-characterized as "total" instead of "partial." Total barrier determinations relied on the use of professional judgment in some cases and were based on our understanding of the level of advancement of planning to remove or otherwise mitigate barriers. Reviewers of the draft of this report noted that insufficient flows exist in some stream systems in some years to allow passage into areas of suitable rearing habitat, even without the presence of total barriers. Our analysis assumes that restoration actions such as provision of instream flows and channel and barrier modifications can be used to allow passage into habitat areas not isolated by total passage barriers.

We next sought to define anchor watersheds based on a threshold of available rearing habitat in the wateshed. We analyzed the dataset of habitat values using cluster analysis. This approach groups watersheds based on variance between the corresponding habitat values. The statistical package JMP®6 was used to apply Ward's method to our dataset. Where they existed, outliers in the dataset were removed and the analysis re-run in order to further distinguish groupings of watersheds based on the amount of available habitat.

For the anchor watersheds, we identified stakeholder groups and other collaborative planning efforts. We supplemented our professional understanding of key players in the candidate anchor watersheds with information generated by internet searches to characterize the groups working on restoration issues. We sought to discuss two chief aspects of restoration planning:

1. the degree of involvement of a wide range of stakeholders, such as citizens, landowners, community groups, environmental groups, local jurisdictions, and state and federal agencies in the restoration process; and

2. the production of professional-quality plans and research concerning steelhead restoration, particularly as reviewed by agency staff and other appropriate professionals.

Information on these characteristics was gathered primarily for the purpose of determining whether sufficient institutional “drivers” were present to advance restoration. We also sought to evaluate the analytical background for proposed watershed restoration activities in the candidate anchor watersheds. We attempted to identify where additional investigations are needed prior to allocating substantial resources toward steelhead restoration.

We also analyzed open space in the anchor watersheds. This approach is intended to inform the discussion of the value of restoration-related expenditure in a candidate anchor watershed based on the level of protection afforded the headwaters. Specifically, we suggest that projects are more likely to be successful in watersheds with higher levels of headwaters protection, since the results of these actions are less likely to be negated by habitat damage from poor land use practices or by issues in inadequate instream flows. For each of the anchor watersheds, we calculated watershed area, open space area, and protected open space area. For our purposes, open space consisted of land with no more than one housing unit per ten acres (or no more than 64 units per square mile). Land qualified as protected open space if it was publicly owned and its use was controlled by plans and policies reflecting natural resource management goals. Open space most often qualified as protected by virtue of being in park or watershed land use.

Appendix B. Results of evaluating San Francisco Estuary watersheds

This appendix presents detailed results of the various components of our analysis. The following text, tables, and figures describe how San Francisco Estuary tributaries did or did not satisfy the screening criteria, and provide the information background we used to characterize reproducing *O. mykiss* populations, habitat, passage barriers, collaborative restoration planning, and open space.

Table B-1 indicates which Bay Area streams have reproducing *O. mykiss* populations and provides several notes regarding "special case" situations. Descriptive habitat information is provided next by county, followed by Table B-2, which summarizes habitat values for the various streams considered in the study. Table B-3 identifies the total passage barriers in the region and the information sources that we used to characterize them. Figure B-1 shows the cluster diagrams we derived to establish our anchor watersheds, while Figure B-2 contains the cluster analysis results for the candidate essential streams. Finally, detailed results regarding our investigations into collaborative restoration planning and open space issues in the anchor watersheds are provided in text and in the series of tables B4A through B4H.

Table B-1. Status of SF Estuary watersheds and streams with respect to reproducing *O. mykiss* populations

Y= yes, recent evidence of reproducing *O. mykiss*

Watershed	Mainstem/tributary	Reproducing *O. mykiss*
Contra Costa County		
Marsh Creek		
	Marsh	
Mt. Diablo Creek		
	Mt. Diablo	
	Mitchell	
	Irish Canyon	
	Donner	
Walnut Creek		
	Walnut	See note 1
	Pacheco	
	Grayson	
	Pine	
	Galindo	
	Little Pine	
	Arroyo del Cerro	
	Las Trampas	
	Tice	
	Lafayette	
	Grizzly	
	Reliez	
	San Ramon	
	Sans Criante	
	Sycamore	
	Green Valley	
	San Catanio	
	Bollinger Canyon	See note 2
Alhambra Creek		
	Alhambra	See note 3
Rodeo Creek		
	Rodeo	
Refugio Creek		
	Refugio	
Pinole Creek		Y
	Pinole	Y
	Simas	See note 2
Garrity Creek		
	Garrity	
San Pablo Creek		Y
	San Pablo	Y

Table B-1(cont.). Status of SF Estuary watersheds and streams with respect to reproducing *O. mykiss* populations

Y= yes, recent evidence of reproducing *O. mykiss*

Watershed	**Mainstem/tributary**	**Reproducing *O. mykiss***
	Bear	
	Lauterwasser	
Wildcat Creek		Y
	Wildcat	Y
Cerrito Creek		
	Cerrito	
Alameda County		
Codornices Creek		Y
	Codornices	Y
Strawberry Creek		
	Strawberry	
Temescal Creek		
	Temescal	
Glen Echo Creek		
	Glen Echo	
Sausal Creek		
	Sausal	See note 2
	Shepherd	See note 2
	Palo Seco	See note 2
Peralta Creek		
	Peralta	
Lion Creek		
	Lion	See note 2
	Horseshoe	See note 2
	Chimes	
Arroyo Viejo Creek		
	Arroyo Viejo	
San Leandro Creek		Y
	San Leandro	Y
	Miller	
	Kaiser	Y
	Buckhorn	See note 2
	Redwood	Y
	Moraga	Y
	Indian	See note 2
San Lorenzo Creek		
	San Lorenzo	See note 4
	Castro Valley	
	Crow	See note 2
	Cull	
	Palomares	
	Eden Canyon	

Table B-1(cont.). Status of SF Estuary watersheds and streams with respect to reproducing *O. mykiss* populations

Y= yes, recent evidence of reproducing *O. mykiss*

Watershed	**Mainstem/tributary**	**Reproducing *O. mykiss***
Alameda Creek		Y
	Alameda	Y
	Dry	
	Stonybrook	Y
	Sinbad	
	Arroyo de la Laguna	
	Vallecitos	
	Arroyo Valle	
	Trout	
	Colorado	
	Arroyo Bayo	
	San Antonio	
	Beau-regard	
	Arroyo Mocho	Y
	Tassajara	
	Arroyo Las Positas	
	Cayetano	
	South San Ramon	
	San Antonio	Y
	Indian	Y
	La Costa	Y
	Indian Joe	Y
	Calaveras	Y
	Arroyo Hondo	Y
	Smith	Y
	Sulphur	Y
	Isabel	Y
	W Tree	See note 2
	Bear Gulch	
Laguna Creek		
	Mission	
Santa Clara County		
Coyote Creek		Y
	Coyote	Y
	Lower Penitencia	
	Berryessa	
	Calera	
	Arroyo de los Coches	
	Upper Penitencia	Y
	Arroyo Aguague	Y

Table B-1(cont.). Status of SF Estuary watersheds and streams with respect to reproducing *O. mykiss* populations

Y= yes, recent evidence of reproducing *O. mykiss*

Watershed	Mainstem/tributary	Reproducing *O. mykiss*
	Lower Silver	
	North Babb	
	South Babb	
	Flint	
	Thompson	
	Quimby	
	Fowler	
	Yerba Buena	
	Dry	
	Upper Silver	
	Fisher	
	San Felipe	Y
	Cow	Y
	Packwood	Y
	Hoover	Y
	Cañada de los Osos	
	Hunting Hollow	
	Big Canyon	See note 2
	Middle Fork Coyote	Y
	East Fork Coyote	See note 2
	Kelly Cabin	
Guadalupe River		Y
	Guadalupe River	Y
	Los Gatos	Y
	Briggs	
	Hooker Gulch	
	Austrian Gulch	Y
	Ross	See note 2
	Guadalupe	Y
	Pheasant	Y
	Hicks	
	Rincon	Y
	Alamitos	Y
	Arroyo Calero	Y
	Barrett	Y
	Herbert	Y
San Tomas Aquino/Saratoga Creek		Y
	San Tomas Aquino	
	Saratoga (Campbell)	Y
	Bonjetti	Y
	McElroy	
	Vasona	

Table B-1(cont.). Status of SF Estuary watersheds and streams with respect to reproducing *O. mykiss* populations

Y= yes, recent evidence of reproducing *O. mykiss*

Watershed	**Mainstem/tributary**	**Reproducing *O. mykiss***
	Wildcat	
	Smith	
Calabazas Creek		
	Calabazas	
	Prospect	
Stevens Creek		Y
	Stevens	Y
	Swiss	
Permanente Creek		
	Permanente	
	Hale	
Adobe Creek		
	Adobe	
Barron / Matadero Creeks		
	Matadero	
	Barron	
	Deer	
San Mateo County		
San Francisquito Creek		Y
	San Francisquito	Y
	Los Trancos	Y
	Bear	Y
	Dry	See note 2
	Bear Gulch	Y
	West Union	Y
	Squealer Gulch	Y
	McGarvey Gulch	Y
	Corte Madera	Y
	Alambique	
	Hamms Gulch	See note 2
	Damiani Gulch	See note 2
	Coal	See note 2
Redwood Creek		
	Redwood	
	Arroyo Ojo	
Cordilleras Creek		
	Cordilleras	
Belmont Creek		
	Belmont	
Laurel Creek		
	Laurel	
San Mateo Creek		Y

Table B-1(cont.). Status of SF Estuary watersheds and streams with respect to reproducing *O. mykiss* populations

Y= yes, recent evidence of reproducing *O. mykiss*

Watershed	Mainstem/tributary	Reproducing *O. mykiss*
	San Mateo	Y
	Polhemus	
Sanchez Creek		
	Sanchez	
Easton Creek		
	Easton	
Mills Creek		
	Mills	
Colma Creek		
	Colma	
Marin County		
Coyote Creek		
	Coyote	
Arroyo Corte Madera del Presidio		Y
	Arroyo Corte Madera del Presidio	Y
	Willow Reed	Y
	Warner	Y
	Old Mill	Y
	Cascade	Y
Corte Madera Creek		Y
	Corte Madera	Y
	Larkspur	
	Tamalpais	Y
	Murphy	
	Ross	Y
	Sleepy Hollow	Y
	San Anselmo	Y
	Fairfax	Y
	Cascade	Y
Miller Creek		Y
	Miller	Y
Pacheco Creek		
	Pacheco	
Arroyo San Jose		
	Arroyo San Jose	See note 2
Novato Creek		Y
	Novato	Y
	Arroyo Avichi	
	Warner	
	Vineyard	Y
	Bowman Canyon	Y

Table B-1(cont.). Status of SF Estuary watersheds and streams with respect to reproducing *O. mykiss* populations

Y= yes, recent evidence of reproducing *O. mykiss*

Watershed	**Mainstem/tributary**	**Reproducing *O. mykiss***
Sonoma County		
Petaluma River		Y
	Petaluma	
	San Antonio	
	Adobe (Casa Grande)	Y
	Lynch	Y
	Washington	
	Lichau	
	Willow Brook (Hoggins)	Y
Sonoma Creek		Y
	Sonoma	Y
	Fowler	Y
	Rodgers	Y
	Felder	Y
	Carriger	Y
	Dowdall	
	Agua Caliente	Y
	Hooker	Y
	Wilson	
	Mill	Y
	Asbury	Y
	Calabazas	Y
	Redwood	Y
	Trinity	Y
	Stuart	Y
	Graham	Y
	Yulupa	
	Kunde	See note 2
	Fisher	See note 2
	Unnamed Trib. near Kenwood	
	Bear	Y
Schell Creek		Y
	Schell	See note 2
	Arroyo Seco	See note 2
	Haraszthy	Y
	Nathanson	Y
Napa County		
Huichica Creek		Y
	Huichica	Y
Napa River		Y
	Napa River	Y
	Carneros	Y
	Suscol	Y

Table B-1(cont.). Status of SF Estuary watersheds and streams with respect to reproducing *O. mykiss* populations

Y= yes, recent evidence of reproducing *O. mykiss*

Watershed	Mainstem/tributary	Reproducing *O. mykiss*
	Tulucay	Y
	Murphy	Y
	Spencer	Y
	Napa	Y
	Browns Valley	Y
	Redwood	Y
	Pickle Canyon	Y
	Milliken	Y
	Sarco	Y
	Camp	
	Salvador Outfall Channel	
	Soda	Y
	Dry	Y
	Hopper	
	Hinman	
	Segassia Canyon	Y
	Wing Canyon	Y
	Campbell	Y
	Montgomery	Y
	Conn	Y
	Rector	Y
	Chiles	
	Moore	
	Sage	Y
	Bale Slough	Y
	Bear Canyon	
	Sulphur	Y
	Heath Canyon	Y
	Iron Mine	Y
	York	Y
	Bell Canyon	Y
	Mill	Y
	Ritchie	Y
	Dutch Henry	Y
	Nash	
	Diamond Mountain	
	Simmons	
	Cyrus	Y
	Garnett	
	Jericho Canyon	Y
	Kimball Canyon	Y

Table B-1(cont.): Status of SF Estuary watersheds and streams with respect to reproducing *O. mykiss* populations

Y= yes, recent evidence of reproducing *O. mykiss*

Watershed	**Mainstem/tributary**	**Reproducing *O. mykiss***
Fagan Creek		
	Fagan	
American Canyon Creek		
	American Canyon	
Solano County		
Unnamed Creek to Cordelia Slough		Y
	Unnamed to Cordelia Slough	Y
Green Valley Creek		Y
	Green Valley	Y
	Wildhorse Valley	
Suisun Creek		Y
	Suisun	Y
	Gordon Valley	
	Wooden Valley	Y
	White	Y

SF Estuary watersheds:	58
Watersheds with *O. mykiss* reproduction:	24

SF Estuary streams:	280
Streams with *O. mykiss* reproduction:	122

Notes:

1. In recent years, chinook salmon and steelhead have entered the lower portion of Walnut Creek on spawning runs. This portion of the creek has been channelized, and fish encounter an impassable barrier near the Willows shopping center adjacent to I-680. Although some spawing may occur, habitat is not considered suitable to support a steelhead population in this system.

2. Although adult *O. mykiss* have been observed in this stream, insufficient evidence exists to characterize the system as supporting a reproducing population.

3. During construction of a restoration project on Alhambra Creek in 2004, adult *O. mykiss* were observed near the Alhambra Adult School. Adults also were observed in 2006 in Franklin Creek, a tributary of Alhambra Creek. A fisheries survey is planned for summer 2007, at which time more substantial evidence of steelhead reproduction may be found.

4. In 2005, consulting biologists observed an adult steelhead in San Lorenzo Creek near the upstream extent of the flood control channel (R. Taylor pers. comm.). Insufficient evidence exists to classify this system as supporting steelhead reproduction.

Information used to determine suitable *O. mykiss* rearing habitat

The following narrative describes the basis for our estimates of stream miles of suitable rearing habitat in each watershed and stream with a reproducing population of *O. mykiss*. Watersheds are listed in clockwise order beginning in Conta Costa County and moving around the San Francisco Estuary.

Contra Costa County

Pinole Creek -A 2005 sediment source assessment of Pinole Creek summarized the status of steelhead habitat by stating, "In general, the habitat available for rearing in the mainstem upstream of I-80, and especially on EBMUD lands appears adequate. Good habitat extends from approximately sample reach 5 to sample reach 10, with the best habitat near sample reaches 8 and 9" (SFEI 2005). These sample reaches include the stream sections from Pinole Valley Road (bridge number 5) to where power lines cross Alhambra Valley Road. Biologists from EBMUD consider rearing habitat to exist from the I-80 crossing upstream to a natural falls, with the best habitat existing in the lower part of EBMUD lands near the Pinole city limits. The I-80 culvert probably precludes migration except in the wettest years (Mulchaey, 2007).

San Pablo Creek - A 2004 study of steelhead habitat in San Pablo Creek found steelhead rearing habitat at four separate survey sites (Anderson and Maldague 2004) and stated, "Habitat surveys of San Pablo Creek's mainstem show that rearing habitat is plentiful in this watershed, specifically in the form of pool diversity, presence of riffles, water temperature and dissolved oxygen content" (Anderson and Maldague 2004, p.14). In 2006 spawning habitat, identified by shade cover and cobble/gravel substrate, was found in three reaches of San Pablo Creek near the railroad tracks (Contra Costa County Community Development Department 2006). The creek was classified as having suitable rearing habitat from the Via Verdi crossing in El Sobrante to the base of San Pablo Dam. Trout in the adfluvial population of San Pablo Reservoir can access an additional 0.5 stream miles to a drop structure just upstream from Bear Creek Road.

Wildcat Creek - In lower Wildcat Creek the Church and Vale sections (from the upstream side of the Church culvert to the upstream side of the San Pablo Culvert) were found to support the largest number of trout and have the best habitat characteristics (EBRPD 2006; SFEI 2001, Figure 20). Perennial flow and viable habitat are available in the Lower Canyon section of Wildcat Creek (SFEI 2001). Additional habitat is available from the northwestern most boundary of the East Bay Regional Park District property to the headwaters (Leidy *et al.* 2005).

Alameda County

Codornices Creek –Several studies and reports by local residents indicate that juvenile steelhead use the reaches between the Union Pacific tracks to the Albina Avenue crossing (Kier Associates 2004). Habitat is limited due to the lack of pools in Codornices Creek (Urban Creeks Council and Far West Restoration Engineering 2005) and the creek has been channelized upstream of Albina Avenue (Kier Associates 2004).

San Leandro Creek - In 1993 Leidy caught 23 juvenile and YOY *O. mykiss* at a sampling site three miles above Upper San Leandro Reservoir (Leidy *et al.* 2005). Additional juveniles and YOY were found at two other sites upstream of the reservoir. Leidy also found four juvenile and YOY *O. mykiss* at a site 0.1 miles downstream from Chabot Reservoir.

Kaiser Creek - Consulting biologist Jeff Hagar found *O. mykiss* in a 0.7 mile long reach from the Buckhorn Creek confluence (near where Kaiser Creek enters the reservoir) to the confluence with an unnamed creek (Leidy *et al.* 2005).

Redwood Creek - Leidy found 61 juvenile and YOY *O. mykiss* at a sampling site 2.2 miles upstream from the Upper San Leandro Reservoir in 1993 (Leidy *et al.* 2005).

Moraga Creek - Habitat exists from Upper San Leandro Reservoir at least 1.9 miles upstream to the Miramonte High School, where fish have been found on several occasions (Leidy *et al.* 2005).

<u>Alameda Creek</u> - Several sections of the Alameda Creek system have been mapped as steelhead spawning and rearing habitat including portions of Stonybrook Creek, Alameda Creek from Calaveras Creek to Alameda Diversion Dam, Alameda Creek from the Alameda Creek Diversion Dam to Valpe Creek, and Arroyo Mocho Canyon upstream from the USGS Gauging Station at first Mines Road crossing (Gunther *et al.* 2000). Two other sections provide the potential for habitat with increased summer flows, but currently have high summer water temperatures. These are the Niles Canyon section of Alameda Creek and the section from the SFPUC's filter plant to Calaveras Creek (Gunther *et al.* 2000).

Stonybrook Creek - "Stonybrook Creek is regarded as potential steelhead habitat based on presence of several age classes of rainbow trout including young-of-year" (Gunther *et al.* 2000, p. 25). Young of the year *O. mykiss* have been observed at the downstream end of an impassable road crossing located 1.5 miles upstream from the Alameda Creek confluence (Leidy *et al.* 2005).

Arroyo Mocho - The reach of Arroyo Mocho Canyon upstream of the USGS gauging station is designated as suitable *O. mykiss* spawning and rearing habitat (Gunther *et al.* 2000). The upstream extent of the habitat in this stream is defined by a gradient barrier approximately four miles upstream from the gauging station.

San Antonio Creek - The reach from the Turner Dam to the Alameda Creek confluence is 1.4 miles long. This stream may support *O mykiss* under certain conditions, specifically when dam releases occur during the dry season. Leidy found 13 juvenile and YOY *O. mykiss* at a sampling site 6.4 miles above the San Antonio Reservoir dam in 1997 (Leidy *et al.* 2005).

Indian Creek - Leidy found four *O. mykiss*, including juveniles, at a site 2.3 miles upstream from the confluence of San Antonio Creek in 1997 (Leidy *et al.* 2005).

La Costa Creek - Leidy caught 18 *O. mykiss*, including some YOY and juveniles, at a sampling site 5.6 miles upstream from the confluence of San Antonio Creek in 1993 (Leidy *et al.* 2005). Additional juveniles and YOY were found at two other sites further downstream.

Indian Joe Creek - Parks district staff sampled this creek in 1999 and found 26 YOY *O. mykiss* at a sampling site 0.4 miles upstream from the Alameda Creek confluence (Leidy *et al.* 2005). Additional YOY were also found in this area and field notes stated that trout are not found further upstream.

Calaveras Creek - The reach from the Calaveras Dam to the Alameda Creek confluence is about 0.7 miles in length. This reach likely can support *O. mykiss* with summer releases from the dam.

Arroyo Hondo - In 1993 Leidy collected three juvenile *O. mykiss* at a sampling site 9.2 miles upstream from Calaveras Reservoir (Leidy *et al.* 2005). Additional juveniles and YOY were collected and observed at three other sites further downstream.

Smith Creek - Leidy caught ten YOY *O. mykiss* in 1997 and observed 50 more in the same size range at a sampling site 6.1 miles upstream from the confluence with Arroyo Hondo (Leidy *et al.* 2005).

Sulphur Creek - In 2002 Leidy noted that juvenile *O. mykiss* were common from the confluence with Smith Creek to a waterfall barrier located 1.5 miles upstream (Leidy *et al.* 2005).

Isabel Creek - Habitat extends from the confluence with Arroyo Hondo to a gradient barrier 2.1 miles upstream. Dr. Jerry Smith described a "healthy" population in this stream (Leidy *et al.* 2005).

Santa Clara County

<u>Coyote Creek</u> - A section downstream of Anderson Reservoir is designated as a Coldwater and Fish Management Zone in FAHCE (FAHCE 2003, p.23). In another study, the area from the Metcalfe Road Bridge to the base of Anderson Dam was identified as having juvenile steelhead rearing habitat (Buchan and Randall 2003). The reach between the southernmost Highway 101 crossing and Anderson Dam was cited as having the best spawning and rearing habitat (Buchan and Randall 2003).

Coyote Creek - Historically, intermittent reaches of good *O. mykiss* habitat existed for 11.3 miles upstream from Coyote Reservoir to where the east and middle forks join to form mainstem Coyote Creek. Individuals have been found as far upstream as the northern portions of Henry Coe State Park (Leidy *et al.* 2005).

Upper Penitencia Creek - The section from Coyote Creek to the confluence of Arroyo Aguague is designated as a Fish Management Zone in FAHCE (FAHCE 2003, p. 23). According to a limiting factors analysis, Upper Penitencia supports steelhead in the section from 3.5 miles upstream from the Coyote Creek confluence to a waterfall barrier just upstream from the Arroyo Aguague confluence (Stillwater Sciences 2006).

Arroyo Aguague - The arroyo was surveyed as part of a limiting factors analysis in 2006. It was found to support steelhead from the mouth to a waterfall barrier 0.7 miles upstream (Stillwater Sciences 2006).

San Felipe Creek - Leidy caught 28 *O. mykiss*, including YOY and juveniles, at a sampling site 10.7 miles upstream from Anderson Reservoir (Leidy *et al.* 2005). Additional juveniles and YOY were found at other sites further downstream.

Cow Creek - Leidy found 17 juveniles at a sampling site 1.2 miles above the confluence with San Felipe Creek (Leidy *et al.* 2005). Additional juveniles were observed at the same location. The upstream extent of the habitat in this stream is defined by a gradient barrier.

Packwood Creek - Leidy observed juvenile *O. mykiss* at a site 4.1 miles upstream from Anderson Reservoir (Leidy *et al.* 2005).

Hoover Creek - Leidy caught 30 YOY and juveniles, and observed 15 more, at a sampling site located 0.7 miles upstream from Packwood Creek (Leidy *et al.* 2005).

Middle Fork Coyote Creek - Leidy found juvenile and YOY *O. mykiss* at a site 4.0 miles upstream from the confluence with Coyote Creek in 1995 and 1997 (Leidy *et al.* 2005).

<u>Guadalupe River</u> - Juvenile *O. mykiss* have been found in the vicinity of the Los Gatos Creek confluence and the I-280 crossing (Leidy *et al.* 2005).

Los Gatos Creek - "Suitable spawning and rearing habitat is limited to the upper 0.5–0.75 miles of creek below the Lexington Reservoir" (Tetra Tech Inc. 2005a, p. 9–66). There is also habitat upstream from Lake Elsman, between Lexington Reservoir and Lake Elsman, and near the Leigh Avenue crossing, where two juvenile *O. mykiss* were seen in the summer of 2001 (J. Abel in Leidy *et al.* 2005).

Austrian Gulch Creek- This creek contains approximately 0.5 miles of habitat (Leidy *et al.* 2005).

Guadalupe Creek - "Guadalupe Creek supports a coldwater steelhead assemblage below the Guadalupe Reservoir to approximately 1.25 miles upstream of its confluence with Guadalupe River" (Tetra Tech Inc. 2005a, p. 8–64). Guadalupe Creek also has approximately 0.8 miles of habitat between Guadalupe Reservoir and a natural falls barrier (Leidy *et al.* 2005).

Pheasant Creek - Habitat is estimated at about 0.3 stream miles based on sampling information (Leidy *et al.* 2005).

Rincon Creek - Habitat is estimated at about 0.1 miles based on sampling information (Leidy *et al.* 2005).

Alamitos Creek - In a 2005 study, a section of the creek downstream of Almaden Reservoir is shown as supporting a trout assemblage (Tetra Tech Inc. 2005a, p. 7–74). In 1997 staff from SCVWD found *O. mykiss* in the 120 meter reach downstream of the McKean Road crossing (Leidy *et al.* 2005). Data sheets from the SCVWD's WMI describe the two reaches below Almaden Reservoir as having "good quality habitat" (WMI 2003, p. 78–85).

Arroyo Calero - A section of the arroyo downstream of Calero Reservoir supports a trout assemblage (Tetra Tech Inc. 2005a, p. 7–74).

Herbert Creek - Habitat is estimated at approximately 1.0 miles based on the observations of biologists (Tetra Tech Inc. 2005a, p. 74; Abel 2006).

Barrett Canyon Creek - Habitat is estimated at approximately 0.5 miles based on the observations of biologists (Tetra Tech Inc. 2005a, p. 74; Abel 2006).

<u>San Tomas Aquino Creek</u> - Suitable habitat in this creek is located between the Quito Road crossing to the headwaters. This area is shown as having a "trout assemblage" on a fisheries study's map, but is described as possibly supporting a "warm water native fishery" in the text (Tetra Tech Inc. 2005b, p. 7–60).

Saratoga Creek - In a fisheries study, Saratoga Creek is described as supporting a "coldwater community including trout" from the Highway 9 crossing upstream to the headwaters (Tetra Tech Inc. 2005b p.8–57).

Bonjetti Creek - Leidy sampled at about 0.2 miles and 0.5 miles above the confluence and found three age classes of trout (Leidy *et al.* 2005).

<u>Stevens Creek</u> - In 1994, Leidy found juvenile *O. mykiss* at four sampling locations downstream from the reservoir (Leidy *et al.* 2005). More recent sampling indicates, "...resident rainbow trout...are present above Steven Creek Reservoir. Steelhead and resident rainbow trout...are present in perennial stream habitat downstream of Stevens Creek Reservoir" (Stillwater Sciences 2004, p. 12). The section of creek from Highway 280 to the dam (approximately four miles) supports a coldwater fish community, including steelhead (Tetra Tech Inc. 2006).

San Mateo County

<u>San Francisquito Creek</u> - A section of creek from the eastern border of the Jasper Ridge Biological Reserve downstream to the Los Trancos Creek confluence is shown as good spawning and rearing habitat in a consultants' report (Northwest Hydraulic Consultants Inc. *et al.* 2002, Figure 3–15). "Steelhead habitat includes San Francisquito Creek from Searsville Dam downstream in wet years to at least Junipero Serra Boulevard, a channel distance of about 5 ¼ miles" (Northwest Hydraulic Consultants Inc. *et al.* 2002, Appendix C, p. 57). "San Francisquito Creek, downstream of Searsville Dam through the Lagunita Diversion, provides quality steelhead habitat. Downstream of this area, the quality of steelhead habitat diminishes greatly" (Northwest Hydraulic Consultants and Jones & Stokes Associates 2004, p. 22). Construction monitoring at the Sand Hill Road bridge and the "Golf Cart Crossing" (in the Stanford golf course) in 2004 resulted in capturing and moving individuals from multiple *O. mykiss* year classes (Alley 2004).

Los Trancos Creek - "On Los Trancos Creek about 2 ½ miles of steelhead habitat exists downstream of the Stanford diversion dam" (Northwest Hydraulic Consultants Inc. *et al.* 2002, Appendix C, p. 57). In 1992, trout (mostly YOY) were found in the pool at the base of the Felt Lake Diversion on Los Trancos Creek and in the section up to 0.25 miles upstream of the diversion. The 0.25 mile section upstream of the diversion was found to contain high quality habitat (DFG 1995). In 2002

Los Trancos Creek was surveyed from the confluence with San Francisquito Creek to 1.6 miles upstream of the Felt Lake Diversion (3.9 miles total) (Vogel 2002). Fry and yearling trout were found in all sections and the report states, "Excellent trout habitats were present upstream and downstream of the diversion dam" (Vogel 2002, p. 10). Upstream of the surveyed area low flows and reduced fish numbers were observed.

Bear Creek - The lower 0.4 miles below a barrier is shown as good spawning and rearing habitat in a map (Figure 3–15) in a sediment impact study (Northwest Hydraulic Consultants Inc. *et al.* 2002). "The lower mile of Bear Creek has a gradient of 1 to 1.5 percent, with the riffles, runs and small pools likely to support more and faster-growing juvenile steelhead in the summer" (Northwest Hydraulic Consultants Inc. *et al.* 2002, Appendix C, p. 60). "In addition, in wet years steelhead utilize all 2 ½ miles of Bear Creek" (Northwest Hydraulic Consultants Inc. *et al.* 2002, p. 57).

Bear Gulch - Two miles of resident rainbow trout habitat exists above the California Water Service Dam located immediately upstream of Highway 84. In wet years steelhead use the lower ¾ mile of Bear Gulch Creek (Northwest Hydraulic Consultants Inc. *et al.* 2002).

West Union Creek - In wet years steelhead utilize the lower 2.5 miles of West Union Creek (Northwest Hydraulic Consultants Inc. *et al.* 2002).

Squealer Gulch - In wet years, steelhead utilized the lower 0.5 miles of accessible habitat in Squealer Gulch Creek (Northwest Hydraulic Consultants Inc. *et al.* 2002).

McGarvey Gulch - In wet years, steelhead utilized the lower 0.5 miles of accessible habitat in McGarvey Gulch Creek (Northwest Hydraulic Consultants Inc. *et al.* 2002).

Corte Madera Creek - "Upstream of Searsville Dam there is about 5 miles of resident rainbow trout habitat in Corte Madera Creek and up to 3 miles of resident rainbow trout habitat in the lower gradient (less than 10% slope) portions of its tributaries" (Northwest Hydraulic Consultants Inc. *et al.* 2002, Appendix C, p. 56).

San Mateo Creek - In 1988 Leidy found 11 *O. mykiss* juveniles in a 30 meter reach immediately upstream from Crystal Springs Reservoir. In 1991 *O. mykiss* were collected immediately upstream of Mud Dam Lake and downstream of Crystal Springs Reservoir. In 1993 Leidy found one adult in a 100 meter reach at Baywood Avenue, 33 *O. mykiss* of multiple age classes in a 30 meter reach at Sierra Drive, 18 individuals in a 50 meter reach at Tartan Trail Drive crossing, and two adults in a 30 meter reach at Arroyo Court, just upstream from the De Ana Camp Historical Marker (Leidy *et al.* 2005).

Marin County

Arroyo Corte Madera del Presidio - In 1995, consulting biologist Alice Rich deemed the area upstream from the Old Mill Creek confluence to the Lee Street crossing to be high quality habitat (Rich 1995). Leidy found at least four *O. mykiss* age classes in four locations in 1997. His sampling stations were between La Gama Street and Blithedale Park (Leidy *et al.* 2005).

Willow Reed (Widow) Creek - In the summer of 2004, Marin County staff noted YOY and age 1+ *O. mykiss* in Willow Reed Creek (Leidy *et al.* 2005).

Warner Creek - In the summer of 2004, Marin County staff noted YOY *O. mykiss* in Warner Creek (Leidy *et al.* 2005).

Old Mill Creek - In 1995, consulting biologist Alice Rich deemed portions of Old Mill Creek (except the downtown Mill Valley section, from Vogue Cleaners to Ethel Avenue) to constitute the best rearing habitat in the watershed, and *O. mykiss* were collected at several sampling sites (Rich 1995). Leidy *et al.* (2005) also noted multiple *O. mykiss* year classes in Old Mill Creek. As the culvert under the post office is believed to present a total passage barrier, individuals upstream from this point are presumed to be resident (Leidy *et al.* 2005).

Cascade Creek - Consulting biologist Alice Rich collected one juvenile *O. mykiss* in 1995 (on the upstream side of the culvert under Cascade Drive). However, she noted, "Due to the steep gradient and low flow conditions, Cascade Creek was not suitable for juvenile trout rearing at the time of the survey" (Rich 1995, p. 52). Leidy *et al.* (2005) also found YOY *O. mykiss* in Cascade Creek.

<u>Corte Madera Creek</u> - According to consulting biologist Alice Rich, the best Corte Madera Creek rearing habitat is between Lagunitas Road and the confluence of Ross Creek (Rich 2000, p. 56).

Tamalpais Creek - Staff from the Department of Fish and Game reported nursery habitat from Ridge View Road to the Corte Madera Creek confluence (Leidy *et al.* 2005).

Ross Creek - According to consulting biologist Alice Rich, Ross Creek between Natalie Coffin Green Park and Phoenix Lake "...provided rearing habitat for trout, albeit to a rather limited extent" (Rich 2000, p. 65). Staff from DFG characterized the reach from Glenwood Avenue to Phoenix Reservoir as nursery habitat (Leidy *et al.* 2005).

San Anselmo Creek - "Although short on water by the end of the summer, there is no question that San Anselmo Creek within the Cascade Open Space offered the best trout habitat of the entire creek" (Rich 2000, p. 62). In 1969, staff from DFG stated that juveniles inhabited two miles of the creek from the Fairfax Creek confluence downstream to the Winship Avenue bridge (Leidy *et al.* 2005).

Sleepy Hollow Creek - According to consulting biologist Alice Rich, the best habitat in the creek exists between Caleta Avenue crossing and Deer Hollow Road. "Although much of the section was dry at the time of the survey, this section was characterized by a great deal of spawning gravel and some good rearing pools with structure in them" (Rich 2000, p. 64). Both Dr. Rob Leidy and and staff from DFG conducted surveys above the Butterfield Road bridge and found juveniles (Leidy *et al.* 2005).

Fairfax Creek - In 2002 Marin County staff noted *O. mykiss* in Fairfax Creek near the Bothin Road bridge (Leidy *et al.* 2005; Lewis 2007). A box culvert immediately upstream from the confluence with San Anselmo Creek was deemed to be a serious impediment to fish passage (Leidy *et al.* 2005). One *O. mykiss* individual was observed in Fairfax Creek during 2006 sampling (Rich 2006). Repeated observations of YOY *O. mykiss* were made during the summer of 2006 by DFG staff (Sarrow pers. comm.).

Cascade Creek - Good quality habitat is present in the Cascade Open Space Preserve. Pools in this area provided rearing habitat (Rich 2000, p. 62). The upper limit to anadromy is Cascade Falls (Leidy *et al.* 2005).

<u>Miller Creek</u> - During stream surveys in 1999 and 2000 steelhead juveniles were observed in pools between Highway 101 and the area downsream from the Grady Bridge (Lewis 2007). In 2001 NMFS recorded 87 *O. mykiss* representing multiple year classes downstream of Mt. Lassen Bridge Drive. In 1997 Leidy found two adults upstream of Highway 101 and 15 YOY downstream from Mt. Shasta Drive. In 1993 Leidy observed one adult in a pool upstream from Las Gallinas Ave, three juvenile/adults in a 16 meter reach downstream of the Miller Creek Road crossing in Marinwood Park, four juvenile/adults in a 30 meter reach upstream of the lowest Lucas Valley Road crossing, and 13 *O. mykiss* in a 46 meter reach downstream from the Upper Lucas Valley Road crossing (Leidy *et al.* 2005). During the summer and fall of 2006 repeated observations of YOY and smolt sized steelhead were seen in the reach beginning at the Las Gallinas Road crossing and continuing upstream to the Mt. Shasta Road crossing (Sarrow pers. comm.).

<u>Novato Creek</u> - According to staff from Marin County Public Works, "…we do know steelhead rear in Novato Creek all the way up to Stafford Lake" (Lewis pers. comm.). Leidy found abundant YOY from the Bowman Canyon Creek confluence to 150 meters downstream, 12 YOY and juvenile *O. mykiss* in a 30 meter reach at Hicks Valley Road within Miwok Park, one adult in a 15 meter reach downstream from Diablo Avenue, two juveniles in a ten meter reach along Hicks Valley Road one mile below Stafford Lake Dam, and four YOY in a 30 meter reach immediately downstream from previous reach (Leidy *et al.* 2005).

Arroyo Avichi - During stream surveys in the spring and summer of 2006, several *O. mykiss* YOY were observed. The individuals were believed to be of anadromous ancestry (Sarrow pers. comm.).

Vineyard Creek - Dr. Rob Leidy observed abundant YOY/juveniles in a 100 meter reach upstream from Mill Road (Leidy *et al.* 2005). Young of the year and juvenile *O. mykiss* were observed to be common downstream from a concrete apron at the intersection of Santa Maria Drive and Brooke Drive.

Bowman Canyon Creek - In 2002, YOY and juveniles were observed to be common from Novato Boulevard downstream to the Novato Creek confluence (Leidy *et al.* 2005). Three juveniles were found upstream of Hicks Valley Road in 1981.

Sonoma County

<u>Petaluma River</u> - Leidy *et al.* (2005) did not find evidence of reproducing *O. mykiss* in mainstem Petaluma River. However, reproduction has been documented in at least two tributaries and the river may serve as a steelhead migration corridor.

San Antonio Creek - According to DFG staff, "On San Antonion Creek the potential habitat is from the Point Reyes-Petaluma Road crossing down to Highway 101" (Cox pers. comm.). Only anecdotal information could be found regarding the presence of steelhead in the creek, and a visit by CEMAR staff during May 2007 did not reveal "good" rearing habitat. (A habitat study is planned for the creek in summer 2007 that should help determine the suitability of the creek for steelhead rearing.)

Adobe Creek - Leidy captured juvenile *O. mykiss* approximately 100 meters upstream from the footbridge in Rancho Adobe State Park in 1997 (Leidy *et al.* 2005). A map by Prunuske Chatham, Inc. shows that the section of creek up to Petaluma Reservoir currently supports a steelhead run (Prunuske Chatham Inc. 1999, p. 12). According to DFG staff, about two miles of good steelhead habitat exists downstream from Petaluma Reservoir and another mile of marginal habitat is present downstream from the Adobe Road crossing (Cox pers. comm.). In 1998 *O. mykiss* were found to be most abundant in a section from Manor Lane to approximately two miles upstream. The habitat in this section also appeared to be "suitable for a variety of age classes of trout" (Rich 1998, p. 29).

Lynch Creek - A 1999 map shows the section of Lynch Creek below 400 feet in elevation as having the potential to support steelhead (Prunuske Chatham Inc. 1999, p. 12). According to DFG staff, the section from Highway 101 to Ely Road contains "marginal" habitat and upstream of Ely Road there is little or no habitat (Cox pers. comm.).

Willow Brook - Staff from DFG states that *O. mykiss* have been seen at the bridge crossing of Jacobson Lane. At least seasonally, the area below the bridge appears to offer good habitat (Cox pers. comm.).

<u>Sonoma Creek</u> - "Sonoma Creek at the entrance to Sugerloaf Ridge State Park is in the 'trout zone' as described by Moyle…The area along Warm Springs Road upstream of Bennett Valley Road may be considered a transition between the 'roach zone' and the 'trout zone'" (SSCRCD 1997, p. 9). According to investigations by the Sonoma Ecology Center, the area between the Graham and Bear creeks confluences was characterized as nursery habitat in 1966 by DFG, and has maintained population levels and habitat quality (Dawson 2005). According to a recent study, "Abundant age 1+ (>10 per habitat units) on Sonoma Creek were concentrated in miles 23–27, corresponding to Reaches 4, 5 and 7, located between Glen Ellen and Kenwood" (SEC 2006a, p. B-5, Figure B-1).

Rodgers Creek - A 1966 map indicates habitat upstream from the Champlin Creek confluence (Dawson 2005).

Felder Creek - According to staff from the Sonoma Ecology Center, the section of creek from Arnold Drive upstream approximately 2,000 feet contains juvenile *O. mykiss* in pools, although the reach may be drying earlier in recent years (Pier pers. comm.).

Carriger Creek/Fowler Creek - According to Sonoma Ecology Center staff, this system has maintained an *O. mykiss* population and habitat quality since 1966 (Dawson 2005). In 1997 Leidy collected three *O. mykiss* year classes in a 30 meter reach upstream of the O'Brien Road bridge and noted that this location contained excellent rearing habitat (Leidy *et al.* 2005).

Agua Caliente Creek- Young of year and juvenile *O. mykiss* were observed in Agua Caliente in 2001, but the specific location was not designated. In 1965 steelhead were noted in scattered pools at the end of Lomita Avenue off Arnold Drive. In 1966 YOY were noted along a 1.5 mile section of stream (Leidy *et al.* 2005).

Hooker Creek - Young-of-year and juvenile *O. mykiss* were observed in Hooker Creek in the summer of 2002, although specific locations were not designated (Leidy *et al.* 2005).

Mill Creek - Surveys by Dr. Rob Leidy and by Sonoma Ecology Center staff have produced *O. mykiss* observations, although the upstream extent of the habitat was not described in subsequent reports (Leidy *et al.* 2005).

Asbury Creek - According to work done by the local RCD, the creek contains limited habitat (Leidy *et al.* 2005). A map produced by the Sonoma Ecology Center indicates a relatively small amount of suitable habitat (Dawson 2005).

Calabazas Creek - A section of the creek between the Dunbar Road crossing and the Redwood Creek confluence has maintained an *O. mykiss* population and habitat quality since 1966, and trout were noted during sampling in 2002 (Dawson 2005). The upper extent of anadromy likely consists of a natural falls upstream from the Redwood Creek confluence (Leidy *et al.* 2005).

Stuart Creek - In a 1996 survey salmonids were observed from the confluence with Calabazas Creek to approximately 1.5 miles upstream, although the habitat in the lower section of the creek was categorized as "poor" to "marginal" (Leidy *et al.* 2005). A 1966 trout population and nursery habitat map compiled by the Sonoma Ecology Center shows some habitat in the middle reach of Stuart Creek (Dawson 2005). Resident trout were observed upstream from a natural falls and were presumed to be ancestors of a 1930s stocking effort. Therefore, this area was therefore not included in our habitat estimate (Leidy *et al.* 2005).

Trinity Creek - Oncorhynchus mykiss was observed in this creek in 2004 (Leidy *et al.* 2005). During a fish passage survey, juveniles and YOY were observed in pools from the Dunbar Road crossing to Trinity Road, approximately one mile upstream (Pier pers. comm.).

Redwood Creek - A section of the creek is designated as having "low numbers" of *O. mykiss* on a population/habitat map (Dawson 2005). Suitable habitat is present and juvenile *O. mykiss* have been observed in pools from the confluence with Calabazas Creek to approximately 0.5 miles upstream where the gradient becomes steep (Pier pers. comm.).

Graham Creek - The creek's lower reach has maintained an *O. mykiss* population and habitat quality since 1966, according to Sonoma Ecology Center staff, and trout were noted in a 2002 survey (Dawson 2005). Sampling has indicated the presence of juveniles (Leidy *et al.* 2005).

Bear Creek - The lower reach of Bear Creek has maintained an *O. mykiss* population and habitat quality since 1966, according to Sonoma Ecology Center staff, and trout were present in a 2002 survey (Dawson 2005). Staff from DFG noted that the creek contains the highest reproduction capacity for its length of the Sonoma Creek system (Leidy *et al.* 2005).

<u>Schell Creek</u>- Leidy *et al.* (2005) did not find evidence that a reproducing population of *O. mykiss* is present in Schell Creek. However, reproduction has been documented in one of its tributaries, and Schell Creek likely serves as a steelhead migration corridor.

Nathanson Creek - In a 1974 DFG survey *O. mykiss* were observed in the reach downstream from a 60 foot natural falls (located 2.5 miles upstream from the Lovall Valley Road crossing), and management as steelhead spawning and rearing habitat was recommended. *Oncorhynchus mykiss* also was observed upstream from the falls. The reach from Lovall Valley Road to the falls provides rearing habitat (Leidy *et al.* 2005). Juvenile *O. mykiss* has been observed where the creek passes through the town of Sonoma, particularly between the East Napa Street and Lovall Valley Road crossings, and along Gehricke Road. Some juveniles also have been observed near Sonoma Valley High School (Pier pers. comm.). The upper limit of anadromy appears to be a series of cascades located about two miles upstream from East Napa Street (Pier pers. comm.).

Haraszathy Creek - There is no recent evidence of *O.mykiss* reproduction, although the creek may currently be accessed by some spawning fish (Leidy *et al.* 2005). Local residents report observations near the end of Thornsberry Road and in the reach downstream from a natural falls located approximately one mile from the Schell Creek confluence (Pier pers. comm.).

Napa County

<u>Huichica Creek</u> - This creek has high quality rearing habitat in a 2.5 mile reach upstream from the Highway 12/121 crossing (Koehler 2007). In recent surveys, FONR/NCRCD found high densities of fish in multiple reaches.

<u>Napa River</u> - Low densities of *O. mykiss* were observed in some sections of the mainstem in 2004 (Koehler 2005). In 1961 DFG observed YOY from one mile north of Calistoga downstream to Zinfandel Lane (11.5 miles). “Staff from DFG considered this reach of the Napa River to be the most important spawning and nursery area of the mainstem…” (Leidy *et al.* 2005, p. 214). In 1969 DFG collected YOY and juveniles at three stations near the Sulphur Creek confluence (*i.e.,* Zinfandel Lane, Pratt Avenue, and Pope Street). In 1969 DFG staff observed juveniles and YOY in the 0.25 mile reach downstream from Kimball Canyon Dam (Leidy *et al.* 2005).

Carneros Creek - Rearing habitat exists from the Old Sonoma Bridge upstream for approximately four miles, and three smolts were observed in April 2007 (Sarrow pers. comm.; Koehler pers. comm.).

Suscol Creek - A portion of the creek’s middle reach showed a low density of steelhead in 2001 (Koehler and Napa County Resource Conservation District 2002). In 1997 Leidy caught eight *O. mykiss* in a 30 meter reach between Devlin Road and Highway 29/37 (Leidy *et al.* 2005).

Tulucay Creek - In 1981 DFG staff observed *O. mykiss* in pools in a reach below the Green Valley Road crossing. A 1958 DFG report noted that the “mid-section” of the drainage had suitable spawning areas (Leidy *et al.* 2005).

Murphy Creek - The lower portion of the creek showed low steelhead abundance in 2001 (Koehler and Napa County Resource Conservation District 2002). In 1990 DFG staff observed *O. mykiss* in pools upstream of the Shady Brook Lane crossing (Leidy *et al.* 2005).

Spencer Creek - Leidy et *al.* (2005) notes that trout have been observed at the Green Valley Road crossing (on Tulucay Creek), which crosses Spencer Creek. Also, a map produced by the NCRCD shows habitat in the lower reaches of this stream (Koehler and Napa County Resource Conservation District 2002).

Napa Creek - “Suitable rearing areas” exist between the Jefferson Street crossing and the confluence of Redwood and Browns Valley creeks (Koehler pers. comm.).

Browns Valley Creek - Juvenile *O. mykiss* was observed recently in the middle portion of the creek (Koehler pers. comm.). (Additional habitat information is forthcoming from the RCD’s pending habitat report.)

Redwood Creek - The lower section of this creek showed medium-high steelhead abundance during a 2001 survey (Koehler and Napa County Resource Conservation District 2002). An 11 foot high concrete dam at upper end of this reach probably limits usage of upstream habitat. Rearing habitat exists between the Browns Valley Creek confluence and the headwaters (Koehler pers. comm.). (Additional habitat information will be available from the RCD’s upcoming habitat report.)

Pickle Canyon Creek - A map produced by the NCRCD indicates the presence of *O. mykiss* habitat (Koehler and Napa County Resource Conservation District 2002).

Milliken Creek - Low to high densities of steelhead were observed in sections downstream from Milliken Reservoir in 2001 (Koehler and Napa County Resource Conservation District 2002). No information was found regarding possible resident trout habitat upstream of the dam.

Sarco Creek - A portion of the middle section showed a low density of steelhead in 2001 (Koehler and Napa County Resource Conservation District 2002). Staff from DFG caught or observed four *O. mykiss* in an area off Langley Park Lane (near 2131 Monticello Road) in 1990 (Leidy *et al.* 2005). Ecotrust also found *O. mykiss* during 2001 surveys in the creek, although the location could not be readily determined from the data source (Leidy *et al.* 2005).

Soda Creek - Surveys sponsored by the NCRCD included the 1.2 reach upstream from the Loma Vista Bridge. Some areas of high quality habitat were observed (Koehler 2005). A 1958 DFG survey noted that the lowest one mile portion of the creek maintained perennial flows and served as a steelhead nursery area (Leidy *et al.* 2005).

Dry Creek - Parts of the middle and upper section (downstream from the Montgomery Creek confluence) showed medium-high steelhead abundance in a 2001 survey (Koehler and Napa County Resource Conservation District 2002).

Segassia Canyon Creek - Surveys by FONR/NCRCD noted high juvenile *O. mykiss* densities in the creek as shown on a 2001 NCRCD map. According to RCD staff, Segassia Creek has approximately 3,500 feet of suitable steelhead spawning and rearing habitat (Koehler pers. comm.).

Wing Canyon Creek - A 0.8 mile section of this creek was surveyed for the Central Napa River Watershed Project. The Napa County RCD's report states, "Wing Canyon Creek offers high quality spawning and rearing habitat for steelhead throughout the entire surveyed length. Perennial flow and frequent cool shaded pools offer favorable conditions for juvenile rearing" (Koehler 2005, p. 112).

Campbell Creek - Leidy caught ten YOY *O. mykiss* immediately upstream from the Oakville Grade Road crossing in 1996 (Leidy *et al.* 2005).

Montgomery Creek - A high density of juvenile steelhead was observed in two reaches in 2001 (Leidy *et al.* 2005). Some spawning occurred in this creek in 2004, although habitat typically is limited by lack of water (Koehler 2005).

Conn Creek - The upper section contains spawning and rearing habitat, but is inaccessible due to Conn Dam (Koehler 2005, p. 57). In 1979, DFG staff sampled *O. mykiss* in locations upstream from the reservoir, upstream from Linda Falls, and near the Angwin Fire Station on College Road (Leidy *et al.* 2005). In 1988 *O. mykiss* were sampled in two reaches near the Rossi Road bridge (upstream from the reservoir). Leidy found juveniles at two locations in 1994: immediately downstream from Domain Chandon vineyard (0.2 miles upstream of the Napa River confluence) and at the confluence with Rector Creek (Leidy *et al.* 2005).

Rector Creek - In 2004 three juveniles were found in one deep perennial pool downstream from the reservoir (Koehler 2005). In 1988 DFG staff collected 53 *O. mykiss* in a 600 meter reach upstream of Rector Reservoir. In 1986, 30 juveniles were sampled between Silverado Trail and the spillway of Rector Reservoir (Leidy *et al.* 2005).

Chiles Creek - This stream supports an adfluvial *O. mykiss* population of native ancestry that could be used to supplement steelhead populations in the Napa River system (Sarrow pers. comm.). No information was found that characterized the geographic extent of rearing habitat in the stream, and it was not included in the habitat estimate for the Napa River watershed.

Sage Creek - This creek contains spawning and rearing grounds that are inaccessible due to Conn Dam (Koehler 2005, p.57). Small numbers of *O. mykiss* were collected in 1990 and 1996 at a site near the confluence of Fir Canyon Creek and another immediately upstream from the junction of Pope Valley and Sage Creek Roads (Leidy *et al.* 2005).

Bale Slough -In 2003 and 2004, YOY and juvenile *O. mykiss* were documented in the 0.3 mile reach upstream from the Whitehall Lane crossing. This reach was noted to have the only persistent pools in the system (Koehler 2005, p. 22). The lower one mile of the channel was dry in June 1981, and in 1958 DFG stated that is the lower reaches serve mainly as a migration corridor to Bear Canyon (Leidy *et al.* 2005).

Sulphur Creek - A fish habitat assessment for the Sulphur Creek watershed was performed by NCRCD in 2003 as a component of a watershed management plan. The surveys indicated steelhead presence as medium to high in the 0.6 mile reaches downstream and upstream from the North Fork Sulphur Creek confluence (Koehler 2003). Rearing habitat also occurs upstream from the Health Canyon Creek confluence (Koehler pers. comm.).

Heath Canyon Creek - The lower section of the creek showed medium-high steelhead abundance in 2001 surveys (Koehler and Napa County Resource Conservation District 2002). "The best available habitat for steelhead spawning and rearing is presently in reach 3 and 4 of main-stem Sulphur Creek, and all of Heath Canyon Creek" (Koehler 2003, p. 2). Location information was gathered from a map developed by the RCD (Koehler 2003, p. 28). An earth slide in the middle of the habitat reach was surveyed by DFG staff, who classified it as a total barrier to fish passage.

Iron Mine Creek- In a fish habitat assessment of Sulphur Creek, reaches three and four are indicated as having the best spawning and rearing habitat (Koehler 2003). This section of Sulphur Creek (the South Fork) is known as Iron Mine Creek.

York Creek - "Juvenile steelhead were observed primarily in the reaches upstream of Highway 29 where year-round water is present" (Koehler 2005, p. 123). The section of York Creek between Highway 29 and a bedrock falls in the upper creek is considered good quality habitat. The Passage Assessment Database characterizes the Upper St. Helena dam as a total barrier (CalFish 2006). Removal of the dam would make an additional 1.5 miles of habitat available (Koehler 2005).

Bell Canyon Creek - The Central Napa River Watershed map shows some steelhead (Koehler 2005). In surveys by the RCD, high quality habitat was noted in the middle reach of a 1.7 mile study area between the Napa River confluence and the dam forming Bell Canyon Reservoir (Koehler 2005).

Mill Creek - A map produced by the NCRCD indicates the extent of habitat in Mill Creek (Koehler and Napa County Resource Conservation District 2002).

Ritchie Creek - The middle and upper sections of the creek showed medium steelhead abundance in a 2001 survey (Koehler and Napa County Resource Conservation District 2002).

Dutch Henry Creek - A short section of the upper creek reach showed high *O. mykiss* abundance in a 2001 survey (Koehler and Napa County Resource Conservation District 2002). In 1987 DFG staff sampled YOY and adults immediately upstream and downstream from the Silverado Trail crossing (Leidy *et al.* 2005).

Diamond Mountain Creek – According to 2001 sampling, the creek showed low juvenile trout density (Koehler and Napa County Resource Conservation District 2002).

Cyrus Creek - According to 2001 sampling, the creek has low juvenile *O. mykiss* density (Koehler and Napa County Resource Conservation District 2002). In 2001 Leidy found *O. mykiss* immediately downstream on Calistoga's old water supply reservoir and in a 30 meter reach at 501 Petrified Forest Road (Leidy *et al.* 2005).

Garnett Creek - According to 2001 sampling, the creek has low juvenile *O. mykiss* density (Koehler and Napa County RCD 2002).

Jericho Canyon Creek - A map produced by the NCRCD indicates high juvenile *O. mykiss* density in a short reach downstream from a natural falls (Koehler and Napa County Resource Conservation District 2002). The downstream extent of this reach was assumed to consist of the "slope break" where the creek enters low gradient terrain. Nearby streams show a pattern of having habitat in higher gradient areas and not in lower gradient areas.

Kimball Canyon Creek - In 1997 Leidy sampled 12 *O. mykiss* in a five meter reach approximately 0.2 miles upstream from the St. Helena Reservoir (Leidy *et al.* 2005).

Solano County

<u>Unnamed to Cordelia Slough</u> - Two adult *O. mykiss* were seen in a pool east of I-80, approximately 200 yards upstream from a PG&E tower, where a pipe crosses the stream (Leidy *et al.* 2005).

<u>Green Valley Creek</u> - Leidy found two juvenile *O. mykiss* in 1997, one each at a site about one mile upstream from I-80 and another about two miles upstream. One adult and two juveniles also were found near Country Club Drive (Leidy *et al.* 2005).

<u>Suisun Creek</u> - In 2001 three adult trout were observed in the five mile reach beginning 11 miles downstream of Lake Curry. An adult also was seen about 0.25 miles downstream from the Wooden Valley Creek confluence. Juveniles were observed downstream from the dam. In 1975 steelhead were found upstream and downstream of the Rockville Road bridge which crosses the creek upstream from I-80 (Leidy *et al.* 2005). In 2002 juvenile *O. mykiss* were observed between 1.2 and 5.5 miles downstream of the dam (Hanson Environmental Inc. 2002). "Mean habitat quality rating for juvenile rearing steelhead was considered to be good within the reach upstream of Putah South Canal, and fair within the reach downstream of Putah South Canal" (Hanson Environmental Inc. 2002).

Wooden Valley Creek - A map of Wooden Valley Creek shows the locations of adult steelhead seen in 2001 (Blizard and CalTrans 2001). In 2002 YOY and juvenile *O. mykiss* were most abundant in the lower creek section (reaches 1, 2, and 3) of the creek (Koehler 2002a, p. 10). The canyon downstream from the Wooden Valley area was found to have highest steelhead abundance in 1959 and 1964 surveys. In 2001, spawning salmon were observed in the lower reach near Wooden Valley Road (Leidy *et al.* 2005).

White Creek - A 0.3 mile section of White Creek was surveyed in 2001 as part of a habitat inventory. Young of the year *O. mykiss* were found throughout the surveyed section (Koehler 2002a). The creek channel was noted to be dry upstream of the surveyed section, while access was not provided to the downstream reach and surveys could not be performed.

Table B-2. Suitable and available *O. mykiss* rearing habitat in selected SF Estuary watersheds and streams.
Watershed values are sums of mainstem and tributaries values. D/S = downstream from total barrier; U/S = upstream from total barrier.

		Habitat (stream miles)				
Watershed	**Stream**	**D/S**	**U/S**	**Total**	**Data source**	**Notes**
Contra Costa County						
Pinole Creek		5.8	0.0	5.8		
	Pinole	5.8	0.0	5.8	SFEI 2005, EBMUD 2007	from SFEI map, reaches 5 through 10, and additional habitat above I-80 to Pinole city limits
San Pablo Creek		4.3	0.5	4.8		
	San Pablo	4.3	0.5	4.8		
		4.3	0.0		Anderson and Maldague 2004; Contra Costa County CDD 2006; Leidy et al. 2005	from Via Verdi to San Pablo Dam
		0.0	0.5		Anderson and Maldague 2004; Contra Costa County CDD 2006; Leidy et al. 2005	above reservoir to drop structure u/s of Bear Creek Road
Wildcat Creek		5.1	0.0	5.1		
	Wildcat	5.1	0.0	5.1		
		0.7	0.0		EBRPD 2006; SFEI 2001; Leidy et al. 2005; Contra Costa County CDD 2006	Curch and Vale sections (EBRPD 2006)
		4.4	0.0		EBRPD 200;, SFEI 2001; Leidy et al. 2005; Contra Costa County CDD 2006	Jewel Lake is total barrier to migration, no evidence of anadromous reproduction above I-80 culvert
Alameda County						
Codornices Creek		1.3	0.0	1.3		habitat in reaches 2 and 3 only (see map in reference document)
	Codornices Creek	1.3	0.0	1.3	Urban Creeks Council and Far West Restoration Engineering 2005	
San Leandro Creek		1.3	8.6	9.9		
	San Leandro	1.3	2.4	3.7		
		1.3	0.0		Leidy et al. 2005	marginal habitat below Chabot Dam
		0.0	2.4		Leidy et al. 2005	above reservoir to 0.45 miles above Canyon Post Office
	Kaiser	0.0	0.9	0.9	Leidy et al. 2005	Above Upper San Leandro Reservoir, downstream from confluence of "Callahan Creek"
	Redwood	0.0	3.4	3.4		
		0.0	1.8		Leidy et al. 2005	Above Upper San Leandro Reservoir, non-functioning fish ladder probable limit to migration
		0.0	1.6		Leidy et al. 2005	West Fork Redwood Creek, surveyed up to 'Big Springs', upper extent gradient barrier
	Moraga	0.0	1.9	1.9	Leidy et al. 2005	Above Upper San Leandro Reservoir at least to Miramonte High School, upper extent unknown
Alameda Creek		12.7	50.6	63.3		
	Alameda	9.5	16.4	25.9		
		5.3	0.0		Gunther et al. 2000	Niles Canyon
		3.6	0.0		Gunther et al. 2000	PUC Filtration to Calaveras confluence
		0.6	0.0		Gunther et al. 2000	Mainstem from Calaveras confluence to Little Yosemite
		0.0	2.3		Gunther et al. 2000	Little Yosemite to diversion dam
		0.0	9.0		Gunther et al. 2000	Above diversion dam to Valpe Creek confluence
		0.0	5.1		CEMAR 2007	from Valpe Creek to gradient barrier
	Stonybrook	1.5	2.9	4.4	NMFS 2005; Gunther 2000	
		1.5	0.0			from mouth to u/s of Winzler & Kelly design (Palomares Rd marker 8.16)
		0.0	2.9			from PM 8.16 to gradient barrier
	Arroyo Mocho	0.0	4.0	4.0	Gunther 2000	upper extent gradient barrier, extremely remote canyon
	San Antonio	1.5	3.6	5.1		
		1.5	0.0		Leidy et al. 2005	below Turner Dam
		0.0	3.6		Leidy et al. 2005	above San Antonio Reservoir, upper extent gradient barrier
	Indian	0.0	3.1	3.1	Leidy et al. 2005	above San Antonio Reservoir, upper extent gradient barrier
	La Costa	0.0	1.4	1.4	Leidy et al. 2005	above San Antonio Reservoir, upper extent gradient barrier

Table B-2 (cont.). Suitable and available *O. mykiss* rearing habitat in selected SF Estuary watersheds and streams.
Watershed values are sums of mainstem and tributaries values. D/S = downstream from total barrier; U/S = upstream from total barrier.

		Habitat (stream miles)				
Watershed	Stream	D/S	U/S	Total	Data source	Notes
	Indian Joe	0.2	0.0	0.2	Leidy et al. 2005	upper extent gradient barrier
	Calaveras	0.7	0.0	0.7	Leidy et al. 2005	
	Arroyo Hondo	0.0	9.2	9.2	Leidy et al. 2005	Above Calaveras Reservoir, up to confluence with Smith and Isabel Creeks
	Smith	0.0	6.4	6.4	Leidy et al. 2005	Above Calaveras Reservoir, upper extent gradient barrier
	Sulphur	0.0	1.5	1.5	Leidy et al. 2005	Above Calaveras Reservoir from Smith Creek confluence to natural falls
	Isabel	0.0	2.1	2.1	Leidy et al. 2005	Above Calaveras Reservoir, upper extent gradient barrier
Santa Clara County						
Coyote Creek		13.7	20.9	34.6		
	Coyote	9.2	3.1	12.3		
		9.2	0.0		FAHCE 2003	below Anderson Dam d/s to southern-most 101 crossing
		0.0	3.1		Leidy et al. 2005	Above Coyote Reservoir to intersection of Gilroy Hot Springs Rd and Cañada Rd
	Upper Penitencia	3.4	0.0	3.4	FAHCE 2003; Stillwater Sciences 2006	Habitat exists up to natural bedrock falls. Evidence of resident population above falls, probably of hatchery origin
	Arroyo Aguague	1.1	0.0	1.1	FAHCE 2003; Stillwater Sciences 2006	Habitat exists up to natural bedrock falls.
	San Felipe	0.0	10.7	10.7	Leidy et al. 2005	Above Anderson Reservoir to Leidy sampling point, u/s extent is gradient barrier
	Cow	0.0	1.2	1.2	Leidy et al. 2005	Above Anderson Reservoir, upper extent gradient barrier
	Packwood	0.0	4.1	4.1	Leidy et al. 2005	Above Anderson Reservoir to confluence with Hoover Creek
	Hoover	0.0	0.7	0.7	Leidy et al. 2005	from confluence with Packwood Creek to Leidy sampling point
	Middle Fork Coyote	0.0	1.1	1.1	Leidy et al. 2005; NMFS 2005	to Leidy sampling point in Henry Coe State Park (Upper Camp)
Guadalupe River		16.7	9.7	26.4		
	Guadalupe River	1.3	0.0	1.3	Leidy et al. 2005	per J. Abel and (Koslowski 2002), see shapefile comments for more detail
	Los Gatos	1.0	6.8	7.8		
		1.0	0.0		Leidy et al. 2005	two juveniles observed at Leigh Av. In summer 2001 (J. Abel in Leidy (2005) p.113)
		0.0	0.7		Tetra Tech Inc. 2005 p.9-66	below Lexington Reservoir
		0.0	3.8		Leidy et al. 2005	between Lexington Reservior and Lake Elsman
		0.0	2.3		Leidy et al. 2005	above Lake Elsman (surveyed after 1962 forest fire)
	Austrian Gulch	0.0	0.5	0.5	Leidy et al. 2005	Above Lake Elsman, upper extent unknown
	Guadalupe Creek	4.2	0.8	5.0		
		4.2	0.0		Tetra Tech Inc. 2005	below Guadalupe Reservoir d/s to 1.25 miles above Lake Almaden
		0.0	0.8		Leidy et al. 2005	above Guadalupe Reservoir to natural falls
	Pheasant	0.2	0.0	0.2	Leidy et al. 2005	up to bedrock falls
	Rincon	0.0	0.1	0.1	Leidy et al. 2005	Above Guadalupe Reservoir, upper extent unknown
	Alamitos	7.6	0.0	7.6	Tetra Tech Inc. 2005; Abel 2006; WMI 2003	from confluence to Almaden Reservoir
	Herbert	0.0	1.0	1.0	Tetra Tech Inc. 2005; Abel 2006	upstream of Almaden Reservoir, extent from SCVWD map
	Barrett Canyon	0.0	0.5	0.5	Tetra Tech Inc. 2005; Abel 2006	upstream of Almaden Reservoir, extent from SCVWD map
	Arroyo Calero	2.4	0.0	2.4	Tetra Tech Inc. 2005	unclear if this reach supports resident or anadromous O. mykiss, below Calero Reservoir
San Tomas Aquino Creek		0.0	10.1	10.1		
	San Thomas Aquino	0.0	4.6	4.6	Leidy et al. 2005	from Quito Rd crossing and drop structure to headwaters
	Saratoga	0.0	4.7	4.7	Tetra Tech Inc. 2005	from Highway 9 crossing upstream to headwaters
	Bonjetti	0.0	0.8	0.8	Leidy et al. 2005	approximately 0.5 miles u/s from confluence with Saratoga Creek

Table B-2 (cont.). Suitable and available *O. mykiss* rearing habitat in selected SF Estuary watersheds and streams.
Watershed values are sums of mainstem and tributaries values. D/S = downstream from total barrier; U/S = upstream from total barrier.

		Habitat (stream miles)				
Watershed	**Stream**	**D/S**	**U/S**	**Total**	**Data source**	**Notes**
Stevens Creek		3.7	4.4	8.1		
	Stevens	3.7	4.4	8.1		
		3.7	0.0		Tetra Tech Inc., 2006	From I-280 to dam
		0.0	4.4		Leidy et al. 2005	above reservoir to Leidy sampling point, upper extent unknown
SF/San Mateo County						
San Francisquito Creek		18.1	6.9	25.0		
	San Francisquito	5.4	0.0	5.4	Northwest Hydraulic Consultants Inc.et al. 2002	downstream extent unknown
	Los Trancos	3.9	0.0	3.9	Northwest Hydraulic Consultants Inc.et al. 2002; Vogel 2003	u/s to 1.6 miles above Felt Lake diversion structure
	Bear	3.3	0.0	3.3	Northwest Hydraulic Consultants Inc.et al. 2002; Smith and Harden 2001	figure includes 3/4 mile of anadromous habitat in Bear Gulch Creek (definitions of what differentiates Bear and Bear Gulch creeks differ between sources)
	Bear Gulch	2.0	0.0	2.0	Northwest Hydraulic Consultants Inc.et al. 2002; Smith and Harden 2001	above California Water Service Dam
	West Union	2.5	0.0	2.5	Northwest Hydraulic Consultants Inc.et al. 2002; Smith and Harden 2001	up to barrier #34 on J.J. Smith map
	Squealer Gulch	0.5	0.0	0.5	Northwest Hydraulic Consultants Inc.et al. 2002; Smith and Harden 2001	up to barrier #25 on J.J. Smith map
	McGarvey Gulch	0.5	0.0	0.5	Northwest Hydraulic Consultants Inc.et al. 2002; Smith and Harden 2001	up to barrier #30 on J.J. Smith map
	Corte Madera	0.0	6.9	6.9	Northwest Hydraulic Consultants Inc. et al. 2002	Above Searsville Reservior, upper extent unknown, includes tributaries (< 10% slope) (these were not mapped as there was no indication as to which tribs should be included)
San Mateo Creek		2.8	0.5	3.3		
	San Mateo	2.8	0.5	3.3		
		0.0	0.5		Leidy et al. 2005	above Crystal Springs res., upper extent unknown
		2.8	0.0		Leidy et al. 2005	lower extent unknown
Marin County						
Arroyo Corte Madera del Presidio		6.7	0.0	6.7		
	Arroyo Corte Madera del Presidio	2.7	0.0	2.7		
		1.1	0.0		Leidy et al. 2005; Rich 1995	u/s to culvert under building (Ross Taylor)
		1.6	0.0		Leidy et al. 2005; Rich 1995	upper extent gradient barrier, numerous other barriers present
	Willow Reed	0.8	0.0	0.8	Leidy et al. 2005; Rich 1995	extent estimated around Leidy sampling points
	Warner	0.8	0.0	0.8	Leidy et al. 2005; Rich 1995	extent estimated around Leidy sampling points
	Old Mill	1.7	0.0	1.7		
		0.1	0.0		Leidy et al. 2005; Rich 1995	from confluence to Post Office
		1.6	0.0		Leidy et al. 2005; Rich 1995	from Post office to Cascade Dam
	Cascade	0.7	0.0	0.7	Leidy et al. 2005; Rich 1995	limited by lack of water, from confluence with Old Mill Creek to just u/s of the culvert at Cascade Falls Trail
Corte Madera Creek		11.6	0.7	12.3		
	Corte Madera	1.4	0.0	1.4	Leidy et al. 2005; Rich 2000	Bay Streams Report indicates that juveniles were found in several locations from the bay to the confluence with San Anselmo Creek
	Tamalpais	0.9	0.0	0.9	Leidy et al. 2005; Rich 2000	downstream from Ridgeview Rd.
	Ross	0.7	0.0	0.7	Leidy et al. 2005; Rich 2000	between Glenwood Ave bridge to reservoir, probably additional resident habitat above Phoenix Lake
	San Anselmo	5.9	0.0	5.9	Leidy et al. 2005; Rich 2000	from confluence with Corte Madera to headwaters
	Sleepy Hollow	2.3	0.0	2.3	Leidy et al. 2005	to upstream of Butterfield Dr (Leidy sample point), upper extent unknown, but several barriers present

Table B-2 (cont.). Suitable and available *O. mykiss* rearing habitat in selected SF Estuary watersheds and streams.
Watershed values are sums of mainstem and tributaries values. D/S = downstream from total barrier; U/S = upstream from total barrier.

		Habitat (stream miles)				
Watershed	**Stream**	**D/S**	**U/S**	**Total**	**Data source**	**Notes**
	Fairfax	0.0	0.7	0.7	Lewis 2007	trout seen up to Bothin Rd bridge. This is upstream of box culvert at confluence with San Anselmo
	Cascade	0.4	0.0	0.4	Leidy et al. 2005; Rich 2000	upper limit is Cascade Falls
Miller Creek		5.0	0.0	5.0	Leidy et al. 2005; Lewis 2007	upper extent gradient barrier, very sparse information on this creek
	Miller	5.0	0.0	5.0		
Novato Creek		4.8	0.0	4.8		
	Novato	2.6	0.0	2.6	Leidy et al. 2005; Rich 1996	possible resident habitat above Stafford Lake
	Arroyo Avichi	1.0	0.0	1.0	Sarrow 2007	from Arthur Rd to Indian Valley/Old Ranch Road intersection
	Vineyard	0.7	0.0	0.7	Leidy et al. 2005; Rich 1996	upper and lower extents unknown, barriers probably limit movement, R. Taylor says up to 4.6 miles available
	Bowman Canyon	0.5	0.0	0.5	Leidy et al. 2005; Rich 1996	upper extent unknown, possible gradient barrier
Sonoma County						
Petaluma River		5.5	0.0	5.5		
	Petaluma				Leidy et al. 2005	no evidence of reproduction in this stream, migration corridor only
	San Antonio	0.0	0.0	0.0	Cox 2007; Furrer 2007	potential habitat, but no confirmed juvenille sightings
	Adobe	3.4	0.0	3.4	SSCRCD 1999; Cox 2007	extent derived from map in referenced document, revised with professional judgement (B. Cox) upper limit is waterfall near Petaluma Reservoir
	Lynch	0.8	0.0	0.8	SSCRCD 1999; Cox 2007	extent derived from map in referenced document, revised with professional judgement (B. Cox)
	Willow Brook	1.3	0.0	1.3	Cox 2007	from just upstream of Jacobson bridge d/s to Adobe Road
Sonoma Creek		27.8	1.3	29.1		
	Sonoma	10.1	0.0	10.1		
		9.3	0.0		Leidy et al. 2005	from Glen Ellen to natural falls above Bear Creek confluence
		0.8	0.0		Dawson 2005; Leidy et al. 2005	small reach on SEC 1966 population/habitat map
	Rodgers	0.6	0.0	0.6	Dawson 2005	from SEC 1966 population/habitat map
	Felder	0.4	0.0	0.4	Pier 2007	W. Pier pers. comm.
	Carriger/Fowler	4.4	0.0	4.4	Dawson 2005; Leidy et al. 2005	from SEC 1966 population/habitat map
	Agua Caliente	1.5	0.0	1.5	Leidy et al. 2005	1.5 miles around Lomita Ave. upper and lower extents unknown
	Hooker	1.8	0.0	1.8	Leidy et al. 2005	SEC found O.mykiss in 2002, from RT 12 crossing to natural falls
	Mill	0.4	0.0	0.4	Leidy et al. 2005	upper extent unknown, SEC survey found fish in 2004, indefinite location
	Asbury	1.5	0.0	1.5	Dawson 2005; Leidy et al. 2005	from SEC 1966 population/habitat map
	Calabazas	3.4	0.0	3.4	Dawson 2005; Leidy et al. 2005	u/s to natural falls
	Stuart	1.5	0.0	1.5	Dawson 2005; Leidy et al. 2005	u/s to natural falls
	Trinity	1.0	0.0	1.0	Pier 2007	confluence u/s to grade change above Trinity Rd.
	Redwood	0.5	0.0	0.5	Pier 2007; Dawson 2005	W. Pier pers. comm.
	Graham	0.2	1.3	1.5		
		0.2	0.0	0.2	Dawson 2005; Leidy et al. 2005	anadromous habitat u/s to barrier formed by ‹water users›
		0.0	1.3	1.3	Dawson 2005; Leidy et al. 2006	resident habitat u/s to Jack London SP
	Bear	0.5	0.0	0.5	Dawson 2005; Leidy et al. 2005	up to bedrock falls
Schell Creek		4.4	0.0	4.4		
	Nathanson	3.1	0.0	3.1	Leidy et al. 2005; Pier 2007	from Sonoma Valley High School to natural falls
	Haraszathy	1.3	0.0	1.3	Leidy et al. 2005; Pier 2007	from Arroyo Seco confluence to Haraszthy Falls

Table B-2 (cont.). Suitable and available *O. mykiss* rearing habitat in selected SF Estuary watersheds and streams.
Watershed values are sums of mainstem and tributaries values. D/S = downstream from total barrier; U/S = upstream from total barrier.

		Habitat (stream miles)				
Watershed	**Stream**	**D/S**	**U/S**	**Total**	**Data source**	**Notes**
Napa County						
Huichica Creek		2.5	0.0	2.5		
	Huichica	2.5	0.0	2.5	Koehler 2007a	upstream from Highway 121 crossing
Napa River		63.4	18.6	82.0		
	Napa River	12.0	0.0	12.0		
		0.5	0.0		Leidy et al. 2005	immediately below Kimball Canyon Dam
		11.5	0.0		Leidy et al. 2005	from 1 mile north of Calistoga d/s to St. Helena
	Carneros	4.0	0.0	4.0	Sarrow 2007	4 miles above Old Sonoma Creek bridge
	Suscol	1.6	0.0	1.6	Leidy et al. 2005; Stillwater Sciences & W. Dietrich 2002	low densities observed - also assumtion that habitat exists between observation points
	Tulucay	1.3	0.0	1.3	Leidy et al. 2005; Stillwater Sciences & W. Dietrich 2002	historical evidence in Bay Streams Report
	Murphy	1.3	0.0	1.3	Leidy et al. 2005; Stillwater Sciences & W. Dietrich 2002	from NCRCD map
	Spencer	0.7	0.0	0.7	Leidy et al. 2005; Stillwater Sciences & W. Dietrich 2002	from NCRCD map
	Browns Valley	1.4	0.0	1.4	Koehler 2007	middle third of overall stream length
	Napa Creek	1.4	0.0	1.4	Koehler 2007	from Jefferson Street to confluence with Redwood/Browns Valley
	Redwood	6.9	2.8	9.7	Leidy et al. 2005; Stillwater Sciences & W. Dietrich 2002	upper limit of anadromy is 11ft dam, natural limit is in headwaters (Archer Taylor Preserve)
	Pickle Canyon	2.4	0.0	2.4	Leidy et al. 2005; Stillwater Sciences & W. Dietrich 2002	extent from NCRCD map
	Milliken	1.4	0.4	1.8		
		0.0	0.4		Leidy et al. 2005; Stillwater Sciences & W. Dietrich 2002	above City of Napa Diversion dam
		1.4	0.0		Leidy et al. 2005; Stillwater Sciences & W. Dietrich 2002	below City of Napa Diversion dam
	Sarco	0.8	0.0	0.8	Leidy et al. 2005; Stillwater Sciences & W. Dietrich 2002; Ecotrust 2001	extent from Ecotrust map, and DFG sampling at Langley Park Rd.
	Soda	1.2	0.0	1.2	Koehler 2005; Leidy et al. 2005	lowest one mile maintains permanent flow and is good nursery area (DFG 1958), NCRCD survey found high quality habitat
	Dry	8.7	0.0	8.7	Leidy et al. 2005; Stillwater Sciences & W. Dietrich 2002	FONR/NCRCD survey, NCRCD 2002 map
	Segassia Canyon	0.5	0.0	0.5	Koehler 2007a	FONR/NCRCD survey, NCRCD 2002 map
	Wing Canyon	0.8	0.0	0.8	Koehler 2005	from NCRCD 2005 map
	Campbell	0.1	0.0	0.1	Leidy et al. 2005	FONR/NCRCD survey, NCRCD 2002 map
	Montgomery	1.6	0.0	1.6	Koehler 2005; Leidy et al. 2005	(Leidy 2005) reports high density surveys from NCRCD in 2001. In 2005, NCRCD reports that creek is significantly limited by lack of water, although physical character is suitable.
	Conn	1.3	7.1	8.4		
		1.3	0.0		Leidy et al. 2005	from confluence with Napa River to Rector Creek confluence
		0.0	7.1		Leidy et al. 2005	upstream from Lake Hennessey to Angwin, upper extent unknown
	Rector	0.7	3.0	3.7		
		0.7	0.0		Leidy et al. 2005; Stillwater Sciences & W. Dietrich 2002	below Rector Reservoir
		0.0	3.0		Leidy et al. 2005	Above Rector Reservoir, assumed upstream DFG sampling point is road crossing
	Sage	0.0	2.7	2.7	Leidy et al. 2005; Stillwater Sciences & W. Dietrich 2002	Above Lake Hennessey
	Chiles	0.0	0.9	0.9	Stillwater Sciences & W. Dietrich 2002; A.A Rich 2007	Above Lake Hennessey to natural barrier per A.A. Rich map, p E-15
	Bale Slough	0.3	0.0	0.3	Leidy et al. 2005; Koehler 2005; Stillwater Sciences & W. Dietrich 2002	primarily migration corridor, juveniles observed in 2004, 0.3 miles above Whitehall Lane (J. Koehler, pers. Comm.)
	Sulphur	1.7	0.0	1.7	Koehler 2003, Koehler 2007	from NCRCD map, p. 28 -- upstream from Heath Canyon confluence to debris flow
	Heath Canyon	1.4	0.0	1.4	Koehler 2003; Leidy et al. 2005	upstream of Sulphur Creek, there is a recent earth slide that may prevent upstream migration.

Table B-2 (cont.). Suitable and available *O. mykiss* rearing habitat in selected SF Estuary watersheds and streams.
Watershed values are sums of mainstem and tributaries values. D/S = downstream from total barrier; U/S = upstream from total barrier.

		Habitat (stream miles)				
Watershed	**Stream**	**D/S**	**U/S**	**Total**	**Data source**	**Notes**
	Iron Mine	0.6	0.0	0.6	Koehler 2003	from Sulphur Creek habitat assessment as well as NCRCD map.
	York	1.6	1.5	3.1		
		1.6	0.0		Leidy et al. 2005; Koehler 2005; Stillwater Sciences & W. Dietrich 2002	from Upper St. Helena dam to bedrock falls
		0.0	1.5		Koehler 2005	removal of the in-stream reservior (scheduled 2006-2008) will make this reach accessible to anadromy
	Bell Canyon	0.6	0.0	0.6	Koehler 2005	from NCRCD 2002 map, d/s from Bell Canyon Dam
	Mill	1.0	0.0	1.0		from NCRCD 2002 map
	Ritchey	2.7	0.0	2.7	Leidy et al. 2005; Stillwater Sciences & W. Dietrich 2002	from Hwy 12 into state park
	Dutch Henry	1.4	0.0	1.4	Leidy et al. 2005; Stillwater Sciences & W. Dietrich 2002	from NCRCD 2002 map, d/s extent estimated
	Diamond Mountain Creek	0.1	0.0	0.1	Leidy et al. 2005; Koehler and Napa County RCD 2002	from NCRCD study, reach #2
	Cyrus	0.4	0.0	0.4	Leidy et al. 2005; Stillwater Sciences & W. Dietrich 2002	extent unknown, surveys limited to pools
	Garnett	0.02	0.0	0.0	Leidy et al. 2005; Koehler and Napa County RCD 2002	from NCRCD study, reach #3
	Jericho Canyon	1.5	0.0	1.5	Koehler and Napa County RCD 2002; Leidy et al. 2005	from NCRCD 2002 map, d/s extent estimated, gradient change
	Kimball Canyon	0.0	0.2	0.2	Leidy et al. 2005	Above Kimball Canyon Reservoir, upper extent unknown
Solano County						
Unnamed to Cordelia Slough		1.7	0.0	1.7	Leidy et al. 2005	creek has perennial flow due to CalDOT dewatering slope under I-80, NMFS refers to reach as «Red Top Creek,» Solano County as «American Canyon Creek»
	Unnamed to Cordelia Slough	1.7	0.0	1.7		
Green Valley Creek		3.9	0.0	3.9	Leidy et al. 2005	very possible that good habitat exists above Green Valley Country Club, upper extent unknown
	Green Valley	3.9	0.0	3.9		
Suisun Creek		9.6	0.0	9.6		
	Suisun	7.9	0.0	7.9	Leidy et al. 2005; Hanson Environmental 2002	good habitat between Putah South Canal and Lake Curry (Hanson, 2002), possibly good resident habitat above Lake Curry
	Wooden Valley	1.4	0.0	1.4	Leidy et al. 2005; Koehler 2002; Stillwater Sciences & W. Dietrich 2002	upper extent unknown, private property limits surveys
	White	0.3	0.0	0.3	Koehler 2002	limited survey length due to landowner access issues

Table B-3. Long-term total passage barriers in San Francisco Estuary watersheds.
Please see Appendix A for method of determination.

Watershed	Stream	Total barrier	Source
Pinole Creek			
	Pinole	none	CEMAR[1]
San Pablo Creek			
	San Pablo	San Pablo Dam	Leidy et al. 2005
Wildcat Creek			
	Wildcat	Jewel Lake Dam	Leidy et al. 2005
Codornices Creek			
	Codornices	none	CEMAR[1]
San Leandro Creek			
	San Leandro	Chabot Dam	Leidy et al. 2005
Alameda Creek			
	Alameda	Alameda Creek Diversion Dam	Leidy et al. 2005
	Stonybrook	none	Leidy et al. 2005
	Arroyo Mocho	none	Leidy et al. 2005
	San Antonio	Turner Dam	Leidy et al. 2005
	Indian Joe	none	Leidy et al. 2005
	Calaveras	Calaveras Dam	Leidy et al. 2005
Coyote Creek			
	Coyote	Anderson Dam	Leidy et al. 2005
	Upper Penitencia	bedrock falls	Leidy et al. 2005
	Arroyo Aguague	bedrock falls	Leidy et al. 2005
Guadalupe River			
	Guadalupe River	none	Leidy et al. 2005
	Los Gatos	Page Dam	Leidy et al. 2005
	Guadalupe	Guadalupe Dam	Leidy et al. 2005
	Pheasant	bedrock falls	Tetra Tech 2005
	Alamitos	Almaden Dam	Leidy et al. 2005
	Arroyo Calero	Calero Reservoir Dam	Leidy et al. 2005
San Thomas Aquino Creek			
	San Thomas Aquino	San Thomas Aquinas Drop Structure	Tetra Tech 2005
	Saratoga	San Jose Water Diversion Dam	Tetra Tech 2005
	Bonjetti	estimated gradient barrier	CEMAR[1]

Table B-3 (cont.). Long-term total passage barriers in SF Estuary watersheds

Watershed	Stream	Total Barrier	Source
Stevens Creek			
	Stevens	Stevens Creek Dam	Leidy et al. 2005
San Francisquito Creek			
	San Francisquito	none	Leidy et al. 2005
	Los Trancos	none	Anderson 1995
	Corte Madera	Searsville Dam	Leidy et al. 2005
	Bear	none	Leidy et al. 2005
	Bear Gulch	California Water Service Dam	Smith & Harden 2001
	West Union	natural falls	Smith & Harden 2001
	Squealer Gulch	boulder falls	Smith & Harden 2001
	McGarvey Gulch	boulder falls	Smith & Harden 2001
San Mateo Creek			
	San Mateo	Crystal Springs Dam	Leidy et al. 2005
Arroyo Corte Madera del Presidio			
	Arroyo Corte Madera del Presidio	none	Leidy et al. 2005
	Willow Reed	none	Leidy et al. 2005
	Warner	none	Leidy et al. 2005
	Old Mill	Cascade Dam	Leidy et al. 2005
	Cascade	none	Leidy et al. 2005
Corte Madera Creek			
	Corte Madera	none	Leidy et al. 2005
	Tamalpais	none	Leidy et al. 2005
	Ross	Phoenix Lake Dam	Leidy et al. 2005
	San Anselmo	natural falls	Leidy et al. 2005
	Sleepy Hollow	none	Leidy et al. 2005
	Fairfax	458-foot box culvert	Leidy et al. 2005
	Cascade	Cascade Falls	Leidy et al. 2005
Miller Creek			
	Miller	estimated gradient barrier	CEMAR[1]
Novato Creek			
	Novato	Novato Creek Dam	Leidy et al. 2005

Table B-3 (cont.). Long-term total passage barriers in SF Estuary watersheds

Watershed	Stream	Total Barrier	Source
	Vinyard	estimated gradient barrier	CEMAR[1]
	Bowman Canyon	estimated gradient barrier	CEMAR[1]
Petaluma River			
	Adobe	none	Leidy et al. 2005
	Lynch	none	Leidy et al. 2005
	Willow Brook	none	Leidy et al. 2005
Sonoma Creek			
	Sonoma	natural falls	Leidy et al. 2005
	Rodgers	none	Leidy et al. 2005
	Felder	none	Leidy et al. 2005
	Carriger	natural falls	Leidy et al. 2005
	Agua Caliente	none	Leidy et al. 2005
	Hooker	natural falls	CalFish 2006, SEC
	Mill	estimated gradient barrier	CalFish 2006, SEC
	Asbury	estimated gradient barrier	CalFish 2006, SEC
	Calabazas	natural falls	CalFish 2006, SEC
	Stuart	natural falls	CalFish 2006, SEC
	Trinity	slope barrier	Pier 2007
	Redwood	estimated gradient barrier	CalFish 2006, SEC
	Graham	none	Leidy et al. 2005
	Bear	natural falls	Leidy et al. 2005
Schell Creek			
	Nathanson	natural falls	Leidy et al. 2005
	Harazathy	Harazathy Falls	Leidy et al. 2005
Huichica Creek			
	Huichica	none	CEMAR[1]
Napa River			
	Napa River	Kimball Canyon Dam	Leidy et al. 2005
	Suscol	none	Leidy et al. 2005
	Tulucay	none	Leidy et al. 2005
	Murphy	none	Leidy et al. 2005
	Spencer	none	Leidy et al. 2005
	Redwood	none	Leidy et al. 2005
	Pickle Canyon	none	Leidy et al. 2005
	Milliken	Milliken Reservoir Dam	Leidy et al. 2005
	Sarco	none	Leidy et al. 2005
	Soda	estimated gradient barrier	CEMAR[1]

Table B-3 (cont.). Long-term total passage barriers in SF Estuary watersheds

Watershed	Stream	Total Barrier	Source
	Dry	none	Leidy et al. 2005
	Segassia	estimated gradient barrier	CEMAR[1]
	Wing Canyon	estimated gradient barrier	CEMAR[1]
	Campbell	none	Leidy et al. 2005
	Montgomery	none	CEMAR[1]
	Conn	Conn Dam	Leidy et al. 2005
	Rector	Rector Reservoir Dam	Leidy et al. 2005
	Bale Slough	none	Leidy et al. 2005
	Sulphur	estimated gradient barrier	CEMAR[1]
	Heath Canyon	earth slide	CalFish 2006, SEC
	Iron Mine	estimated gradient barrier	CEMAR[1]
	York	York Dam (Upper St. Helena)	Leidy et al. 2005
	Bell Canyon	Bell Canyon Dam	Leidy et al. 2005
	Mill	estimated gradient barrier	CEMAR[1]
	Ritchey	none	Leidy et al. 2005
	Dutch Henry	none	Leidy et al. 2005
	Cyrus	Fiege Reservoir	Leidy et al. 2005
	Jericho Caynon	series of natural falls	Leidy et al. 2005
Unnamed Creek (Red Top)			
	Unnamed	none	CEMAR[1]
Green Valley Creek			
	Green Valley	estimated gradient barrier	CEMAR[1]
Suisun Creek			
	Suisun	Gordon Valley Dam (Lake Curry)	Leidy et al. 2005
	Wooden Valley	none	Leidy et al. 2005
	White	estimated gradient barrier	CEMAR[1]

1 CEMAR generated a slope (gradient) raster from a 30-meter digital elevation model (DEM) and used visual analysis to estimate gradient barriers on streams without other indication of upstream limits on anadromy.

Identifying anchor watersheds

We found reliable evidence of *O. mykiss* reproduction in twenty four watersheds tributary to the San Francisco Estuary and developed habitat information for each. A review of total passage barriers unlikely to be modified or removed in the near term suggested that we consider a subset of the habitat as "available". Specifically, for each watershed we estimated the stream miles of "good" rearing habitat accessible to steelhead in an average water year so that we could compare among watersheds. This process reduced the number of candidate anchor watersheds to 23, as there was found to be no available habitat in the San Tomas Aquino/Saratoga Creek watershed.

Variance analysis of the habitat data in these watersheds revealed three clusters, one of which consisted of only one watershed, the Napa River (Figure B-1, top). The two other clusters were more closely related to one another than to the one-watershed cluster. Since the analytical method is very sensitive to outliers (Milligan 1980) we removed the associated (Napa River watershed) datum and re-analyzed the set (Figure B-1, bottom). The results again showed three clusters, including one consisting of only one watershed (Sonoma Creek). However, in the second analysis, the middle cluster was more closely related to the one-watershed cluster than to the top cluster (of watersheds containing lesser amounts of habitat). Therefore, we did not consider the Sonoma Creek habitat value to be an outlier and did not remove it and re-analyze the dataset.

Although data quality and habitat variability issues suggest against over-interpretation of statistics in our method, we chose to establish a threshold value for anchor watershed status for purposes of convenience. In the dataset without the Napa River datum, we averaged the median of the upper cluster (4.3 stream miles) with the median of the group consisting of the lower two clusters (13.7 stream miles), producing an anchor watershed threshold habitat value of nine stream miles. Available habitat values for the watersheds comprising these clusters are found in Table 2 in the body of the report and in Table B-2 in this appendix.

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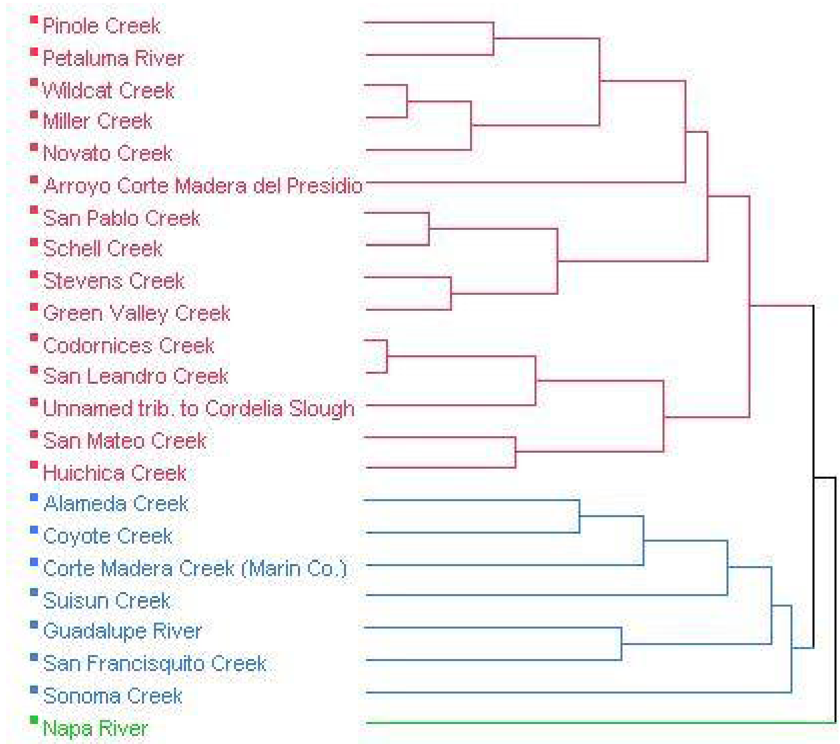
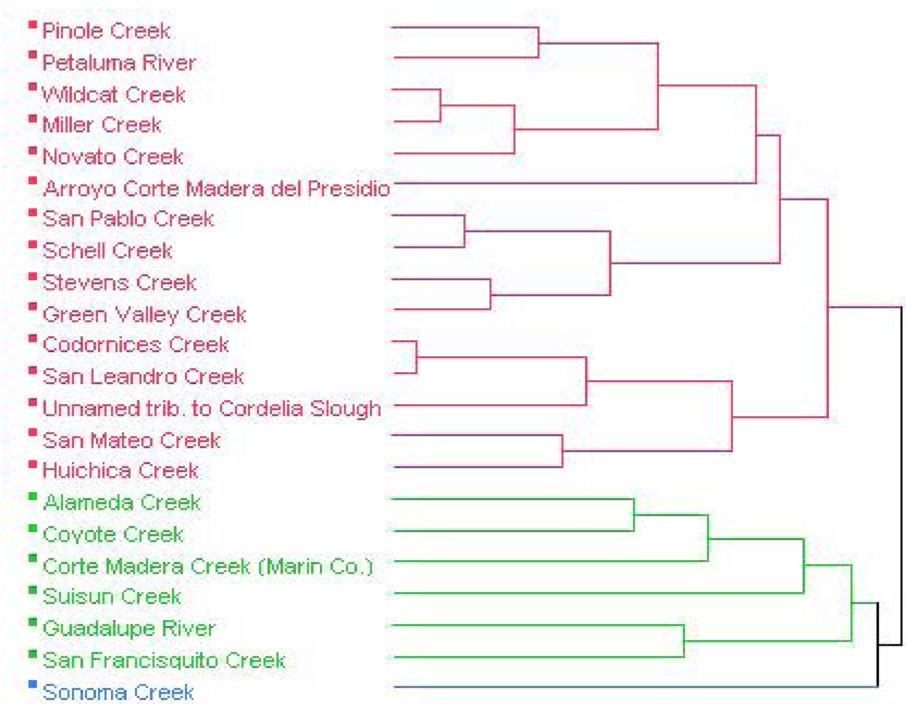
Figure B-1. Cluster analysis of selected SF Estuary watersheds by available *O. mykiss* rearing habitat with and without Napa River datum.
In first (upper) diagram, analysis of variance defines three clusters indicated in red, blue, and green. Upper two (red and blue) clusters are more closely related to one another than to bottom (green) cluster. Watersheds are listed in order of increasing available habitat.

Second (lower) diagram shows cluster analysis without Napa River value. Three clusters (red, green and blue) are defined in this data-set also, but lower two (green and blue) clusters are more closely related to one another than to upper (red) cluster.





Stakeholder groups and restoration planning

The following summarizes the results of our analysis collaborative restoration planning occurring in the anchor watersheds. Watersheds are considered beginning in Alameda County and proceding around the bay in a clockwise diretion.

Alameda Creek. The Alameda Creek Fisheries Restoration Workgroup has identified the actions required to restore a viable steelhead population to the watershed and has advanced substantially the process of barrier modifications and habitat restoration necessary to re-establish a steelhead run (Alameda Creek Fisheries Restoration Workgroup website). Participants in this continuing process include community groups, environmental groups, water management and flood control agencies, and resource agencies. The Alameda Creek Fisheries Restoration Workgroup sponsored the publication of an assessment of the potential for restoring steelhead to Alameda Creek, along with several other studies.

Stakeholders involved with restoration planning in Alameda Creek include the Alameda Creek Fisheries Restoration Workgroup, Alameda Creek Alliance, East Bay Regional Parks District, San Francisco Public Utilities Commission, California State Coastal Conservancy, Alameda County Water District, California Department of Fish and Game, Center for Ecosystem Management and Restoration, Zone 7 Water Agency, and the Alameda County Flood Control and Water Conservation District. Restoration planning in Alameda Creek has resulted in the production of several professional-quality plans and reports addressing steelhead issues (Gunther *et al.* 2000; CH2M HILL 2001; CEMAR 2003; Wood Rodgers 2006).

Coyote Creek. Collaborative restoration planning in the Coyote Creek watershed is occurring through the Santa Clara County Fisheries and Aquatic Habitat Collaborative Effort (FAHCE), a comprehensive settlement addressing impacts on salmon and steelhead and their habitat in Coyote Creek, the Guadalupe River, and Stevens Creek (FAHCE website). The FAHCE program has included the development of a Fish Habitat Management Plan, a 30-year program to improve and maintain salmon and steelhead in these watersheds.

Stakeholders involved with restoration planning in Coyote Creek include the Santa Clara Valley Water District, California Department of Fish & Game, US Fish & Wildlife Service, National Marine Fisheries Service, San Francisco Bay Regional Water Quality Control Board, Natural Heritage Institute, City of San Jose, and the Santa Clara Valley Audubon Society. Restoration planning in the Coyote Creek watershed has resulted in the production of several professional-quality plans and reports addressing steelhead issues (FAHCE 1998; Buchan and Randall 2003; FAHCE 2003; Stillwater Sciences 2006).

Guadalupe River. As noted above, collaborative restoration planning in the Guadalupe River watershed is occurring through the FAHCE process. The FAHCE program has included the development of a Fish Habitat Management Plan for the Guadalupe River, a 30-year program to improve and maintain salmon and steelhead in the watershed. Two barriers to fish migration on the Guadalupe River have been removed and a fish ladder has been constructed on the Guadalupe River.

Stakeholders involved with restoration planning in the Guadalupe River include the Santa Clara Valley Water District, California Department of Fish & Game, US Fish & Wildlife Service, National Marine Fisheries Service, San Francisco Bay Regional Water Quality Control Board, Natural Heritage Institute, City of San Jose, and the Santa Clara Valley Audubon Society. Restoration planning in the Guadalupe River watershed has resulted in the production of several professional-quality plans and reports addressing steelhead issues (FAHCE 1998; FAHCE 2003; Tetra Tech Inc. 2005a).

San Francisquito Creek. The San Francisquito Watershed Council's steering committee includes local residents and participants from "neighborhood associations, Stanford University, environmental organizations, local cities, and federal, state, and local resource agencies." (San Francisquito Watershed Council website). The Steelhead Task Force, another multi-stakeholder workgroup, was created to advise the Watershed Council on issues related to steelhead habitat and in 2001 it commissioned a study of passage barriers in the San Francisquito watershed. Restoration planning has resulted in the improvement of fish passage at 11 barriers and projects are planned at seven more locations.

Stakeholders involved with restoration planning in San Francisquito Creek include the San Francisquito Watershed Council, the San Franciquito Creek Joint Powers Authority, the Santa Clara Valley Water District, DFG, NMFS, the Conservancy, the cities of Menlo Park and Palo Alto, Stanford University, The San Mateo County Parks Department, the town of Portola Valley, and local residents. Restoration planning in the Stevens Creek watershed has resulted in the production of several professional-quality plans and reports addressing steelhead issues (Smith and Harden 2001; Brosseau and Ruby 2002; San Francisquito Watershed Council 2005).

Corte Madera Creek (Marin County). The Friends of Corte Madera Creek Watershed manages various restoration activities in the watershed and has successfully commissioned the production of several professionally produced technical reports including a study of fishery resources and a geomorphic assessment (Friends of Corte Madera Creek website). Their projects have involved collaboration with various local agencies such as The Coalition for Corte Madera Creek, which is also active in this watershed, particularly with pollution prevention and flood control efforts. The Ross Valley Flood Protection and Watershed Program was formed in 2006 and has created a technical working group to develop a flood protection and watershed restoration plan addressing Corte Madera Creek (RVFPWP website).

Stakeholders involved with restoration planning in Corte Madera Creek include the Friends of Corte Madera Creek, Coalition for Corte Madera Creek, Marin Municipal Water District, Marin County Department of Public Works, the City of Larkspur and the towns of Fairfax, Ross, and San Anselmo, and local high schools and colleges. Restoration planning in Corte Madera Creek has resulted in the production of several professional-quality plans and reports addressing steelhead issues (Rich 2000; Ross Taylor & Associates 2006)

Sonoma Creek. Collaborative restoration planning in Sonoma County is occurring through the Sonoma Ecology Center and the Southern Sonoma Resource Conservation District. The Sonoma Ecology Center has published a Limiting Factors Analysis for steelhead in Sonoma Creek, as well as a sediment source analysis, and also coordinates the Stream Stewardship project with citizen volunteers (SEC website). The Sonoma County RCD has completed fish passage enhancement and bank stabilization projects in Carriger Creek. The RCD also prepared the Sonoma Creek Watershed Enhancement Plan in 1997 and has been implementing the goals since then (SSCRCD website).

Stakeholders involved with restoration planning in Sonoma Creek include the Sonoma Ecology Center, Southern Sonoma County RCD, the Sonoma County Water Agency, DFG, and local residents. Restoration planning in Sonoma Creek has resulted in the production of several professional-quality plans and reports addressing steelhead issues (SSCRCD 1997; SEC 2004; Dawson 2005)

Napa River. The Napa County Resource Conservation District and Friends of the Napa River are both active in steelhead restoration in the watershed. The Napa RCD conducts surveys to monitor steelhead populations and publishes a Watershed Owners Manual to educate local residents (NCRCD website). Friends of Napa River conducts river clean-ups and educational programs, participates on local committees and is active in the planning of a flood control project and in the production of the Napa Watershed Historical Ecology Project (Friends of the Napa River website).

Stakeholders involved with restoration planning in the Napa River include the Napa County RCD, Friends of the Napa River, California State Coastal Conservancy, DFG, San Francisco Regional Water Quality Control Board, Watershed Information Center and Conservancy of Napa County, Napa County Flood Control & Water Conservation District. Restoration planning in the Napa River watershed has resulted in the production of several professional-quality plans and reports addressing steelhead issues (Koehler 2002b; Stillwater Sciences and Dietrich 2002; Koehler 2005).

Suisun Creek. The Suisun Creek Restoration Team (SCRT) was formed in 1999 with the goals of restoring steelhead habitat in Suisun Creek and providing the means to involve a range of interests in the restoration process (Beuttler and Marcus 2002).

Stakeholders involved with restoration planning in Suisun Creek include the Suisun Creek Restoration Team, California Sportfishing Protection Alliance, Save the Suisun Creek Alliance, the City of Vallejo, DFG, Napa and Solano Farm Bureaus, Solano Water Agency, and NMFS. Restoration planning in the Suisun Creek watershed has resulted in the production of the *Suisun Creek Watershed Assessment and Enhancement Plan* (Laurel Marcus & Associates 2004)

Table B4-A. Alameda Creek watershed open space and protected open space

Watershed area[1]	652 mi^2
Open space[2]	585 mi^2 (90%)
Other[3]	67 mi^2 (10%)
Protected open space	146 mi^2
Bay Area Open Space Council Categorized Lands (BAOSC)[4]	137 mi^2 (21%)
Private and Conservation Trust Lands (PCTL)[5]	8 mi^2 (1%)
Waterbodies[6]	2 mi^2 (<1%)
Open space/Watershed area	90%
Protected open space/Watershed area	22%
Protected open space/Open space	25%

[1] Data from the California Department of Forestry and Fire Protection (CDF)—Fire and Resource Assessment Program (FRAP). These data are based on the USGS National Landcover Dataset (NLCD 2000), and are modified to account for classification errors. Complete metadata for this dataset is available online from: http://frap.cdf.ca.gov/data/frapgisdata/select.asp

[2] CDF-FRAP Land Use/Land Cover (LULC) classes 1-5 (No Housing Units to 1 housing unit per 10 acres (32-64 units/mi^2))

[3] CDF-FRAP LULC classes 6-10, 24 and 86 (1 or more housing units per 10 acres (64 units/mi^2) to 5 or more housing units per acre (≥ 3200 units/mi^2))

[4] Please contact the author for information regarding this dataset.

[5] This figure indicates PCTL lands not included in the BAOSC dataset. Data from the California Resources Agency. Complete metadata for this dataset is available online from: http://gis.ca.gov/meta.epl?oid=31122

[6] This figure indicates waterbody areas not included in either the PCTL or BAOSC datasets. Data from the USGS National Hydrography Dataset. Complete metadata for this dataset is available online from: http://nhd.usgs.gov

Table B4-B. Coyote Creek watershed open space and protected open space

Watershed area[1]	371 mi^2
Open space[2]	288 mi^2 (78%)
Other[3]	83 mi^2 (22%)
Protected open space	126 mi^2
Bay Area Open Space Council Categorized Lands (BAOSC)[4]	118 mi^2 (32%)
Private and Conservation Trust Lands (PCTL)[5]	4 mi^2 (1%)
Waterbodies[6]	4 mi^2 (1%)
Open space/Watershed area	78%
Protected open space/Watershed area	34%
Protected open space/Open space	44%

[1] Data from the California Department of Forestry and Fire Protection (CDF)—Fire and Resource Assessment Program (FRAP). These data are based on the USGS National Landcover Dataset (NLCD 2000), and are modified to account for classification errors. Complete metadata for this dataset is available online from: http://frap.cdf.ca.gov/data/frapgisdata/select.asp

[2] CDF-FRAP Land Use/Land Cover (LULC) classes 1-5 (No Housing Units to 1 housing unit per 10 acres (32-64 units/mi^2))

[3] CDF-FRAP LULC classes 6-10, 24 and 86 (1 or more housing units per 10 acres (64 units/mi^2) to 5 or more housing units per acre (≥ 3200 units/mi^2))

[4] Please contact the author for information regarding this dataset.

[5] This figure indicates PCTL lands not included in the BAOSC dataset. Data from the California Resources Agency. Complete metadata for this dataset is available online from: http://gis.ca.gov/meta.epl?oid=31122

[6] This figure indicates waterbody areas not included in either the PCTL or BAOSC datasets. Data from the USGS National Hydrography Dataset. Complete metadata for this dataset is available online from: http://nhd.usgs.gov

Table B4-C. Guadalupe River watershed open space and protected open space

Watershed area[1]	160 mi^2
Open space[2]	86 mi^2 (54%)
Other[3]	73 mi^2 (46%)
Protected open space	53 mi^2
Bay Area Open Space Council Categorized Lands (BAOSC)[4]	51 mi^2 (32%)
Private and Conservation Trust Lands (PCTL)[5]	<1 mi^2 (<1%)
Waterbodies[6]	2 mi^2 (1%)
Open space/Watershed area	54%
Protected open space/Watershed area	33%
Protected open space/Open space	61%

1 Data from the California Department of Forestry and Fire Protection (CDF)—Fire and Resource Assessment Program (FRAP). These data are based on the USGS National Landcover Dataset (NLCD 2000), and are modified to account for classification errors. Complete metadata for this dataset is available online from: http://frap.cdf.ca.gov/data/frapgisdata/select.asp

2 CDF-FRAP Land Use/Land Cover (LULC) classes 1-5 (No Housing Units to 1 housing unit per 10 acres (32-64 units/mi^2))

3 CDF-FRAP LULC classes 6-10, 24 and 86 (1 or more housing units per 10 acres (64 units/mi^2) to 5 or more housing units per acre ($\geq$ 3200 units/mi^2))

4 Please contact the author for information regarding this dataset.

5 This figure indicates PCTL lands not included in the BAOSC dataset. Data from the California Resources Agency. Complete metadata for this dataset is available online from: http://gis.ca.gov/meta.epl?oid=31122

6 This figure indicates waterbody areas not included in either the PCTL or BAOSC datasets. Data from the USGS National Hydrography Dataset. Complete metadata for this dataset is available online from: http://nhd.usgs.gov

Table B4-D. San Francisquito Creek watershed open space and protected open space

Watershed area[1]	40 mi^2
Open space[2]	21 mi^2 (52%)
Other[3]	19 mi^2 (48%)
Protected open space	16 mi^2
Bay Area Open Space Council Categorized Lands (BAOSC)[4]	15 mi^2 (37%)
Private and Conservation Trust Lands (PCTL)[5]	1 mi^2 (3%)
Waterbodies[6]	<1 mi^2 (<1%)
Open space/Watershed area	52%
Protected open space/Watershed area	40%
Protected open space/Open space	78%

[1] Data from the California Department of Forestry and Fire Protection (CDF)—Fire and Resource Assessment Program (FRAP). These data are based on the USGS National Landcover Dataset (NLCD 2000), and are modified to account for classification errors. Complete metadata for this dataset is available online from: http://frap.cdf.ca.gov/data/frapgisdata/select.asp

[2] CDF-FRAP Land Use/Land Cover (LULC) classes 1-5 (No Housing Units to 1 housing unit per 10 acres (32-64 units/mi^2))

[3] CDF-FRAP LULC classes 6-10, 24 and 86 (1 or more housing units per 10 acres (64 units/mi^2) to 5 or more housing units per acre ($\geq$ 3200 units/mi^2))

[4] Please contact the author for information regarding this dataset.

[5] This figure indicates PCTL lands not included in the BAOSC dataset. Data from the California Resources Agency. Complete metadata for this dataset is available online from: http://gis.ca.gov/meta.epl?oid=31122

[6] This figure indicates waterbody areas not included in either the PCTL or BAOSC datasets. Data from the USGS National Hydrography Dataset. Complete metadata for this dataset is available online from: http://nhd.usgs.gov

Table B4-E. Corte Madera Creek watershed open space and protected open space

Watershed area[1]	25 mi^2
Open space[2]	10 mi^2 (42%)
Other[3]	14 mi^2 (58%)
Protected open space	9 mi^2
Bay Area Open Space Council Categorized Lands (BAOSC)[4]	9 mi^2 (37%)
Private and Conservation Trust Lands (PCTL)[5]	<1 mi^2 (<1%)
Waterbodies[6]	<1 mi^2 (<1%)
Open space/Watershed area	42%
Protected open space/Watershed area	37%
Protected open space/Open space	90%

[1] Data from the California Department of Forestry and Fire Protection (CDF) -- Fire and Resource Assessment Program (FRAP). These data are based on the USGS National Landcover Dataset (NLCD 2000), and are modified to account for classification errors. Complete metadata for this dataset is available online from: http://frap.cdf.ca.gov/data/frapgisdata/select.asp

[2] CDF-FRAP Land Use/Land Cover (LULC) classes 1-5 (No Housing Units to 1 housing unit per 10 acres (32-64 units/mi^2))

[3] CDF-FRAP LULC classes 6-10, 24 and 86 (1 or more housing units per 10 acres (64 units/mi^2) to 5 or more housing units per acre (≥ 3200 units/mi^2))

[4] Please contact the author for information regarding this dataset.

[5] This figure indicates PCTL lands not included in the BAOSC dataset. Data from the California Resources Agency. Complete metadata for this dataset is available online from: http://gis.ca.gov/meta.epl?oid=31122

[6] This figure indicates waterbody areas not included in either the PCTL or BAOSC datasets. Data from the USGS National Hydrography Dataset. Complete metadata for this dataset is available online from: http://nhd.usgs.gov

Table B4-F. Sonoma Creek watershed open space and protected open space

Watershed area[1]	155 mi^2
Open space[2]	125 mi^2 (80%)
Other[3]	30 mi^2 (20%)
Protected open space	35 mi^2
Bay Area Open Space Council Categorized Lands (BAOSC)[4]	26 mi^2 (17%)
Private and Conservation Trust Lands (PCTL)[5]	6 mi^2 (4%)
Waterbodies[6]	3 mi^2 (2%)
Open space/Watershed area	80%
Protected open space/Watershed area	22%
Protected open space/Open space	28%

[1] Data from the California Department of Forestry and Fire Protection (CDF)—Fire and Resource Assessment Program (FRAP). These data are based on the USGS National Landcover Dataset (NLCD 2000), and are modified to account for classification errors. Complete metadata for this dataset is available online from: http://frap.cdf.ca.gov/data/frapgisdata/select.asp

[2] CDF-FRAP Land Use/Land Cover (LULC) classes 1-5 (No Housing Units to 1 housing unit per 10 acres (32-64 units/mi^2))

[3] CDF-FRAP LULC classes 6-10, 24 and 86 (1 or more housing units per 10 acres (64 units/mi^2) to 5 or more housing units per acre ($\geq$ 3200 units/mi^2))

[4] Please contact the author for information regarding this dataset.

[5] This figure indicates PCTL lands not included in the BAOSC dataset. Data from the California Resources Agency. Complete metadata for this dataset is available online from: http://gis.ca.gov/meta.epl?oid=31122

[6] This figure indicates waterbody areas not included in either the PCTL or BAOSC datasets. Data from the USGS National Hydrography Dataset. Complete metadata for this dataset is available online from: http://nhd.usgs.gov

Table B4-G. Napa River watershed open space and protected open space

Watershed area[1]	417 mi^2
Open space[2]	348 mi^2 (84%)
Other[3]	35 mi^2 (8%)
Protected open space	82 mi^2
Bay Area Open Space Council Categorized Lands (BAOSC)[4]	71 mi^2 (17%)
Private and Conservation Trust Lands (PCTL)[5]	7 mi^2 (2%)
Waterbodies[6]	4 mi^2 (1%)
Open space/Watershed area	84%
Protected open space/Watershed area	20%
Protected open space/Open space	24%

[1] Data from the California Department of Forestry and Fire Protection (CDF)—Fire and Resource Assessment Program (FRAP). These data are based on the USGS National Landcover Dataset (NLCD 2000), and are modified to account for classification errors. Complete metadata for this dataset is available online from: http://frap.cdf.ca.gov/data/frapgisdata/select.asp

[2] CDF-FRAP Land Use/Land Cover (LULC) classes 1-5 (No Housing Units to 1 housing unit per 10 acres (32-64 units/mi^2))

[3] CDF-FRAP LULC classes 6-10, 24 and 86 (1 or more housing units per 10 acres (64 units/mi^2) to 5 or more housing units per acre ($\geq$ 3200 units/mi^2))

[4] Please contact the author for information regarding this dataset.

[5] This figure indicates PCTL lands not included in the BAOSC dataset. Data from the California Resources Agency. Complete metadata for this dataset is available online from: http://gis.ca.gov/meta.epl?oid=31122

[6] This figure indicates waterbody areas not included in either the PCTL or BAOSC datasets. Data from the USGS National Hydrography Dataset. Complete metadata for this dataset is available online from: http://nhd.usgs.gov

Table B4-H. Suisun Creek watershed open space and protected open space

Watershed area[1]	51 mi^2
Open space[2]	50 mi^2 (99%)
Other[3]	<1 mi^2 (1%)
Protected open space	5 mi^2
Bay Area Open Space Council Categorized Lands (BAOSC)[4]	5 mi^2 (10%)
Private and Conservation Trust Lands (PCTL)[5]	<1 mi^2 (<1%)
Waterbodies[6]	<1 mi^2 (<1%)
Open space/Watershed area	99%
Protected open space/Watershed area	10%
Protected open space/Open space	11%

[1] Data from the California Department of Forestry and Fire Protection (CDF)—Fire and Resource Assessment Program (FRAP). These data are based on the USGS National Landcover Dataset (NLCD 2000), and are modified to account for classification errors. Complete metadata for this dataset is available online from: http://frap.cdf.ca.gov/data/frapgisdata/select.asp

[2] CDF-FRAP Land Use/Land Cover (LULC) classes 1-5 (No Housing Units to 1 housing unit per 10 acres (32-64 units/mi^2))

[3] CDF-FRAP LULC classes 6-10, 24 and 86 (1 or more housing units per 10 acres (64 units/mi^2) to 5 or more housing units per acre (≥ 3200 units/mi^2))

[4] Please contact the author for information regarding this dataset.

[5] This figure indicates PCTL lands not included in the BAOSC dataset. Data from the California Resources Agency. Complete metadata for this dataset is available online from: http://gis.ca.gov/meta.epl?oid=31122

[6] This figure indicates waterbody areas not included in either the PCTL or BAOSC datasets. Data from the USGS National Hydrography Dataset. Complete metadata for this dataset is available online from: http://nhd.usgs.gov

Identifying essential streams

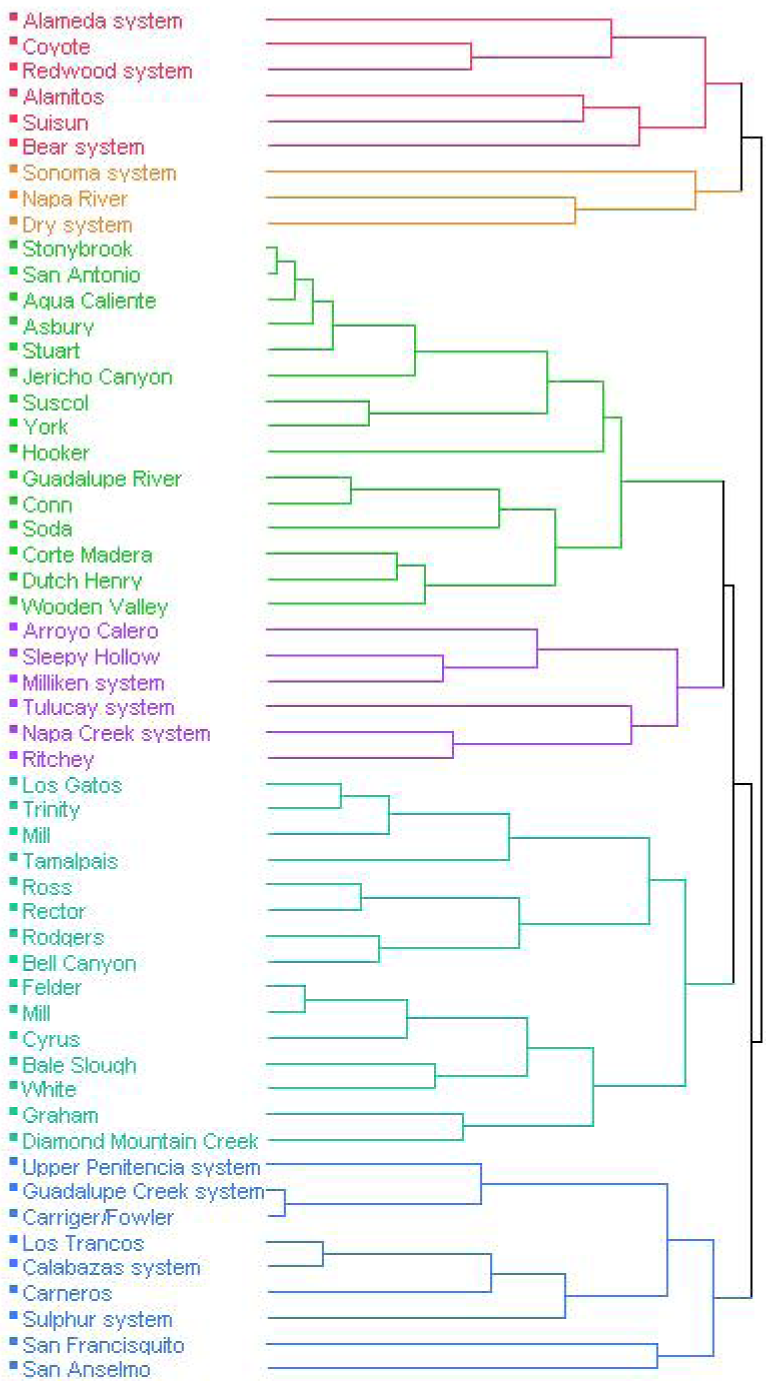
The eight anchor watersheds appear to comprise 54 streams with non-zero available habitat values that form the group of candidate essential streams. These streams consist of both mainstems and tributaries. We assembled a dataset of the habitat values and applied cluster analysis (Ward's method) to show distinctions between groups based on variance. The results are presented in Figure B-2.

Variance analysis of the habitat data in these watersheds revealed six clusters, two of which (red and yellow) are more closely related to one another than to the remaining four clusters. The red and yellow clusters comprise nine streams that contain the greatest amount of habitat in the candidate group. As such, they comprise our primary essential streams.

We next reviewed the streams in the cluster with the next greatest amount of habitat (blue) for indications that they should be considered also as essential streams. The references we consulted consistently referred to the importance of these streams in sustaining the steelhead resources of their respective watersheds. We therefore included streams in this cluster as essential streams. Repeating this process for the cluster with the next highest amount of habitat (purple), we determined that streams in the group were not cited in references as major contributors of steelhead resources. We therefore did not include streams in this cluster as essential streams.

Although data quality and habitat variability issues suggest against over-interpretation of statistics in our method, we chose to establish a threshold value for essential stream status for purposes of convenience. We averaged the median habitat value of the lowest essential stream cluster (blue) and the median of the next highest cluster (purple). These values are 4.4 and 2.6 stream miles, respectively, producing an essential stream threshold value of 3.5 stream miles. Available habitat values for the streams comprising these clusters are found in Table 4 in the body of the report and in Table B-2 in this appendix.

Figure B-2. Cluster analysis of O. mykiss rearing habitat in SF Estuary anchor watershed streams.
Cluster analyis defines six major groups (red, yellow, green, purple, turquoise, and blue). Top two clusters (red and yellow) have most habitat and are closely associated. Lowest (blue) cluster has next highest values.



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