ENVIRONMENTAL AND BIOLOGICAL ASSESSMENT OF PORTIONS OF THE CARMEL RIVER WATERSHED

2004

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Executive Summary

Environmental and Biological Assessment of Portions of the Carmel River Watershed Monterey County, California

Prepared by Monterey Peninsula Water Management District
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Qualitative and quantitative methods were used to assess several indicators of the health and resiliency of the Carmel River main stem. This report provides a baseline of biologic data compiled in 2003 and early 2004 by the Monterey Peninsula Water Management District (MPWMD) from MPWMD records and other publicly available documents. Data and analysis are presented on stream functionality, riparian vegetation, California red-legged frogs (CRLF), steelhead, large wood, water quality, and insects in the channel bottom known collectively as benthic macroinvertebrates (BMI).

Detailed biologic information is sparse prior to the early 1980's, but data gathered since on steelhead numbers and habitat, channel form, water quality, and riparian vegetation are relatively robust. However, information on CRLF and the BMI community is limited, which makes analysis and observations of trends subject to a degree of uncertainty.

Relatively large data sets exist for the following:

- adult steelhead population counts at San Clemente Dam (first report in 1954, some years missing until an automatic counter was installed in 1992)
- adult steelhead population counts at Los Padres Dam (first report in 1949 and most years since)
- main stem juvenile density (1973, 1974, most years after 1983)
- water quality data at the lagoon, San Clemente Dam, and at Los Padres Dam (1991 to present)
- water temperature data at 11 locations

Less extensive data sets that form a baseline include:

- assessment of riparian functions (2003-2004)
- California red-legged frog sightings, surveys, and habitat mapping (1991 to present)
- distribution of large wood in the main stem (2002 and 2003)
- sampling data for benthic macroinvertebrates (1982 and 2000-2003)

Information about the main stem is regularly updated by MPWMD and there are other public and private agencies also gathering data in the watershed. Data presented in this assessment is from records in the possession of MPWMD and it is possible that more information on the topics presented here exists. Because many organizations and agencies continue to gather environmental data on the Carmel River Watershed, the information presented here should be considered a first step in understanding and assessing the watershed.

It is apparent that many reaches of the river can provide high quality, productive habitat for steelhead; however, the current steelhead population is below historic numbers for the Carmel River and is well below populations found in Northern California coastal streams. Likely factors contributing to this decline include habitat fragmentation and degradation, introduced non-native predator species, impaired fish passage, and water diversions that alter natural streamflows. Other contributing factors may include water and air pollution and events outside of the watershed such as changes in the ocean going steelhead population. However, the increasing density and abundance of the juvenile population since 1997, the sharp recovery of the juvenile population since the 1987 to 1991 drought, and strength of the juvenile population compared to other coastal, regional, and local streams indicates the population is resilient and recovering.

Another species of concern, California red-legged frogs, has recently begun to be studied intensively after its listing in 1996 as a threatened species under the Federal Endangered Species Act. This species is difficult to investigate and its life cycle and population in the watershed is only just beginning to be understood. Although these frogs are found in many areas within the watershed, it is unclear whether the population is growing, shrinking, or stable. Most of the information gathered about this species is from observations in the Carmel River lagoon, along the main stem, and at San Clemente Reservoir.

Surveys of riparian-wetland areas along the nine-mile reach upstream of Los Padres Reservoir show these areas are the least impacted by human influences and remain naturally sustainable. Between Los Padres Dam and the Narrows, a distance of approximately 15 miles, riparian areas appear to be in reasonably good condition, although channel degradation (incision into sediment deposits) immediately downstream of Los Padres Dam and San Clemente Dam has left the root structures of many streamside trees exposed to scour and erosion. In addition, the paucity of spawning-sized gravels and cobbles in these reaches renders portions of the habitat unsuitable for steelhead spawning in an area that should provide significant opportunity for spawning. Between the Narrows and the Pacific Ocean, a distance of approximately 10 miles, much of the riparian-wetland area is functionally impaired due to water extraction and development adjacent to the streambanks.

The cumulative effect of human influences has resulted in a fragmented environment in the lower 27 miles of the river that requires intensive management efforts. Between Los Padres Dam and the Narrows, flow releases from storage are required in summer to maintain aquatic habitat. The lower 10 miles of the river (downstream of the Narrows), where the impacts from water extraction are concentrated, requires irrigation and maintenance of streamside vegetation, reconstruction of streambanks after high winter flows, annual CRLF and steelhead rescues, habitat enhancement activities, and extensive monitoring. Regulation of water extraction from the basin is in effect under orders from the California State Water Resources Board (Order No. 95-10 and subsequent related orders). A program to mitigate for the effects of water extraction on the main stem is carried out locally by the Monterey Peninsula Water Management District under its Mitigation Program.

Riparian (Streamside) Areas

The proper functioning condition (PFC) method for assessing the condition of riparian-wetland areas, which was developed by the U.S. Bureau of Land Management and U.S. Forest Service for use by land managers, was used to assess 37 sites along the main stem from the Carmel River Lagoon to the headwaters. These assessments, which were carried out during Fall 2003 and Spring 2004, confirm that many reaches are currently functioning properly between the Narrows at approximately River Mile (RM, measured from the ocean) 10 and the headwaters at RM 36. However, several reaches downstream of the Narrows are considered "functional at-risk," meaning that without actions to mitigate for the effects of water diversions, these reaches are at risk of becoming non-functional. A map showing the ratings and locations of these assessments and others performed by the Carmel River Watershed Conservancy in the tributaries is included in Section 5.4. "Assessment of Riparian Functions and Conditions."

Since the mid-1980's, points of water diversion during summer and fall have gradually been shifted downstream into the lower river and groundwater extraction from reaches downstream of the Narrows has been increased. This has increased summer and fall surface flow in the 8.6-mile reach between the Narrows and San Clemente Dam, resulting in an increase in aquatic habitat quality, quantity, and diversity upstream of the Narrows. But increased groundwater extraction downstream of the Narrows may have increased vegetation stress in the lower river, resulting in the loss of streamside vegetation and an increase in bank instability.

Between 1986 and 2001, riparian wooded areas within the streamside corridor downstream of San Clemente Dam have increased from an estimated 299 acres (*McNeish,1986*) to an estimated 438 acres (*Christensen, 2003*). This increase is due to natural recovery after an episode of bank erosion between 1978 and 1986 combined with increased surface flows and restoration work by a variety of groups including private property owners and public agencies.

An inventory of large wood (LW), which is defined as branches and pieces of trunks greater than six inches in diameter and five feet in length, was conducted in the channel bottom in 2002 and 2003 between the Carmel River Lagoon and Stonepine Resort at RM 16 (*Smith and Huntington, 2004*). The study, which documented 471 occurrences of LW, showed a considerable range in the frequency of single pieces and accumulations found in each reach, but the trend shows that frequency decreases in the downstream direction. LW in the lower river tended to be larger and more stable than in upstream reaches, a condition that is to be expected as winter streamflows normally increase in the downstream direction and wash smaller pieces out to the ocean. Almost 30% of wood was fostering pool habitat in the bed. About 70% of LW had no significant impact to lateral channel stability. Less than 4% was found to encourage bank erosion. About 7% of LW had been deliberately placed to enhance aquatic habitat.

In general, higher frequencies of LW were associated with higher densities of steelhead, although there were notable exceptions. In reaches where LW was relative abundant, but steelhead numbers were low, it is likely that the availability of LW was not a limiting factor and that other factors such as substrate condition, food availability, and water quantity and quality were more significant.

The riparian corridor between Highway 1 and Schulte Road Bridge remains fragmented and is very thin in some areas (as little as one or two trees wide along the streambank) due to urbanization. In these locations, wildlife mobility is limited by the poor quality and quantity of the riparian corridor. Some streamside areas in the alluvial portion of the river, between the ocean and Carmel Valley Village, continue to come under development pressure as real estate values in Carmel Valley escalate and property owners carve out niches for additional urban living space or seek to stop the natural meanderings of the river. Examples of poor landowner practices include thinning and removing streamside vegetation for view corridors, placing structures adjacent to the stream, and constructing illegal bank protection works.

Steelhead Returns, Spawning, and Juvenile Rearing

The numbers of returning steelhead adults hit a low in the early 1990s, and the run was declared to be nearly extinct by the California Department of Fish and Game (*McEwan and Jackson, 1996*). The number of returning adults has rebounded from the drought years of the early 1990's when only a handful of fish were counted and appears to have stabilized in the range of 400-800 fish. Upstream of Los Padres Dam, adult returns have averaged 190 fish since 1997. Between Los Padres Dam and San Clemente Dam, a comparison of returns before and after 1980 indicates that the adult return to this portion of the basin has not recovered to levels that were common in the earlier period. Since 1997, the number of adults counted at San Clemente Dam has averaged 604 and ranged from a low of 388 fish in 2004 to a high of 861 fish in 1998, with a clear upward trend during the seven-year period immediately following the 1987-1991 drought. But, the overall population has not reached levels that were common prior to the 1976-77 drought, when the index of adult returns from the 1962 to 1975 period indicates the run was about 30 percent higher than the average in recent years.

Factors limiting the steelhead population include obstructions of fish passage, water diversions from the basin, and degradation of spawning and rearing habitat. The most significant fish passage problems are at the main stem dams and reservoirs, but passage in tributary drainages may also be hindered by poorly designed and constructed culverts. At San Clemente Dam, the fish ladder is outdated and flow across the reservoir sediments if often shallow. Fish mortality occurs as downstream migrants plunge 70 feet over the dam spillway to the pool below. At Los Padres Dam, a trap and truck operation is required for upstream migrants and downstream migrants must slide down a concrete spillway before dropping into the river. Water diversions from the basin reduce flows for adult migration and juvenile rearing. Habitat degradation from within stream channels, loss of riparian vegetation, and reductions in water quality degrade also limit the population.

Estimates based on the amount of suitable habitat available in the basin to produce adult steelhead have ranged from 3,500 to 4,200 adults, with habitat similar to conditions in 1975 and 1982. Comparing the number of adults counted at San Clemente and Los Padres Dams with the capacity of the basin to produce adults indicates that the existing adult steelhead population is about one-third of the potential adult production. Some of the factors that limit the adult population include flow diversions between San Clemente Dam and the Carmel River Lagoon, degraded spawning habitat, fish passage problems at Los Padres Reservoir, sand deposition in the Lagoon, and loss of streamside vegetation.

Most of the tributaries and main stem areas containing spawning habitat have been surveyed, with Chupines and Hitchcock Creeks being notable exceptions. Within surveyed areas, approximately 66.9 miles of stream are accessible to adults in normal and above water years. When no temporary barriers limit upstream migration, adult steelhead spawn in a total of 60.5 miles of stream, including 24.5 miles of the main stem, 30 miles of primary tributaries, and six miles of secondary tributaries. In the remaining 6.4 miles of accessible stream, spawning is limited by water availability in late spring. In dry and some below normal water years, adults probably do not ascend to the uppermost permanent barriers on the primary and secondary tributaries, but utilize the entire 24.5 miles of the main stem up to Los Padres Dam. Those unable to migrate past barriers are forced to spawn below smaller falls and chutes or in the main stem.

It is estimated that the spawning habitat in the main stem can support approximately 2,400 nests, equivalent to a run of 4,800 adults or about 193 spawners per mile of stream. However, 50% of this habitat is located upstream of Los Padres Dam, where disproportionately low returns of adults to Los Padres Dam indicate that spawning habitat upstream of Los Padres Dam has not been fully utilized for many years and that the amount of spawning habitat upstream of the reservoir is most likely not the primary limiting factor. This condition was first noted by CDFG in the 1950's shortly after completion of the Los Padres Dam. Spawning areas influenced by the armoring effect of the main stem dams are estimated to have 25% of the habitat per mile found in similar areas upstream of Los Padres Reservoir. Armoring refers to the coarsening of the channel bottom over time as gravel and cobble is stripped out by high flows with no new gravel and cobble able to pass the dams to replace lost materials. This effect is dramatic in the reaches from Los Padres Dam to the confluence with Cachagua Creek and from San Clemente Dam to the confluence with Tularcitos Creek. In these reaches, much of the channel bottom is covered with boulders and sand, with little spawning sized material visible. Armoring lessens in the downstream direction due to inputs of gravel and cobbles from tributaries and main stem bed and bank erosion.

In most years, 49 to 53 miles of rearing habitat are available in the watershed with approximately one-half in the main stem and the remainder in primary and secondary tributaries. The length of viable habitat is somewhat dependent on flow levels downstream of San Clemente Dam and on the amount of diversion of subsurface flow (i.e., the volume of water pumped from wells). It is estimated that this rearing habitat can support up to 245,000 young-of-the-year steelhead. Similar to spawning habitat, an estimated 42% of juvenile rearing habitat is located above Los Padres Reservoir, where fish densities appear to be much lower than in other areas of the river.

For areas downstream of Los Padres Dam, juvenile density per mile of stream remains 72% of the density found in previous Carmel River studies by CDFG carried out between 1973 and 1986. The juvenile population rapidly recovered from low numbers extant during the 1987-92 drought, and now is similar to levels that were common in the 1970's and early 1980's. Based on annual adult counts and fall population surveys, it is likely that the current juvenile population in the main stem is between 89,000 and 94,000 fish (for comparison, the mean estimate for the entire watershed for 1973 and 1974 was 94,500 fish). It should be noted that the perennial portion of the river may have been shorter in previous surveys, due primarily to water extraction practices. The current population of fish in the tributaries is unknown. For comparison purposes, the main stem juvenile population is 19% of that found in northern coastal streams on a per unit area basis.

In addition to the factors limiting the adult population, juveniles are limited by the amount and quality of rearing habitat, which is directly linked to surface flow and channel conditions. Projects recommended to improve adult and juvenile populations include:

- water supply augmentation for the Monterey Peninsula in order to increase streamflow in the Carmel River
- management of fine-grained sediment entering and moving through stream channels
- passage of coarse-grained sediment around main stem dams
- modification of fish passage barriers
- introduction of large wood into stream channels
- enhancement of habitat insect production
- increase summer/fall Lagoon water levels
- management of water quality (temperature and chemical content) of releases from Los Padres Reservoir

California red-legged frogs (CRLF)

The listing of CRLF in 1996 as a threatened species by the U.S. Fish and Wildlife Service (USFWS) has triggered additional scrutiny of water extraction and land management practices in Carmel Valley and has required development projects to undergo extensive investigations and monitoring for CRLF. Carmel Valley is one of the few remaining locations in California with a significant CRLF population. These frogs, which are the largest native frogs in North America, are found throughout the main stem. Most habitat and animal surveys and sightings of CRLF have been confined to the main stem and Carmel River Lagoon. There have been few surveys in the remainder of the watershed, with the exception of the Santa Lucia Preserve. At the Preserve, surveys of ponds in Potrero, Robinson Canyon, Las Garzas, San Clemente, and Hitchcock Creeks were conducted each spring between 2000 and 2003. All life stages (egg masses, larvae, and adults) have been found in these tributary drainages, but not each year and the trend appears to show fewer sightings each year; however, it is not known if these surveys are directly comparable from year to year.

Limiting factors for this species includes the introduction of non-native species such as bullfrogs, crayfish, bass, and mosquito fish, habitat fragmentation and degradation due to urbanization, and water extraction practices. Upstream of Los Padres Reservoir, the only known limiting factor for CRLF is the presence of bullfrogs. Limiting factors increase downstream of Los Padres Dam, with the highest number of limiting factors found between Carmel Valley Village and the Lagoon. The number of potential reproductive sites along the main stem varies from year to year and depends on hydrologic conditions. Main stem habitat surveys in 2002 and 2003 showed 67 and 54 potential reproductive sites, respectively, with the majority concentrated around San Clemente Reservoir and in the alluvial reach between the Lagoon and Carmel Valley Village. Actual reproduction occurred in 37% of the sites in 2002 and 52% of the sites in 2003 (*Reis, 2003*).

A recovery plan, which was published by USFWS in 2002, makes detailed recommendations for recovery and sets out five requirements for delisting of the species, including maintenance of a stable population. A minimum of 15 years of data would be needed, which would require a significant monitoring program to document population status.

Water Quality Conditions in the Main Stem and Lagoon

Water temperature has been measured at a total of 11 locations including the Lagoon (two sites), the Narrows, Garland Park, Sleepy Hollow weir, San Clemente Reservoir (three sites), San Clemente Creek, and Los Padres Reservoir (two sites). One of the Lagoon sites has been discontinued due to vandalism.

Chemical and physical data on surface water quality, including temperature, dissolved oxygen (DO), carbon dioxide (CO_2), pH, and specific conductance have been collected since 1991 immediately downstream of Los Padres and San Clemente Dams and at the Carmel River Lagoon. Beginning in 1996, continuous recording temperature sensors were placed at these locations and at two additional locations – Garland Park and the Sleepy Hollow Rearing Facility.

In general, DO, CO_2, and pH levels in the main stem have met Central Coast Basin Plan objectives set by the California Regional Water Quality Control Board. However, average daily water temperature during the late summer and fall commonly exceeds the range for optimum steelhead growth (50-60°F). Monitoring stations in the flowing portions of the river (i.e., excluding the Lagoon and main stem reservoirs) shown that water temperature during these months remains in a stressful range and can reach levels that threaten aquatic life (above 70°F). Linear trend analysis of data from the eight-year period between 1996 and 2004 at the Garland Park station, where water temperature annually exceeds 70°F, shows a slight downward trend in maximum daily water temperature. This may be due to the recovery of the riparian zone upstream and the shade it provides along the river. Water temperature in winter and spring is frequently in the range that is considered optimum for steelhead growth.

Turbidity in the main stem is normally low, except during winter when storm runoff events can elevate turbidity for several days during and after a storm event. Very wet years, such as in 1998, can cause extensive landslides and bank erosion, which can increase turbidity in the main stem for up to several months. More recently, in the reach immediately downstream of the San Clemente Dam, it appears that fine sediment released from the reservoir during drawdown operations has increased turbidity at the Sleepy Hollow weir.

Water quality in the Lagoon typically declines during late summer and fall as freshwater inflows cease and ocean waves start to overtop the sandbar at the mouth of the river. Water temperature often exceeds 70°F, which is above Central Coast Basin Plan guidelines. DO levels also periodically drop below guidelines (not less than 7.0 mg/L), probably due to a combination of increasing water temperature and decomposition of marine organic material washed into the lagoon by high ocean waves.

Benthic Macroinvertebrate Community

The community of insects living in the river bottom, which are called benthic macroinvertebrates (BMI), is an important food source for steelhead and an indicator of water quality. But the study of this community as an indicator of a stream's health is relatively new. For the Carmel River, a limited amount of information is available. In fall of 2000, MPWMD established four sites on the Carmel River to conduct the Carmel River Bioassessment Program (CRBP).

Recommendations

There are several short-term actions (i.e., over the next five to ten years) that the Carmel River Watershed Council may wish to consider that would improve Carmel River habitat quantity and quality including:

- expand the existing program of periodic injections of spawning-sized gravels and cobbles downstream of Los Padres and San Clemente Dams to a level that restores the channel bottom to a condition similar to areas upstream of Los Padres Reservoir;
- implement riparian corridor restoration projects that will establish permanent CRLF habitat;
- actively promote stewardship concepts and projects among river front property owners through peer-to-peer groups and multi-media outreach (newspaper, television, internet, mailings, etc.).

Additional activities that could improve management of the riparian corridor include:

- decrease the sampling frequency for BMI to once per year and add BMI sampling locations upstream of Los Padres Reservoir, at the Pine Creek confluence with the main stem, in a sandy reach in the lower river, and at the Carmel River Lagoon;
- develop a data collection program to document the CRLF population within the watershed;
- investigate whether control or eradication of non-native aquatic species (especially bullfrogs) is feasible;
- develop a database of documents pertaining to the riparian corridor such as reports, environmental analyses, biological opinions, and regulations.

Below are several recommendations that would help ensure a long-term increase of habitat quantity and quality in the main stem of the Carmel River and could help shift the environment to a more naturally sustainable condition. However, these activities have one or more physical, financial, institutional, or social constraints to resolve:

- investigate means to reduce summer heating of the river as it passes through reservoir areas;
- increase the use of steelhead spawning and rearing habitat upstream of Los Padres Reservoir;
- implement a dredging program or other method to pass bedload (sand, gravel, and cobble) from the upper watershed around Los Padres and San Clemente Reservoirs
- expand riparian forest areas in the alluvial reach between Carmel Valley Village and the Lagoon to increase habitat areas and allow for natural meandering;
- remove San Clemente Dam and the accumulated fine sediments from within the reservoir area and reestablish spawning areas within the channel bottom;
- consider the feasibility of approximating an unimpaired flow condition downstream of Los Padres Dam during the summer low flow season (i.e., a surface flow in the river equivalent to the flow that would occur in the absence of surface and groundwater diversions).

Future Water Supply Projects and Los Padres Reservoir Sedimentation

In 1995, California American Water (Cal-Am) was ordered by the California State Water Resources Control Board (State Board) to reduce its water extraction from Carmel Valley by 20% and to implement actions to end unlawful diversions either by obtaining additional water rights or by obtaining replacement water from other sources. The portion of Cal-Am's water use representing unlawful diversions at the time of the State Board's order was 10,730 acre-feet per year. This is currently a topic of study by Cal-Am and several public agencies, but no definitive timeline for completion of a water supply project or combination of projects is currently available. Initially, any new water supplies for the Monterey Peninsula would likely reduce diversions of water from the Carmel Valley during the dry season thereby increasing flow to the lower river, which would benefit riparian vegetation and aquatic species. However, Cal-Am has no program to maintain surface storage capacity at Los Padres Reservoir, which is currently about 50% filled in with sediment, or at San Clemente Reservoir, currently about 90% filled in with sediment. The progressive loss of surface storage in the future due to sedimentation of the reservoirs will reduce the volume of stored water available to augment dry season flows and dry season releases to the lower river will need to be reduced as a result.

New water supplies would reduce diversions from Carmel Valley and help reduce the dependency on dry season flow releases from storage to maintain flow to the lower river. But as Los Padres Reservoir fills with sediment and summer releases are reduced, existing legal water diversions by Cal-Am and other water right holders could result in dry season river conditions that are similar to current conditions (i.e., intermittent flow in some years between Carmel Valley Village and the Narrows and a dry riverbed downstream of the Narrows in many years).

It is estimated that unless sediment is removed, within 40 to 50 years Los Padres Reservoir will be 100% silted in and have virtually no surface storage capacity. However, the sedimentation rate at Los Padres Reservoir is not uniform over time and significant storage loss can occur in a single winter season. The planning and implementation of a program or project(s) to cope with the inevitable sedimentation of Los Padres Reservoir and reduced dry season flows could take several years.

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5.4.1 ASSESSMENT OF RIPARIAN FUNCTIONS AND CONDITIONS

The proper functioning condition (PFC) method for assessing the condition of riparian-wetland areas is a qualitative approach developed by the U.S. Bureau of Land Management and U.S. Forest Service for use by land managers. The method uses observations of hydrologic, vegetative, and erosional/depositional (soils) attributes to evaluate the health of a stream. A total of 17 "yes/no" questions are posed about the characteristics of a stream reach, resulting in one of three ratings that reflect stream resiliency: (1) proper functioning condition; (2) functional-at-risk; or (3) non-functional.

A rating of "proper functioning condition" means that a stream is resilient, i.e., the riparian-wetland area is stable during most high-flow events. A resilient stream produces desired values such as high quality fish and bird habitat. "Functional-at-risk" means the stream reach is currently functional, but is at risk of becoming non-functional due to an observed condition that could impact the reach in the future. "Non-functional" indicates that there is a condition in the reach or watershed interfering with the natural functions of the stream.

Individual assessments were performed at 37 sites along the main stem by two Monterey Peninsula Water Management District interdisciplinary teams with local, on-the-ground experience in the quantitative sampling techniques that support the PFC checklist. The Carmel River Watershed Conservancy performed 95 assessments in tributary drainages.

Included in this section is a map of the watershed showing reach ID number and the rating assigned to each reach. Appendix 5.4.1 contains the PFC checklist and photographs taken at each site. In addition, a geographic information system (GIS) layer was created with ARCGIS that links each labeled reach on the watershed map to the respective assessment. The GIS layer is included on a data disc supplied with this assessment.

Discussion of Main Stem Riparian Areas

Prior to the mid-1980's, several reaches between the Narrows and Robles del Rio in Carmel Valley Village periodically went dry due to water diversions. In the mid-1980s, tighter regulation of water extraction from Carmel Valley and improvements in the management of surface and groundwater supplies increased summer river flows down to the Narrows. The reach between the Narrows and Robles del Rio has benefited greatly from the additional flow, which has encouraged vegetation growth and greater diversity of wetland and riparian species. Beginning in 1996, summer and fall diversions at San Clemente Dam were halted and in the late 1990's, municipal well water diversions were concentrated in the furthest downstream wells. It is unclear whether these latter incremental increases in flow have benefited riparian vegetation downstream of Schulte Road Bridge.

Between Schulte Road Bridge and the Rancho Cañada golf course, the increase in municipal groundwater extraction during the summer and fall may have exacerbated plant stress along the streambanks and led to a weakening of the vegetative cover. An episode of bank erosion occurred in this reach between 1993 and 1998 – just a few years after groundwater extraction in this area was increased. A similar episode of erosion occurred in the reach between Schulte

Bridge and Robles del Rio between 1978 and 1983 as a result of a significant increase in groundwater extraction in that area that began in the mid-1960's.

Between 1986 and 2001, riparian wooded areas within the streamside corridor downstream of San Clemente Dam have increased from an estimated 299 acres (*McNeish, 1986*) to an estimated 438 acres (*Christensen, 2003*). This increase is due both to natural recovery after an episode of bank erosion between 1978 and 1986 and to restoration work by a variety of groups including: 1.) CALTRANS (1996) in the vicinity of the lagoon; 2.) MPWMD (1984 to the present) at multiple projects in the main stem between Via Mallorca and the deDampierre ball fields; and 3.) privately sponsored projects. Riparian forest areas, especially in floodplains adjacent to the river, have also become more diverse due to public and private revegetation efforts. In addition, at the time this report was developed, California State Parks had started work on a project to convert 100 acres of agricultural land west of Highway 1 to open water, wetland, and riparian habitats.

The riparian corridor remains very thin in some areas (as little as one or two trees wide along the streambank) due to urbanization. In these locations, wildlife mobility is limited by the poor quality and quantity of the riparian corridor. Some streamside areas continue to come under development pressure as real estate values in Carmel Valley escalate and property owners carve out niches for additional urban living space or seek to stop the natural meanderings of the river. Examples of poor landowner practices include thinning and removing streamside vegetation for view corridors, placing structures adjacent to the stream, dumping of deleterious material, and constructing illegal bank protection works.

Recent gains in riparian vegetation growth and diversity, especially between Robles del Rio and Schulte Road Bridge, may be short-lived as the ability to augment dry season flows with releases from storage at Los Padres Reservoir will decrease due to sedimentation. Should the overall level of water diversions in Carmel Valley remain unchanged, decreased dry season flows downstream of San Clemente Dam would likely have significant effects on water quality, habitat value, and streambank stability.

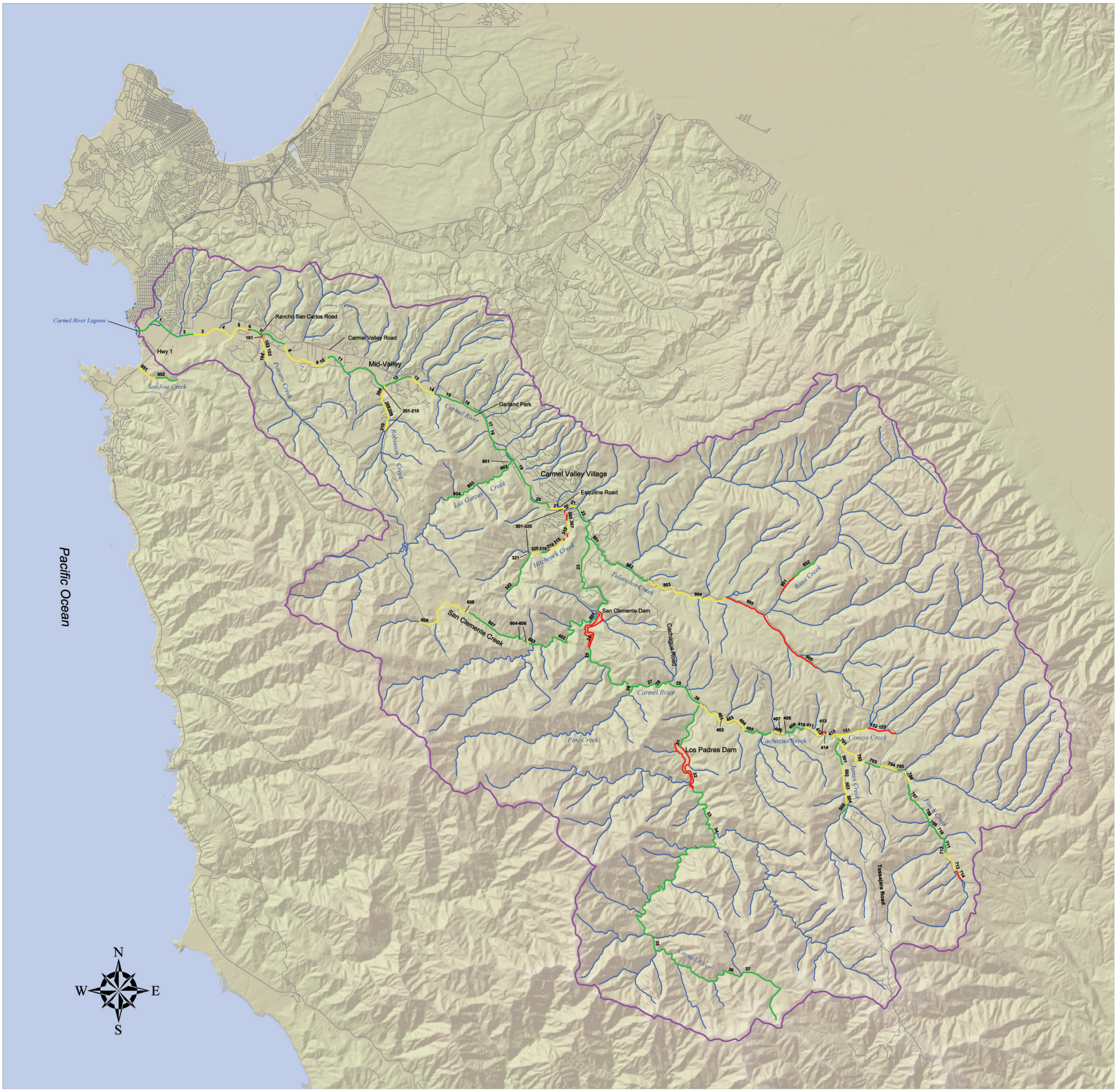
Shifting the points of water diversion into the lower river (downstream of the Narrows) has benefited aquatic species upstream of the Narrows. But this shift has also increased vegetation stress in the lowest reaches of the river, resulting in loss of vegetation and increased bank instability, as seen during the floods of the 1990's. The relatively poor groundwater quality of the aquifers in the lower 10 miles of the river makes irrigation of the riparian corridor with raw water difficult and expensive. In addition, high concentrations of iron and manganese in these aquifers has led to failures and/or poor performance in several of Cal-Am's domestic supply wells. Because well failures in the lower river normally must be made up by pumping water from further upstream in the system, surface flow conditions immediately downstream of the Narrows can change drastically in a matter of a few days during the summer low flow season.

An inventory of large wood (LW), which is defined as pieces greater than six inches in diameter and five feet in length, was conducted in the channel bottom in 2002 and 2003 between the Stonepine Resort and the Lagoon (*Smith and Huntington, 2004*). The frequency of single pieces and accumulations found in each reach ranged from 16/mile (Via Mallorca to the Lagoon) to

68/mile (Stonepine Resort to Robles del Rio). The trend shows that frequency decreases in the downstream direction. In general, higher frequencies of LW were associated with higher densities of steelhead, although there were notable unexplained exceptions in a few reaches. One explanation for this is that LW may not be a limiting factor for steelhead in these reaches. LW in the lower river tended to have a lower frequency of occurrence, but was larger and more stable, a condition that is to be expected as winter stream flows normally increase in the downstream direction and sweep smaller pieces out to the ocean. A majority of LW appears to have no effect on bed or bank stability, while a small percentage (less than 4%) were found to negatively affect bank stability.

Because the management of LW in the channel bottom has changed recently and data on LW is limited, it is not clear what an appropriate density is for the Carmel River. Past management practices included extensive removal and modification of large wood after floods and episodes of erosion. This is no longer the practice in the main stem, so it is reasonable to assume that the volume of wood in the channel bottom will increase in the future.

Proper Functioning Condition Assessment of the Carmel River and Tributaries



Carmel River and Tributaries

PFC Rating

- Unrated
- Proper Functioning Condition
- Functional at Risk
- Non-functional
- Carmel River Watershed Boundary
- Roads
- **37** PFC ID number

Miles: 0 1 2 4 6 8

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Monterey Peninsula Water Management District

Proper functioning condition (PFC) is a qualitative method developed by the U.S. Bureau of Land Management and U.S. Forest Service to assess the condition of riparian-wetland areas based on hydrology, vegetation, and erosion/deposition (soils) attributes. A total of 17 "yes/no" questions are posed about the characteristics of the stream, resulting in one of three ratings that reflect stream resiliency: (1) proper functioning condition; (2) functional-at-risk; or (3) non-functional. A rating of "proper functioning condition" means that a stream is resilient, i.e., the riparian-wetland area is stable during most high-flow events. A resilient stream produces desired values such as high quality fish and bird habitat. "Functional-at-risk" means the stream reach is currently functional, but is at risk of becoming non-functional due to an observed condition that could impact the reach in the future. "Non-functional" indicates that there is a condition in the reach or watershed interfering with the natural functions of the stream.

These PFC assessments were performed by two interdisciplinary teams with local, on-the-ground experience in the quantitative sampling techniques that support the PFC checklist. The 37 PFC assessments for the Carmel River were performed by Monterey Peninsula Water Management District (MPWMD), and 95 tributary assessments were performed by the Carmel River Watershed Conservancy.

5.5.1.1 DISTRIBUTION MAPS FOR SPAWNING AND REARING HABITATS BETWEEN LAGOON AND HEADWATERS

Extent of Spawning Habitat in the Carmel River Basin – Barriers keep adult steelhead from migrating upstream and ultimately limit the amount of spawning habitat utilized annually in the Carmel River Basin. **Table 5.5.1.1-A** lists the known upper barriers to adult steelhead migration and the location and the extent of spawning habitat is shown on **Figure 5.5.1.1-A**. In normal and above water years, when no temporary barriers limit upstream migration, adult steelhead spawn in a total of 60.5 miles of stream, including 24.5 miles of the Carmel River mainstem, 30 miles of primary tributaries, and 6 miles of secondary tributaries. In dry and some below normal water years, adults probably do not ascend to the uppermost permanent barriers on the primary and secondary tributaries, but utilize the entire 24.5 of the mainstem. Those unable to migrate past barriers are forced to spawn below smaller falls and chutes or in the mainstem.

Quantity and Quality of Spawning Habitat in the Mainstem Carmel River – Based on 1989 surveys, the amount of spawning habitat in the mainstem upstream of the Narrows totals ~120,000 square feet, including 50,000 square feet in the reach from the Narrows to San Clemente Dam (41% of total), 11,000 square feet from San Clemente Reservoir to Los Padres Dam (9% of total), and 60,000 square feet upstream of Los Padres Reservoir (50% of total) (**Table 5.5.1.1-B**). Based on these estimates, the spawning habitat in the mainstem can support approximately 2,400 nests, equivalent to a run of 4,800 adults or about 193 spawners per mile of stream. The large amount of habitat upstream of Los Padres Dam, but disproportionately low returns of adults to Los Padres Dam, indicates that spawning habitat upstream of Los Padres Dam has not been fully utilized for many years and that spawning habitat is most likely not the primary limiting factor upstream of Los Padres Dam.

Spawning Habitat between San Clemente Reservoir and Los Padres Dam and below San Clemente Dam – The amount and quality of spawning habitat in these reaches is limited by the inadequate supply of gravel from the upper Watershed, caused by entrapment of bedload in Los Padres and San Clemente Reservoirs. No natural gravel recruitment has occurred in the reach immediately below San Clemente Dam since 1920. Similarly, no recruitment from upstream of Los Padres Reservoir has occurred since 1948, when Los Padres Dam was constructed. The historical loss of spawning gravel is indexed by the trend in **Figure 5.5.1.3-B**, illustrating that habitat between the dams and immediately below San Clemente Dam contains only one-quarter as much habitat per mile, as compared to upstream of Los Padres Reservoir. Habitat is most limited in the reach between Cachagua Creek and Los Padres Dam where in 1990 there was only enough area to support 14 nests, or about 24 spawners per mile (**Table 5.5.1.1-B**). To address this situation, the MPWMD has partially restored spawning habitats in the reach between the dams and immediately below San Clemente Dam with two grants from the California Department of Fish and Game and another from the federal government. As a result, the quality of spawning habitat has been improved at key locations and the increased amount has partially offset historical loses.

Spawning Habitat in Selected Tributaries – As part of studies evaluating impacts of water supply alternatives on steelhead populations, the MPWMD assessed the quantity of spawning habitat in three primary tributaries to the mainstem, including Danish Creek, Cachagua Creek and San Clemente Creek. Following is a brief account of spawning habitats in each of these tributaries.

> <u>*Danish Creek*</u> – This basin contains about 5,100 square feet of available spawning habitat and could support about 100 steelhead nests (**Table 5.5.1.1-B**). The extent of habitat is limited by a bedrock chute and waterfall 1.7 miles upstream from the confluence with the Carmel River. Substantial habitats are probably available upstream of this barrier, but no surveys have been done to quantify the amount.

> <u>*Cachagua Creek*</u> – Spawning habitat in Cachagua Creek and its tributaries, Finch and James Creeks, totals 4,416 square feet, or enough for 88 nests (**Table 5.5.1.1-B**). Although over 8 miles of stream is available to steelhead in Cachagua Creek Basin, the narrow stream widths and low flow limits the amount of spawning habitat and yields an spawners index of only 22 fish per mile. Although the value of spawning habitat in Cachagua Basin is marginal, the stream performs the important function of replenishing spawning sized gravels to the mainstem Carmel River below Los Padres Dam.

> <u>*San Clemente Creek*</u> – Spawning habitat in the San Clemente Basin totals 10,250 square feet, equivalent to 205 nest sites (**Table 5.5.1.1-B**). Despite narrower stream widths and lower flows, San Clemente Creek supports about the same number of nest sites as the mainstem Carmel between San Clemente Reservoir and Los Padres Dam.

Juvenile Rearing Habitat in selected portions the Carmel River Basin – **Figure 5.5.1.1-B** illustrates the extent of known juvenile rearing habitat in the Carmel River Basin. In most years, 49 miles of rearing habitat are available with ~20 miles in the mainstem, 24 miles in primary tributaries, and 5 miles in second tributaries. Juvenile rearing habitat in the mainstem can be divided into three reaches based on the physical character of the channel and summer flow regimes:

<u>Upper Mainstem</u> – Most rearing habitat upstream of Los Padres Dam is within the Ventana Wilderness area, where river flow is unregulated, roads and trails have not caused erosion, the gradient is steep (~320 feet per mile), and bedrock outcrops control the course of the channel. Typically, deep pools separated by short, shallow glides and long, cobble/boulder riffles and runs predominate throughout the reach.

<u>Middle Mainstem</u> – The configuration of the reach between the dams is controlled by bedrock outcrops and large boulders. The substrate is a mixture of cobbles and boulders and lacks a natural source of gravel because most of it is trapped behind Los Padres Dam. During summer, water stored in Los Padres Dam is released into the channel and diverted or released at San Clemente Dam. By agreement with DFG, Cal-Am maintains a minimum flow of 5 cubic feet per second (cfs) below Los Padres Dam. Because of variation in natural accretion, the augmented dry-season flows range from 5 cfs in critical years to 15 cfs in wet years.

<u>Lower Mainstem</u> – Below San Clemente Dam, the river is controlled primarily by bedrock outcrops downstream to near Paso Hondo Road (Powell's Hole). Below that point, the

interaction of alluvial deposits and storm flows periodically rearrange, scour, and deposit bedload along the river. Beginning in 1984, MPWMD, DFG, and Cal-Am negotiated an agreement to release water during the low-flow season. Under the annual agreements, releases have varied from 2.5 cfs to 10 cfs and have improved aquatic habitat in the reaches downstream of San Clemente Dam, particularly upstream of Robinson Canyon, where the State Water Resources Control Board and NOAA-Fisheries limit Cal-Am pumping from the alluvium.

Table 5.5.1.1-A

Estimates of the linear extent of stream accessible to adult steelhead in the Carmel River Basin[3]

PORTION OF BASIN, Stream	Length Accessible (ft)	(miles)	Type of Permanent Barrier	Permanent Barrier Field Checked	Type of Temporary Barriers
DOWNSTREAM OF SAN CLEMENTE DAM					
- Carmel River mainstem	64,750	12.26	none	yes	shallow riffles, flow barrier at Old Carmel Dam, reservoir drawdown at San Clemente Dam
-- Robinson Canyon Cr. [1]	5,850	1.11	unknown	no	boulder piles
-- Las Gazas Creek [1]	13,150	2.49	unknown	no	unknown
-- Tularcitos Cr. [2]	22,750	4.31	concrete ford	yes	Bedrock chutes, culverts
FROM SAN CLEMENTE RESERVOIR TO LOSPADRES DAM					
- Carmel River mainstem	28,550	5.41	none	yes	Shallow riffles,bedrock chutes, concrete fords, & summer dams
-- San Clemente Creek	22,200	4.20	unknown	no	boulder piles, recreation dams
--- Black Rock Cr.	15,800	2.99	recreation dam & waterfall	no	recreation dams, boulder piles, & bedrock chutes
-- Pine Creek [1]	29,050 7,750	5.50 1.47	unknown	no	boulder piles, bedrock chutes
-- Cachagua Creek	25,250	4.78	none	yes	shallow riffles
--- Finch Cr. [2]	10,900	2.06	unknown	no	shallow riffles, bedrock chutes, boulder piles
--- James Cr. [2]	5,600	1.06	unknown	no	boulder piles
UPSTREAM OF LOS PADRES RESERVOIR					
- Carmel River mainstem	35,800	6.78	waterfall	yes	shallow riffles, boulder piles
-- Miller Fork [1]	31,000	5.87	unknown	no	shallow riffles, bedrock chutes
-- Danish Creek	9,000	1.70	bedrock chute & waterfall	yes	bedrock chute
Subtotals:					
- Carmel River mainstem	129,100	24.45			
-- Primary Tributaries	158,250	29.97			
--- Secondary Tribs.	32,300	6.12			
TOTAL IN CARMEL RIVER BASIN:	319,650	60.54			

[1] Limit of spawning habitat assumed at elevation where average slope of stream exceeds 13 percent

[2] Limit of spawning habitat assumed at elevation where streamflows were judged inadequate for successful spawning.

Summary of steelhead spawning habitat measured in 26 reaches of the Carmel River Basin upstream of the Narrows and estimates of spawning habitat in the Carmel River and selected tributaries upstream of the Narrows [1]

STREAM	REACH	Length of Reach (ft)	Portion of Reach Surveyed (ft)	Spawning Habitat Measured in Portion of Stream Surveyed (sqft)	Estimate of Total Spawning Habitat in Reach (sqft)	Potential Number of Steelhead Nests (nos.)	Spawner Index (nos./mi)
Mainstem Carmel River	Narrows to Sleepy Hollow	57,750	57,750	45,445	45,445	909	166
	Sleepy Hollow to San Clemente Dam	7,000	5,350	1,864	2,439	49	74
	subtotal	64,750			47,884	958	156
	San Clemente Res. to Pine Creek	10,600	8,122	3,369	4,397	88	88
	Pine Creek to Syndicate Camp	5,350	5,478	2,482	2,482	50	98
	Syndicate Camp to Cachagua Creek	6,300	3,594	1,797	3,150	63	106
	Cachagua Creek to Los Padres Dam	6,300	6,503	722	722	14	24
	subtotal	28,550			10,751	215	80
	Danish Creek to Bluff Camp	7,200	5,171	7,480	10,415	208	306
	Bluff Camp to Bruce Fork	5,900	1,785	1,573	5,199	104	186
	Bruce Fk to trib. above Sulphur Sprgs.	3,850	1,828	2,987	6,291	126	345
	Trib. above Sulphur Spr to trib below Buckskin Camp	5,650	2,733	2,254	4,660	93	174
	Trib. below Buckskin Camp to rightbank trib. above Buckskin	4,350	1,811	6,826	16,396	328	796
	Rightbank trib above Buckskin Camp to trib below Benchmark 1743	4,750	3,234	10,557	15,506	310	689
	Tributary below Benchmark 1743 to Barrier above Ventana Mesa Creek	4,200	489	119	1,022	20	51
	subtotal	35,900			59,489	1,190	350
	Total Mainstem Carmel River	129,200	103,848	87,475	118,124	2,362	193
	(miles)	24.47	19.67				

Summary of steelhead spawning habitat measured in 26 reaches of the Carmel River Basin upstream of the Narrows and estimates of spawning habitat in the Carmel River and selected tributaries upstream of the Narrows [1]

STREAM	REACH	Length of Reach (ft)	Portion of Reach Surveyed (ft)	Spawning Habitat Measured in Portion of Stream Surveyed (sqft)	Estimate of Total Spawning Habitat in Reach (sqft)	Potential Number of Steelhead Nests (nos.)	Spawner Index (nos./mi)
MILLER FORK	Confluence with Carmel River to meadow ~ 1 mile upstream	5,150	1,117	137	632	13	26
	Meadow to Clover Basin Camp	5,750	1,908	1,659	5,000	100	184
	Clover Basin Camp to Miller Canyon	2,850	1,503	698	1,324	26	98
	Miller Canyon Camp to probable migration barrier	17,300	1,201	50	720	14	9
	Subtotal Miller Fork Basin	31,050	5,729	2,544	7,675	154	52
	(miles)	5.88	1.09				
DANISH CREEK	Confluence with Carmel River to migration barrier	9,000	2,442	1,386	5,108	102	120
	(miles)	1.70	0.46				
CACHAGUA CREEK	From Carmel River to Conejo Creek	24,500	14,011	841	1,471	29	13
	Conejo Creek to Finch Creek	750	680	56	62	1	17
-Finch Creek	From James Creek to Big Creek	10,900	2,405	543	2,461	49	48
-James Creek	From Finch Creek to Lambert Ranch	5,600	451	34	422	8	16
	Subtotal Cachagua Creek Basin	41,750	17,547	1,474	4,416	88	22
	(miles)	7.91	3.32				
SAN CLEMENTE CREEK	San Clemente Reservoir to Trout Pond Dam	9,000	?	?	3,906	78	92
	Trout Pond Reservoir to Black Rock Creek	3,450	2,315	1,005	1,498	30	92
	Confluence with Blk Rk Crk to end of permanent flow	9,750	669	161	2,346	47	51
-Black Rock Creek	Confluence with San Clemente Creek to confluence of North and South Forks	3,450	1,460	410	969	19	59
--No.Fork Black Rock Cr	Confluence with South Fork to permanent barrier at White Rock Dam	12,350	1,494	184	1,522	30	26

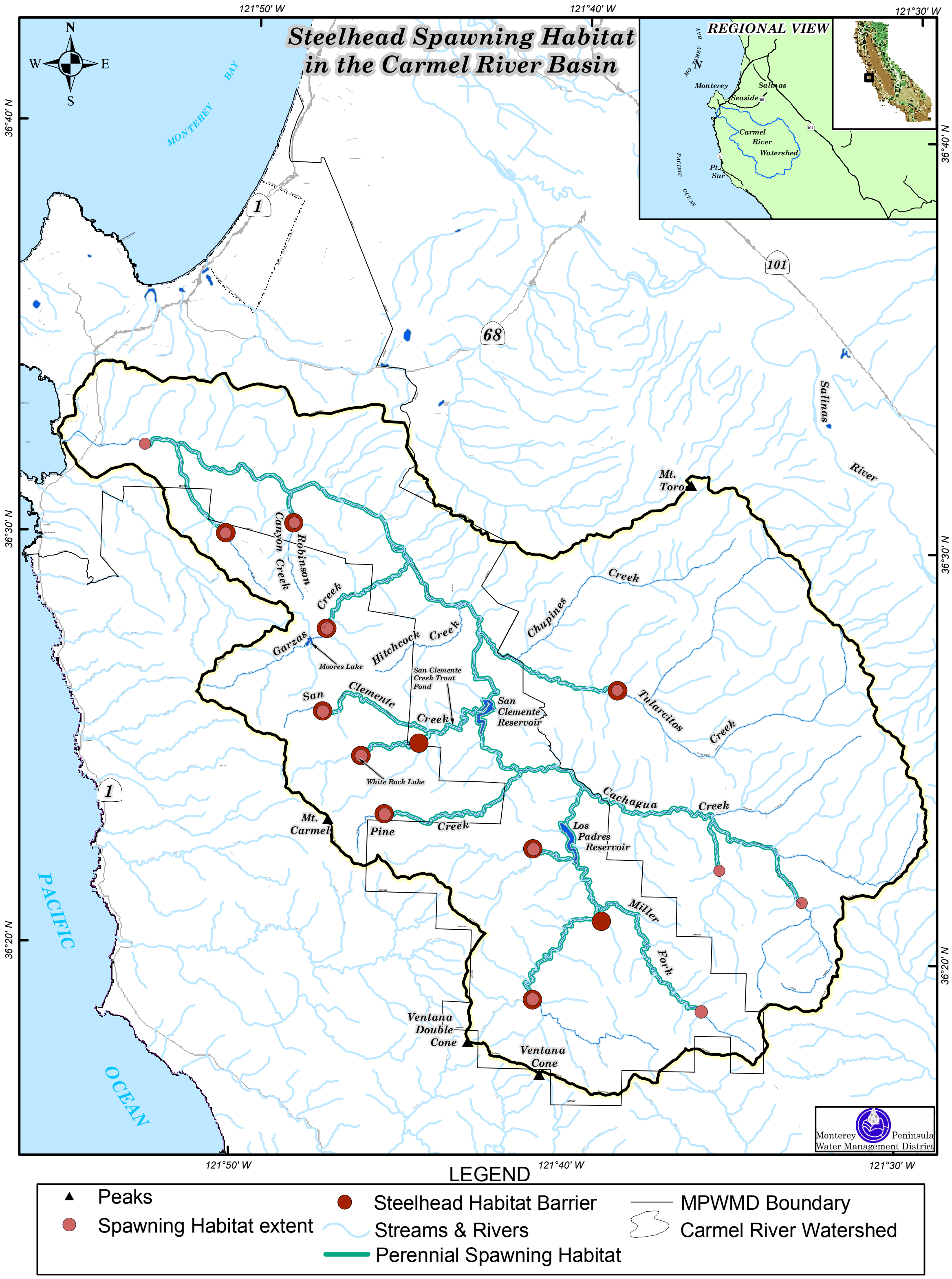
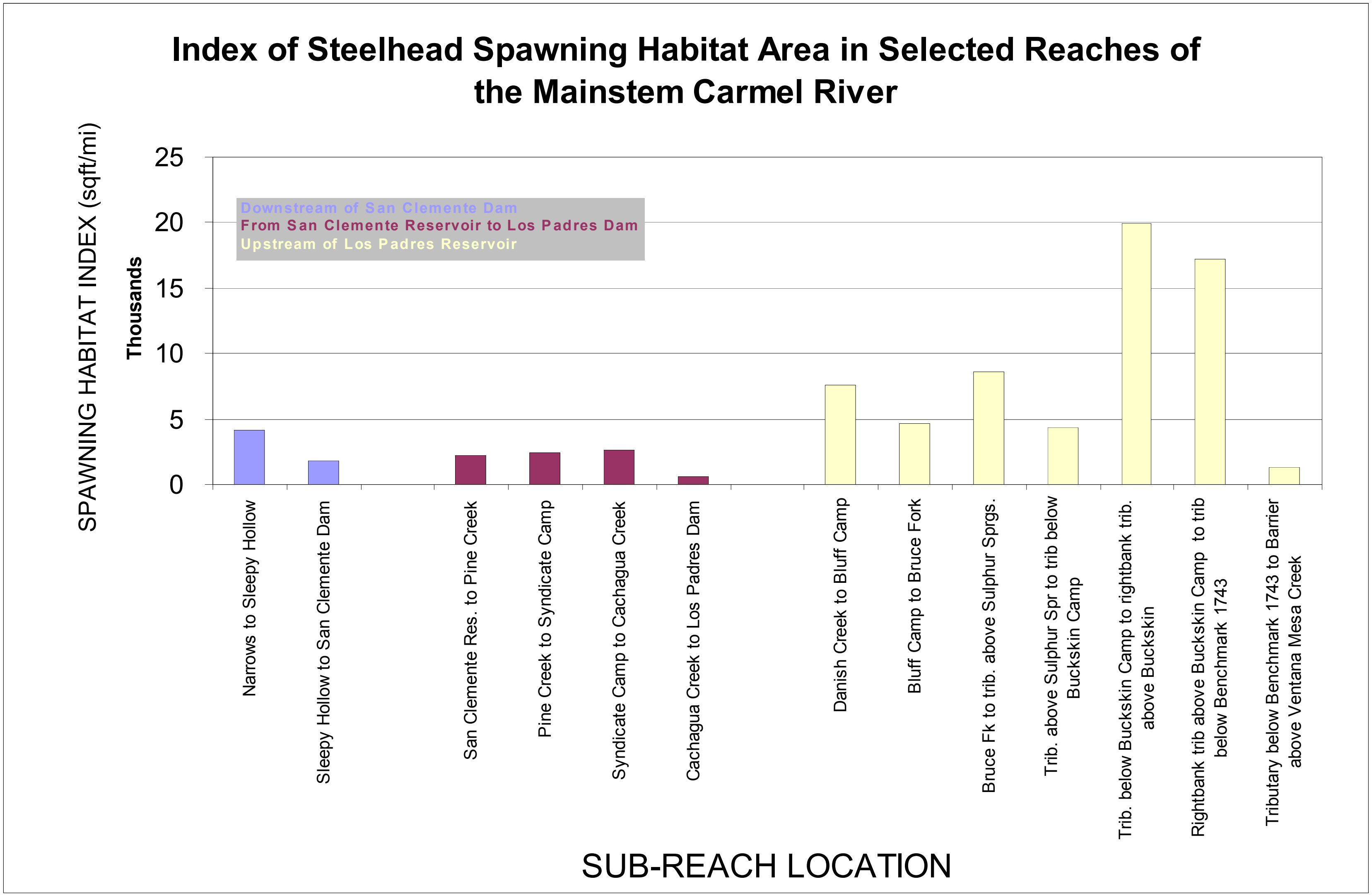


Figure 5.5.1.1-A

Figure 5.5.1.1-B



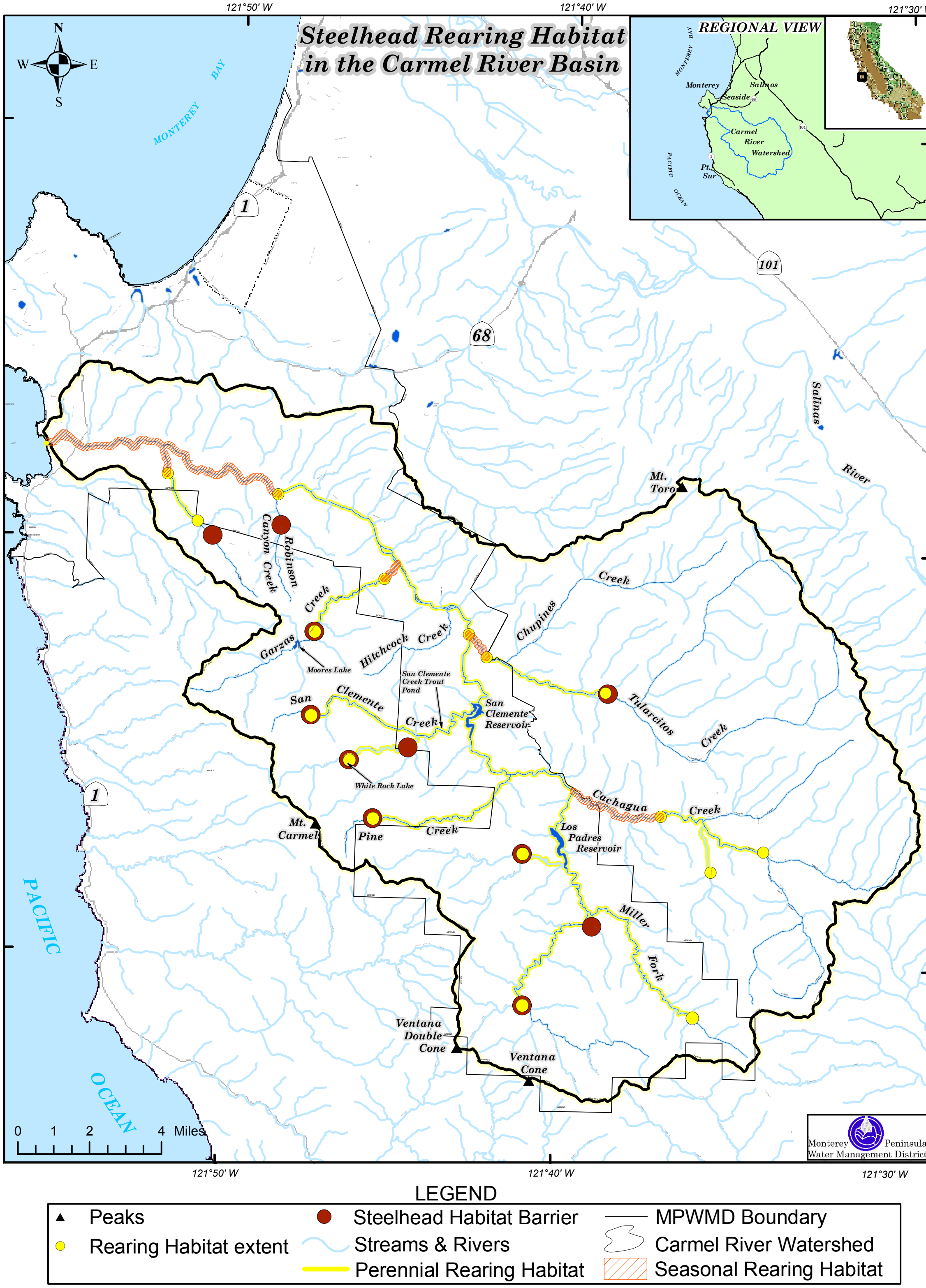


Figure 5.5.1.1-C

5.5.1.2 DELINEATE POTENTIAL REARING HABITAT AND POPULATION SURVEYS FOR JUVENILE STEELHEAD

The purpose of this section is to 1) review and update the existing data on juvenile steelhead habitat, 2) provide a quantitative assessment of the quantity and quality of juvenile habitat in several streams, including the main stem from the Narrows upstream to the upper boundary of steelhead migration, Cachagua Creek, and San Clemente Creek, 3) review and update data on juvenile populations in the Carmel River, and 4) provide estimates of the carrying capacity of young-of-the-year steelhead in key reaches of the mainstem.

POTENTIAL REARING HABITAT – REVIEW AND UPDATE

Early Habitat Surveys – The CDFG surveyed the mainstem of the Carmel River in 1957 as part of an effort to evaluate the feasibility of passing fish over Los Padres Dam (Elwell, 1957). Though not as quantitative as later efforts beginning in the 1970's, this information provides an important insight into the nature of juvenile steelhead populations in the basin and CDFG management of the river, ten years after the construction of Los Padres Dam (**Appendix 5.5.1.2**). Regarding the habitat quality and productive capacity of the river, the CDFG report found,

> "*The productive capacity of this river* [upstream of Los Padres Dam], *as evidenced by the very small game fish population present, appears to be limited. RT* [rainbow trout] *2" to 6" were fairly common, but certainly not as abundant as they should be in a river of this size. Fish of the year were conspicuously absent along the margins of the main river and tributaries."* The report continued*, "It is not felt that this scarcity of trout can be attributed to fishing pressure alone, which is fairly light in this section* [upstream of Los Padres], *or other forms of predation. Moreover, all other conditions for successful natural propagation appear to be favorable in this section with two known exceptions – limited spawning areas and a pronounced scarcity of bottom food ... it seems reasonable to assume that the same limiting factors would also affect an anadromous population in the same manner.*"

Based on the results of this habitat study the author opined,

> "*there would be little or no benefits derived from attempting to re-establish a steelhead run in the Carmel River* [upstream of Los Padres] *by transporting adult steelhead over the Los Padres Dam."* This rationale, while ultimately flawed, guided CDFG policy and management on the river for another 15 years, until renewed interest in restoration of the population emerged as follow ups to the California Fish and Wildlife Plan of (CDFG 1965) and to Cal-Am's project to drill additional wells in lower Carmel Valley.

Habitat Surveys in the 1970's – During the 1973-75 period, the CDFG surveyed juvenile rearing habitat in selected portions of the Carmel River Basin as part of its mandate to inventory, protect and restore the habitat for anadromous fish stocks throughout California (Snider, 1983). [1] This work was the first to provide a quantitative description of the juvenile steelhead habitat in the Carmel River. At the time of this survey, fall 1975, juvenile rearing habitat totaled 48 acres in just over 34 miles of stream channel (**Table 5.5.1.2-A**). Approximately, 90 percent of the viable rearing habitats were distributed in the upper drainage basin above San Clemente Dam, as this was prior to any provision for streamflow releases at the base of the dam. This pattern was noted by Snider[2], "*Nursery habitat in the lower drainage, below Tularcitos Creek, was lacking both in quality and quantity. Following the termination of releases from San Clemente Dam in June 1975, flow receded rapidly leaving only 1 mile of perennial flowing river in the lower drainage (RM 15 to RM 14). The stream in this [*flowing*] section was generally less than 6 inches deep, the result of 1-2 cfs spreading across a wide, low gradient streambed*."

Table 5.5.1.2-A[3]

TABLE 7. Steelhead Habitat Available in the Carmel River Basin during Low Flow Period (July - October).1/

Study Area	Flow at time of measurement (cfs)	Stream miles	Surface area (acres)	Riffle area (acres	Pool area	Spawning2/ habitat (acres)	Nursery habitat (acres)
Danish Creek	1-2	0.75	0.36	0.36	0.14	0.22	0.36
Carmel River, upstream of Los Padres Dam	5-10	14.00	17.57	15.26	10.19	7.66	17.57
Cachauga Creek	1	2.0	1.21	0.73	0.48	0.36	1.21
Pine Creek	1-2	5.50	4.00	2.00	2.00	2.00	4.00
San Clemente Creek	2-3	4.50	2.73	1.37	1.37	1.37	2.73
Carmel River, between San Clemente and Los Padres dams	10-20	5.50	16.67	8.34	8.34	4.25	16.67
Carmel River, downstream of San Clemente Dam							
Flowing section	1-2	1.25	3.03	1.82	1.21	--	3.03
Non-flowing section	0	0.75	2.27	0	2.27	--	2.27

1/Measured July-October 1975.

2/Area estimated to meet spawning criteria during January-April spawning period.

[1] The complete Snider (1983) Anadromous Fish Branch Report is provided in Appendix 5.5.1.2. The forward of the Snider (1983) report set the stage for future restoration efforts by the CDFG, "*The California Fish and Game Commission recognizes steelhead as a valuable resource with strict environmental requirements. It is the Commission's policy to provide a vigorous, healthy steelhead resource by maintaining an adequate breeding stock and suitable spawning area and by providing for natural rearing of young fish to migratory size. The policy emphasizes management programs, which inventory and protect and wherever possible, restore or improve the habitat of natural steelhead stocks. It mandates the CDFG to develop and implement such programs by measuring and wherever possible, increasing steelhead abundance. Protection is to be provided by assessing habitat status and adverse impacts and by alleviating those aspects of projects, developments, or activities which would or already do adversely impact steelhead habitat or steelhead populations*." Although stated over twenty years ago, this preamble to Snider's report still guides the efforts of the CDFG in managing and restoring steelhead populations, even as many are listed as threatened or endangered under the Federal Endangered Species Act.

[2] Snider (1983), page 22

[3] Source: Snider (1983), page 21.

Habitat Surveys by D. W. Kelley and Associates 1980 to 1989 – The Monterey Peninsula Water Management District (MPWMD) hired D. W. Kelley and Associates (DWKA) to conduct surveys of steelhead habitat, first as part of the planning efforts for New San Clemente Dam and later for New Los Padres Dam. The goal of this work was to delineate habitat in key reaches of the mainstem between major tributaries and to develop means for predicting juvenile populations with and without new dams in place. While the efforts to construct and operate new reservoirs have now been essentially abandoned, the underlying work in delineating habitat and assessing the quality and quantity of rearing habitats is still valid, given an understanding of how streamflow and streambed conditions may change in the future. This work, summarized in Dettman and Kelley (1986), and modified to reflect current conditions indicates that viable rearing habitats are currently distributed over approximately 53 miles of stream channel (**Table 5.5.1.2-B**). This is a substantial increase compared to the 34.5 miles of available habitat that was measured by Snider in 1975 and represents over 80 percent of the channel available to adult steelhead for spawning. The increase is a direct result of efforts over the last 20 years to increase available rearing habitat by making releases from the base of San Clemente Dam beginning in 1983 and changing the order of pumping from wells in Carmel Valley beginning in 1993.[4] [5]

<u>The Quality and Quantity of Juvenile Rearing Habitat in the Carmel River Basin</u> – While the length of stream channel with juvenile rearing habitats is a valuable index, it does not allow comparisons amongst tributaries and the mainstem within the Carmel River Basin or with other coastal steelhead streams of differing sizes. In the 1980's, DWKA developed a method for assessing the rearing habitats for young of the year and yearling steelhead that results in a Rearing Index (RI) of the quality and quantity of habitats.[6] DWKA and subsequently MPWMD applied this method to the mainstem from the Narrows to San Clemente Dam, from San Clemente Reservoir to Los Padres Dam and upstream of Los Padres Reservoir. In addition, rearing habitats were assessed in San Clemente and Cachagua Creeks. Following are short descriptions of habitats and RIs in these streams.[7]

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[4] Beginning in 1983 the California Department of Fish and Game initiated an annual Memorandum of Agreement (MOA) governing California-American Water's schedule of operations at Los Padres and San Clemente Dams. Over time, the operation has changed to restrict direct diversions and increase the release requirements at San Clemente Dam. In addition, in 2001 Cal-Am operations were further restrained under terms of a Conservation Agreement with NOAA Fisheries to preclude any direct diversion during the low-flow season, defined as periods when streamflow at the MPWMD gaging station at Don Juan Bridge is less than 20 cfs for five consecutive days.

[5] As a result of recommendation from the CDFG, the SWRCB ordered Cal-Am Water to change the sequence of pumping subsurface flow from their lower Carmel Valley Wells. Beginning in 1993 under a testing program, and continuing from 1995-on under Water Rights Order 95-10 and 98-04, the SWRCB ordered, " *To the maximum extent feasible without inducing sea water intrusion or unreasonably affecting the operation of other wells, Cal-Am shall satisfy the water demands of its customers by extracting water from ins most downstream wells*".

[6] Dettman, D.H. 2001. A method for Assessing Critical Habitats for Juvenile Steelhead in Coastal Streams. MPWMD Files, Memorandum dated January 9, 2001 from D. H. Dettman to L. Hampson. Memorandum summarizes the D W Kelley method for assessing rearing habitat and developing Rearing Indexes for young-of-the-year and juvenile steelhead. The January 9 2001 Memorandum is provided in Appendix 5.5.1.2

[7] For a more complete description of habitats, see Chapter IV of Dettman and Kelley (1986), which is included in Appendix 5.5.1.2

Upstream of Los Padres Reservoir – The principle streams available for rearing steelhead are 7.0 miles of the mainstem, 5.7 miles of Miller Fork, and 1.7 miles of Danish Creek. The rearing habitats within the upper watershed are of exceptionally high quality and quantity with over 400,000 sq. ft. of good-excellent habitat for young-of-the-year, representing over 97 percent of the total stream area. (**Table 5.5.1.2-C**) In 1982, the average young-of-the-year RIs in these streams ranged from 2 to 5 times as high as RI's measured in other coastal streams at similar flows.[8] The upper watershed is almost entirely within the confines of the Ventana Wilderness Area, so the rearing habitats will probably remain in good-excellent condition for the foreseeable future and beyond.

Los Padres Dam to San Clemente Reservoir – During the last 55 years, the Carmel River between Los Padres Dam has been used to convey water released from Los Padres Reservoir and diverted at San Clemente Dam. The minimum streamflow release at Los Padres Dam is 5 cfs, as required by the SWRCB.[9] Due to variation in natural accretion, the augmented dry season flows in this reach vary from about 5 cfs to 15 cfs in wet years. Bedrock outcrops and boulders control the river configuration in this reach (**Figure 5.5.1.2-A**). The substrate is a large cobble boulder mixture. Gravels are scarce above Cachagua Creek, due to entrapment by Los Padres Dam, but more prevalent below there. At times, the substrate below Cachagua Creek is embedded with sand that originates from development and roads in the Cachagua Creek basin, but most often the physical habitat is of good to excellent quality, due to an ample supply of large substrate and augmented flow.

Rearing habitat quality ratings are lower in this reach, as compared to above Los Padres, but because the stream is wider and flows are augmented, the RIs tend to be higher than in the upper Carmel River Basin (**Table 5.5.1.2-D**). In the reach between Syndicate Camp and Cachagua Creek, the rearing habitat is more constrained by higher degrees of cobble embeddedness. Nonetheless, the rearing habitat for young-of-the-year totals 763,000 sq. ft. in the reach between the dams, which is about 60% of the amount upstream of Los Padres and 23% of the total habitat area in the mainstem, upstream of the Narrows (**Figure 5.5.1.2-D**).

During late summer and early fall months of below median flow years, the release of epilimnetic water from Los Padres Reservoir can result in stream temperatures above the optimum level for steelhead. For example, in 1997 the reservoir was drawn down to 50% of maximum storage by September and this resulted in very warm releases of water during August and September 1997 (**Figure 5.5.1.2-D**). In contrast, during wet years when the reservoir stays fuller over the dry season, the temperature of the release is cooler (**Figure 5.5.1.2-E**). In future years, the pattern of temperature releases will tend to earlier, warmer releases of water, as Los Padres Reservoir continues to fill with sediment. Maintenance of the current pattern of cooler temperatures may require additional

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[8] Dettman, and Kelley (1986)

[9] SWRCB on July 7, 1948, in the Matter of Application 11674, issued Decision 582 established minimum streamflow requirement of 5 cfs in the Carmel River directly below the outlet structure of the Los Padres Dam at all times during which water is being stored, subject to temporary reductions for operating purposes and emergencies.

measures such as dredging to restore storage capacity or installation of a cooling tower to keep water within an acceptable range for juvenile steelhead.

Figure 5.5.1.2-A. Stream habitat in the mainstem of the Carmel River between San Clemente Reservoir and Cachagua Creek, April 19, 2004. Streamflow was approximately 30 cfs at the time of the survey.

The Narrows to San Clemente Dam – Large numbers of adult steelhead successfully spawn in the 14-mile reach of the river between San Clemente Dam and Via Mallorca Bridge. In winter and early spring, water quality and substrate conditions are usually adequate to ensure reasonably good hatches and fry emergence, so that the reach begins most springs well seeded with young steelhead.

Currently, summer streamflow is maintained in the 11.4-mile reach below San Clemente Dam downstream to the vicinity of Schulte Road at RM 6.7. Historically, flows throughout most of this reach were reduced to critical levels each summer as Cal-Am diverted all surface inflow to San Clemente Reservoir at the dam and through the Carmel Valley Filter Plant. Since 1983, diversions at San Clemente Dam have been gradually constrained by loss of surface storage and agreements with NOAA-Fisheries, CDFG, MPWMD, and the California Department of Water Resources. Currently, all surface inflow to San Clemente Reservoir is released into the river channel, once the flow declines to 20 cfs as measured at the MPWMD gaging station at Don Juan Bridge (RM 10.8).

In 1982, DWK measured the quantity and quality of rearing habitat in five representative sections of the river between San Clemente Dam and the Narrows, at flows ranging from ~ 6 to 53 cfs (**Table 5.5.1.2-E**).[10] At the time, the habitat below the Narrows was not assessed due to the sandy substrate and lack of surface flow in most years.[11] Discounting habitats in the stream below the Narrows, the total rearing habitat area at the low end of the flow range (~6 cfs) was 1.3 million square feet (msf), with quality ratings ranging from 2.0 to 2.5 and the RI averaging 65.9 units. Accounting for a reasonable adjustment to improved habitat downstream of the Narrows since 1994 raises the total area to 1.6 msf for young-of-the-year and 1.0 msf for yearlings at flows ranging from 3 to 6 cfs (**Table 5.5.1.2-E).**

As long as current water storage in Los Padres Reservoir is maintained and Cal-Am operates its wells according to the approved sequence in Lower Carmel Valley, an average minimum streamflow of about 5 cfs can be maintained below San Clemente Dam, for the foreseeable future. With these conditions, it is reasonable to expect that flow can persist downstream through the Lower Carmel River to about Schulte Road, where Cal-Am pumping removes most of the surface and subsurface flow. With a 5 cfs release at San Clemente Dam, the quality and quantity of rearing habitat is substantial in the reach above Schulte Bridge, totaling 1.3 msf and 3.3 million Rearing Index units (mRIU) (**Table 5.5.1.2-F**).[12] These totals represent about 37% of the habitat area for young-of-the-year and 24% of the total Rearing Index Units in the basin upstream of Schulte Road (**Figure 5.5.1.2-B**).[13]

Cachagua Creek – Near the intersection of Tassajara Road and Cachagua Road, James Creek, Finch Creek and Conejo Creek join together to form Cachagua Creek, which drains a large watershed (46 sq mi). The unit runoff is low compared to the remainder of the upper Carmel River watershed. Gaging records by MPWMD and the USGS since 1992 show that average annual runoff from Cachagua Creek is only 6.5% of the average runoff at Robles del Rio, although the Cachagua Basin represents 24% (46 sq mi /193 sq

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[10] Dettman and Kelley (1986), pages 71-83.

[11] Since 1983, and especially since 1993 when the SWRCB required Cal-Am to pump their wells from a downstream to upstream sequence and curtail most pumping above the Narrows, the viable summer rearing habitats have extended downstream, ranging from near Highway One Bridge (RM 1.1) in 1998 to Robinson Canyon (RM 8.5) in 1994. No systematic measurements have been made of rearing habitats in this reach, but the quantity and quality of habitats in the extended reach is probably similar to habitat in the reach from the MPWMD gaging station at the Narrows to the Eucalyptus Grove at the lower end of Garland Park.

[12] Table 5.5.1.2-F provides summary of totals in major reaches of the mainstem and in selected tributaries. See **Appendix 5.5.1.2-D** for a detailed accounting of habitat quality and quantity, rearing indexes and capacity to rear young-of-the-year in specific reaches of each stream.

[13] The totals in **Table 5.5.1.2-F** and **Figure 5.5.1.2-D** do not include assessments of habitat in Pine Creek, Tularcitos, Hitchcock Canyon and Garzas Creek, which have not been surveyed since 1974. Habitats in Pine and Garzas creeks are similar to San Clemente Creek and habitat in Tularcitos Creek is similar to Cachagua Creek. Habitat quality and quantity is severely constrained in Tularcitos and Garzas Creeks by lack of surface flow during summer months. Pine Creek is relatively pristine in character with only minor diversions of surface flow and few landform disturbances.

mi) of the drainage area. Summer flows are correspondingly low, with annual minimums frequently declining to zero by early summer in the lowermost reach of the creek. Along the lower portions of the creek, the canyon and riparian corridor are relatively open; but there are patches of alder, live oak, and sycamore that provide shade in the narrow canyon reach immediately downstream of Tassajara Road. Similar habitat exists upstream of Tassajara Road, along Finch Creek and James Creek. Streamflow in these canyon reaches can persist in some years, providing limited amounts of rearing habitat. In 1982, DWKA surveyed rearing habitat in three reaches of Cachagua Creek at two flows. By summer's end, juvenile rearing habitat was poor and the quality was higher upstream than downstream, reflecting more persistent flow and lower levels of embeddedness in the upper reaches. In comparison to other portions and tributaries draining the Santa Lucia Range, the quantity and quality of habitat for young-of-the-year is limited in Cachagua Creek, totaling only 110,000 sq. ft. and 218,000 RIUs (**Table 5.5.1.2-F**). These indexes represent about 2-3% of the rearing habitat in the basin (**Figure 5.5.1.2-B**).

San Clemente Creek – San Clemente Creek flows through a steep, narrow, well-shaded canyon. Its relatively small watershed of 15.6 sq. mi. contributes 13% of the average annual runoff in the Carmel River at Robles del Rio (James, 2003). Summer flows are regulated by releases from San Clemente Creek Trout Pond, 1.6 miles above San Clemente Reservoir and set at 1 cfs, or the natural flow, whichever is less. The dry-season low flows typically decline to less than 0.3 cfs at the MPWMD gaging station, above San Clemente Reservoir, but only rarely does the streamflow cease. Based on surveys in 1990, it appears that steelhead utilize all of the San Clemente Creek and its tributaries, except the south fork of Black Rock Creek, where a waterfall blocks adult migration. In 1982, DWKA surveyed steelhead habitat in four sections of the creek at flows ranging from 0.6 to 3.9 cfs. The amount of suitable young-of-the-year habitat decreased from 74,000 sqft at 2.7 cfs to 47,000 sq ft at 0.6 cfs, but the quality of the remaining habitat declined only slightly from 3.4 to 2.9 units.[14] Because of this, the RI for San Clemente Creek is maintained at a relatively high level, as the low flows persist during the dry season. Based on 1982 information, the habitat area for young-of-the-year totals about 204,000 sq ft in the basin and RIUs total 760,000, representing 6 % of the total habitat and RIUs in the Carmel River Basin (**Table 5.5.1.2-F and Figure 5.5.1.2-B**).

JUVENILE STEELHEAD POPULATION SURVEYS – REVIEW AND UPDATE EXISTING INFORMATION

In coastal streams, conducting surveys of the juvenile steelhead population is an effective way to assess whether freshwater systems are providing for a healthy, self-reproducing steelhead resource. Surveys provide basic information on the numbers of fish, sizes of individual fish and population density, which are crucial to assessing the success of adult reproduction and to determine whether freshwater habitats are adequately seeded with juveniles. Traditionally, surveys have been conducted in coastal streams during the end of the low-flow season, usually in October, prior to the onset of fall and winter storms, which displace or cause individual fish to

[14] Dettman and Kelley (1986), pages 64-67.

move downstream. Numerous surveys have been conducted in the Carmel River Basin. Following is a brief account of existing information from the surveys.

CDFG Population Surveys in the 1970's and 1980's –The CDFG surveyed juvenile steelhead in the reaches upstream and downstream of Los Padres in 1973 and 1974.[15] Mean population density in these sections ranged from 1,371 fish/mile in the reach upstream of Los Padres to ~5,120 fish/per mile in the short flowing section below San Clemente Dam (**Table 5.5.1.2-G**). In the reach upstream of Los Padres Reservoir, the population included resident steelhead, which affected the age distribution and shifted the age structure to include 13-15% age 1+ and older fish (**Table 5.5.1.2-H**). CDFG continued population surveys below San Clemente Dam in 1983 and 1985-87.[16] For areas downstream of Los Padres Dam, lineal density for the period prior to the 1987-1991 drought averaged 6,032 fish per mile and ranged from a low of 3,648 fish/mi in 1974 to 9,307 fish/mi in 1986 (**Table 5.5.1.2-I**)

DWKA Surveys in 1982 – DWKA (1986) measured juvenile steelhead abundance and size in two reaches of the Carmel River during summer/fall 1982. Upstream of Los Padres Reservoir, where the population was comprised of a mixed resident/anadromous population of steelhead, the population was estimated at 45,630 fish, including 29,079 young-of-the-year and 16,551 older juvenile and resident fish. Density of the combined population in 1982 averaged 3,179 fish per mile, approximately twice the levels measured by CDFG in 1973 and 1974.

Population Surveys since 1990 – Since Fall 1990, the MPWMD has surveyed the juvenile steelhead population in the Carmel River below Los Padres Dam. The extent of sampling within the 25-mile long reach below Los Padres Dam has been expanded from four stations in 1990 to eleven in 2002. (**Tables 5.5.1.2-J and 5.5.1.2-K**) Over the last fourteen years, the lineal density of the juvenile population at these stations averaged 4,367 fish per mile (fpm) of stream, ranging from a low of 2,083 fpm at the Lower River Sites to a high of 8,139 fpm at the Cachagua Site, and density progressively increased from lower elevation to higher elevation sites, with the highest density usually at the Cachagua site, about 0.5 mile below Los Padres Dam. (**Figure 5.5.1.2-C**) The pattern of areal density was similar to lineal density with the overall station density averaging 0.036 fish per square foot ($fpft^2$) and ranging from 0.016-0.017 $fpft^2$ at lower river sites and lower San Clemente inundation zone to 0.067 $fpft^2$ at the Cachagua site below Los Padres Dam.

The trend from lower density at low elevation stations to higher density at upper elevations is probably due to a combination of more favorable water temperatures and substrate conditions in the upper reaches. Two exceptions to this trend occur in the vicinity of San Clemente Dam, where population density is consistently low, just downstream of San Clemente Dam (Sleepy Hollow Station) and within the inundation zone at the SCR Delta Lower Station. Population density at the Sleepy Hollow Station is often the lowest of the annual survey series, which is most likely due to the combination of high water temperatures released from San Clemente Dam and the low production of aquatic invertebrates. Although the substrate at this site is ideal for juvenile steelhead, the narrow stream channel combined with almost a century of scour has

[15] Snider (1983), Appendix 5.5.1.2-B, pages 25-26
[16] Snider (1983, included as Appendix 5.5.1.2-B) and CDFG Office files in Monterey, CA.

reduced the habitat to a series of long, deep pools separated by short riffles. Invertebrate production in this reach may be low due to the preponderance of boulder/pool habitat and the short nature of riffles, resulting from 80 years of sediment trapping in the reservoir. Population density within the inundation zone of San Clemente Reservoir ranges from very low levels at the lowermost station to above average levels at the uppermost site. Since 1997, when the flashboards were no longer raised at San Dam, the inundation zone has been transitioning from a shallow reservoir back to stream environment.

CAPACITY TO REAR JUVENILE STEELHEAD IN THE CARMEL RIVER BASIN

The information summarized in the preceding sections on habitat surveys and juvenile population density can be used to develop estimates of the carrying capacity of young-of-the-year steelhead in the Carmel River and selected tributaries.

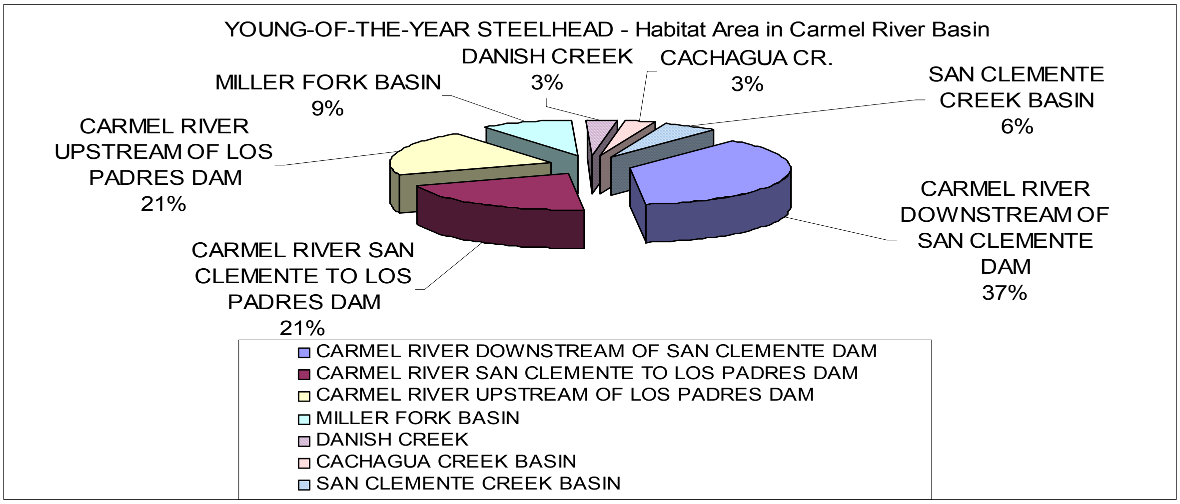
Estimated Carrying Capacity Based on Habitat Surveys – Dettman, Kelley and Reuter (1987) developed estimates of the juvenile steelhead carrying capacity in the mainstem of the Carmel River and selected tributaries, based on 1982 survey information. Their estimates have been updated for this watershed assessment by including potential habitat in the reach from Schulte Bridge to the Narrows and by modifying the 1987 estimates with information from 1989 surveys at 35 sites in the reach between San Clemente Reservoir and Los Padres Dam.[17] Using this approach the ~3.6 million square feet of rearing habitat in the Carmel Basin yields a total potential population of ~245,000 young-of-the-year steelhead (**Table 5.5.1.2-F**). Of this total, approximately 25% is downstream of San Clemente Dam, 33% is between San Clemente and Los Padres Dam, and 42% is upstream of Los Padres Dam (**Figure 5.5.1.2-B**). In terms of the mainstem only, the total capacity is 174,600 fish, including 60,200 fish downstream of San Clemente, 52,000 fish between the dams, and 62,400 fish upstream of Los Padres Reservoir (**Table 5.5.1.2-F**).

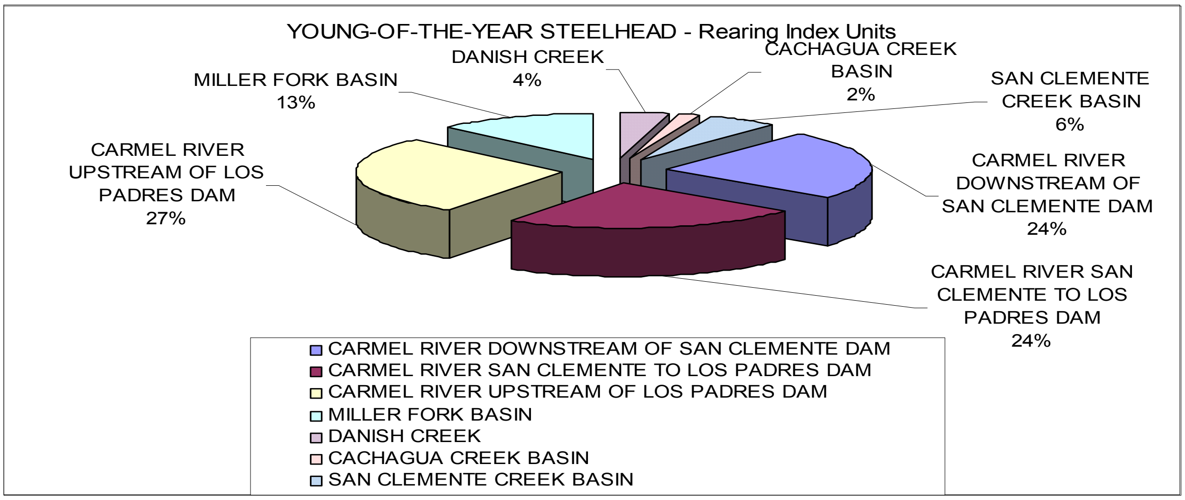
Estimated Carrying Capacity Based on Population Surveys – Another way to estimate carrying capacity is to expand estimated population densities in specific reaches, represented by sampling stations.[18] **Table 5.5.1.2-L** is a compilation and expansion of population densities in seventeen reaches of the mainstem Carmel River. Using this approach the estimated capacity of the mainstem ranges from 89,000 to 94,000 fish, substantially lower than the estimated capacity of 174,500 fish, based on habitat indexes. While the differences between the habitat-based and actual densities are substantial, this is to be expected given that the returning adult population was substantially reduced during and following the 1987-91 drought.

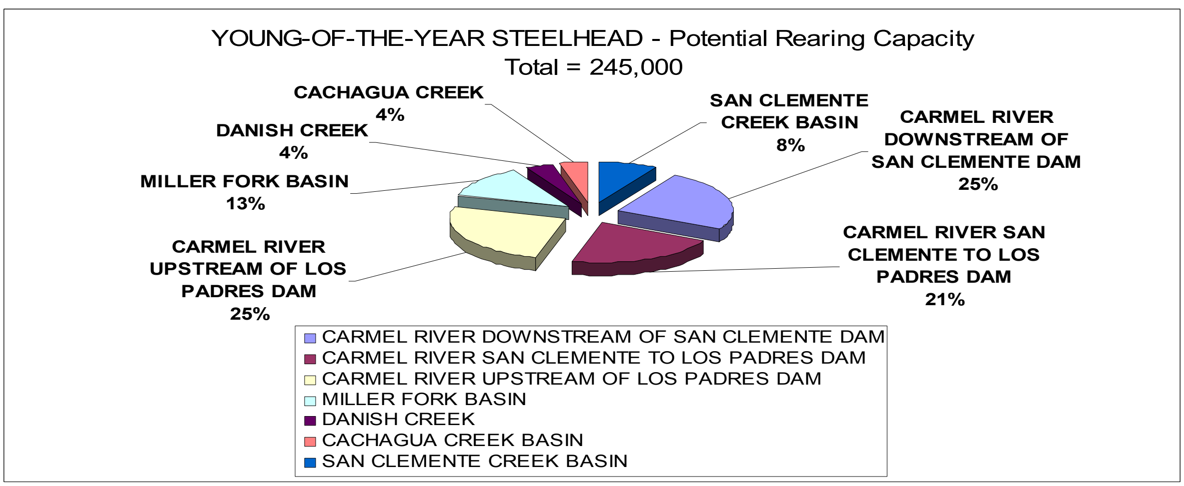
[17] See Dettman, Kelley and Rueter (1986) and Dettman and Kelley (1986) for a detailed discussion of the method used to estimate carrying capacity, based on a calibration of rearing indexes with the density of juvenile steelhead populations in central California coastal streams.

[18] This method for estimating carrying capacity has an advantage in streams where a long time series of population density data is available, but tends to underestimate carrying capacity in streams where the habitat is under seeded with swim-up fry due to insufficient number of spawning adults or to poor survival during larval incubation and emergence of alevins.

Figure 5.5.1.2-B

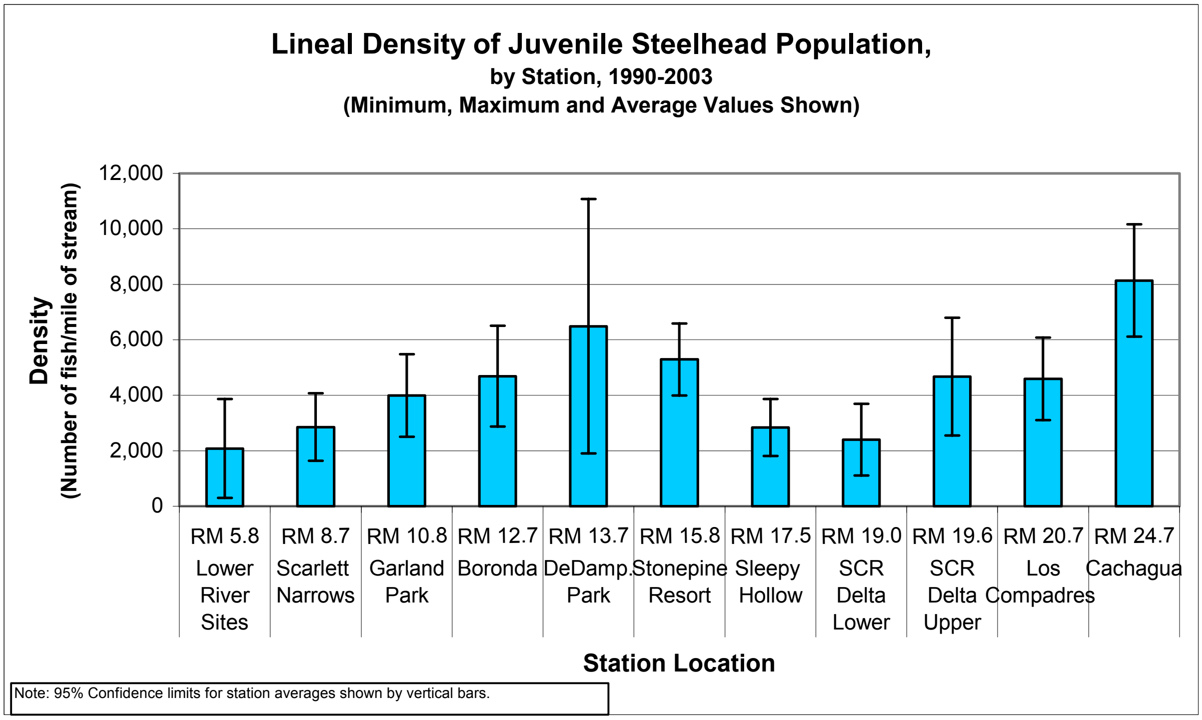


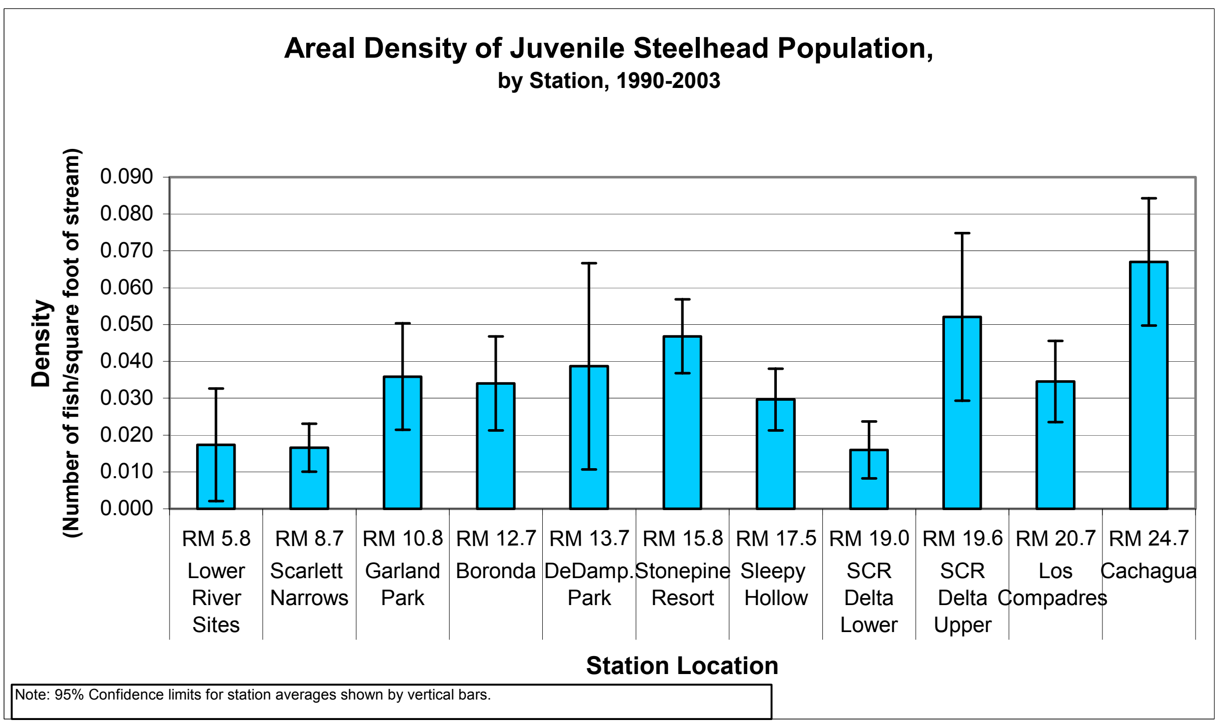




Rearing Habitat Area (upper chart), Rearing Habitat Index Units (middle chart), and Potential Rearing Capacity (lower chart) for young-of-the-year steelhead in the mainstem Carmel River and selected tributaries upstream of Tularcitos Creek (see chart).

Figure 5.5.1.2-C





Average Lineal Density (upper graph) and Areal Density (lower graph) of the juvenile steelhead population in monitoring stations on the Carmel River between Los Padres Dam and the annual wetted front of the lower river. Note: Based on surveys completed in October 1990-2003 and on repetitive 3-pass removal method using an electrofisher. Not all stations were sampled each year. See Tables 5.5.1.2-J and 5.5.1.2-K for detailed accounting of sampled stations and annual data.

Table 5.5.1.2-B Estimates of the linear extent of rearing habitat in the Carmel River Basin.

PORTION OF BASIN, - Stream	Length Accessible to Adult Steelhead [2]		Length w/Flow Suitable for Rearing[1]	
	(ft)	(miles)	(ft)	(miles)
DOWNSTREAM OF SAN CLEMENTE DAM				
- Carmel River mainstem [3]	95,568	18.1	62,832	11.9
-- Lagoon	2,640	0.5	1,320	0.3
-- Robinson Canyon Cr.	5,850	1.1	2,500	0.5
-- Las Gazas Creek [4]	13,150	2.5	6,600	1.3
-- Tularcitos Cr.	22,750	4.3	15,000	2.8
BETWEEN SAN CLEMENTE RES & LOS PADRES DAM				
- Carmel River mainstem	28,550	5.4	28,550	5.4
-- San Clemente Creek	22,200	4.2	22,200	4.2
--- Black Rock Cr.	15,800	3.0	13,800	2.6
-- Pine Creek	29,050	5.5	29,050	5.5
-- Cachagua Creek	25,250	4.8	10,560	2.0
--- Finch Cr.	10,900	2.1	5,000	0.9
--- James Cr.	5,600	1.1	5,600	1.1
UPSTREAM OF LOS PADRES RES.				
- Carmel River mainstem	35,800	6.8	35,800	6.8
-- Miller Fork	31,000	5.9	31,000	5.9
-- Danish Creek	9,000	1.7	9,000	1.7
SUBTOTALS				
- Carmel River mainstem	162,558	30.8	128,502	24.3
-- Primary Tributaries	158,250	30.0	125,910	23.8
--- Secondary Tribs.	32,300	6.1	24,400	4.6
TOTAL IN CARMEL RIVER BASIN	**353,108**	**66.9**	**278,812**	**52.8**

[1] Estimated portion with perennial flows based on field surveys during summers of 1974 & 1975 (CF&G report by Snider,1983); 1982 &1989 (D.W. Kelley & Associates, 1986 and MPWMD Tech Memo 1990-03); and 1994-2003 (MPWMD, files).

[2] Based on field reconnaisssance of migration barriers in mainstem Carmel River and San Clemente Creek (see Table 5.5.1.1, this report).

[3] Annual portion of the mainstem with perennial flow and viable habitat ranges from 10.5 to 12.8 miles, depending on diversions of subsurface streamflow and releases at San Clemente Dam.

[4] Annual portion of Garzas Creek with perennial flow and viable habitat ranges from zero to 2.5 miles, depending in part on natural accretion, releases from Moore's Lake Dam and possibly diversions of subsurface inflow in the Garzas Creek Basin. Releases at the dam are set according to an agreement and protocol between NOAA Fisheries, California Department of Fish and Game, and the Santa Lucia Preserve. The protocol allows for no minimum release of water from the dam when measured surface inflow to the reservoir declines to zero.

Table 5.5.1.2-C

Quantity and quality of juvenile rearing habitat in twelve reaches of the Carmel River upstream of Los Padres Reservoir[1]

STREAM	REACH	REACH LENGTH (ft)	FLOW (cfs)	PORTION MEASURED (ft)	MEASURED SURFACE AREA (sqft)	ESTIMATED TOTAL SURFACE AREA (sqft)	YOUNG-OF-THE-YEAR STEELHEAD: Measured Habitat Area (sqft)	Estimated Total Habitat Area (sqft)	Mean Habitat Quality (0-8)	Rearing Index
Carmel River, Main Fork	Danish Creek to Bluff Camp	8,078	~10	3,009	67,600	181,480	65,365	175,480	4.9	106.9
	Bluff Camp to Bruce Fork	5,174	~10	1,785	40,959	118,724	39,543	114,619	5.1	112.0
	Bruce Fork to Trib. u.s. of Sulphur Sprgs	3,960	~7	1,828	41,288	89,442	38,315	83,002	5.1	107.3
	Trib u.s. of Sulphur Sprgs. to trib. d.s. of Buckskin Camp	6,178	~6	2,733	56,575	127,889	56,175	126,985	4.5	93.0
	Tributary d.s. of Buckskin Camp to rb trib. u.s. of Buckskin Camp	4,541	~5	1,811	41,506	104,074	39,672	99,476	5.8	126.1
	Right bank trib u.s. of Buckskin Camp to trib d.s. BM1743	4,752	~4	3,234	68,293	100,349	67,525	99,220	5.2	109.4
	Trib d.s. BM 1743 to Barrier u.s. Ventana Mesa Creek	4,171	~4	489	8,621	73,534	8,148	69,500	5.4	90.5
	SUBTOTALS	36,854		14,889	324,842	795,492	314,743	768,281		
Miller Fork	Confluence with Carmel River to meadow ~1 mi upstream	5,280	~2-3	1,117	14,773	69,831	13,705	64,783	4.1	50.8
	Meadow to Clover Basin Camp	5,544		1,908	20,824	60,507	19,368	56,277	4.4	44.7
	Clover Basin Camp to Miller Cyn Camp	3,168	~2-3	1,503	20,098	42,362	20,063	42,288	6.2	82.4
	Miller Canyon Camp to barrier d.s. China Camp	16,104	~1	1,201	12,585	168,750	12,151	162,931	5.4	54.2
	SUBTOTALS	30,096		5,729	68,280	341,451	65,287	326,279		
Danish Creek	Confluence with Carmel River to u.s. barrier	8,976	~2	2,442	30,010	110,307	29,275	107,605	4.7	57.0
	OVERALL TOTALS	75,926		23,060	423,132	1,247,250	409,305	1,202,166		

[1] Source: Dettman, D. H. 1990. The Quantity of Steelhead Rearing Habitat Inundated or Blocked by Alternative Water Supply Projects in the Carmel River Basin. Technical Memorandun Disitrict. 21 pp. Based on measurements of rearing habitat using method developed by Dettman and Kelley (1986) in twelve stations upstream of Los Padres Reservoir, October 18-26, '

Table 5.5.1.2-D

Quantity and quality of juvenile rearing habitat in four reaches of the Carmel River between San Clemente Reservoir and Los Padres Dam[1]

						YOUNG-OF-THE-YEAR STEELHEAD				YEARLING & OLDER STEELHEAD			
REACH	REACH LENGTH (ft)	FLOW (cfs)	PORTION MEASURED (ft)	MEASURED SURFACE AREA (sqft)	ESTIMATED TOTAL SURFACE AREA (sqft)	Measured Habitat Area (sqft)	Estimated Total Habitat Area (sqft)	Mean Habitat Quality (0-8)	Rearing Index	Measured Habitat Area (sqft)	Estimated Total Habitat Area (sqft)	Mean Habitat Quality (0-8)	Rearing Index
San Clemente Reservoir to Pine Creek	10,600	~5-16	600	17,958	311,902	16,035	276,347	4.5	108.7	12,851	215,260	1.3	27.0
Pine Creek to Syndicate Camp	5,350	~5-16	753	22,640	160,422	19,332	137,759	5.6	108.7	14,835	111,084	1.8	30.6
Syndicate Camp to Cachagua Creek	6,300	~5-16	753	22,640	233,212	19,332	209,369	4.5	108.7	14,835	136,338	1.4	27.8
Cachagua Creek to Los Padres Reservoir	6,300	~5-16	636	18,280	163,273	16,149	139,346	6.7	108.7	14,738	127,871	2.0	38.5
OVERALL TOTALS	28,550		2,742	81,518	868,809	70,848	762,821	5.3	108.7	57,259	590,553	1.6	31.0

[1] Source: Dettman, D. H. 1990. The Quantity of Steelhead Rearing Habitat Inundated or Blocked by Alternative Water Supply Projects in the Carmel River Basin. Technical Memorandum, 90-03. Monterey Peninsula Water Management Distirict. 21 pp. Based on measurements of rearing habitat using method developed by Dettman and Kelley (1986) in 35 stations in the reach between San Clemente Reservoir and Los Padres Dam, April 17 - June 5, 1989.

Table 5.5.1.2-E

REACH	REACH LENGTH (ft)	FLOW (cfs)	PORTION MEASURED (ft)	SURFACE AREA (sqft)	TOTAL SURFACE AREA (sqft)	YOUNG-OF-THE-YEAR STEELHEAD Habitat Area (sqft)	Total Habitat Area (sqft)	Mean Habitat Quality (0-8)	Rearing Index	YEARLING & OLDER STEELHEAD Habitat Area (sqft)	Total Habitat Area (sqft)	Mean Habitat Quality (0-8)	Rearing Index
Narrows to Bedrock	11,128	46	4,606	208,524	503,790	201,664	487,216	4.1	181.4	129,992	314,058	3.8	107.6
Pools u.s. of		40	3,245	165,018	565,892	140,400	481,470	3.7	159.1	77,533	265,882	3.5	83.4
Garland Park		18	3,299	168,185	567,312	160,235	540,496	3.4	168.4	118,256	398,894	2.7	99.7
		8.5	3,589	131,487	407,687	117,026	362,849	2.0	64.6	57,988	179,797	1.3	21.5
Bedrock Pools u.s.	4,122	46	4,361	207,041	195,694	201,119	190,097	6.4	297.1	175,375	165,764	4.2	167.5
of Garland Park		40	4,456	204,799	189,448	194,871	180,264	5.5	242.4	159,869	147,886	4.2	152.0
to Garzas Creek		16	3,859	157,801	168,556	156,426	167,087	3.8	153.1	114,527	122,332	2.5	73.6
		5.6	3,812	139,059	150,368	130,656	141,281	2.3	78.0	95,931	103,732	1.7	42.0
Garzas Creek to	10,380	49	3,058	144,576	490,745	144,156	489,320	5.8	275.0	126,977	431,008	3.7	153.0
Rosies Bridge		38	2,844	145,038	529,358	138,310	504,802	5.3	259.3	117,325	428,211	3.7	151.0
(Esquiline Road)		19	3,011	150,107	517,473	110,181	379,834	3.6	130.8	25,694	88,576	2.8	23.6
		6.6	2,763	90,247	339,039	85,214	320,131	2.1	71.6	64,179	241,107	1.3	32.3
Rosies Bridge to	7,040	53	3,664	148,057	284,476	148,057	284,476	5.1	207.5	142,539	273,874	4.8	186.7
Stonepine Bridge		38	3,512	135,645	271,908	130,937	262,471	4.6	171.8	104,460	209,396	4.1	120.6
(Tularcitos Creek)		18	3,476	122,105	247,301	109,895	222,572	3.2	110.7	57,558	116,573	2.8	46.7
		8.5	3,478	112,378	227,470	91,304	184,813	2.8	73.6	51,837	104,926	2.3	34.0
Stonepine Bridge to	14,940	53	3,153	115,061	545,199	109,042	516,679	5.2	178.2	91,440	433,274	4.7	153.8
San Clemente Dam		38	2,214	65,376	441,155	65,376	441,155	5.9	174.1	82,687	557,969	5.3	155.7
		18.5	2,942	86,251	437,998	57,059	289,756	3.5	67.8	39,362	199,887	2.5	35.3
		5.6	2,933	67,004	341,302	66,154	336,973	2.5	55.8	55,909	284,787	0.8	15.9
Schulte Bridge to the Narrows [2]	15,300	*~3.5*			*220,000*		*206,000*	*0.9*	*40*		*124,000*	*0.6*	*20*
1982 TOTALS	47,610	49			2,019,904		1,967,787		214.7		1,617,978		148.9
		39			1,997,762		1,870,163		194.7		1,609,345		132.3
		18			1,938,640		1,599,744		118.8		926,264		52.8
		7			1,465,865		1,346,047		65.9		914,349		25.7
EXISTING TOTALS	62,910	*~3.5-7*			1,685,865		1,552,047		59.6		1,038,349		24.3

[1] Source: Dettman and Kelley (1986), Table IV-11, pp 72-73. Based on measurements of rearing habitat using method developed by Dettman and Kelley (1986) in five stations in the reach between the Narrows and San Clemente Dam, June 15 - July 30, 1982. Measurements in 1982 did not include habitats downstream of the Narrows.

[2] For reach from Schulte Bridge to Narrows, habitat area, habitat quality, and rearing indexes for young-of-the-year and yearlings based on values for reach from the Narrows to Bedrock Pools upstream of Garland Park, projected to lower flow of ~3.5 cfs.

Table 5.5.1.2-F

Summary of estimated total habitat area and rearing index units for young-of-the-year and yearling steelhead and capacity to rear young-of-the-year steelhead in the Carmel River upstream of Schulte Road Bridge and in selected tributaries upstream of Tularcitos Creek [1]

				YOUNG-OF-THE-YEAR STEELHEAD				YEARLING AND OLDER STEELHEAD			
STREAM & REACH [2]	REACH LENGTH		TOTAL SURFACE AREA	Total Habitat Area	Total Rearing Index Units	Projected Populaton Density	Potential Rearing Capacity	Total Habitat Area	Total Rearing Index Units	Projected Populaton Density	Potential Rearing Capacity
	(ft)	(mi)	(ft)	(sqft)	(RI units)	(no/ft)	(nos.)	(sqft)	(RI units)	(no/ft)	(nos.)
CARMEL RIVER DOWNSTREAM OF SAN CLEMENTE DAM	56,550	10.7	1,461,147	1,339,860	3,288,080	1.06	60,171	878,540	1,319,130	NA	NA
CARMEL RIVER SAN CLEMENTE TO LOS PADRES DAM	28,550	5.4	868,809	762,821	3,204,260	1.82	51,997	590,553	867,600	NA	NA
CARMEL RIVER UPSTREAM OF LOS PADRES DAM	35,900	6.8	775,104	748,391	3,817,320	1.74	62,417	611,067	2,512,140	NA	NA
MILLER FORK BASIN	31,050	5.9	350,261	334,631	1,691,145	1.01	31,439	240,242	953,570	NA	NA
DANISH CREEK	9,000	1.7	110,602	107,893	513,000	1.05	9,432	86,314	304,200	NA	NA
CACHAGUA CREEK BASIN	27,060	5.1	162,871	109,605	217,551	0.36	9,811	42,056	33,843	NA	NA
SAN CLEMENTE CREEK BASIN	38,000	7.2	361,098	203,600	760,495	0.53	20,147	138,365	167,030	NA	NA
TOTAL CARMEL RIVER BASIN	226,110	43	4,089,892	3,606,801	13,491,851		245,413	2,587,137	6,157,513		

[1] Table 5.5.1.2-F provides summary of totals in major reaches of the mainstem and in selected tributaries. See **Appendix 5.5.1.2-D** for a detailed accounting of habitat quality and quantity, rearing indexes and capacity to rear young-of-the-year in specific reaches of each stream.

[2] Table does not include assessment of juvenile rearing habitats or potential rearing capacity for young-of-the-year in Pine Creek, Tularcitos Creek Hitchcock Canyon, Garzas Creek or Potrero Creek. Habitats in Pine and Garzas creeks are similar to San Clemente Creek and habitat in Tularcitos Creek is similar to Cachagua Creek. Habitat quality and quantity is severely constrained in Tularcitos and Garzas Creeks by lack of surface flow during summer months. Pine Creek is relatively pristine in character with only minor diversions of surface flow and few landform disturbances.

Table 5.5.1.2-G

TABLE 9. Juvenile Steelhead and Resident Rainbow Trout Population Estimate in the Carmel River Basin, 1973 and 1974.

Study area	Year	No./mile	No./acre	Total/study area
1. Danish Creek[1/]	1973	2,323	4,840	1.742
	1974	1,637	3,411	1,228
	Mean	1,980	4,136	1,485
2. Carmel River, upstream of Los Padres Dam[1/]	1973	1,475	1,175	20,650
	1974	1,267	1,010	17,738
	Mean	1,371	1,092	19,194
3. Cachauga Creek	1973	Not sampled		
	1974	2,165	3,579	4,330
4. Pine Creek	1973	6,389	8,785	35,140
	1974	4,013	5,518	22,072
	Mean	5,201	7,152	28,606
5. San Clemente Creek	1973	2,633	4,340	11,849
	1974	1,531	2,524	6,890
	Mean	2,082	3,432	9,370
6. Carmel River, between San Clemente and Los Padres dams	1973	6,072	2,003	33,396
	1974	3,590	1,184	19,745
	Mean	4,831	1,594	26,571
Carmel River, downstream of San Clemente Dam				
7. Flowing section	1973	6,336	2,613	7,920
	1974	3,904	1,610	4,880
	Mean	5,120	2,112	6,400
8. Non-flowing section	1973	211	70	158
	1974	581	192	436
	Mean	396	131	297
Entire River	1973	---	----	110,855
	1974	---	----	78,319
	Mean	---	----	94,587

[1/] Rainbow trout found upstream of Los Padres Dam were not considered anadromous.

Source: Snider (1983), page25. See Appendix 5.5.1.2-B, this report.

Table 5.5.1.2-H

TABLE 10. Juvenile Steelhead and Resident Rainbow Trout Age Class Distribution in the Carmel River Basin, 1973 and 1974.

Study area	Year	Age 0+ No.	Age 0+ %	Age 1+ and older No.	Age 1+ and older %
1. Danish Creek 1/	1973	1,724	99	18	1
	1974	1,216	99	12	1
	Mean	1,470	99	15	1
2. Carmel River upstream of Los Padres Dam 1/	1973	17,965	87	2,685	13
	1974	15,077	85	2,661	15
	Mean	16,506	86	2,688	14
3. Pine Creek	1973	34,086	97	1,054	3
	1974	19,644	89	3,428	11
	Mean	26,865	93	1,741	7
4. Cachauga Creek	1973		Not sampled		
	1974	4,287	99	43	1
5. San Clemente Creek	1973	11,731	99	118	1
	1974	6,821	94	69	6
	Mean	9,276	96	94	4
6. Carmel River, between San Clemente and Los Padres dams	1973	33,129	99	267	1
	1974	18,560	92	1,185	8
	Mean	25,845	96	727	4
Carmel River, downstream of San Clemente Dam					
7. Flowing section	1973	7,841	99	79	1
	1974	4,490	92	390	8
	Mean	6,166	96	235	4
8. Non-flowing Section	1973	119	75	39	25
	1974	144	33	292	67
	Mean	132	54	166	46
All areas	1973	106,595	96	4,260	4
	1974	70,239	90	8,080	10
	Mean	88,417	93.5	6,170	6.5

1/ Rainbow trout found upstream of Los Padres Dam were not considered anadromous.

Source: Snider (1983), page 26. See Appendix 5.5.1.2-B, this report.

Table 5.5.1.2-I

	Lineal Density			Carmel River - Areal Density		North Coast Streams - Areal Density
Year	(no/mi)	(no/100ft)	(no/meter)	(no/sqft)	(no/sqm)	(no/sqm)
1973	6,121	116.4	0.355	0.0486	0.523	
1974	3,648	69.4	0.212	0.0290	0.312	
1983	6,116	116.3	0.355	0.0468	0.503	0.430
1984						0.800
1985	4,966	94.4	0.288	0.0544	0.585	0.550
1986	9,307	177.0	0.540	0.1037	1.116	0.930
1987	5,107	97.1	0.296	0.0492	0.529	0.840
1988						0.810
1989	22	0.4	0.001		0.000	0.800
1990	733	13.9	0.042	0.0185	0.199	0.690
1991	1,294	24.5	0.075	0.0148	0.159	0.590
1992	3,098	58.7	0.179	0.0313	0.337	0.630
1993	5,075	96.1	0.293	0.0524	0.564	1.110
1994	2,713	51.4	0.157	0.0291	0.313	0.590
1995	5,281	100.0	0.305	0.0529	0.569	
1996	5,890	111.6	0.340			
1997	4,359	82.6	0.252			
1998	3,901	73.9	0.225			
1999	3,403	64.4	0.196			
2000	9,680	183.3	0.559			
2001	3,716	70.4	0.215			
2002	5,734	108.6	0.331			
2003	7,738	146.5	0.447			
Averages:						
1973, 74, 83, 85-86	6,032	115	0.350	0.0565	0.608	0.678
1987,89,90, 91	1,789	34	0.104	0.0339	0.243	0.785
1995-2003			0.319			
1992-2003	5,049	96	0.292	0.0361	0.388	0.730

[1] Source: CDFG file reports, MPWMD files and Cramer, et al. 1995)

Table 5.5.1.2-J

CARMEL RIVER JUVENILE STEELHEAD ANNUAL POPULATION SURVEY [1]

Lineal Population Density at Survey Stations (numbers per foot of stream) [3, 4]

	Lower River Sites	Scarlett Narrows	Garland Park	Boronda	DeDamp. Park	Stonepine Resort	Sleepy Hollow	SCR Delta Lower Station	SCR Delta Upper Station	Los Compadres	Cachagua	**Overall Annual Average**		**Average [2] 1994-on Comparison**	
YEAR	RM 5.8	RM 8.7	RM 10.8	RM 12.7	RM 13.7	RM 15.8	RM 17.5	RM 19.0	RM 19.6	RM 20.7	RM 24.7	**(nos./ft)**	**(nos./mi)**	**(nos./ft)**	**(nos./mi)**
1990	0	0	0	0	0	0.50	0.27			0.26	0.22	**0.14**	**733**	--	--
1991	0	0	ND	0.12	0	0.74	0.39			0.09	0.62	**0.25**	**1,294**	--	--
1992	ND	ND	0.67	0.36	ND	0.96	0.30			0.40	0.83	**0.59**	**3,098**	--	--
1993	ND	0.62	0.91	0.92	0.82	0.84	0.52			1.22	1.84	**0.96**	**5,075**	**0.96**	**5,075**
1994	ND	0.44	0.23	0.43	0	0.50	0.29			1.51	0.71	**0.51**	**2,713**	**0.51**	**2,713**
1995	0.49	0.65	1.01	1.61	ND	1.42	0.69			0.50	1.63	**1.00**	**5,281**	**1.07**	**5,666**
1996	0.24	1.52	0.82	1.05	2.03	1.22	0.29			0.95	1.92	**1.12**	**5,890**	**1.23**	**6,468**
1997	0.02	0.22	1.02	1.74	1.15	0.5	0.22			1.15	1.41	**0.83**	**4,359**	**0.93**	**4,891**
1998	0.19	0.30	0.67	0.34	1.50	0.27	0.60			0.54	2.24	**0.74**	**3,901**	**0.81**	**4,264**
1999	0.17	0.26	0.50	0.32	0.62	1.67	0.45			0.46	1.35	**0.64**	**3,403**	**0.70**	**3,716**
2000	0.91	1.03	0.64	1.38	5.66	1.71	1.46			1.41	2.3	**1.83**	**9,680**	**1.95**	**10,289**
2001	ND	0.48	0.35	0.63	0.68	1.08	0.32			0.47	1.62	**0.70**	**3,716**	**0.70**	**3,716**
2002	ND	0.68	0.85	1.67	0.83	1.07	0.5	0.33	0.68	1.52	2.73	**1.09**	**5,734**	**1.09**	**5,734**
2003	1.53	0.82	2.16	1.86	1.45	1.55	1.23	0.58	1.09	1.69	2.16	**1.47**	**7,738**	**1.46**	**7,704**
Station Ave (no./ft)	**0.39**	**0.54**	**0.76**	**0.89**	**1.23**	**1.00**	**0.54**	**0.46**	**0.89**	**0.87**	**1.54**	**0.85**	**4,472**	**1.04**	**5,476**
Station Ave (no./mile)	**2,083**	**2,852**	**3,992**	**4,688**	**6,486**	**5,291**	**2,840**	**2,402**	**4,673**	**4,590**	**8,139**				
Overall Station Averages:												**0.83**	**4,367**		

[1] Surveys completed in October and results based on repetitive 3-pass removal method using an electrofisher.

[2] Average 1994-on comparison does not include data for lowest river sites at Meadows Road (1995); Schulte Area (1996), and Red Rock Area (1997-2003).

[3] RM; indicates miles from rivermouth

[4] Data listed as single digit 0; indicates stream was dry at sampling station

Table 5.5.1.2-K

CARMEL RIVER JUVENILE STEELHEAD ANNUAL POPULATION SURVEY [1]

	Areal Population Density at Survey Stations (numbers per foot of stream) [3,4]														
	Lower River Sites	Scarlett Narrows	Garland Park	Boronda	DeDamp. Park	Stonepine Resort	Sleepy Hollow	SCR Delta Lower Station	SCR Delta Upper Station	Los Compadres	Cachagua	**Overall Annual Average [5]**		**Average [2] 1994-on Comparison**	
YEAR	RM 5.8	RM 8.7	RM 10.8	RM 12.7	RM 13.7	RM 15.8	RM 17.5	RM 19.0	RM 19.6	RM 20.7	RM 24.7	**(nos./ft^2)**	**(nos./m^2)**	**(nos./ft^2)**	**(nos./m^2)**
1990	0	0	0	0	0	0.022	0.015			0.009	0.003	**0.005**	**0.059**	--	--
1991	0	0	ND	0.007	0	0.044	0.030			0.003	0.031	**0.014**	**0.155**	--	--
1992	ND	ND	0.041	0.023	ND	0.056	0.023			0.017	0.044	**0.034**	**0.366**	--	--
1993	ND	0.021	0.064	0.055	0.034	0.055	0.038			0.048	0.087	**0.050**	**0.540**	**0.050**	**0.165**
1994	ND	0.017	0.014	0.026	0	0.031	0.023			0.061	0.033	**0.025**	**0.274**	**0.025**	**0.084**
1995	0.030	0.019	0.058	0.069	ND	0.080	0.054			0.024	0.067	**0.050**	**0.539**	**0.053**	**0.174**
1996	0.008	0.044	0.035	0.025	0.065	0.054	0.024			0.041	0.064	**0.040**	**0.430**	**0.044**	**0.144**
1997	0.001	0.006	0.048	0.054	0.005	0.032	0.018			0.053	0.069	**0.031**	**0.338**	**0.035**	**0.116**
1998	0.004	0.011	0.019	0.010	0.037	0.009	0.021			0.019	0.088	**0.024**	**0.260**	**0.027**	**0.087**
1999	0.010	0.012	0.018	0.012	0.020	0.069	0.019			0.018	0.058	**0.026**	**0.282**	**0.028**	**0.092**
2000	0.033	0.031	0.021	0.035	0.178	0.061	0.058			0.053	0.101	**0.063**	**0.682**	**0.067**	**0.220**
2001	ND	0.014	0.014	0.024	0.025	0.040	0.013			0.018	0.068	**0.027**	**0.290**	**0.027**	**0.088**
2002	ND	0.020	0.036	0.072	0.038	0.045	0.022	0.012	0.041	0.057	0.131	**0.047**	**0.508**	**0.047**	**0.155**
2003	0.070	0.022	0.099	0.065	0.063	0.058	0.059	0.020	0.064	0.063	0.096	**0.062**	**0.664**	**0.061**	**0.200**
Station Ave (nos./ft^2)	**0.017**	**0.017**	**0.036**	**0.034**	**0.039**	**0.047**	**0.030**	**0.016**	**0.052**	**0.035**	**0.067**	**0.036**	**0.385**	**0.042**	**0.139**
Station Ave (nos./m^2)	**0.187**	**0.178**	**0.386**	**0.366**	**0.416**	**0.504**	**0.319**	**0.172**	**0.561**	**0.372**	**0.721**				
Overall Station Averages:												**0.035**	**0.380**		

[1] Surveys completed in October and results based on repetitive 3-pass removal method using an electrofisher.

[2] Average 1994-on comparison does not include data for lowest river sites at Meadows Road (1995); Schulte Area (1996), and Red Rock Area (1997-2003).

[3] RM; indicates miles from rivermouth

[4] Data listed as single digit 0; indicates stream was dry at sampling station

[5] Station and annual averages converted to numbers per square meter by applying conversion factor 10.764 square feet per square meter.

Table 5.5.1.2-L

Estimated Carrying Capacity for Young-of-the-Year Steelhead in the mainstem of the Carmel River

STREAM	REACH	REACH LENGTH (ft)	(mi)	Total Habitat Area (sqft)	Juvenile Population Density: Lineal (no/ft)	Aerial (no/ft2)	Estimated Carrying Capacity, based on: Lineal Density (nos.)	Aerial Density (nos.)
CARMEL RIVER	Schulte Bridge to the Narrows	15,300	2.9	206,000	0.39	0.017	5,967	3,502
	The Narrows to Bedrock Pools u.s. of Garland Park	11,650	2.2	362,849	0.54	0.017	6,291	6,168
	Bedrock Pools u.s. of Garland Park to Garzas Creek	4,100	0.8	141,281	0.83	0.035	3,383	4,945
	Garzas Creek to Rosies' Bridge (Esquiline Road) [1]	3,500	0.7	107,944	1.06	0.037	3,710	3,940
	Rosies' Bridge to Stonepine Bridge (Tularcitos Creek)	7,050	1.3	184,813	1.00	0.047	7,050	8,686
	Tularcitos Creek to San Clemente Dam	14,950	2.8	336,973	0.54	0.030	8,073	10,109
	Subtotal DOWNSTREAM OF SAN CLEMENTE DAM [2]	56,550	10.7	1,339,860			34,474	37,351
	San Clemente Res. to Pine Creek	10,600	2.0	276,347	0.87	0.035	9,222	9,672
	Pine Creek to Syndicate Camp	5,350	1.0	137,759	0.87	0.035	4,655	4,822
	Syndicate Camp to Cachagua Creek	6,300	1.2	209,369	1.21	0.051	7,592	10,678
	Cachagua Creek to Los Padres Dam	6,300	1.2	139,346	1.54	0.067	9,702	9,336
	Subtotal SAN CLEMENTE TO LOS PADRES DAM [2]	28,550	5.4	762,821			31,170	34,508
	Danish Creek to Bluff Camp	7,200	1.4	156,407	0.80	0.028	5,782	4,364
	Bluff Camp to Bruce Fork	5,900	1.1	130,702	0.75	0.032	4,407	4,169
	Bruce Fk to trib. above Sulphur Sprgs.	3,850	0.7	80,696	0.69	0.036	2,660	2,897
	Trib. above Sulphur Spr to trib below Buckskin Camp	5,650	1.1	116,132	0.53	0.023	3,017	2,717
	Trib. below Buckskin Camp to rightbank trib. above Buckskin	4,350	0.8	95,292	0.54	0.021	2,349	2,039
	Rightbank trib above Buckskin Camp to trib below Benchmark 1743	4,750	0.9	99,179	0.76	0.049	3,591	4,810
	Tributary below Benchmark 1743 to Barrier above Ventana Mesa Creek	4,200	0.8	69,983	0.46	0.022	1,915	1,554
	Subtotal UPSTREAM OF LOS PADRES DAM [3]	35,900	6.8	748,391			23,722	22,551
	TOTAL IN MAINSTEM OF CARMEL RIVER						89,365	94,409

[1] Estimates habitat length and area excludes portion of reach which normally drys up by the end of summer.

[2] Estimated densities downstream of Los Padres Dam based on average density in sampling stations, 1990-2003. (See Table 5.5.1.2-I and 5.5.1.2-J)

[3] Estimated densities upstream of Los Padres Dam from Dettman and Kelley (1986), Table IV-3, page 52, based on 1982 samples

5.5.1.3 POPULATION COUNTS OF ADULT STEELHEAD AT LOS PADRES AND SAN CLEMENTE DAMS

Old Carmel Dam – Upstream migrating adult steelhead must pass into and through the Carmel Lagoon and move approximately 18.3 miles to reach the first of three dams on the Carmel River. Old Carmel Dam, built in 1881-1883 was originally fitted with a fish ladder to provide fish passage. No records exist of fish passing this dam, which served as a water supply for the Pacific Improvement Company holdings in Carmel and Monterey until 1920.

San Clemente Dam – On reaching San Clemente Dam, adult upstream migrants must climb a 65½-foot high ladder and pass through the existing San Clemente Reservoir. San Clemente Dam, built in 1920 by the Del Monte Properties Company (DMPC), originally served as the primary storage and diversion facility for water supplied to the Monterey Peninsula area by DMPC and its successor California-American Water Company. The original plans for San Clemente Dam show the ladder much as it exists today, except that the original design included a series of screened water outlets on the three uppermost bays. A few modifications to the fish ladder have been made over the years, including extension of the lowermost bay to counteract the down-cutting of coarse sediment and water surface below the dam, the addition of submerged orifices at the top of the ladder to help control flow through the ladder, and the addition of an automatic fish counter in 1992 to record the total number of steelhead passing the dam.

The first systematic counts of adult steelhead in the Carmel River are reported to have begun in 1962 at San Clemente Dam by personnel from California-American Water Company's predecessor California Telephone and Telegraph Company. Prior to that time, isolated counts of migrating fish were made, but no records exist, except for a report of the first attempted count by the California Department of Fish and Game personnel in 1954. As reported, a trap was operated during the period from February 23 to March 12 with a total count of 162 fish. Additional isolated counts of fish may have been made at San Clemente Dam, but several searches of Cal-Am archives and CDFG records have failed to turn up any additional information. Cal-Am made daily counts at SCD for the 1962 to 1973 period by turning off the ladder flow twice each day and tallying up fish visible in the ladder. Counts made in this fashion are a good annual index of the abundance of fish that historically migrated past San Clemente Dam, but do not represent a true measure of the total number of steelhead passing the dam. In 1974 and 1975 the California Department of Fish and Game Cal-Am installed an automated counter that recorded the total number of migrants. No counts were made during the 1976-1989 period, except for a special 1984 study commissioned by the MPWMD, which included counting fish passing the dam, as well as numbers of fish caught in the river downstream of San Clemente Dam. Beginning in 1990, the MPWMD reinitiated the visual counts at San Clemente Dam, and in 1992 constructed an automated counter, which has been in continuous operation since that time. Typically, the counter is installed in November of each migration season, prior arrival of adults from the ocean, and operates through the following May 31 of each migration season.

<u>Monthly Counts</u> – A summary of monthly and annual counts at San Clemente Dam is provided in the **Table 5.5.1.3-A** and **Figure 5.5.1.3-A**, respectively.

Daily Counts – Detailed daily counts from the MPWMD fish counter are provided in **Appendix 5.5.1.3**, in tabular and graphical form. The data includes daily flow estimates at the MPWMD Sleepy Hollow Weir gaging station below the dam, or at the San Clemente Dam spillway.

Los Padres Dam – Los Padres Dam, built in 1949, is 148 feet high and originally held 3,030 AF. Since that time, approximately ½ of the original capacity has been lost to sedimentation with the current capacity at 1, 569 AF.

When it was built, the dam had no fish passage facilities, except for a trap located at the base of the dam. Data from the early trapping program, prior to 1982 are sketchy, at best, with records available for isolated years. A summary of the annual counts is provided in **Table 5.5.1.3-A** and **Figure 5.5.1.3-B**. The original trapping station below Los Padres Dam was replaced in 1981, and the replacement was operated for the next 18 years, until 2000, when a new trap was constructed along the left bank of the plunge pool below the dam. Since 2000, Cal-Am has operated both traps below the dam. Daily trapping records at Los Padres Dam are provided in **Appendix 5.5.1.3** with 1995-1999 counts in Adobe Portable Document Format (*.pdf), and the last five years (2000-2004) in EXCEL spreadsheet format (*.xls).

Table 5.5.1.3-A

Historical counts of adult steelhead migrating past San Clemente Dam and of steelhead trapped and passed over Los Padres Dam, 1949-04

YEAR	NOV	DEC	JAN	FEB	MAR	APR	MAY	TOTAL	Method [1]	LOS PADRES (Annual)
	MONTHLY COUNTS AT SAN CLEMENTE DAM [4]									
1949				no data available						147
1950				"						124
1951				"						154
1952				"						86
1953				"						
1954				"				162 [3]		
1955				"						
1956				"						
1957				"						
1958				"						
1959				"						
1960				"						
1961				"						
1962				"				568	VC	558
1963				"				255	VC	8
1964		0	113	118	327	201		759	VC	
1965		203	814	152	181	0		1,350	VC	257
1966		76	319	451	69	0		915	VC	
1967		0	546	275	493	0		1,314	VC	
1968		0	0	153	93	0		246	VC	
1969		0	205	818	313	0		1,336	VC	
1970		0	206	51	105	0		362	VC	
1971		0	244	168	265	92		769	VC	6
1972		0	0	77	17	0		94	VC	0
1973		0	390	444	188	0		1,022	VC	2
1974		16	69	39	224	47		395	AC	3
1975		0	0	285	1,002	0		1,287	AC	9
1976		0	0	0	0	0		0	VC [2]	0
1977		0	0	0	0	0		0	VC	0
1978										
1979										
1980										
1981										
1982				no data available						138
1983				no data available						171
1984		1	3	24	289	63		380	AC	51
1985				no data available						27
1986				no data available						42
1987				no data available						
1988		0	0	0	0	0	0	0		0
1989		0	0	0	0	0	0	0		0
1990		0	0	0	0	0	0	0		0
1991		0	0	0	1	0	0	1	VC	0
1992		0	0	3	12	0		15	VC	5
1993		0	132	73	65	13		283	VC	26
1994		0	0	37	49	5		91	AC	4
1995		0	39	191	76	4		310	AC	30
1996		8	46	107	188	78	11	438	AC	93
1997	5	61	118	154	340	86	11	775	AC	227
1998	0	1	44	111	568	129	8	861	AC	122
1999	0	2	13	126	218	46	0	405	AC	120
2000	0	0	34	176	198	59	5	472	AC	204
2001	0	2	39	231	433	95	4	804	AC	347
2002	2	21	24	232	298	60	5	642	AC	284
2003	8	17	90	141	194	30	3	483	AC	105
2004			14	197	163	12	2	388	AC	111
Averages:										
1962-75		13	109	151	199	32	4	505	33	96
1997-04		30	279	263	195	14		780	13	190
1949-90		15	47	171	302	65	5	604	7	81

[1] Counting Method: VC, visual count; AC, automatic counter.

[2] Total counts in 1976, 1977, 1988, 1989 and 1990 assumed to be zero for sea-run fish, as no outflow from the lagoon occurred during these years, however a small number of resident-type fish may have migrated upstream past San Clemente Dam.

[3] In 1954, count at San Clemente Dam reported for 3-week long period, Feb 23 to March 12, 1954

[4] Based on Snider (1983), Dettman (1986), Alley (1994), and California Department of Fish and Game, California-American Water Company, and Monterey Peninsula Water Management District files. The 1962-73 and 1991-93 counts at San Clemente Dam are the sum of daily counts of fish made by shutting off the flow in the ladder. The 1974, 1975, 1984, and 1994-04 data are complete counts registered on an automatic counter as the fish climbed the ladder.

[5] The counts at Los Padres Dam for the 1995-2004 period exclude small, resident type steelhead, which migrated upstream after maturing in freshwater.

Figure 5.5.1.3-A

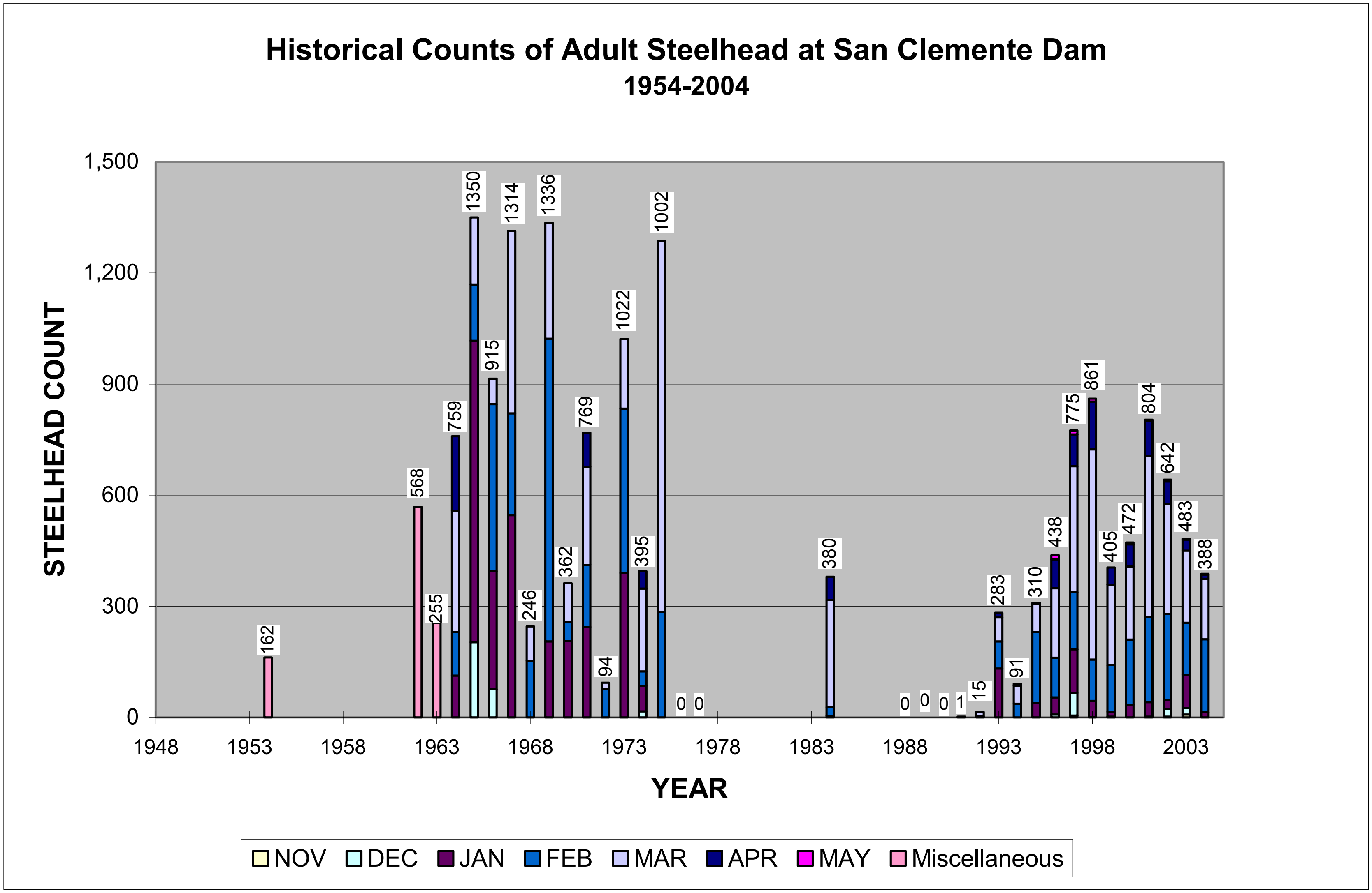
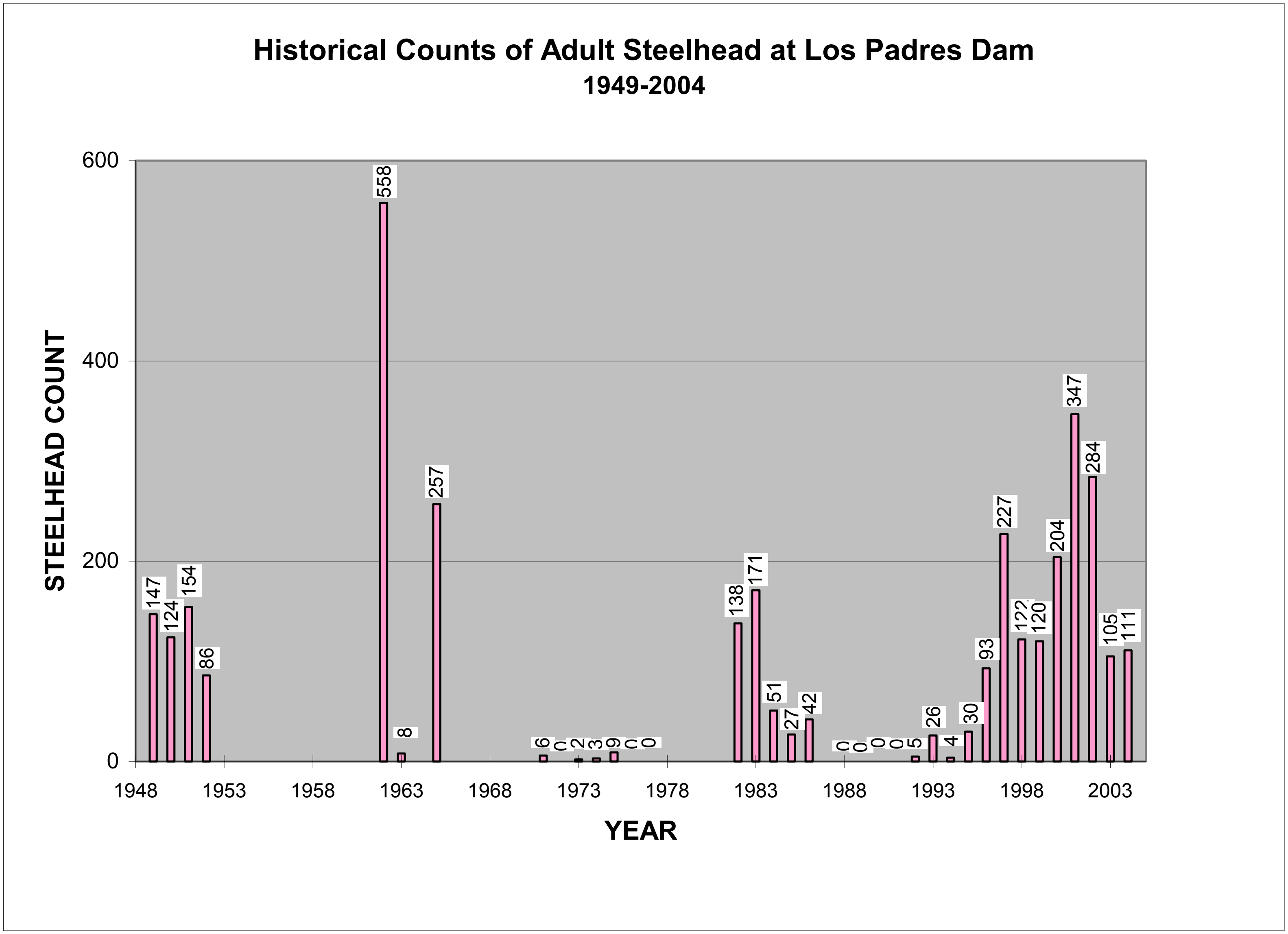


Figure 5.5.1.3-B



5.5.1.4 TREND ANALYSIS FOR JUVENILE AND ADULT STEELHEAD

In their Steelhead Restoration and Management Plan, the California Department of Fish and Game (CDFG) noted the precipitous decline of steelhead populations in most of the coastal streams south of San Francisco Bay.[1] They highlighted the population in the Carmel River as, *"a good example of how fast an anadromous fish population can decline to the point of near extinction"* and attributed population declines throughout the region to *"urbanization and other watershed disturbances, blocked access to headwater spawning and rearing areas, and partial and total dewatering of streams by water diversions and groundwater pumping."*

Past reviews of environmental problems in the Carmel River have led to a general understanding of the principal factors associated with the historical population decline[2] including: 1) Inadequate passage facilities for adults and juveniles at Los Padres Dam; 2) Diversion of surface flows at San Clemente Dam; 3) Subsurface diversion of streamflow which percolates into the Carmel River Aquifer between San Clemente Dam and the Lagoon; 4) Reduction in the number of trees and canopy of the riparian forest downstream of Robles del Rio; 5) Increased erosion of sand and gravel from denuded riverbanks by winter flows; 6) The interruption of streamflow at San Clemente Dam and temporary or seasonally complete blockage of smolt migration past San Clemente Dam in some years when flashboards are raised in the spring; and 7) Deposition of sand in the Lagoon which reduces habitat in it for adults during the winter, for smolts during the spring, and for juveniles during the summer and fall months. Since these reviews, significant progress has been made on correcting many of these problems, but the major problems caused by excessive subsurface diversions of streamflow remain. The purpose of the following sections is to provide a time-series analysis of whether the steelhead population in the Carmel River is recovering from the effects of the 1987-1992 drought and to what extent. This assessment is based on a review of data from historical populations surveys of juvenile steelhead by CDFG and MPWMD, comparisons of the juvenile population to other local and regional streams and on counts of adult steelhead at Los Padres Dam and San Clemente Dam by Cal-Am and MPWMD.

Historical Juvenile Population – As presented in section 5.5.1.2, the CDFG surveyed juvenile steelhead in the reach downstream of Los Padres Dam in 1973 and 1974, and in the reach below San Clemente Dam in 1983 and 1985-87.[3] Lineal population density for the period prior to the 1987-1991 drought averaged 5,878 fish per mile (fpm) and ranged from a low of 3,648 fpm in 1974 to 9,307 fpm in 1986. Population density declined during the drought years of 1987-1991, averaging 683 fpm and dropping to a low of 22 fpm in 1989 (**Table 5.5.1.4-A**). The low population density was indicative of insufficient spawning adults and of juveniles that were trapped in small freshwater refuges during the drought years. Based on captures of resident-type steelhead and observations of fry during the drought, it appears that some of the trapped fish matured in freshwater and spawned without emigrating to the ocean. Others of the trapped fish waited until 1992 to emigrate to the ocean. Following the drought, the juvenile population increased rapidly for the first seven years, averaging 5,890 fish per mile by 1996, but then

[1] McEwan, D. and T. A. Jackson. 1996. Steelhead Restoration and Management Plan for California. Calif. Dept. Fish and Game. Inland Fisheries Division, Sacramento, CA. 234 p.
[2] Kelley and Dettman, 1981; Kelley, Dettman, and Turner, 1982; Snider, 1983; and Dettman and Kelley, 1987; Dettman, 1991; Cramer, S. P., et al., 1995; Bryant, G. J. and J. Lynch, 1996.
[3] Snider 1983, and CDFG office files in Monterey, CA.

decreased slightly to about 4,000 fpm. Since the end of the drought population densities have ranged from about 4,000 to 6,000 fpm, except in two years, 2000 and 2003, when population density averaged 9,700 and 7,700 fpm, respectively. (**Figure 5.5.1.4-A**) Based on available data, it appears that the juvenile population rapidly recovered from low numbers extant during the 1987-91 drought, and now is similar to levels that were common in the 1970's and early 1980's.

Comparison of Juvenile Population to Coastwide, Regional and Local Data -- The density of the juvenile population in the Carmel River can be compared to levels in other steelhead streams in California.

Statewide Comparison: In 1996, the Association of California Water Agencies commissioned a review of the status of steelhead stocks in California, as part of a study to develop recommendations for the National Marine Fisheries Service (NOAA Fisheries) regarding the Service's biological assessment and listing of steelhead under the Endangered Species Act (Cramer *et al*., 1995). This review included a compilation of available data on juvenile steelhead population along the coast of California from the Oregon border, south to Ventura County.[4] Prior to 1987, the density of the juvenile population in the Carmel River was similar to northern California streams, but ranged well below the northern levels during the 1987-91 drought (**Figure 5.5.1.4-B)**. Subsequent to the drought years, the population in the Carmel River increased, but still ranges well below the levels in northern California, where numbers remained relatively consistent during the drought years and post-drought years.[5]

Regional Comparison: Trihey and Associates compiled population survey data from Lagunitas Creek in Marin County during the period from 1970 through 1995.[6] Based on a comparison of selected years, when comparable data is available from the Carmel River, it appears population densities in the Carmel River were once about 50 percent higher than in Lagunitas Creek, but this pattern broke down during the 1987-91 drought. Since the end of the drought, no clear relation was evident, but during two out of those years, population density in the Carmel River exceeded levels in Lagunitas Creek (**Figure 5.5.1.4-C**).

Local Comparison: More locally, D. W. Alley and Associates (2002, 2004) has surveyed steelhead population densities in the San Lorenzo River and Soquel Creek watersheds since 1994.[7] [8] Population density in the main stem portion of the San Lorenzo River, where the

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[4] Population data from a wide variety of streams should be compared on a unit area basis to compensate for the effect of stream size.

[5] Data for north coast streams based on Cramer, et al. 1995 (1983-1994); and CDFG 2003 (1995-1999) and includes limited data from the Eel River Basin (1983-1992), the Mattole River Basin (1981,1988-1999) and the Gualala River Basin (1994).

[6] Trihey and Associates. 1995. Abundance of Steelhead and Coho Salmon in the Lagunitas Creek Drainage, Marin County, California. Report to the Marin Municipal Water District, 31 pp.

[7] D. W. Alley and Associates. 2004. Comparison of Juvenile Steelhead Densities, 1997- 2001 and 2003, In the Middle and Upper San Lorenzo River and 4 Tributaries, Santa Cruz County, California; With an Estimate of Juvenile Population Size and an Index of Adult Returns. Report Prepared by D.W. ALLEY & Associates, Aquatic Biology For the Following Agencies; San Lorenzo Valley Water District and the County of Santa Cruz.

[8] D. W. Alley and Associates. 2004. Comparison of Juvenile Steelhead Densities, Population Estimates and Habitat Conditions In Soquel Creek, Santa Cruz County, California; 1997-2003; With an Index of Expected Adult Returns. Report Prepared for the Soquel Creek Water District and County of Santa Cruz Planning Department.

stream is similar in size to the Carmel River, averaged 47 fish per 100 feet (fp100f) of stream over the surveyed years and ranged from an average of 19 fp100f in 2000 to 97 fp100f in 1996. Generally, population density in the Carmel River has exceeded levels in the San Lorenzo River, averaging 99 fp100f over the same time period. Interestingly, the annual pattern of high and low averages was similar in the Carmel and San Lorenzo Rivers prior to 2000, but in following years the population density in the Carmel River has increased to range well above population density in the San Lorenzo River (**Figure 5.5.1.4-D**) This may be due to the biological effects of fine-grained sediment in the San Lorenzo Watershed, where the streambed is chronically affected by excessive erosion and deposition of sand and silt. Average population density in Soquel Creek was lower than in the Carmel River, averaging 26 fp100f during the same period. This difference probably results from a larger stream size, higher baseflow and better substrate conditions in the Carmel River. (**Figure 5.5.1.4-D**).

Population Abundance – Estimates of juvenile population density can be expanded to estimate the abundance of juvenile steelhead in specific reaches, represented by the sampling stations. **Table 5.4.1.4-B** is a compilation and expansion of historical population densities into abundance estimates for seven reaches between Los Padres Dam and the downstream edge of viable habitat near the Narrows. Since 1990, overall estimated abundance averaged 70,500 fish and ranged from 16,000 fish in 1991 to 153,000 fish in 2000 and 2003 (**Figure 5.5.1.4-E**). On average, the population in the reach between the dams averaged 28,700 fish, which represents about 41 percent of the total juvenile population below Los Padres Dam. This abundance is similar to the average abundance estimated by CDFG for 1973 and 1974[9], but is a lower percentage of the total population because habitats downstream of San Clemente Dam are currently maintained by release of stored water from Los Padres Dam. [10] Although the estimated abundance of juvenile fish has increased since 1990, two distinct declines are evident from 1996 to 1999 and following 2000. These declines were probably associated with brief periods of poor to fair substrate conditions affected by high sedimentation rates during and following the 1995 and 1998 floods. During these events high concentrations of fine sediment from Cachagua and Tularcitos Creeks were washed downstream of these tributaries along with sediment from main stem bed and bank erosion, thereby reducing the quality of rearing habitats and number of juvenile steelhead reared during the summer and fall months.

Adult Steelhead Returns -- As described in Section 5.5.1.3, MPWMD has tallied adult steelhead returns at San Clemente Dam since 1993 with the aid of a mechanical/electronic fish

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[9] Snider, 1983.

[10] During 1973 and 1974 no streamflow releases were made at San Clemente Dam and habitats below the dam supported only 6,400 juveniles. In contrast, since 1990 the juvenile population below San Clemente Dam has averaged 40,193 fish, or a six-fold increase as compared to 1973 and 1974. The primary factor responsible for this increase has been the restoration of streamflow in the reach upstream of Robinson Canyon. Prior to 1983, no releases were made from San Clemente Dam, but since 1983 the stored water in Los Padres Reservoir has been used to supplement natural runoff during the dry season and to maintain flows below San Clemente Dam. In addition, since 2001, the historical surface diversion from San Clemente Reservoir has been curtailed during the dry season and groundwater pumping from Cal-Am wells in Aquifer Subunits 1, 2 and 3 has been constrained to maximize surface flow in the reach upstream of Robinson Canyon.

counter and tallies prior to 1993 were made visually.[11] At Los Padres Dam, California American Water operates a trap and truck facility to pass adult steelhead over the dam.[12]

San Clemente Dam: Since 1997, the number of adults counted at San Clemente Dam has averaged 604 adults and ranged from a low of 388 fish in 2004 to 861 in 1998, with a clear upward trend during the seven-year immediately following the 1987-1991 drought (**Table 5.5.1.3-A** and **Figure 5.5.1.3-A**). Although the number steadily climbed following this drought, the upward trend appears to have stabilized in the range of 400-800 fish.

During the period from 1962 through 1975, visual counts of adult steelhead at San Clemente Dam averaged 780 fish and ranged from a low of 94 fish in 1972 to 1,350 fish in 1965. While not directly comparable to actual counts from the last reporting period, the index from the 1962 to 1975 period was about 30 percent higher than the average count during the last eight years. Based on this information, it appears recent returns of adults have not reached levels that were common prior to the 1976-77 drought.

No adult sea-run steelhead migrated upstream of the dam during the 1987-90 period and this led to low populations of juvenile fish during 1990 and 1991 (see **Figure 5.5.1.4-A**). In turn, these low juvenile populations produced low numbers of sea-run adults in 1994. The returns following 1994 represented improved production of juvenile steelhead from the 1991 and 1992 broods, good to excellent conditions for survival of smolts in 1993, the positive effect of rescue and transport of almost all smolts in 1994, and production of steelhead smolts from the Carmel River steelhead Association steelhead brood stock program. It is important to note the majority of natural juvenile production from the 1991 and 1992 broods may have been due to stream-maturing steelhead, which were rescued as juveniles from the lower river, transported upstream to permanent habitat and matured without migrating to the ocean.

Los Padres Dam: Historically, the number of adults trapped and transported over the dam averages 96 fish, ranging from zero in several years to 558 in 1962. Since 1997, the number of adults trapped at Los Padres Dam has averaged 190 fish and ranged from 105 fish in 2003 to 347 fish in 2001. (**Table 5.5.1.3-A and Figure 5.5.1.3-B**) The 1997-on average is about twice the average count prior to 1997 and indicates a strong increase in returns to Los Padres Dam. The pattern in **Figure 5.5.1.3-B** indicates that the population upstream of Los Padres Dam has crashed at least twice, once from 1970 to 1977 and again from 1988 to 1994. Each time the population has shown a strong recovery, but the most recent increase may be more robust than the short-lived increase immediately following the 1976-1997 drought.

Watershed Basin Between the Dams: In selected years, the number of adults returning to the watershed between the dams can be estimated by subtracting the number of adults at Los

[11] Prior to 1991, counts of adult steelhead passing the dam are available for 1984 and 1975; since 1963, visual counts of fish in the ladder are available for selected years. These visual counts were made by turning off flow through the ladder and counting adult fish in it. As such, the visual counts are an index of the run, and may be biased due to under- or over-counting. Nonetheless, visual counts are valuable as a relative measure of the run prior to 1975 and the counts in 1975, 1984, and since 1991 provide accurate estimates of the run size, not including fish taken by legal and illegal fishing

[12] Records at Los Padres Dam are available for the years 1949-51, 1962, 1963, 1964, 1975-1978, 1982-86 and 1988-present.

Padres Dam from the number counted at San Clemente Dam. Since 1997, the run of adults in this portion of the watershed averaged 414 fish and ranged from 268 to 739 fish (**Figure 5.5.1.4-F**). Although the estimates are spotty prior to 1991, a comparison of returns before and after 1980 indicates that the adult return to this portion of the basin has not recovered to levels that were common prior to 1980. This is in contrast to the relative pattern for reaches upstream of Los Padres Dam where adult returns have increased.

Overall Assessment of Recovery – Ultimately, the success of efforts to restore the steelhead population will be measured by the abundance and persistence of sea-run adults and by their progeny that live in freshwater as juveniles, prior to seaward migration. Estimates of the capacity of the basin to produce adult steelhead have ranged from 3,500 to 4,200 adults, with habitat similar to conditions in 1975 and 1982.[13] [14] These estimates were made assuming steelhead were provided unhampered access to all available spawning and rearing habitats in the basin, had unrestricted access to the ocean during smolt emigration, and could rear during summer months as far downstream as the Narrows. Establishment of a goal of 3,500 adults is reasonable, if the above assumptions were true. However, the first assumption has not been met for many years due to passage problems at Los Padres Dam, so it is unreasonable to expect that 3,500 adult fish would be produced from the basin in the short term. With impaired passage conditions at Los Padres Dam, a more reasonable expectation is for a total return of 2,600 adults, including: 500 fish upstream of Los Padres Dam; 1,200 fish from the basin between the dams; and 800 fish from habitat between the Narrows and San Clemente Dam. These expectations can be used as a benchmark to gage the effectiveness of restoration efforts and long-term recovery of the resource. Currently, a comparison of the adults counted at San Clemente and Los Padres Dams to this benchmark indicates that the existing adult steelhead population is about one-third of the potential adult production. However, the increasing density and abundance of the juvenile population since 1997, the sharp recovery of the juvenile population since the last drought, and the strength of the juvenile population compared to other coast-wide, regional and local streams indicates that the population is resilient, robust, and recovering.

Although the steelhead population in the Carmel Basin appears to be recovering, a continuing concern remains regarding whether the recovery can persist. Recently, the National Marine Fisheries Service (NOAA Fisheries) assessed and updated the status of listed salmonid species along the western US coast, including the steelhead population in the Carmel River, which is a major portion of the South-Central California ESU.[15] In their assessment of data from the Carmel River they noted a significant positive trend in adult returns over the 1988-2002 period, but opined that the time series was, "too short to infer anything about the underlying dynamical cause of the trend". As discussed in a following section, the persistence of a positive trend most likely depends on the occurrence of flows that are necessary to complete key phases of the steelhead lifecycle, including upstream migration of spawning adults from the ocean and downstream emigration of smolts to the ocean. In turn, the successful completion of these critical life history stages depends largely on the lack of drought periods, especially in the

[13] Snider. W. M. 1983.
[14] Kelley, Dettman, and Rueter. 1987.
[15] National Marine Fisheries Service. Feb 2003. Preliminary conclusions regarding the updated status of listed ESUs of West Coast salmon and steelhead. Draft report prepared by West Coast Salmon Biological Review Team. Northwest Fisheries Science Center and Southwest Fisheries Science Center. 134 pp.

Carmel River where the magnitude of annual water diversions can exceed unimpaired annual runoff. Due to the uncertainty regarding the frequency, magnitude and duration of future droughts, the status of the Carmel River population as well as other streams in the South-Central California ESU continues to be rated at a threatened level, despite the recent positive population trend.

Table 5.5.1.4-A

Density of juvenile steelhead population in the Carmel River, 1973-2003 with a comparison to selected northern California Streams

	Carmel River Lineal Density Indexes [1]			Carmel River Areal Density		North Coast Streams
Year	(no/mi)	(no/100ft)	(no/meter)	(no/sqft)	(no/sqm)	(no/sqm)[2]
1973	6,121	116.4	0.355	0.0486	0.523	
1974	3,648	69.4	0.212	0.0290	0.312	
1983	6,116	116.3	0.355	0.0468	0.503	0.430
1984						0.800
1985	4,966	94.4	0.288	0.0544	0.585	0.550
1986	9,307	177.0	0.540	0.1037	1.116	0.930
1987	5,107	97.1	0.296	0.0492	0.529	0.840
1988						0.810
1989	22	0.4	0.001		0.0003	0.800
1990	733	13.9	0.042	0.005	0.059	0.690
1991	1,294	24.5	0.075	0.014	0.155	0.590
1992	3,098	58.7	0.179	0.034	0.366	0.630
1993	5,075	96.1	0.293	0.050	0.540	1.110
1994	2,713	51.4	0.157	0.025	0.274	0.590
1995	5,281	100.0	0.305	0.050	0.539	0.873
1996	5,890	111.6	0.340	0.040	0.430	1.190
1997	4,359	82.6	0.252	0.031	0.338	0.400
1998	3,901	73.9	0.225	0.024	0.260	0.230
1999	3,403	64.4	0.196	0.026	0.282	0.720
2000	9,680	183.3	0.559	0.063	0.682	
2001	3,716	70.4	0.215	0.027	0.290	
2002	5,734	108.6	0.331	0.047	0.508	
2003	7,738	146.5	0.447	0.062	0.664	
Averages:						
1973, 74, 83, 85-87	5,878	112	0.341	0.0553	0.595	0.710
1989-1991	683	13	0.039	0.0099	0.071	0.693
1992-2003	5,049	96	0.292	0.0401	0.431	0.718

[1] Source: CDFG file reports, Monterey Office and MPWMD files)

[2] Source: 1983-1994 Cramer, et al. 1995; and 1995-1999, CDFG 2003, including limited data from Eel River Basin (1983-1992), Mattole River Basin (1981,1988-1999) and Gualala River Basin (1994).

Table 5.5.1.4-B

Abundance and density indexes of juvenile steelhead population, and length of viable habitat in the mainstem of the Carmel River, between the riverfront and Los Padres Dam, Selected Reaches and Years, 1973 to 2003.

YEAR	PROJECTED ANNUAL TOTAL JUVENILE POPULATION										
	Below San Clemente Dam (Nos.)	San Clemente Reservoir Zone (Nos.)	San Clemente Reservoir to Los Padres Dam (Nos.)	**Overall** (Nos.)	Downstream of San Clemente Dam	San Clemente Reservoir Zone	San Clemente Reservoir to Los Padres Dam	Downstream of San Clemente Dam (Nos./mile)	San Clemente Reservoir Zone (Nos./mile)	San Clemente Reservoir to Los Padres Dam (Nos./mile)	**Overall** (Nos./mile)
1973	8,078		33,396	**41,474**	2.0		5.5	4,039		6,072	5,530
1974	5,316		19,745	**25,061**	2.0		5.5	2,658		3,590	3,342
1983	62,717				9.5			6,595			
1985	15,549				4.2			3,738			
1986	105,913				6.5			16,421			
1987	19,724				4.7			4,215			
1990	9,019		7,254	**16,273**	4.7		5.4	1,927		1,341	1,613
1991	15,295		5,909	**21,204**	8.0		5.4	1,910		1,093	1,580
1992	23,789		14,129	**37,918**	8.0		5.4	2,970		2,613	2,826
1993	43,703		38,737	**82,440**	10.8		5.4	4,043		7,164	5,084
1994	16,177		38,070	**54,248**	8.7		5.4	1,870		7,041	3,859
1995	71,187		21,394	**92,581**	13.8		5.4	5,162		3,957	4,823
1996	58,848		33,234	**92,081**	12.6		5.4	4,659		6,146	5,105
1997	42,134		34,471	**76,605**	11.3		5.4	3,739		6,375	4,593
1998	38,700		26,127	**64,827**	17.5		5.4	2,209		4,832	2,828
1999	38,615		18,740	**57,355**	12.6		5.4	3,057		3,466	3,180
2000	107,173		45,863	**153,036**	13.2		5.4	8,119		8,482	8,225
2001	35,693		20,664	**56,357**	12.8		5.4	2,795		3,822	3,100
2002	52,019	3,161	51,016	**103,035**	11.2	1.4	5.4	4,649	2,274	9,435	6,208
2003	101,980	5,334	51,208	**153,188**	12.6	1.4	5.4	8,113	3,837	9,471	8,521

Figure 5.5.1.4-A

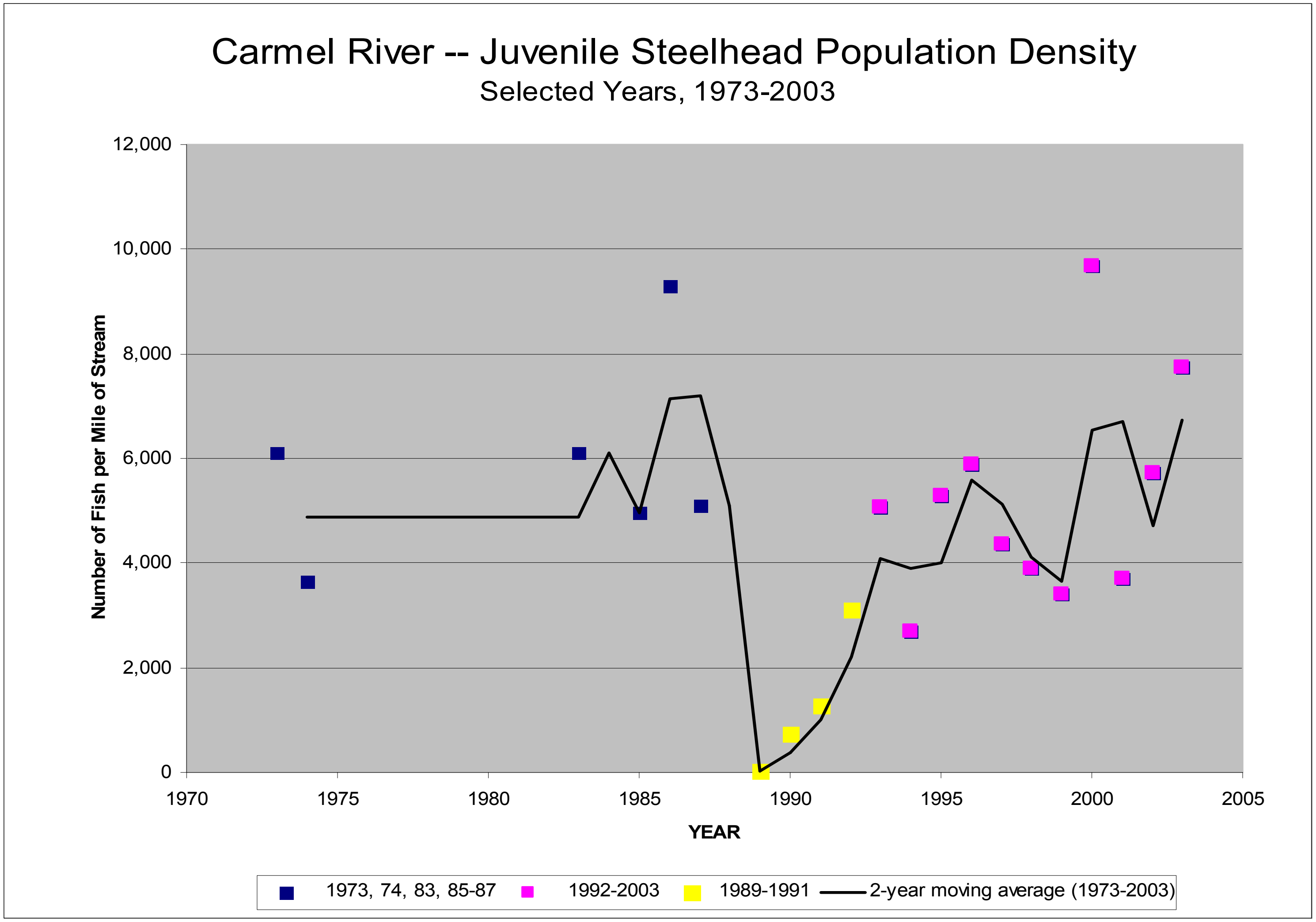


Figure 5.5.1.4-B

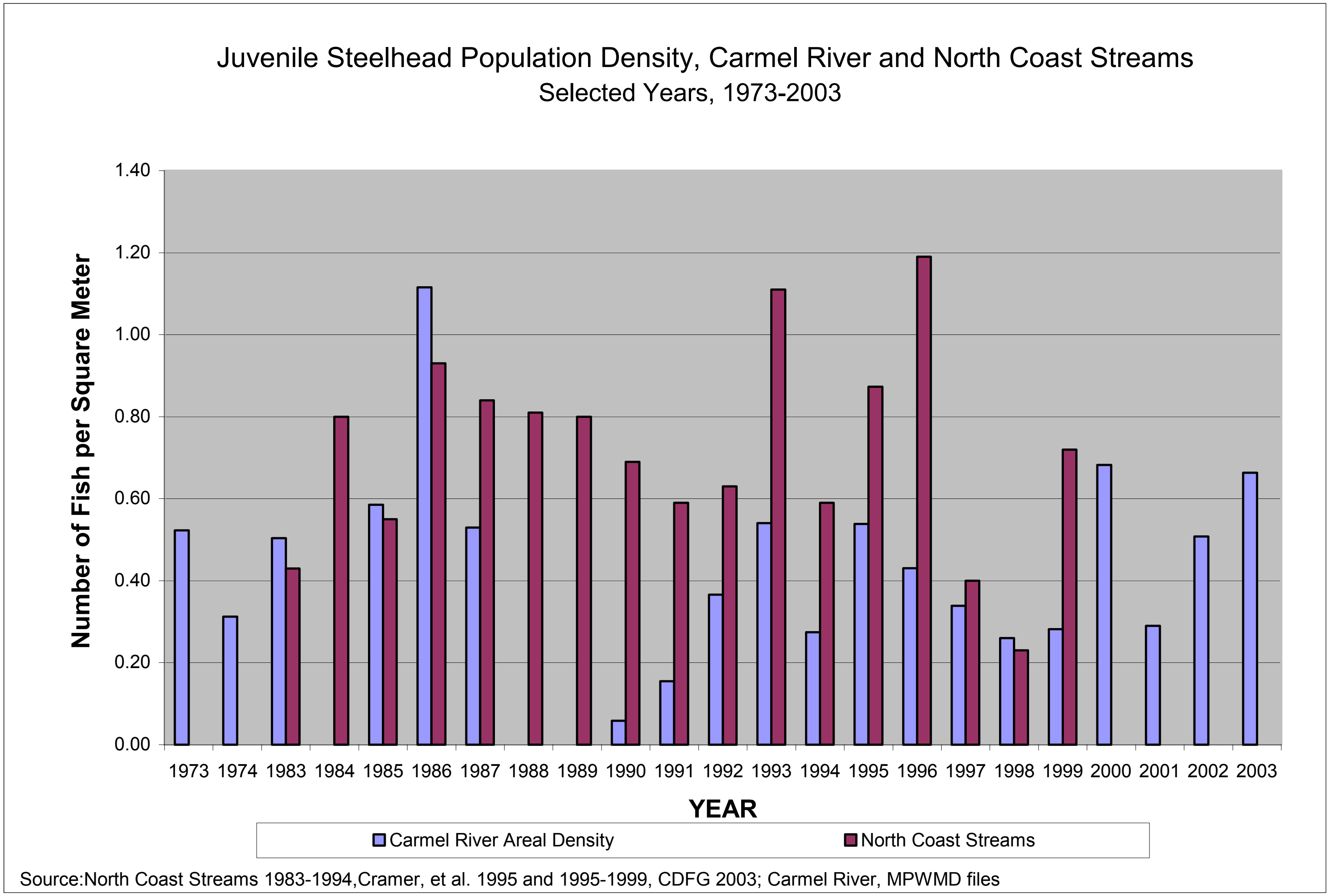


Figure 5.5.1.4-C

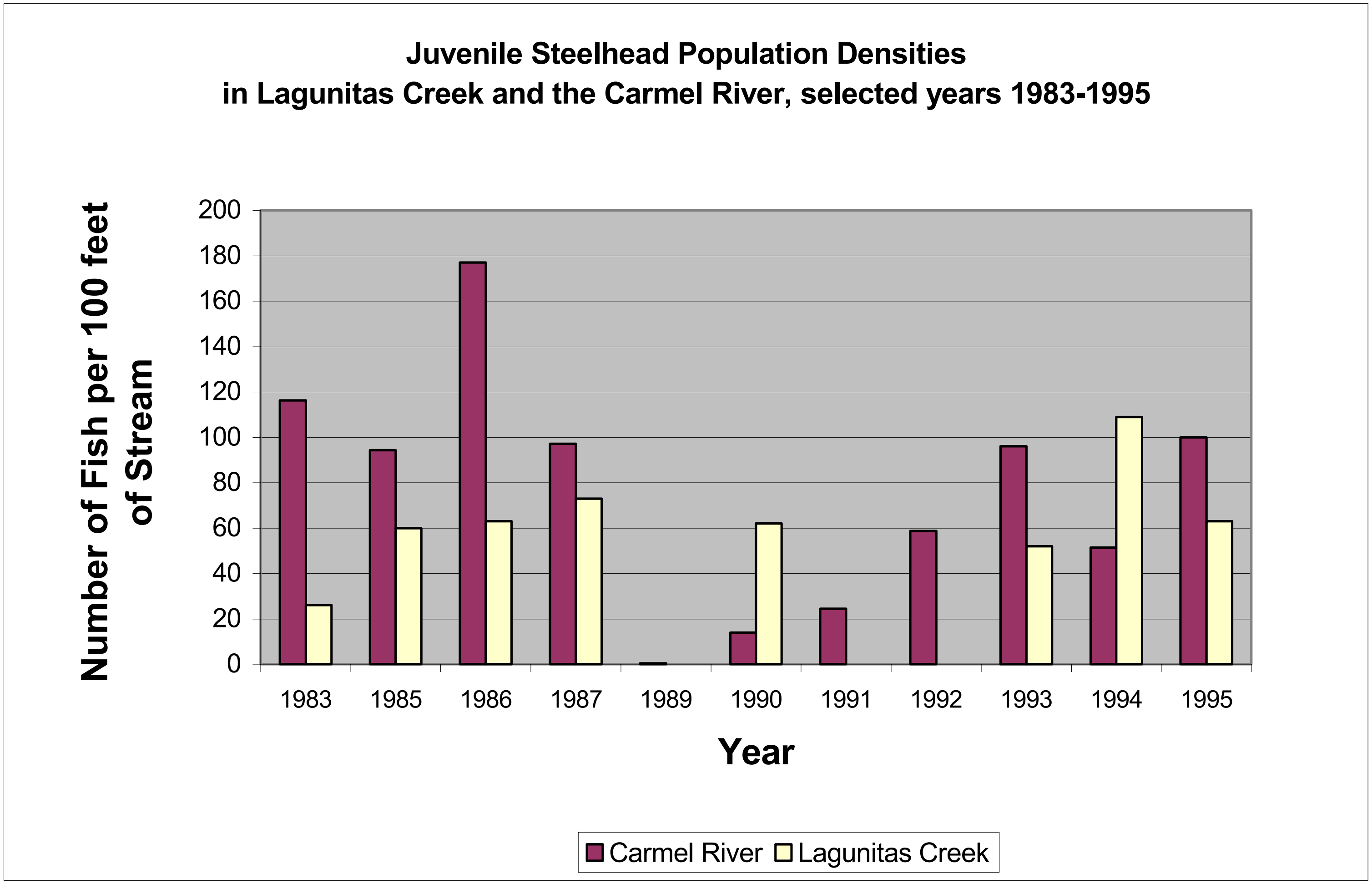


Figure 5.5.1.4-D

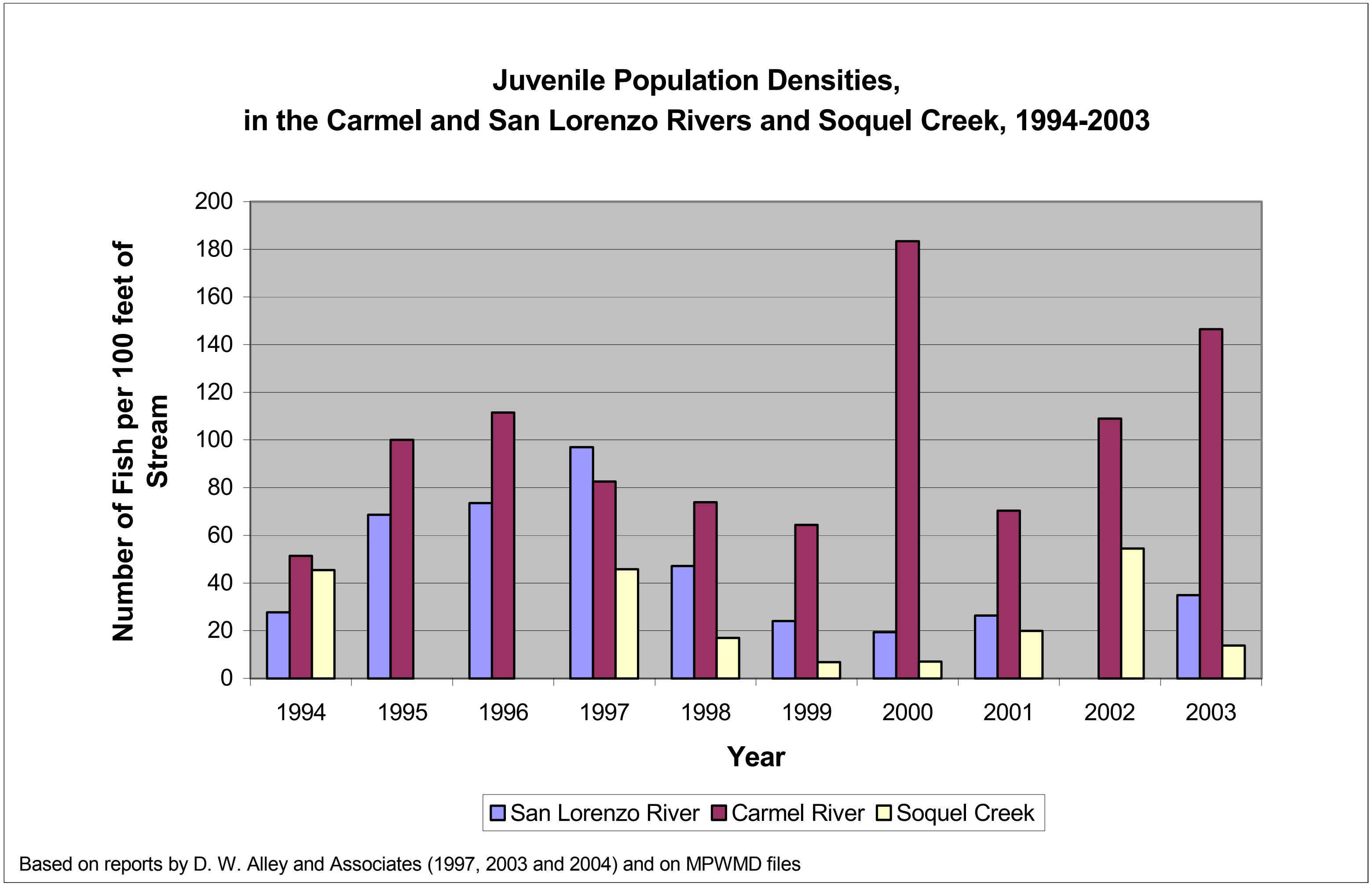


Figure 5.5.1.4-E

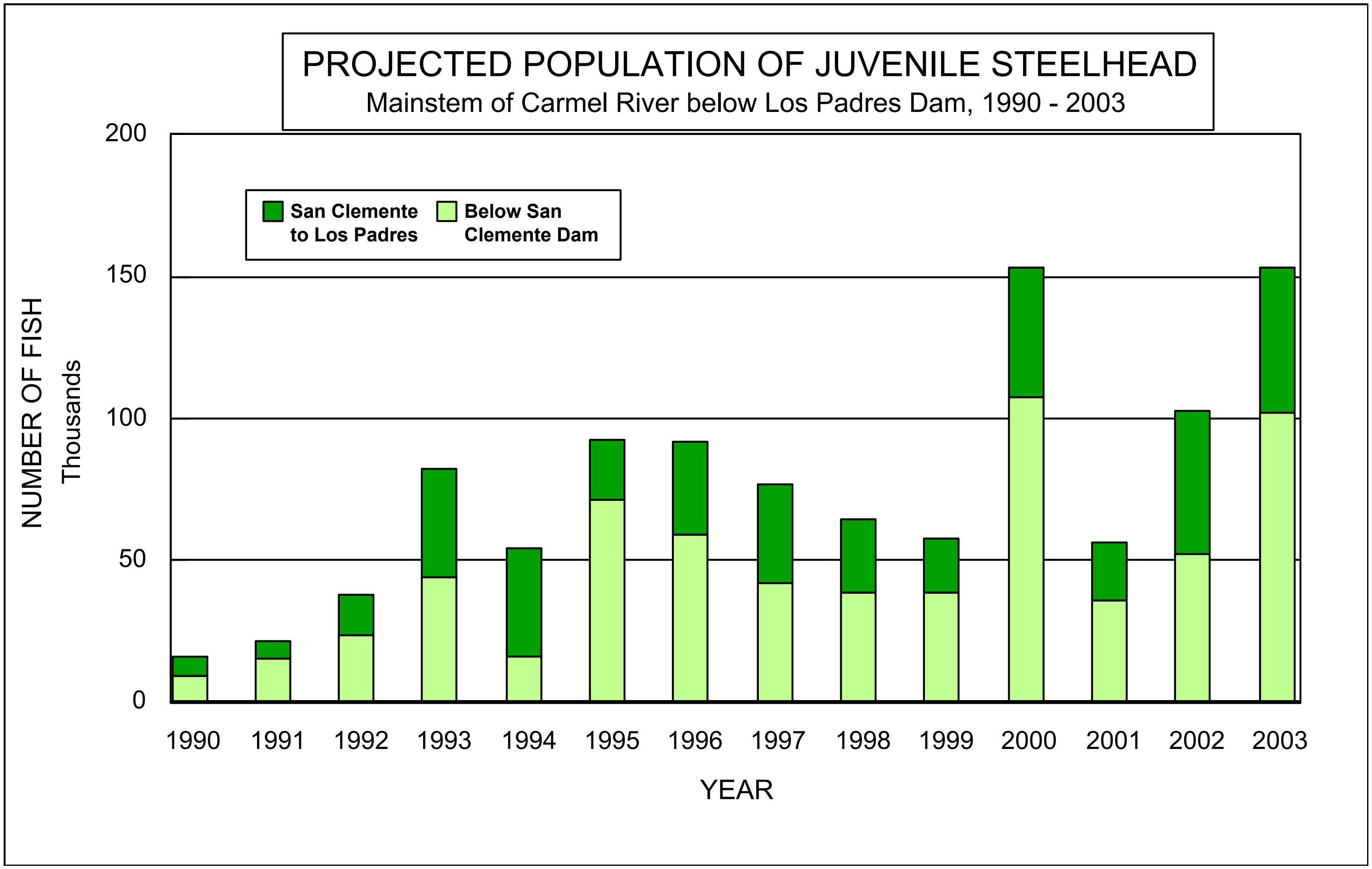
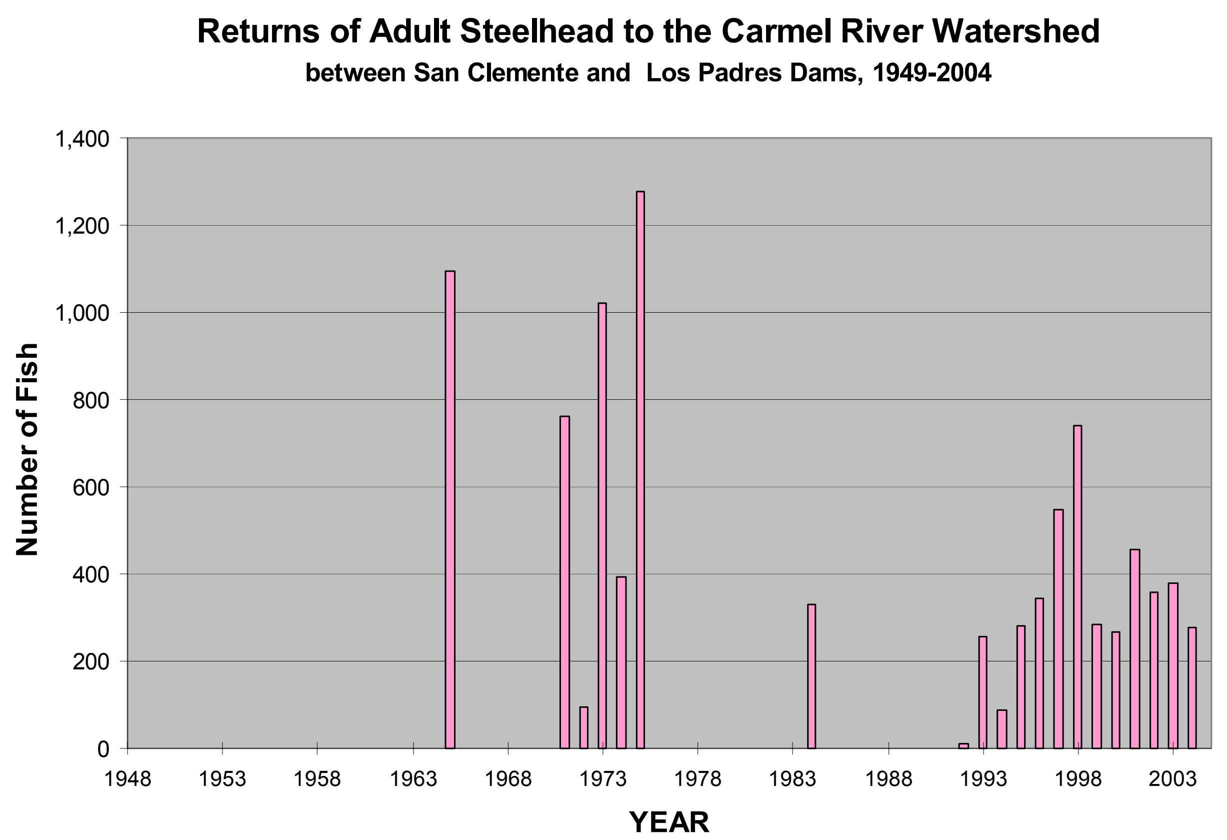


Figure 5.5.1.4-F



Number of fish estimated by subtracting annual number of fish trapped at Los Padres Dam from the annual number of adults counted at San Clemente Dam. Source of data: California-American Water daily reservoir operation reports and MPWMD record of fish counts at San Clemente Dam.

SECTION 5.5.1.5 Distribution of Woody Debris and Its Role In Steelhead Ecology

Introduction

Large woody debris (LWD) can influence physical and biological functions of aquatic habitat throughout an entire watershed. Large wood manipulates surface flow and sediment transport. It also provides cover, substrate and food used by fish and aquatic invertebrates. The purpose of this section is to review the functions of LWD, the relationship between LWD and aquatic biota and the current information available on LWD in the Carmel River watershed.

Distribution of LWD within a Watershed

Distribution of LWD in a watershed is related to past and present recruitment rates, decay rates, rates of movement through the channel and land-use practices. LWD is recruited within a river channel by mortality from the adjacent riparian forest, windstorms, flooding, fire, bank erosion, and landslides (Keller and Swanson 1979; Benda et al. 2003.) Output processes of LWD are leaching, fragmentation, microbial decay, invertebrate consumption, and fluvial transport (Keller and Swanson 1979).

LWD abundance is correlated to stream size (Bilby and Ward 1989). Small channels tend to contain more pieces of LWD. As channel size increases the abundance of LWD decreases. This is because larger channels have the ability to transport larger pieces of wood. The average size of LWD is also related to stream size. The larger the stream size the larger the average piece of wood (Bilby and Ward 1989). Smaller pieces of wood are generally flushed from the larger channels during high flow events. Leaving only large pieces and causing a decrease in wood abundance, but an increase in average piece size.

Effects of LWD on Channel Geomorphology

LWD affects river geomorphology by manipulating and redirecting surface flows. This influences pool frequency, rates of bank erosion, and routing of sediment and organic matter (Montgomery et al. 2003; Cherry and Beschta 1989; Bilby and Ward 1989).

LWD creates pools by providing an obstruction within the channel, which concentrates flow and causes scouring of the bed. The type of pool created is dependent on its orientation and position above the bed (Montgomery et al. 2003). The size of the pool will depend on the size of the wood, angle of the orientation, flow velocity and amount of organic debris accumulated (Bilby and Ward 1989; Cherry and Beschta 1989).

Depending on the orientation of the wood, rates of bank erosion can be manipulated. LWD can accelerate the rate of erosion by redirecting flow into the channel bank and scouring the bank. In contrast, LWD can provide an armoring effect by deflecting the flow away from channel bank, sequentially stabilizing the bank.

Low flow velocities and bed scour created by LWD causes sediment deposition. Where flow deflected by LWD scours a pool, a depositional site will develop, partially defining the boundaries of the associated pool. The average size of depositional sites increases with channel size (Bilby and Ward 1989).

Substrate roughness is also affected by LWD. LWD encourages the transport of fine sediment, which exposes the gravel and cobble substrate. In general, streamflow determines the influence LWD has on routing and rates of scour and fill. At low flows, pools formed by wood tend to fill and riffles tend to scour, but when flow is high, pools scour and riffles are depositional.

Biological Influence of LWD

LWD has an important biological role by influencing flow, channel morphology, storage of organic material and providing cover and substrate. This influences the food supply of fish, the habitat available and the amount of energy they expend when swimming.

Invertebrates use wood in all stages of their life cycle. They use wood for resting and reproductive activities, refuge, substrate and as a source of food. In addition, the accumulation of organic matter and sediment LWD entraps, creates habitats favored by certain types of aquatic invertebrates (Dudley and Anderson 1982). Productivity, abundance and biomass of macro-invertebrates tend to be greatest in areas of high organic matter availability (Wallace et al. 1995).

Pools created by LWD provide low velocity habitats where fish can maintain their position and expend the least amount of energy, yet are in close proximity to swift currents to maximize access to invertebrate drift. Pools that are deep enough, can thermally stratify, providing coldwater refuge during increasing stream temperatures.

In addition to creating pool habitat and low velocity areas, LWD provides a source of cover and habitat complexity. During summer low flows, the pool depth is reduced and LWD cover is often the only protection from predators. Conversely, during high flows, LWD creates velocity breaks, which allow fish to maintain positions in favorable areas. Fish that take refuge in pools with complex cover have greater opportunities to be visually isolated. As complexity increases, there is an increase in available habitat, which tends to support more fish.

Status of LWD in the Carmel River

California State University at Monterey Bay's (CSUMB) Watershed Institute conducted a large woody debris inventory on the Carmel River during the summer of 2002 and 2003 (Smith and Huntington, 2004). This is the only LWD study to date that has been done on the Carmel River. The inventory sampled the lower river from Stonepine Resort down to the Highway 1 Bridge (**Figure 5.5.1.5-A**). The study included data on abundance, size, location, orientation and condition of large wood debris within the wetted channel. The inventory found that there were 471 occurrences of large wood or large wood accumulations within the surveyed reach. Average density per rivermile within the reach was 36.7 occurrences or 20.5 pieces/km, ranging from 10-40 pieces/km. Generally, the density of LWD decreased downstream of Stonepine Bridge, located approximately 2.5 km below San Clemente Dam (**Figure 5.5.1.5-B**). Garland Park was noted as having amongst the highest concentrations of LWD in the study, whereas the areas from Robinson Canyon Road to Schulte Road Bridge and downstream of Via Mallorca Road Bridge had the lowest concentrations.

Figure 5.5.1.5-A. Sample reaches and distribution of LWD in Carmel River (CSUMB Watershed Institute, 2004). White stars represent reaches where no data were collected.

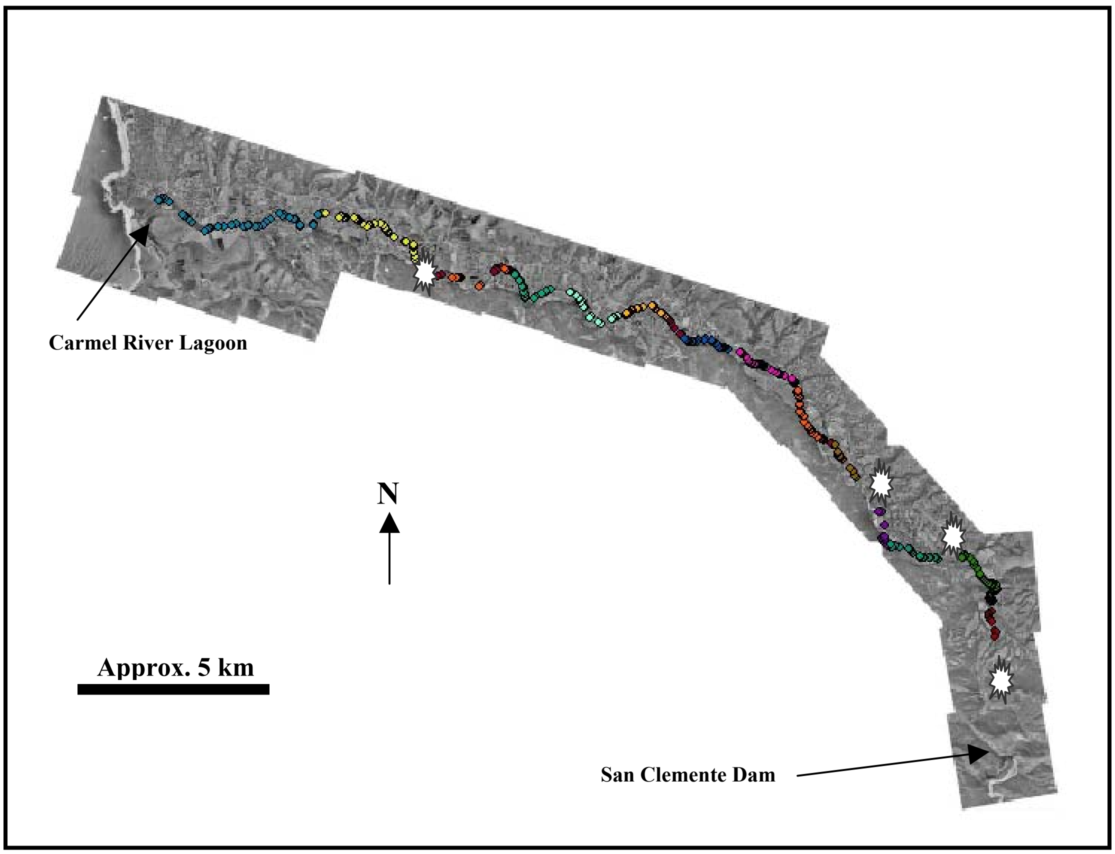
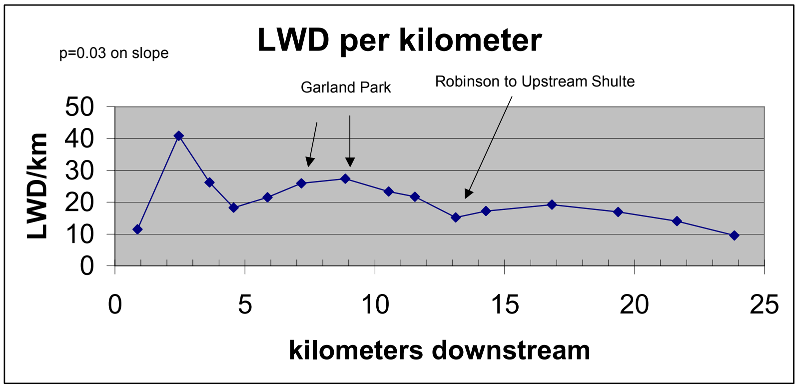


Figure 5.5.1.5-B. Density of LWD with distance downstream (CSUMB Watershed Institute, 2004).



Bilby and Ward (1989), found that the abundance of LWD increases with decreasing channel size. Their study showed that a stream with a channel width of 18 meters, the approximate channel width of the lower Carmel River, contains about 150 pieces/km. In contrast, the Carmel River averaged 20.5 pieces/km, only one-seventh of the density measured by Bilby and Ward (1989). It is important to note that the Bilby and Ward (1989) study was conducted in an old-growth conifer forest in southwestern Washington, and may not be directly comparable to the conditions present in the Central California region. While not directly comparable, the generally low density of LWD in the lower Carmel River probably reflects the decades old effort to remove wood following flood events and the overall reduction in riparian forest cover along the floodplain.

Management of LWD on the Carmel River

During the period from 1990-1998, MPWMD conducted an annual channel- clearing program that included the removal of vegetation by hand with chainsaws and loppers and the modification of large wood. Modifications to large wood included bucking up logs into 2- to 3-foot sections and sometimes moving them onto higher terraces out of the low flow channel. The recent listing of the California red-legged frog (*Rana aurora draytonii*) and the steelhead (*Oncorhynchus mykiss*) as threatened under the Federal Endangered Species Act (ESA) has drawn attention to the value that riparian vegetation and large woody debris has to these species. In 2003, MPWMD adopted guidelines for vegetation management that emphasize the protection of wood within the channel to the maximum extent practicable (MPWMD, 2003).

The transport of floating woody debris past Los Padres and San Clemente Dams is facilitated by California American Water Company (Cal-Am). The Los Padres Dam has a log boom which regularly traps large wood in the reservoir (**Figure 5.5.1.5-C**).

Figure 5.5.1.5-C. Picture of Los Padres Dam log boom taken on 11/15/2002.

This wood usually becomes waterlogged and sinks to the bottom of the reservoir. The wood remains until decomposition occurs and breaks it down. Depending on flows and the water level in the reservoir, large wood will sometimes pass onto the spillway and make its way back into the Carmel River unassisted. Large wood that migrates through the San Clemente Reservoir to the dam spillway is manually passed through the spill gates if the orientation and size of the wood does not allow natural passage.

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5.5.1.6 CONSTRAINTS AND LIMITING FACTORS FOR STEELHEAD POPULATION AND POTENTIAL RESTORATION PROJECTS

The purpose of this section is to provide an assessment of constraints and limiting factors for the steelhead population in the Carmel River and to recommend projects for restoring and maintaining critical freshwater habitats in the Carmel River Basin. The following sections provide a review and update of the historical constraints and limiting factors, describe the relationships between returning adults and juvenile populations, develop indexes of juveniles and returning adults in key reaches, describe the existing and future limiting factors, and ends with a description of projects to restore and maintain freshwater habitats and steelhead production within the basin.

Review of Constraints and Limiting Factors – As mentioned in Section 5.5.1.4, past reviews of environmental problems in the Carmel River have led to a general understanding of the principal factors associated with the historical population decline in the Carmel River Basin[1], including the following factors:

1) Inadequate passage facilities for adults and juveniles at Los Padres Dam.
2) Dry season surface diversions at San Clemente Dam.
3) Subsurface diversion of percolating streamflow and groundwater.
4) A reduction in the extent and diversity of streamside vegetation, a reduction of the number of trees and the canopy in the riparian forest, and reduced amounts of large wood in the active channel downstream of Robles del Rio.
5) Retention in main stem reservoirs of sediment that is beneficial to steelhead and benthic macroinvertebrates (insects in the river bottom).
6) Chronic and episodic bank erosion in tributaries and the main stem that introduces fine sediments into spawning and rearing habitats.
7) Prior to 1997, the temporary or seasonal blockage of smolt emigration at San Clemente Dam in some years when flashboards were raised in the spring.
8) Sand deposition in the Lagoon that reduce habitats for adults during the winter, for smolts during the spring, and for juveniles during the summer and fall months.
9) Changes in dry season (late spring to fall) water quality, including increased water temperature, reduced oxygen levels, and higher salinity levels (Lagoon only).
10) Loss of surface storage in Los Padres Reservoir due to sedimentation.

The following sections review and update how each of these historical factors has affected the steelhead population. In addition, two new factors are discussed in light of future expected changes and impacts, including the release and deposition of fine-grained sand and silt from San Clemente Dam and the loss of surface storage in Los Padres Reservoir.

1. Inadequate passage facilities for adults and juveniles at Los Padres Dam – When Los Padres Dam was constructed in 1949, a wooden ladder and trap was built to collect adults that returned to the dam. According to anecdotal sources, the ladder and its supporting structure washed out during

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[1] Kelley and Dettman, 1981; Kelley, Dettman, and Turner, 1982; Snider, 1983; and Dettman and Kelley, 1987; Dettman, 1991; Dettman; Dettman, 1992; Cramer, S. P., et al., 1995; Bryant, G. J. and J. Lynch, 1996.

the April 1958 flood, which peaked at about 12,500 cubic feet per second (cfs) at the USGS Robles del Rio stream gage. Subsequently, the wooden ladder was replaced with a 50-foot long Denil ladder, trap, and small holding tank. Adults were dip-netted, placed into a 100-gallon tank, and trucked upstream to Los Padres Reservoir. In 1982, a low flow fish gabion barrier made out of gabions (rock-filled baskets) was placed just upstream of the ladder entrance to prevent fish from passing into the plunge pool below the spillway. Fisheries engineer Charles Wagner[2] reviewed the design and operation of the existing facilities and noted several problems:

> "It was reported that at high river flows fish can and do pass over and around the left end of the barrier dam."
>
> "Observation of the high water marks led to the conclusion that at least part of the dam also becomes submerged at higher river flows and evidence of stream bed degradation downstream of the barrier dam was noted. Concern was expressed... over the possible short life of the wire in the gabion mesh and the gabion's ultimate collapse."
>
> "At the low river flow observed on September 7, 1983, the flow from the Denil fish ladder did produce good attraction flow into the river. It is not known whether this attractive flow condition continues at higher river flows, particularly when there is spill over the gabion dam."

When Los Padres Dam was constructed, no specific facilities were built to pass juvenile and adult steelhead downstream past the dam. Most biologists and engineers who have examined downstream passage conditions at Los Padres Dam agree the historical situation was detrimental for emigrating smolts and adults over a wide range of streamflow. Wagner[3] noted, "the spillway at Los Padres Dam is rough, particularly the ogee section, and fish probably suffer extensive abrasion at low flows. At low spillway flows, the depth of flow over the ogee and chute will be extremely shallow and much of the flow will fall on the rocks below … Particularly when water depth is not adequate for fish to avoid contact with the spillway surface, internal as well as external injuries are expected as they pass over this spillway."

Improvements to the spillway were made in 1986, when an eight-inch high sill was installed in the lower section of the spillway to concentrate and increase the depth of flow and lower the risk of abrasion. In addition, a metal extension was added to the end of the spillway and a large boulder below the spillway was blown up to prevent emigrating fish from landing on rocks as they passed into the plunge pool below the spillway. In 1992, MPMWD conducted an experiment with smolts to test whether these improvements were successful.[4] The results indicated that substantial mortality and injuries were still occurring due to impingement on rocks below the spillway, and this led to further improvement by Cal Am to remove additional rock from the plunge pool.[5]

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[2] Wagner, C. 1983. Study of upstream and downstream migrant steelhead passage facilities for the Los Padres Project and New San Clemente Project. Report prepared for the Monterey Peninsula Water Management District. 57 pp. + Appendix.
[3] Wagner, C. op cit.
[4] Dettman, D. H. and B. M. Hanna. 1993.
[5] As part of SWRCB Order 95-10, Cal Am was required to remove additional rock at the base of the spillway. This was completed in 1997.

In 1998, the Carmel River Steelhead Association received grants from the California Department of Fish and Game (CDFG) and the National Wildlife Foundation to design and build a new fish ladder and trap with an entrance in the plunge pool on the left bank of the stream (looking downstream). This project, which was completed in 1999, resulted in substantial improvements to the trap and haul operations at Los Padres Dam and has been used to effectively transport adult steelhead since winter 2000.

In 2003, Cal Am modified the gabion structure below the plunge pool to improve passage conditions, while retaining flexibility to use the older 50-foot Denil ladder on the right bank. This project involved removing rusted, broken sections of the gabion wire baskets, buttressing the fish ladder with boulders, removing several mid-channel willows and adjusting the gradient of the streambed above the older ladder. This project resulted in improved passage conditions, particularly at streamflows less than 65 cfs (**Figure 5.5.1.6-A**).

2. Dry season surface diversions at San Clemente Dam – Since construction of Old Carmel Dam in 1881-83, water has been diverted from the Carmel River for municipal use in Carmel Valley and the Monterey Peninsula. Beginning in 1921, surface flows were diverted at San Clemente Dam and piped along the river to the Cal Am filter plant about a mile downstream of the dam. Prior to the end of World War II, diversions ranged up to about 5,000 acre feet (AF) per year with a distinct increase in 1926, corresponding to an expansion associated with the construction of San Clemente Dam and the Filter Plant (**Figure 5.5.1.6-B**). The post-war expansion of the population on the Monterey Peninsula stimulated further diversions, ranging up to 7,500 AF during the mid 1950's. Additional growth during the late 1950's and early 1960's resulted in maximum surface diversions totaling 9,800 AF by 1965, or a mean annual value of 13.5 (cfs), which was close to the maximum capacity of the Filter Plant. Between 1966 and 1983 diversions averaged 7,400 AF/year, ranging from a minimum of 2,700 AF in 1977 to a maximum of 9,500 AF in 1967.

Prior to the 1983 water year (WY), Cal Am pursued an aggressive program to control leakage at San Clemente Dam, culminating in an ambitious project to replace wooden stoplogs that were used to raise the reservoir level with 24 steel encased concrete gates in the spillway openings. This effort, which virtually sealed the dam against leaks, combined with surface diversions at the dam periodically reduced flow in the river downstream to nearly zero during the dry season months. For example, in the 1981 dry season Cal Am diverted surface flows ranging from 15 to 7 cfs, as streamflow in the Carmel River declined from 1.5 to 0.33 cfs (**Figure 5.5.1.6-C**).

In most California streams south of San Francisco Bay the quality and quantity of late spring, summer, and early fall rearing habitats for juvenile steelhead are directly influenced by streamflow. Several investigators have studied this relationship in the Carmel River.[6] While their methods differed, their results strongly support a conclusion that dry season habitat is a crucial factor limiting the population of steelhead. For example, Snider (1983) observed,

> *"Under historic, natural conditions (i.e. no diversions and no development) the lower river provided abundant nursery habitat. Flow occurred throughout the lower river in 6 out of 10 years, and in the lower 3 to 6 miles, 8 out of 10 years. The riparian canopy maintained amenable temperatures; pool habitat was present; and even during years of*

[6] USWFS, 1980; Snider, 1983; Dettman and Kelly, 1986; Alley, Hoefler, and Mori, 1990;

no September flow, perennial surface water most likely sustained juvenile steelhead. A few perennial pools occurred in the lower river as late as 1975. Many of the 100,000+ young-of-the-year and yearling steelhead which are annually stranded and perish with the cessation of flow in later spring would survive to sea-run adults given natural flow."

In 1983, CDFG challenged Cal Am's insistence on diverting flow at San Clemente Dam, citing Section 5937 of the CDFG Code.[7] CDFG prevailed in its challenge, which set the stage for changes in the way inflow was allocated. As a result, in 1983 CDFG, Cal Am, and MPWMD negotiated a Memorandum of Agreement (MOA) regarding the magnitude of flow releases at the dam. Since 1983, the scope of the MOA has been expanded to include limitations on diversion rates through the Filter Plant, pumping from Upper Carmel Valley Wells during the dry season, the sequence of pumping water from Cal Am wells in Lower Carmel Valley, and how Cal Am supplies water to its customers in the Carmel Valley Village and the former Water West Service Area.[8]

Since 1983, the releases and limitations specified in the MOAs have resulted in increased streamflow during late spring, summer, and fall months. Increased flows have improved rearing habitats for juvenile steelhead and other aquatic resources below San Clemente Dam, as far downstream as the Narrows in all years, and to Via Mallorca during the wet hydrologic years. The importance of changing the operation of Cal Am facilities can be seen by comparing flows, diversions, habitat and juvenile populations in 1973-75 (pre-MOA) and 1999-2001 (post-MOA) (**Figure 5.5.1.6-D**). In 1975, Snider (1983) estimated there was a total of 5.3 acres (231,000 sq ft) of rearing habitat in a two-mile long reach below Tularcitos Creek and only 8,078 juvenile fish below San Clemente Dam. During this study, summer flows at Robles Del Rio averaged 1.9 cfs and ranged from 0.24 to 14 cfs[9], and the river extended only two miles below Tularcitos Creek to the vicinity of the Carmel Valley Trail and Saddle Club. At the same time, Cal Am diverted an average of 14 cfs at San Clemente Dam[10].

In contrast to the condition of the river in 1975, during the summer of 2000 the flows at Robles del Rio averaged 11.3 cfs and ranged from 6.4 to 28 cfs, while diversions at San Clemente Dam averaged 0.2 cfs.[11] As a result of reduced diversions at San Clemente Dam and changes to the lineal distribution of well water production (diversions were concentrated between RM 2 and RM 7), surface flow extended downstream to the vicinity of Cal Am's Cypress Well at RM 5.4, totaling a net increase of about 8.5 miles of stream habitat. The effect of these changes on the juvenile

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

[8] The MOA reflects conditions imposed by the SWRCB in Water Rights Orders 95-10, 98-04 and 2002-0002 and agreed to in the 2002 Conservation Agreement between Cal Am and the National Marine Fisheries Service.

[9] Range and average flow based on USGS data at Robles del Rio for July-October 1995.

[10] California American Company production records, July-October 1975.

[11] Range and average flow based on USGS data at Robles del Rio for July-October 2000 and Cal Am production records, July-October 2000.

steelhead population has been to increase the population by almost 100,000 fish (107,200 in 2000 compared to 8,100 in 1975).[12]

3. Subsurface Diversion of Percolating Streamflow and Groundwater from the Carmel Valley Aquifer Below San Clemente Dam

The nature of the relationship between surface flows and ground water in the Carmel River Basin was disputed for many years. Resolution of this dispute occurred in 1995, when the SWRCB declared,

> *"…we find that downstream of RM 15 the aquifer underlying and closely paralleling the surface water course of the Carmel River is water flowing in a subterranean stream and subject to the jurisdiction of the SWRCB."*[13]

While Order WR 95-10 clarified the legal relationship between groundwater, subsurface and surface flows, it only partially addressed a physical solution to the problems created by pumping groundwater and diverting subsurface flows.[14] Because of this, the diversions from the surface and subsurface from the Carmel Valley Aquifer continue to affect four distinct parts of the steelhead's lifecycle in the Lower Valley including: migration of juveniles during fall and winter, upstream migration of adult steelhead during winter, downstream emigration of pre-smolts and smolts during spring, and juvenile habitats during spring/summer.

Juvenile Migration During The Fall And Winter – In the Carmel River, initial flows of the year often spill over San Clemente Dam and percolate into the downstream aquifer to replace water that was pumped during the previous dry season(s). At the same time, many juvenile steelhead that have reared upstream or in the vicinity of San Clemente Dam begin to move downstream toward the Lagoon. As flows decline following storms, the juveniles who have moved below the Narrows face a risk of being isolated and stranded. For example, as **Figure 5.5.1.6-E** shows**,** the storms in WY 1991 on March 4th and 13**th** increased the mean daily flow at the USGS Robles del Rio gage from 2 to 357 cfs on March 5th and from 44 to 131 cfs on March 15th. During this period flows at the USGS Near Carmel gage remained at zero, but the river advanced to within a few hundred feet of the Near Carmel gage. Following the advance, the river retreated at an average rate of two miles per day as flow percolated into the aquifer upstream of the gage. The risk of stranding as the river retreats is exacerbated during years when the Carmel Valley Aquifer is drawn down during the preceding summer.

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12 Estimates of the total juvenile steelhead population below San Clemente Dam during the post MOA era (1990-on) are illustrated in Figure 5.5.1.4-E and range from 9,000 to 107,200. During the period from 1990 to 1994 the population was affected by low numbers of returning adults. Since 1995, the population has ranged from 35,700 to 107,200 fish, likely in response to increased streamflow, total suitable habitat area, improved substrate conditions, and suitable water temperatures.

13 SWRCB, July 1995. Order No. WR 95-10. Page 12

14 In Order No WR 95-10 the SWRCB placed an annual limit of 11,285 AF on Cal Am's diversions from the Carmel River Basin, which had averaged 14,106 AF during the ten-year period from 1979 to 1988. This represents a 20 percent reduction. Of the average 14,106 AF of historical diversions, the SWRCB determined that Cal Am has legal water rights to 3,376 AF, meaning that Cal Am currently diverts about 10,730 AF from the Carmel River or its subsurface flow without a valid basis of right.

Adult Migration During The Winter – The extraction of subsurface flow and groundwater during summer months results in a delay or elimination of flows needed for the upstream migration of adults during the following January, February, and March. The impact is most prevalent during extended droughts. For example, during the 1987-1991 drought, the withdrawal of groundwater completely eliminated the only available flows for attraction and migration of steelhead for three years in a row (**Figure 5.5.1.6-F**).

Emigration Of Pre-Smolts And Smolts During Spring – Adequate March, April, May and early June streamflows are needed to rear steelhead smolts below San Clemente Dam and to allow their successful emigration from the lower river into the ocean or lagoon. Prior to the early 1960s, the diversion of normal springtime flow was a minor problem for steelhead in the Carmel River because the surface diversion at the Filter Plant was most often a small fraction of the total spring flow in the river. Beginning in 1959, when the first major production wells were installed in the Carmel Valley Aquifer, there was a gradual, but steady, increase in the water demand that was met from subsurface diversions (**Figure 5.5.1.6-B**). As overall water production increased, spring flows in the lower river declined in response to increased pumping and the river dried up earlier, as steelhead smolts were emigrating downstream. Currently, the diversion of spring flows interferes with or eliminates the emigration of steelhead smolts into the ocean, threatens emigrating fish by stranding them in drying pools, and reduces habitat for juveniles and other aquatic life. The degree of interference varies from year to year, depending on total runoff and occurs most frequently during below normal, dry, and critical years, when the rate of groundwater production exceeds the combination of flow releases from San Clemente Dam and natural accretion from tributaries below the dam.[15] The varying impacts are illustrated in **Figure 5.5.1.6-G** for 1994, a critically dry year, and in **Figure 5.5.1.6-H** for 2002, a below normal year. In Water Year 1994 (WY1994), runoff totaled only 13,300 and the streamflow declined rapidly, well before the major smolt emigration period in April and May, and as a result the last opportunity for successful emigration to the ocean was on March 29, 1994 (**Figure 5.5.1.6-G**). Moreover, flows were so low in spring 1994 that rescues of smolts from the lower river were required throughout April, May and early June. In WY 2002, runoff totaled 32,500 AF and the emigration period extended until May 25 with the last opening of the rivermouth on May 26, 2002 (**Figure 5.5.1.6-H**). Even with higher flows experienced in below normal years, opportunities for successful emigration are limited due to the reduced frequency and duration of time that the rivermouth is open. For example, in 2002 the lagoon was closed a number of times during May, as shown in **Figure 5.5.1.6-H**.[16] The flow changes and reduced opportunities for successful emigration habitat for pre-smolts and smolts tend to reduce the overall survival of emigrating smolts and ultimately reduce the population of returning

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[15] In the Carmel River runoff classifications are based on selected exceedence frequency values computed from the long-term reconstructed unimpaired flow record at the San Clemente Dam site (1902-2003). "Extremely Wet" refers to flows exceeded 12.5% of the time (>=129,600 AF); "Wet" refers to flows exceeded between 12.5% and 25% of the time (101,800 to 129,500 AF); "Above Normal" refers to flows exceeded between 25% and 37.5% of the time (71,500 to 101,700 AF); "Normal" refers to flows exceeded between 37.5% and 62.5% of the time (41,700 to 71,400 AF); "Below Normal" refers to flows exceeded between 62.5% and 75% of the time (29,500 to 41,600 AF); "Dry" refers to flows exceeded between 75% and 87.5% of the time (14,700 to 29,400 AF); and "Critically Dry" refers to flows exceeded less than 87.5% of the time (<14,700 AF). Source: D. Fuerst, 2003. MPWMD files.

[16] In general surface inflow in the range greater than 20 cfs keeps the rivermouth open frequently, depending on tide and wave action. The rivermouth closes finally as inflow declines below 10 cfs. A detailed assessment of the relationship between inflow and rivermouth openings is provided in James, G. 1994. Surface hydrology of the Carmel River Lagoon, Water Years 1991 through 1994. Technical Memorandum 94-05. MPWMD.

adults. Although these factors have been partially mitigated by changes to Cal Am operations, the spring diversions remain as a primary factor limiting the population of steelhead in the Carmel River.[17]

<u>Juvenile Steelhead During Late Spring and Summer</u> – Currently, the aquatic habitats above Robinson Canyon are maintained in most years by releases of stored water from Los Padres Reservoir, but aquatic habitat in the reach below Robinson Canyon Road is reduced to zero in nearly all years by the diversion of surface and subsurface flow during late spring and summer. By mid- to late- summer, streamflow usually ceases at the USGS Near Carmel gage. Aquatic habitats in the lower river are reduced to critical levels at a flow of about one cfs; pools become separated by long, shallow glides and riffles. Below one cfs, the continuity of the river is broken, and by the end of summer the riverbed is dry. This situation impacts juvenile steelhead and other aquatic biota by restricting their movement, by isolating them in discontinuous pools, by subjecting them to increased predation, and finally by suffocation as the pools dry up. Since 1990, this impact has been mitigated by annual rescues of juvenile steelhead in the reach from Highway One to a location upstream where riverflow can sustain steelhead.[18]

<u>4. Extent and diversity of streamside vegetation, the number of trees and canopy of the riparian forest, and reduction of large wood downstream of Robles del Rio</u> – The number of trees, species composition, and the extent of the riparian forest canopy are three important factors which influence steelhead populations. This importance relates to three ecological aspects of juvenile steelhead life in the river, including:

Habitats – Scour and eddies around limbs and roots of living riparian trees and around woody debris from dead riparian trees creates critical rearing habitat for juvenile steelhead. The absence of such features often results in little or no habitat, even when streamflow is adequate.

Temperature Control – The overhanging canopy of the riparian forest shades the stream from direct sunlight, thereby reducing the heat gained from solar radiation and ameliorating water temperatures that approach, and occasionally, exceed lethal levels.

Sources of Food – Riparian trees are habitat for a diverse assemblage of terrestrial insects and for many aquatic insects that use overhanging trees during their adult breeding phase and

[17] Impacts from Cal Am spring diversions have been partially mitigated by SWRCB WRO 95-10 (Conditions 3 & 5) and SWRCB Order WR 98-04 (Conditions 1 & 2). These conditions require: Cal Am to pump no more than 11,285 AF from the Carmel River Basin each Water Year; Cal Am to maximize production from the Seaside Aquifer for the purpose of serving existing connections, honoring existing commitments and to reduce diversions from the Carmel River to the greatest practicable extent during periods of low flow; Cal Am, to the maximum extent feasible without inducing sea water intrusion or unreasonably affecting the operation of other wells, to satisfy the water demands of its customers by extracting water from its most downstream wells.

[18] Between 1989 and 2004 a total of about 215,000 steelhead were rescued from the drying reaches by the Monterey Peninsula Water Management District and another 5,000 to 16,000 per year were rescued by the Carmel River Steelhead Association. These fish were released into permanent habitats upstream of Robinson Canyon Road Bridge or reared over the summer months at MPWMD's Sleepy Hollow Steelhead Rearing Facility. The rescue program is required by the SWRCB as a condition for temporarily allowing Cal Am's diversions to continue at 11, 285 AF per year.

for incubating eggs. These insects are an important source of food for juvenile steelhead in the Carmel River.[19] The extent of riparian vegetation and the proximity of the trees to the edge of the stream are important because the insects usually must fall into the water before they can be eaten. For example, experimental manipulation of insect drift has shown nearly seven times as many organisms, and three times the biomass of organisms, in the Carmel River adjacent to canopied areas versus open areas.[20]

Since the late 1950's, the riparian forest along the lower Carmel River has experienced several episodic changes, including a general historic decline in the number of trees and extent of the riparian forest along the banks of the Carmel River. Li (1986) documented the decline between 1956 and 1982, and McNeish (1989) summarized the historical changes prior to 1956 and following 1982.[21] [22]

Prior to the 1959-61 drought, an average of 78 percent of the riverbanks between the Lagoon and the Robles del Rio Bridge were covered by riparian vegetation. By 1980 the average had been reduced to about 44 percent, with several reaches having only 15 to 20 percent coverage (**Figure 5.5.1.6-I**). These historical changes reduced the tree canopy along the Carmel River, reduced the food available to juvenile steelhead, increased water temperatures, and reduced the quality and quantity of juvenile and adult steelhead habitat. More recently, an inventory of the riparian vegetation by Christensen (2003) shows that the wooded riparian area has increased by 139 acres, or 46%, from about 300 to 438 acres during the period from 1986 to 2001.[23] Much of the increase has occurred in the reach between Via Mallorca Road and Robles del Rio, where massive vegetation die-off and bank erosion followed the 1976-77 drought and 1978-1983 floods. This change has directly benefited juvenile steelhead by providing more overhead cover along the streambanks and increasing habitats for aquatic and terrestrial insects. For example, a detailed analysis of the change in riparian vegetation in a portion of the Valley Hills Restoration Project shows that the area of riparian vegetation increased from 1.4 to 4.1 acres within the 5.3-acre site (**Figure 5.5.1.6-J**).[24] Importantly for steelhead habitats, this recovery has increased the vegetated lineal streambank cover from 676 feet to 1,143 feet, or by 69 percent in the approximately 1,000-foot long study reach. This change indicates that tree coverage along the streambanks has increased to nearly the level that was extant during the 1950's and 1960's (**Figure 5.5.1.6-I**).

The overall increase in riparian area downstream of San Clemente Dam since the early 1980's can be attributed to several factors including relatively normal rainfall amounts, changes in Cal Am's pumping and diversion regimen that have allowed natural recruitment in the active channel between

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[19] Fields, W.C. 1986. The invertebrate Fauna of the Carmel River System and Food Habits of Fish in the Carmel River. Appendix C to D. H. Dettman and D.W. Kelley. 1986. Assessment of the Carmel River Steelhead Resource, Vols. I and II. D.W. Kelley and Associates, Newcastle, CA.
[20] Op. cit.
[21] Li, S.K. 1983. Application of the Theurer-Voos Instream Water Temperature Model to the Carmel River. Appendix D to D. H. Dettman and D.W. Kelley. 1986. Assessment of the Carmel River Steelhead Resource, Vols. I and II. D.W. Kelley and Associates, Newcastle, CA.
[22] McNeish, C.M. 1989. An Inventory of the Riparian Vegetation Resource of the Carmel Valley. Report to Monterey Peninsula Water Management District.
[23] Christensen, T. 2003. Using GIS To Quantify Riparian Area Overlying The Carmel River Alluvial Aquifer. Technical Memorandum 2003-02. Monterey Peninsula Water Management District. 10 pp.
[24] Watters, P.J. 2004. The Valley Hills Restoration Project: Quantification of Riparian Vegetative Cover, A GIS project for the Monterey Peninsula Water Management District.

San Clemente Dam and the Narrows, and in the reach that is annually dewatered, to revegetation and irrigation projects by the District and others.

5. Blockage and entrapment of beneficial sediment – The existing dams on the main stem have blocked the transport of gravel, cobble and boulder substrates since 1921 at San Clemente Dam and since 1948 at Los Padres Dam. While entrapment of fine-grained sediment behind the dams has generally improved substrate conditions for spawning adults and rearing juveniles, the blockage of larger-sized particles has caused a decline in the quality of spawning habitats below both main stem dams.[25] In the reach between the Narrows and San Clemente Dam, the suitability of spawning habitats is generally poor with available gravels on the coarse end of the spectrum of sizes utilized by adult steelhead (**Figure 5.5.1.6-K)**.

While the physical suitability of rearing habitats below Los Padres Dam has not yet been reduced, the extent and quality of rearing habitats below San Clemente Dam has been affected by scour for a longer period and shows evidence of a decline in some areas where deep, slow moving water predominates. Although not completely unsuitable, this type of habitat is not preferred by juvenile steelhead, which thrive in channels predominated by riffles separated by short, deep pools.

To alleviate the long-term effects of gravel entrapment and increase spawning habitat, MPWMD received a grant in 1991 from the California Wildlife Conservation Board (CWCB) to restore spawning habitats in a 7.4-mile long reach between Los Padres Dam and the Sleepy Hollow area below San Clemente Dam. The contract with the CWCB called for placing gravel into selected spawning sites and maintaining the sites over a ten-year period.[26] Over the 10-year duration of the project, the District has injected a total of 2,444 cubic yards of gravel into the Carmel River and steelhead have used this material throughout the reaches below both dams. Injection of spawning sized material over the ten-year period has not been sufficient to reverse the long-term reduction in the amount and extent of cobble sized material that is favored by juvenile steelhead and preferred habitats for aquatic insects. This level of restoration would require significant increases in the annual amount injected and a wider range of sizes. If long-term trends are to be reversed below each dam, a program to pass large fractions of the naturally transported gravel and cobble bedload at each dam should be considered and implemented.

6. Increased erosion of sand and fine-grained sediments – A primary constraint to high quality steelhead habitats in most California coastal streams is the deposition of sand and finer sediments on the stream bottom. The sediment fills in spaces between gravel, cobbles and boulders that are critical habitat for juvenile steelhead and aquatic insects. The impact of sediment on steelhead habitat is quantified by an index of sedimentation known as "embeddedness", which was developed

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[25] Dettman, D.H. and B.M. Hanna. 1991. Development of a Substrate Suitability Curve for Adult Spawning Habitat in the Carmel River, Downstream of San Clemente Dam. Tech. Memo. 91-04. MPWMD. 5 pp + Figures and Tables.

[26] The District acquired a Section 404 permit from the U. S. Army Corps of Engineers (No. 19958S09, dated May 26, 1993), which was valid for a five-year period until 1998 to allow the District to add gravel below each dam for maintenance of spawning habitats. In August 1998, the District applied for a renewal of its permit, which was granted in October 1998. The renewal authorized injection of spawning gravel until spring 2003. Currently, the District is preparing another permit application to dredge spawning sized gravel from the San Clemente Reservoir inundation zone and inject up to two acre feet of this material below San Clemente Dam.

for streams in the Rocky Mountains of Idaho.[27] Kelley and Associates applied and tested the embeddedness index in steelhead streams in several central California and found excellent correlations between the density of the steelhead population, embeddedness, and cobble abundance.[28] [29]

Currently, embeddedness influences rearing habitats predominantly in the reach downstream of the Robinson Canyon where limited amounts of cobble and boulder are often covered by extensive deposits of sand, especially following episodic floods that mobilize and transport fine-grained sediment from major tributaries basins, including the Tularcitos Basin. Curry and Kondolf concluded that most of the sand which impaired steelhead habitat in the lower Carmel River, prior to 1983, originated from riverbanks which had lost the protective cover of riparian vegetation and were washed away during high winter flows following the 1976-77 drought.[30] Since that time, most of the open, unprotected river banks upstream of the Narrows have healed or been repaired, but sand from isolated sections below the Narrows still washes into the reach below the Robinson Canyon where it forms extensive flats in shallow glides and riffles and fills pools. When this sand embeds more than one-half the vertical dimension of the cobble, the number of steelhead reared during late summer declines from about 0.10 to less than 0.02 fish per square meter, a five-fold reduction. Because of this, most juveniles in embedded sections of the river are distributed along the banks where they can hide under overhanging vegetation, emergent cover, or woody debris.

Upstream of the Narrows, where cobble and boulders are more abundant, embeddedness is usually lower and most often influences habitat quality only in long, slow moving runs and glides. This pattern of lower embeddedness in the reach upstream of the Narrows has been influenced by San Clemente Reservoir, which has trapped and prevented transport of most fine-grained sediment into the reach below San Clemente Dam. In habitats between San Clemente Reservoir and Los Padres Dam the embeddedness levels are usually within the ideal range for rearing high population densities of juvenile steelhead, except in the one or two years following episodic floods that cause erosion and sediment transport from the Cachagua Creek Basin (**Figure 5.5.1.6-L**).

7. Mobilization of sand and silt within the inundation zone at San Clemente Dam, transport and deposition in the main stem downstream of San Clemente Dam – Currently, San Clemente Reservoir is nearly filled with sediment (**Figure 5.5.1.6-M**). In the near future, the late fall, winter, and spring runoff between the dams will increase the transport and passage of fine-grained sediments and suspended sediments through the reservoir and over the dam. In addition, the

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[27] Review of the development and application of the embeddedness index is provided in Bjourn, T.C. et al., 1977. Transport Of Granitic Sediment In Streams And Its Effects On Insects And Fish. Completion Report, Project B-036-IDA, Bulletin 17, Idaho Cooperative Fishery Research Unit, University of Idaho, Moscow, ID. The index is a measure of the relative depth to which coarse-grained material (gravel, cobble, and boulder) is buried in sand and finer-grained material. For example, an index of 0.5 means that one-half of the diameter of coarse-grained material is buried by finer-grained material.

[28] Kelley, D. W. and D. H. Dettman. 1980. Relationships between rearing habitat, substrate conditions, and juvenile steelhead populations in Lagunitas Creek, Marin County, 1979. Report submitted to Marin Municipal Water District, Corte Madera, CA. Steelhead population density was inversely related to embeddedness levels with about one-fifth the number of fish reared per unit area in habitats where embeddedness increased from 0.2 to 0.5 units.

[29] Kelley, D. W. and D. H. Dettman. 1981. The Zayante Dam Project, measures to make it compatible with fish and wildlife resources. Report submitted to the City of Santa Cruz Water Department, Santa Cruz, CA.

[30] Curry, R. and G.M. Kondolf. 1983. Sediment Transport and Channel Stability, Carmel River, CA. (draft)

California Department of Water Resources Division of Safety of Dams has ordered Cal Am to bring San Clemente Dam up to current standards for seismic safety of dams. All of the alternatives currently being considered to meet this order have the potential to exacerbate the problem of passage fine sediments.

The linkage between benthic macroinvertebrate populations that exist in channel substrates and the steelhead population in a stream is well established in the literature. Juvenile steelhead are known to opportunistically feed on drifting aquatic insects and their larvae. In systems similar to the Carmel River, where water temperatures are a challenge to steelhead during summer months, more food (i.e., drift and benthos) in the system increases the energy available to the juvenile population as a whole. Scant food supplies, which are associated with highly embedded streams, combined with high temperatures, would be highly detrimental, leading to low growth and survival and lower overall production. This type of impact would reduce the adult returns in the Carmel River to even lower levels than existing conditions, similar to those found in the main stem and tributaries of the Salinas and Pajaro Rivers.

The level of suspended and fine-grained sediment will soon increase in the river below San Clemente Dam, increasing the likelihood that the streambed will become sandier and more embedded. Depending on the alternative selected to achieve a safe condition at San Clemente Dam and on the mitigation measures implemented with the project, the increased passage and deposition of fine-grained sediment may reduce the suitability of rearing habitats and production of the juvenile steelhead population. A thorough analysis of these alternatives in relation to sediment mobilization, sediment transport and potential streambed deposition is needed to make an informed decision on the best alternative for the seismic retrofit. This task is beyond the scope of the current biological assessment.

Regardless of the alternative selected for San Clemente Dam, it may be important to manage the sediment production from selected tributaries, canyons, and roadsides in the basin downstream of Los Padres Dam as a way to minimize the impacts of increased transport of fine material through San Clemente Reservoir. MPWMD sampled grain sizes and cobble embeddedness at key sites in the main stem in 1990 and other discrete measurements were made in 1984 and 1989.[31] This historical monitoring shows that embeddedness is generally low and that in riffles the predominance of cobble and boulder particles is similar in the reaches below both dams (**Figure 5.5.1.6-N**). In the pool and glide habitats between the dams, the predominance of cobble and boulder has not equaled the levels immediately below San Clemente Dam, presumably due to the greater period of time that San Clemente Reservoir has trapped sediment. In 2000, monitoring of substrate sizes and embeddedness was added as a regular component of the benthic macroinvertebrate and juvenile population surveys. In the future, this data can be used as a baseline for historical conditions, comparisons to other streams, and the development of management goals.

<u>8. Historical interruption of streamflow at San Clemente Dam</u> – Prior to 1997, Cal Am annually raised the spillway gates and installed stoplogs at San Clemente Dam during the spring to increase the usable storage in the reservoir. The period between initial closure of the gates and

[31] D. H. Dettman. 1999. Inventory of Substrate Data for the Carmel River, Monterey County, Ca. Technical Memorandum 99-01. Monterey Peninsula Water Management District. 5pp + Tables and Figures.

subsequent spill lasted from several days to several weeks and as the reservoir filled, the streamflow declined in the river downstream of the dam, thereby blocking migration at the dam and reducing the frequency of openings of the rivermouth. Historically, this flow decline reduced habitats, increased water temperatures, and probably reduced the number of smolts that successfully emigrated to the ocean. Since 1997, this practice has been modified to leave the flashboards out of the spillway gates. This has allowed free passage either over the spillway or down the fish ladder throughout the spring and reduced delays in emigration. Overall, this probably resulted in significant improvements to smolt survival, but the effect has not been well studied with experimental data or observations.

9. Deposition of sand in the Lagoon and lack of surface and subsurface inflow – The combination of no surface freshwater inflow, low subsurface inflow and extensive sand deposits in the Lagoon results in undesirably high water temperatures, low dissolved oxygen (DO) levels, high salinities, and shallow water depths. The shallow water, low DO, and high temperature interact to encourage high levels of bird predation on steelhead and reduce habitats in the lagoon for adults during the winter, for smolts during the spring, and for juveniles during the summer and fall months. These interactions have been known since 1982, or earlier, and were most recently manifested in summer 2004 at the same time that the California Department of Parks and Recreation was constructing a restoration project to increase the area of aquatic, riparian and wetlands habitats in the lagoon.

A long-term solution to the ecological problems caused by the lack of freshwater inflow may involve major reductions in diversions from the Carmel River Basin. In the short term, some relief may be possible by directly injecting surplus reclaimed water into the wetlands surrounding the lagoon. This option is being developed and studied by the Carmel Area Wastewater District, as part of their current project to retrofit the Treatment Plant located next tot he Carmel River and Forest Lake facilities for storing water. Under emergency conditions, it may be possible to use wells in the vicinity of Highway One to temporarily inject water directly into the lagoon, as was done during summer 2004.

Ultimately, the long-term solution to the lack of dry-season surface and subsurface inflows to the Lagoon needs to be addressed as part of a project(s) to reduce the export of groundwater out of the Carmel River Basin, particularly during summer months. The level of reduction needed to result in meaningful improvements is probably on the order of several thousand acre-feet per year. Efforts by Cal Am, MPWMD, and Monterey County to develop either a Desalination Project or large Aquifer Storage and Recovery project in the Seaside Basin to offset a major portion of Cal Am's summer diversions from the basin would improve conditions in the Carmel River Lagoon for steelhead and other aquatic resources.

10. Loss of surface storage in Los Padres Reservoir and impacts on extent of aquatic habitats and water temperature below the dam – Currently, the maintenance of surface streamflow during the dry season is managed through a cooperative Memorandum of Agreement (MOA) signed by Cal Am, the CDFG, and MPWMD, and is affected by Cal Am's Conservation Agreement with NOAA Fisheries. While the MOA specifies releases of natural inflow and a portion of water stored in Los Padres Reservoir, the success of this management approach is directly linked and dependent on the maintenance of existing storage volume in Los Padres Reservoir. Currently, no program exists to maintain the storage in the reservoir, so it is gradually filling with sediment at the average rate of about 20 acre-feet per year. Importantly, this average rate is rarely realized and filling tends to fluctuate widely in response to episodic floods, droughts and fire. For example, following the 1987-1991drought and 1995-98 floods, the reservoir lost about 600 acre-feet of storage as storage was reduced from 2,179 AF to 1,569 AF.

The impacts of this storage loss are manifested in two important ways for steelhead and all other aquatic life that depend on surface flow. First, as the storage gradually diminishes, the ability to release sufficient flows to balance evaporative losses and diversions is reduced. This impact has been well studied in several MPMWD EIRs on water supply alternatives and most recently was described as an impact of the No Project Alternative in the December 2003 Administrative Draft EIR on Water Supply Projects in Volume II, Appendix C.[32] Second, as the storage is depleted, the ability and flexibility to maintain suitable water temperatures for cool water species including steelhead, California red-legged frogs, and other native invertebrate species is reduced.

With existing storage of about 1,569 AF, streamflow and adequate temperature can be maintained downstream of the Narrows to Robinson Canyon or Schulte Road during most years. But, as the reservoir fills during the next 15-30 years, these attributes would be lost if flow at the Narrows declines below the combined levels of groundwater pumping associated with Cal Am's recognized rights (3,376 AF/yr) and other private water systems (about 3,000 AF/yr). Should this occur, the persistence and extent of habitats downstream of the Narrows will fade as there would be only brief periods of early summer flow for a little more than a mile, or so, of stream. In the reach upstream of the Narrows, streamflow is likely to be higher than natural (unimpaired) conditions for the next 15 years. But, after this period flows between San Clemente Dam and the Narrows will likely decline below natural levels. Eventually, the benefits of surface storage will be lost, as the value of aquatic habitats are reduced to essentially zero when the streamflow drops to lethal levels, especially in below normal, dry, and critically-dry years (**Figure 5.5.1.6-O**). Preventing the impact over the medium- to long-term will require a project to maintain, recover or perhaps slightly increase storage in the reservoir, depending on how long it takes to implement the project. Though not well studied, it may be possible to increase the storage to levels somewhat above the 1948 as-built level by excavating within the watermark of the original reservoir.

Recommended List of Projects to Restore/Maintain Freshwater Habitats and Steelhead Production – The purpose of this section is to recommend a range of specific projects designed to improve the environment for steelhead and other native aquatic species that depend on or interact with steelhead in the Carmel River. The list and a brief description of projects follow:

1) Streamflow Restoration and Supply Augmentation – As highlighted in the last section and referenced throughout this assessment, steelhead and other native aquatic species in the Carmel River depend on adequate levels of streamflow. For the Carmel River, this is important because the existing annual diversions exceed inflow in several months of most years, resulting in drying of the lower river. Addressing this impact at the annual level of 10,700 acre-feet as required by the SWRCB will require development of a relatively large alternative source, which is likely to take at least several more years. In the meantime, significant restoration of aquatic

[32] Jones and Stokes. 2003. Draft Environmental Impact Report, Volumes I &II. Prepared for the Monterey Peninsula Water Management District. 18 Chapters (Volume I) and 7 Appendices (Volume II).

habitats could be realized by one or more projects. For example, expansion of MPWMD's Pilot Aquifer Storage and Recovery Project in the Seaside Basin, which utilizes excess/surplus winter flows from the Carmel River Basin as a source of recharge in the Seaside Coastal Aquifer. This project, though relatively small at the present time, could be expanded to divert up to ~1,000 to 1,500 acre-feet per year. This quantity of stored water in the Seaside Basin, if made available at nominal rate of 2-3 cfs during the dry season, could obviate the need for Cal Am pumping upstream of Schulte Bridge in most years and extend aquatic habitats downstream by an additional one to three miles depending on the water year. Dredging at Los Padres Reservoir, particularly if instituted as a long-term maintenance/restoration project would augment surface storage in a system that depends on storage for creating perennial flow in the reach upstream of the Robinson Canyon.

2) Erosion Control and Sediment Management – Embryos, fry and juvenile steelhead depend on relatively clean substrate to complete their lifecycle phases in freshwater habitats and are sensitive to small changes in the quality of substrate, especially the degree of sedimentation on the streambed. For a myriad of reasons, projects that are designed to reduce soil erosion at the source, or lessen the risk that fined-grained sediment, once mobilized, deposits on the streambed, will have direct beneficial effects on steelhead and other sensitive aquatic species. Based on a review of the results outlined in the chapters on Hydrology and Geology, it is appropriate to focus on small to medium scale erosion control projects in several main tributaries and sub-basins including Tularcitos, San Clemente, and Cachagua Creeks. A primary challenge in the near term will be managing the sediment flux through San Clemente Reservoir as it fills with sediment and a seismic retrofit project proceeds. It is likely that the alternative which allows the most flexibility in controlling transport and release of fine-grained sediment at the retrofitted dam and deposition in the river below the dam will be the most successful in restoring and maintaining critical habitats for steelhead sensitive species. It is beyond the scope of this biological assessment to fully evaluate this situation and recommend the best retrofit project. However, it is reasonable to conclude that additional erosion control projects in tributaries throughout the watershed will assist future management activities at the San Clemente dam site.

3) Gravel/Substrate Management – Projects that are designed to improve passage and transport of coarse-grained sediment around or through both of the dams will directly improve the quality and quantity of spawning habitats for steelhead. While the MPWMD's spawning gravel restoration project has improved spawning habitats below both dams and fish have utilized much of the material added, continuing observations of spawning adults and data from the juvenile population surveys indicates that addition of larger quantities of gravel would benefit steelhead. This is especially the case below San Clemente Dam, where many "restored" gravel patches were perched above the lower water channel by floods in 1995 and 1998, and the material added since that time has moved only a short distance downstream.

4) Barrier Modification and Habitat Expansion – A thorough, detailed survey needs to be completed of all potential barriers to steelhead migration. Nonetheless, there are several known locations were modification of barriers would result in expansion of spawning and rearing habitats for steelhead, including Danish and Black Rock Creeks, where natural barriers limit the passage of adult steelhead. In addition, man-made partial barriers, many road culverts, and some stream crossings in many tributaries could be modified to improve passage and expand spawning

habitats. Specific locations are known on Tularcitos, Potrero, Garzas, San Clemente, and Cachagua Creeks, and Hitchcock Canyon.

5) Large Woody Debris Restoration and Management – Steelhead adults and juveniles rely on woody debris as critical habitat components in freshwater. Small-scale restoration projects to increase the smaller sized fraction of this material can result in direct improvements to steelhead habitats, although by nature, the smaller sized material tends to scour and wash away with high flows. While CDFG has tended to not fund small-scale projects, because the material is not permanent, this logic should be reevaluated in light of widely published literature documenting that the mobility of this material does not lessen its importance in maintaining ecological function for steelhead and other sensitive macroinvertebrates. By its nature, the small sized fraction of LWD is more abundant and although it moves through alluvial systems more rapidly, it is important in the energy budget and habitat forming processes. A major advantage is that it can be added to large-scale restoration projects at a very moderate cost because it does not need to be anchored. For these reasons, and the fact that historical efforts to remove living riparian vegetation may have affected the abundance, distribution and diversity of smaller sized fractions, it is important to implement a range of projects to increase the abundance of all sizes of LWD. Fortunately, this is relatively easy to do with small tool/hand cutting and placement and is ideally suited to groups of volunteers.

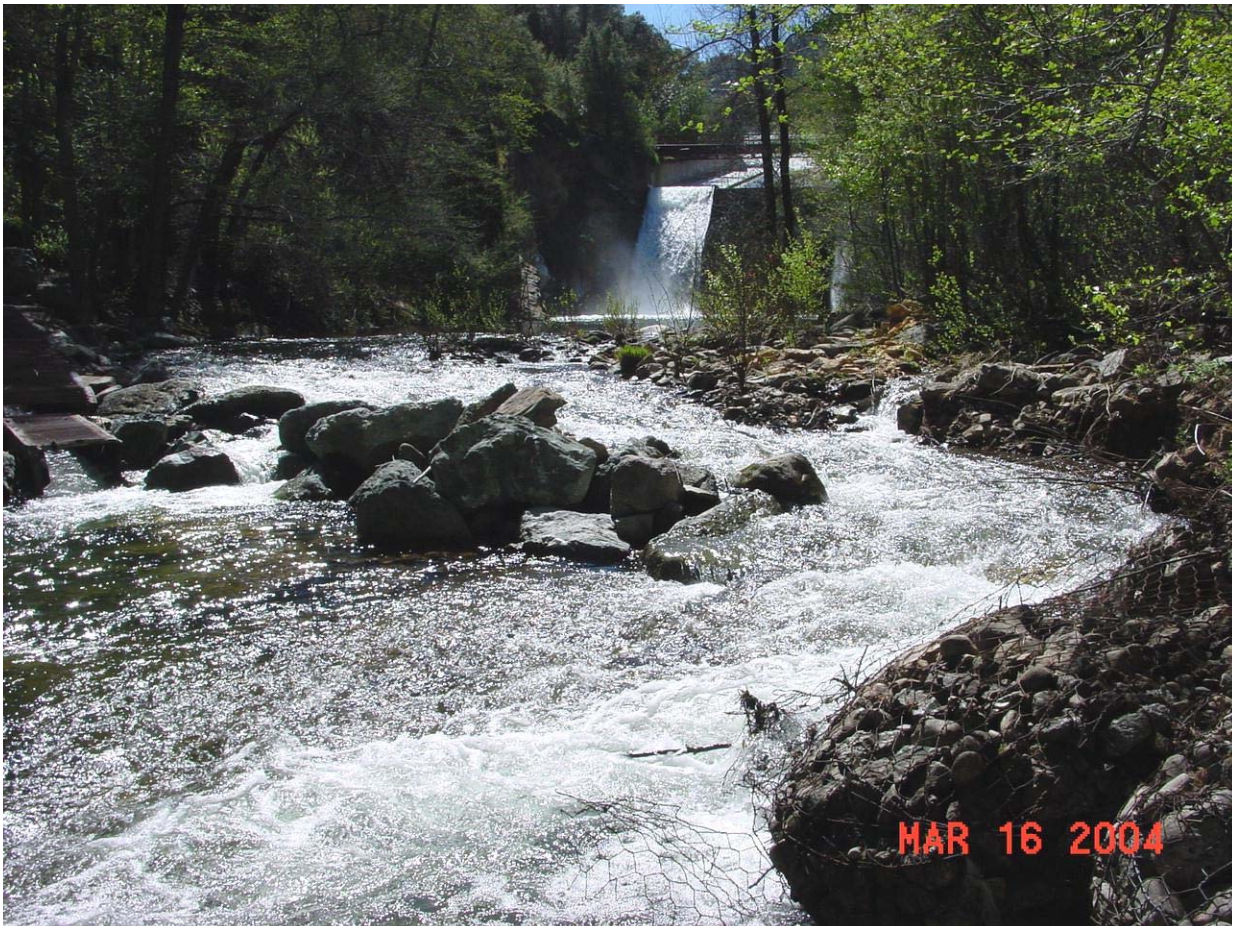
6) Lagoon Restoration and Water Levels – The California Department of Parks and Recreation recently completed Phase I of a project to expand the quantity of aquatic habitats at the Carmel River Lagoon. Depending on how the expanded lagoon interacts with surrounding groundwater and subsurface seeps, the quality of the new and original habitats may be improved. The CDPR should monitor water quality in the lagoon and adaptively manage the situation to maintain improved environmental conditions for steelhead and other sensitive species, notably the California red-legged frog. Other projects to increase surface inflow during critical periods should be investigated and implemented, if feasible. This includes the CAWD's concept of discharging tertiary treated water onto the surrounding wetland habitats and the CDPR's temporary, emergency discharge from their wells near the Highway One Bridge. Another project worthy of implementation would be a surface drain on the lagoon to allow a moderate level of control on the water surface elevation during late fall and early winter, when it becomes necessary to breach the river mouth for flood protection. Operation of a drain could effectively forestall the need to open the lagoon too early, when steelhead juveniles are not adapted to seawater and it could be used to somewhat regulate salinity levels by preferentially releasing highly, saline bottom water.

8) Water Temperature Management – The need to manage water temperature will become more important as Los Padres Reservoir fills with sediment. Currently, the water released during late summer and early fall is often too warm good growth of steelhead and may affect the abundance and distribution of benthic macroinvertebrates. Compounding the high temperature water is the tendency to release hydrogen sulfide laden water, especially just prior to the fall turnover in the reservoir. One project for effectively dealing with these problems is to increase reservoir storage, but this could be time consuming and take several decades to implement. An alternative project to manage water quality would be construction and operation of a "cooling tower" similar in concept and design to the tower used by the MPWMD to cool intake water at

Sleepy Hollow Steelhead Rearing Facility. This device would be very efficient in cooling water, especially in the hotter, drier climate at Los Padres Dam and would eliminate the problem with hydrogen sulfide and accompanying low dissolved oxygen.

9) Enhancement of Benthic Macroinvertebrate Production – Increasing the abundance and diversity of aquatic insects species will enhance benthic macroinvertebrate production and lead to higher growth rates and production in the juvenile steelhead population and other species that feed on the invertebrates. This can be accomplished by implementing three projects specifically designed to improve steelhead habitats, including restoration of gravel deposits, planting riparian vegetation along the stream edge and in the floodplain terraces, and direct placement of smaller sized fraction of LWD into the stream. The latter two projects are especially important in sandy reaches downstream of the Robinson Canyon where overhanging vegetation and LWD function as critical habitats for steelhead and the insects that form the base of the food chain. Enhancement of benthic production in these areas functions to provide higher food resources for steelhead in habitats where the water temperature is outside of the optimal range for growth and dampens the detrimental effects of warmer water.

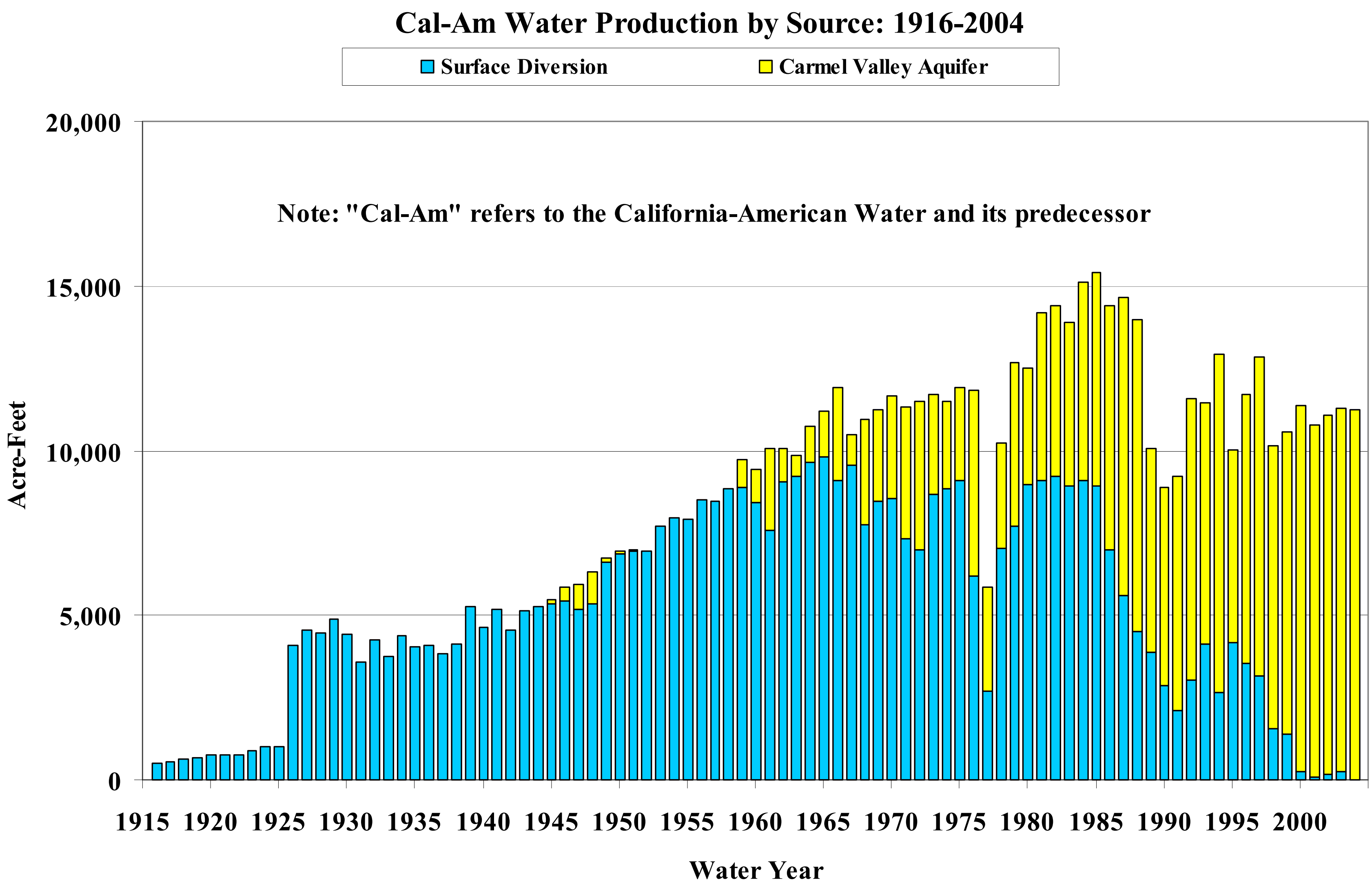
Figure 5.5.1.6-A



Source: Dave Highland, CDFG

Photo of Rock Gabion Structure below Los Padres Dam, constructed in spring 2004 to guide steelhead around old fish ladder and into plunge below the dam. Streamflow at time of photo was 67 cfs. Note: old wire basket material in lower right-hand corner was removed on March 29, 2004.

Figure 5.5.1.6-B



Production values for the 1916-1978 period from Cal-Am Exhibit 90 at the 1992 State Water Resources Control Board hearings regarding Cal-Am's diversions from the Carmel River system. Production for the 1978-2004 period were compiled by the Monterey Peninsula Water Management District from monthly production reports submitted by the Cal-Am's Monterey Division.

Figure 5.5.1.6-C

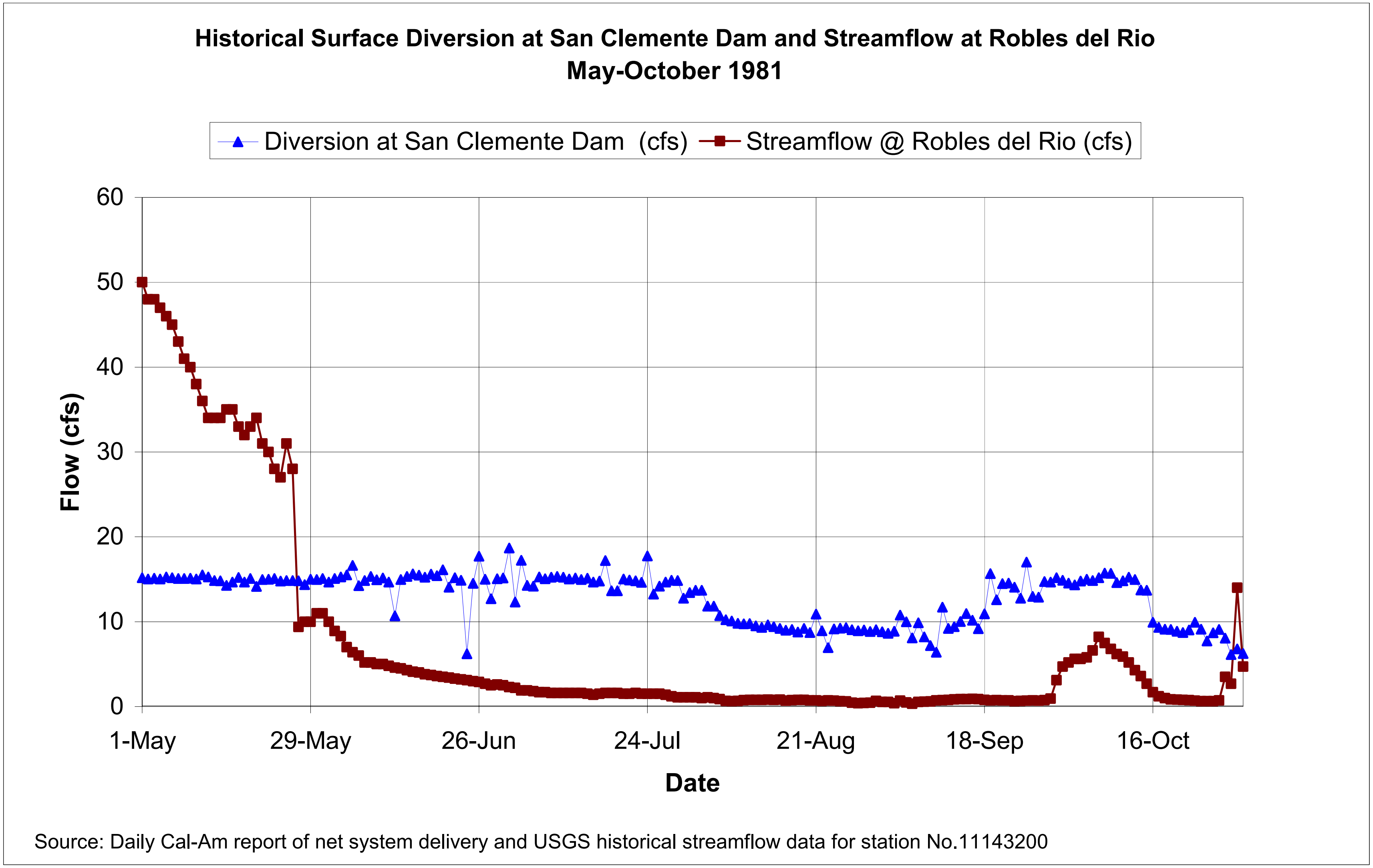


Figure 5.5.1.6-D

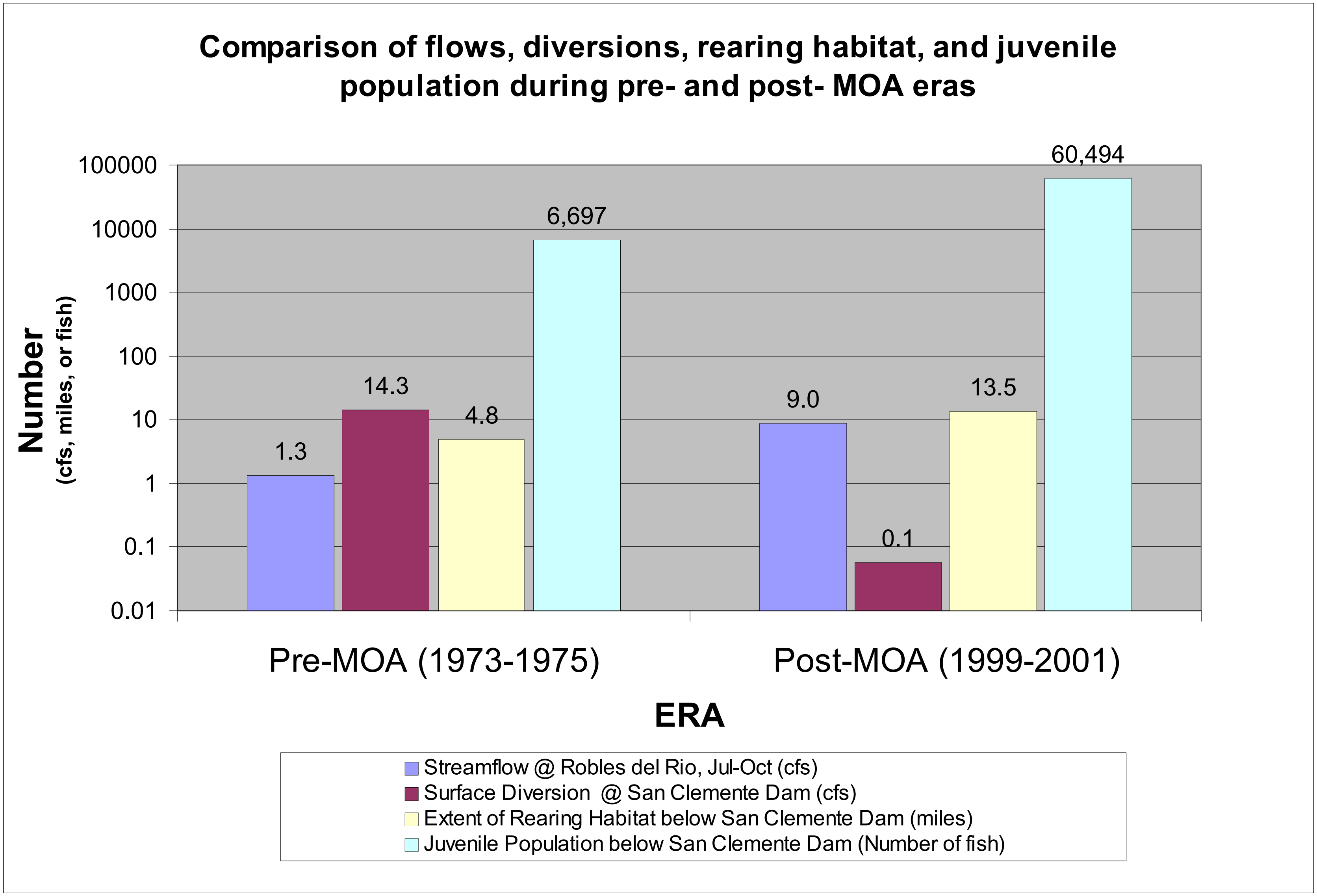
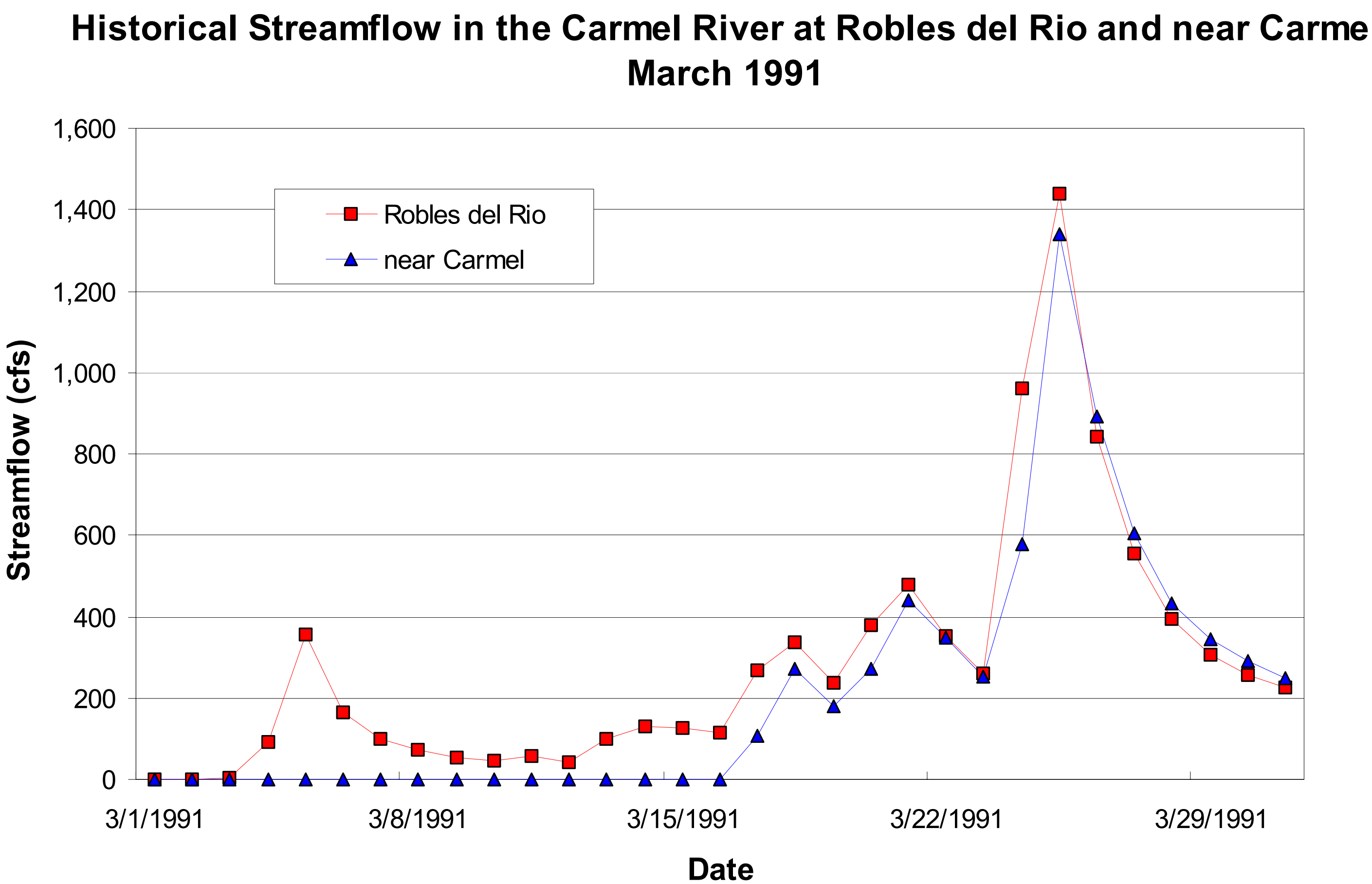


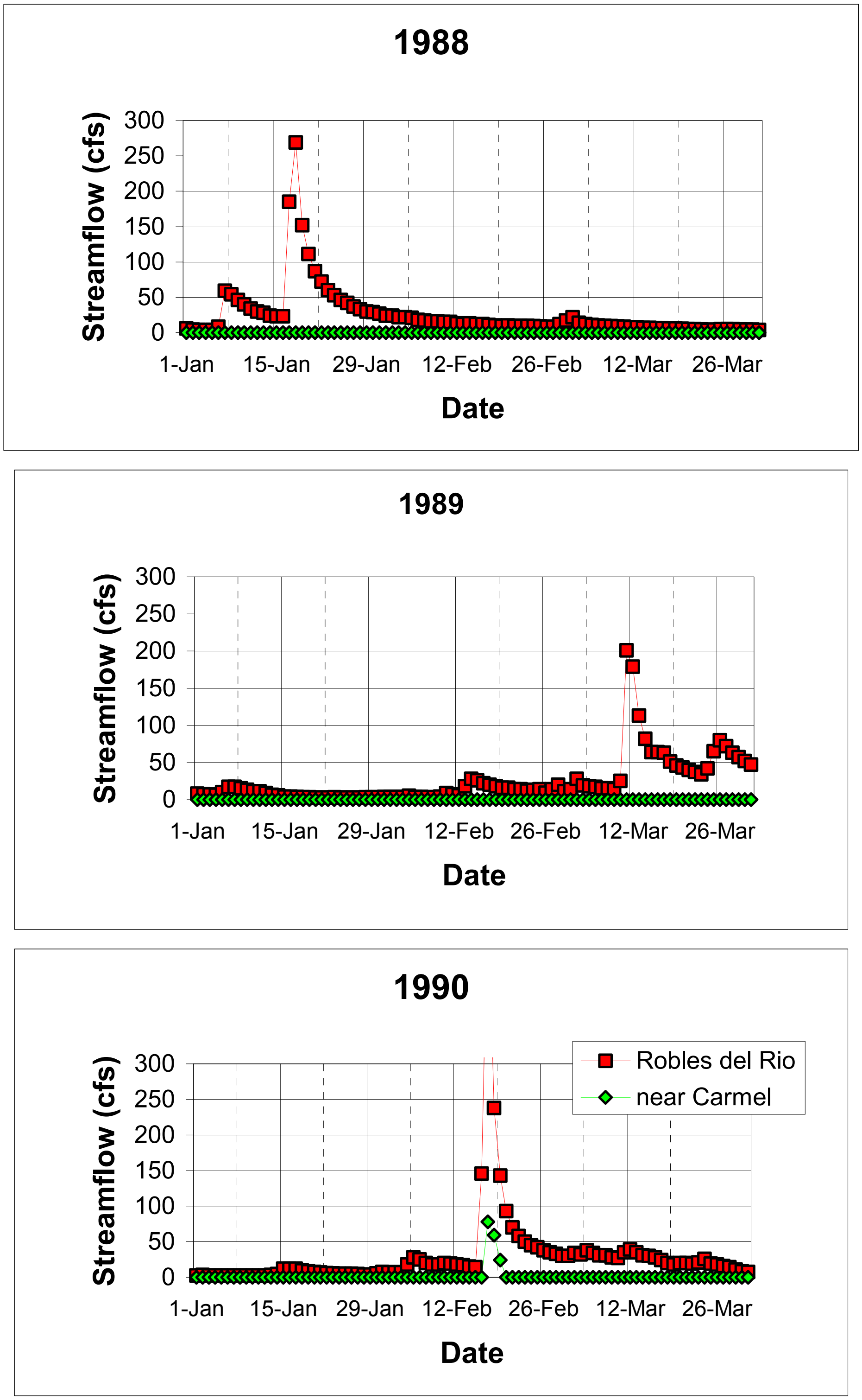
Figure 5.5.1.6-E



Source: Trujillo, L.F. 1992. Water Resources Data, California, Water Year 1991. Volume 2. Report No. CA-91-2. USGS, 315 pp.

Figure 5.5.1.6-F

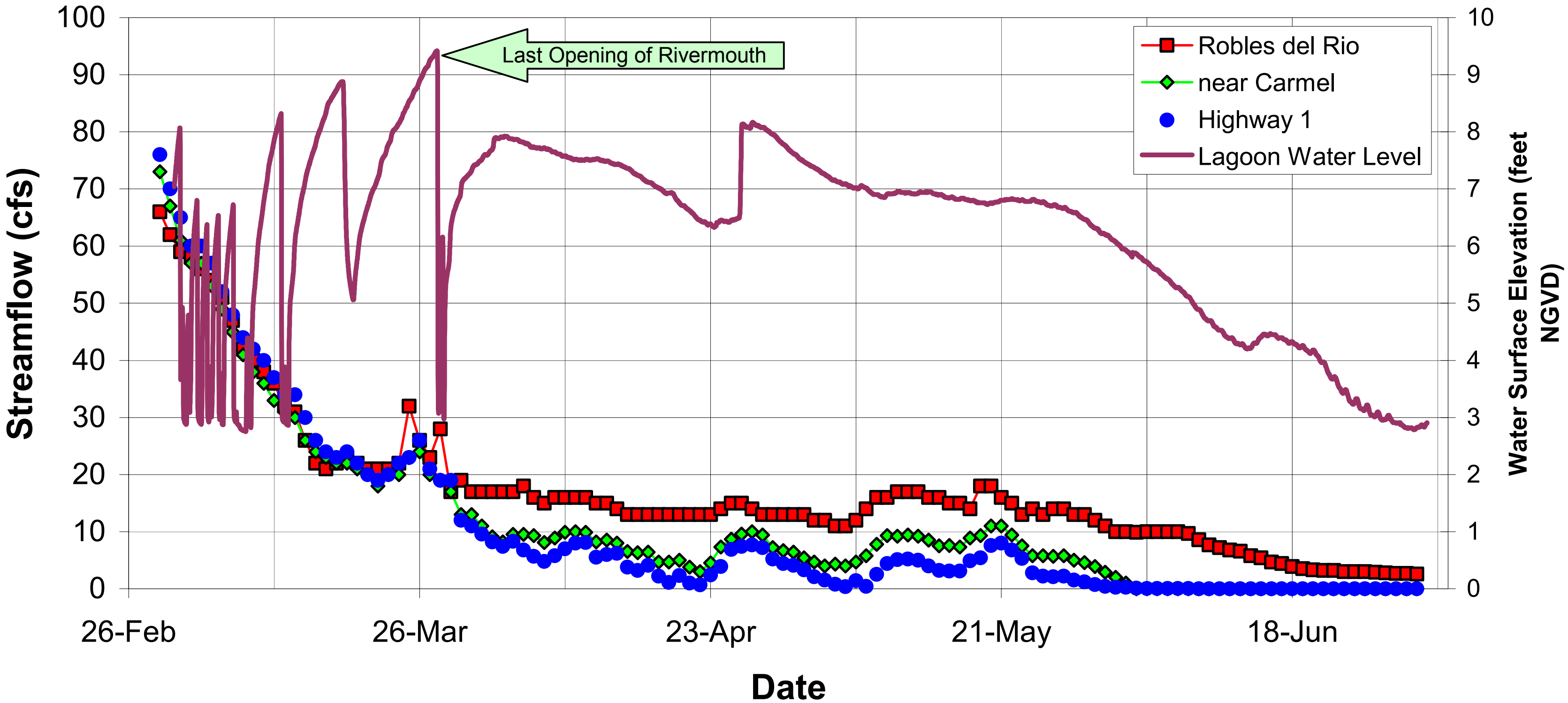
Historical streamflow in the Carmel River at Robles del Rio and Near Carmel January-March 1988, 1989, and 1990[33]



[33] Trujillo, L. F. 1992 Water Resources Data, California Water Years 1988, 1989, & 1990. Report Nos. CA-88-2; CA-89-2; and CA-90-2. U.S. Geological Survey.

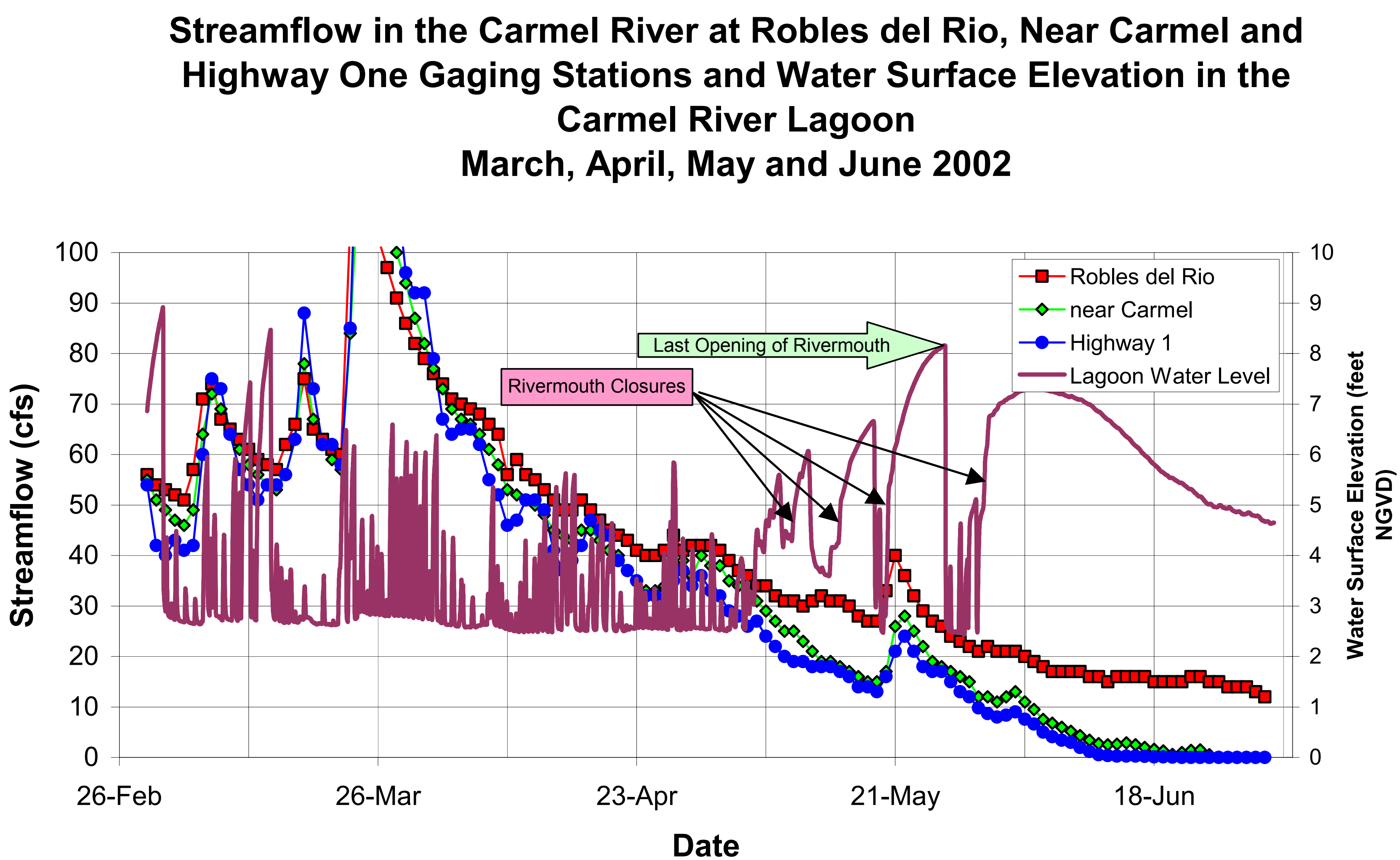
Figure 5.5.1.6-G

Streamflow in the Carmel River at Robles del Rio, Near Carmel and Highway One Gaging Stations and Water Surface Elevation in the Carmel River Lagoon
March, April, May and June 1994



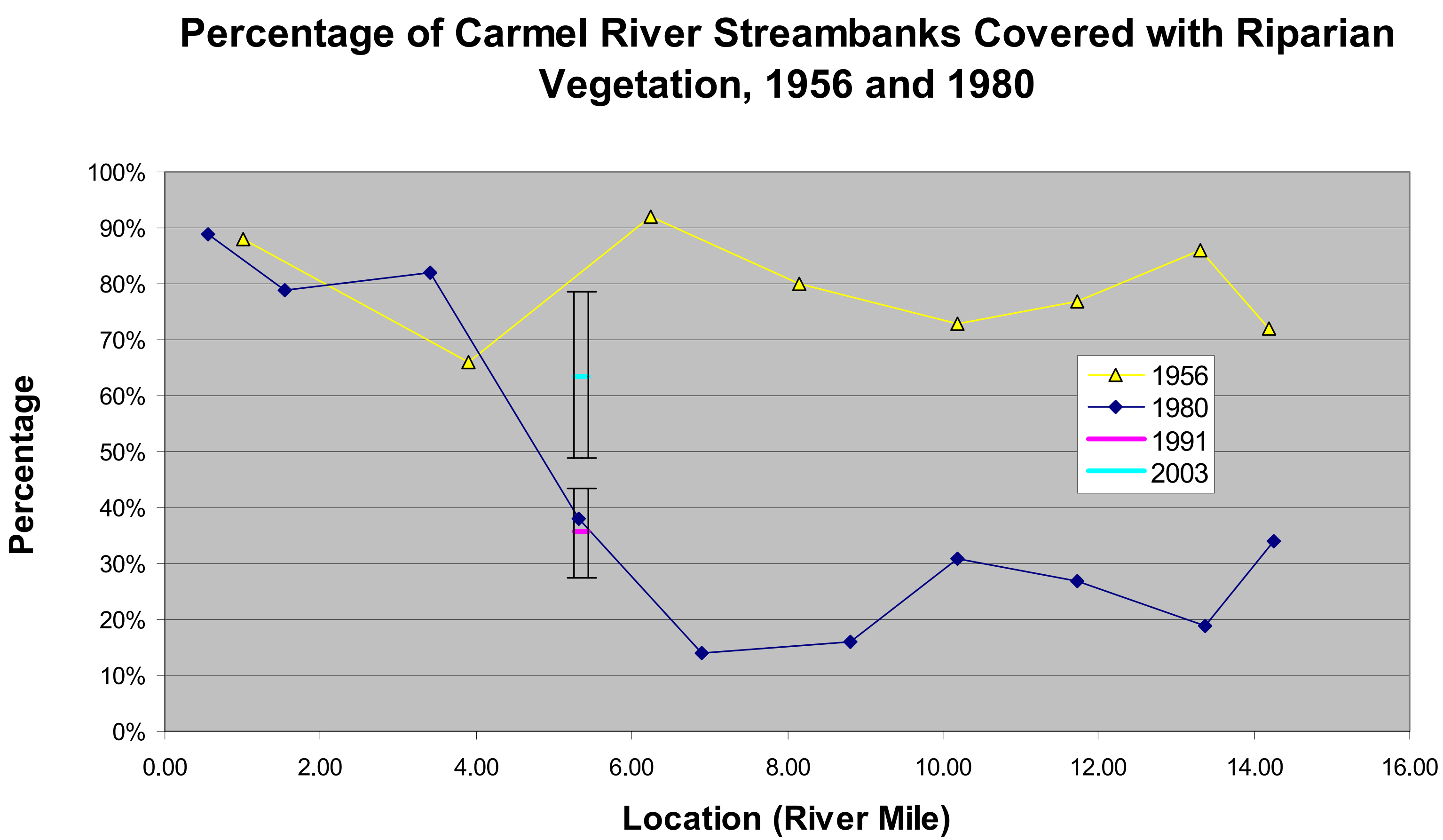
Source: U.S. Geological Survey and Monterey Peninsula Water Management

Figure 5.5.1.6-H



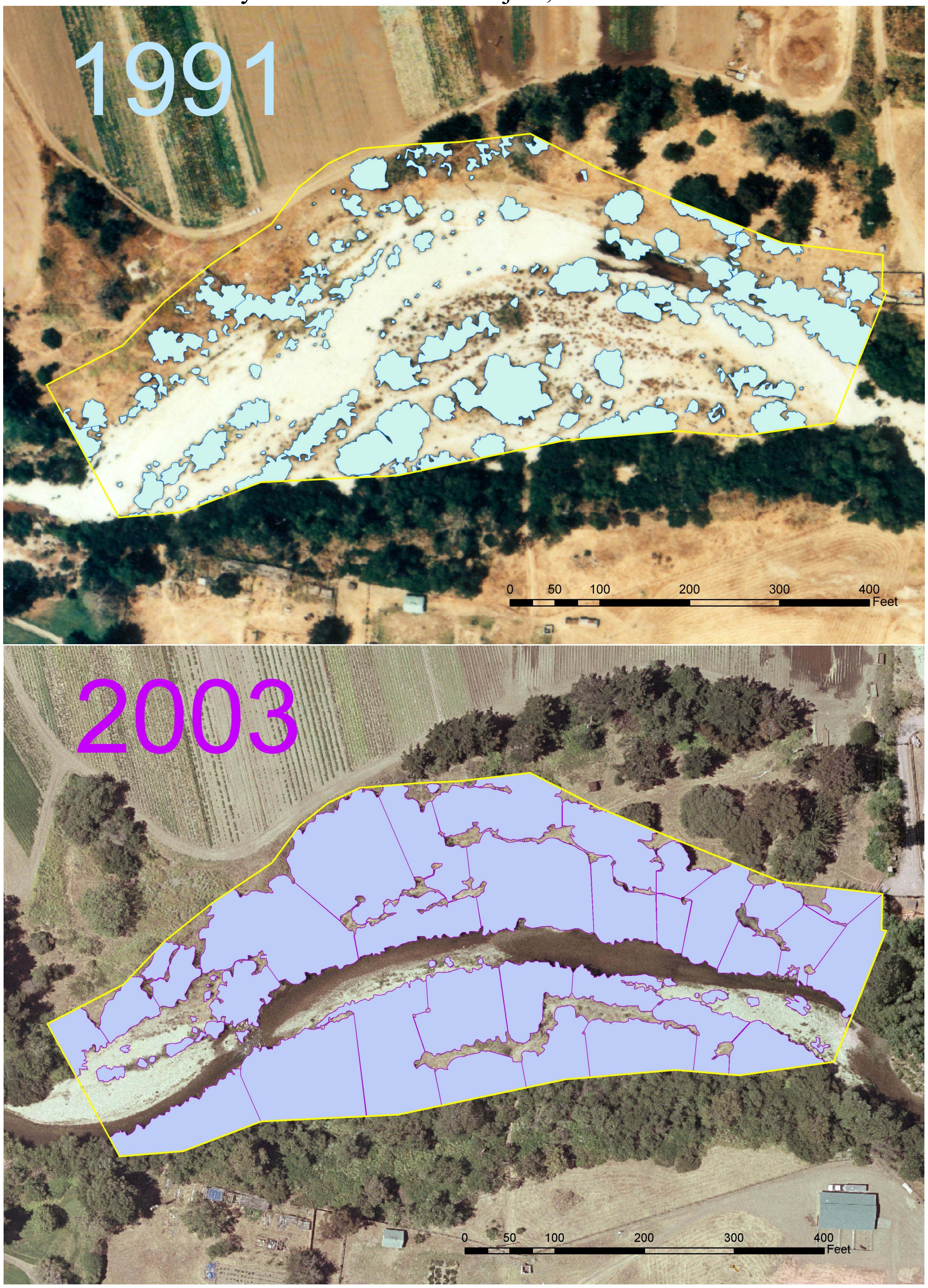
Source: U.S. Geological Survey and Monterey Peninsula Water Management District

Figure 5.5.1.6-I



Adapted from Figure D-5, Li (1983) and based on measurements of the lineal extent of vegetation from aerial photographs. Data for 1991 and 2003 based on measurements from delinated riparian vegetation on aerial photos of the Valley Hills Project by P. Watters. Range of values for 1991 and 2003 shows variation from right to left streambanks.

Figure 5.5.1.6-J
Valley Hills Restoration Project, 1991 and 2003[34]



The areal coverage of the riparian forest increased from 1.4 acres in 1991 to 4.1 acres in 2003 and the percentage of streambank covered with riparian vegetation along the low water channel increased from 36% to 63% as a result of this restoration project.

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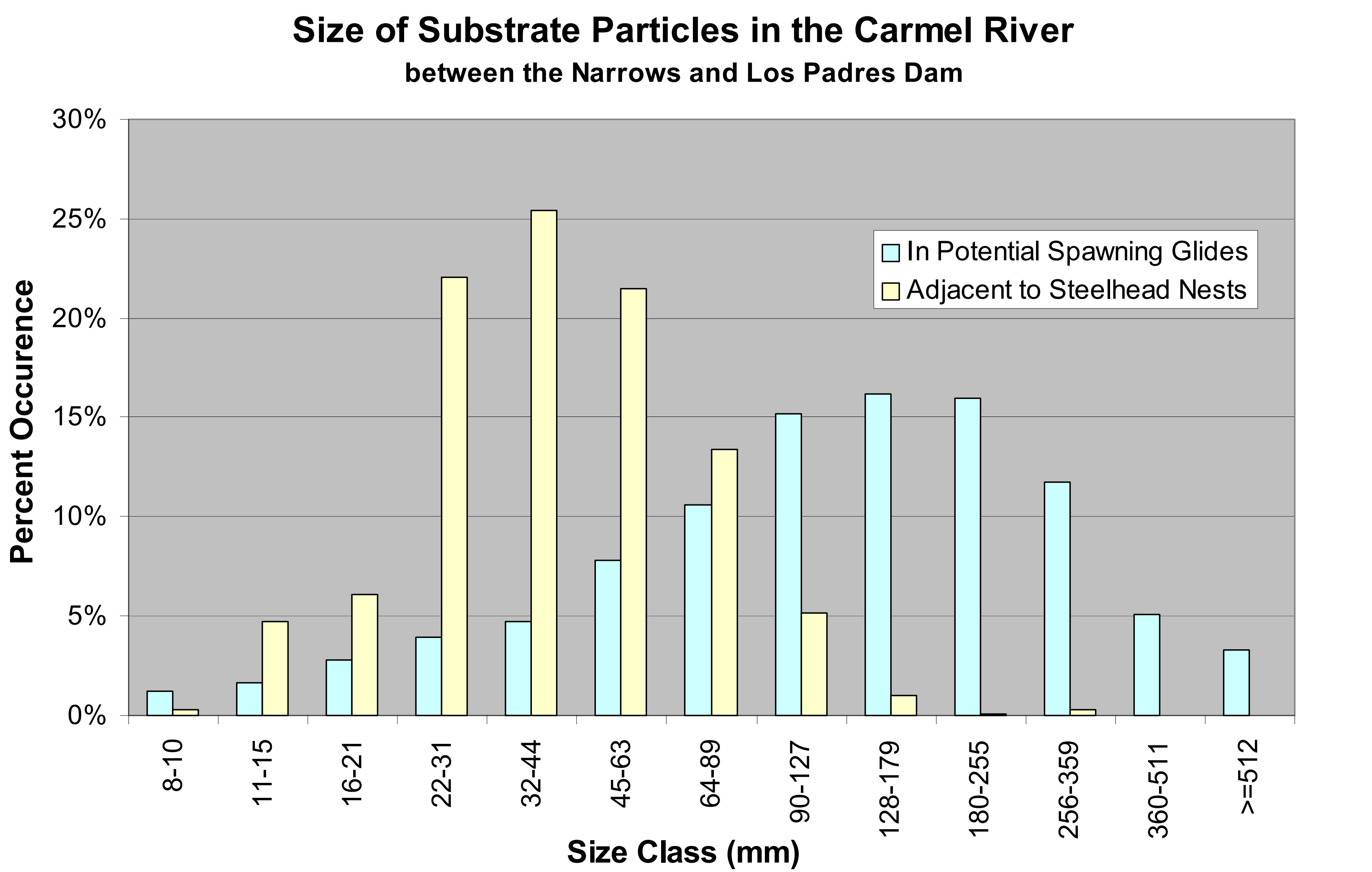
[34] Watters, P.J. 2004. The Valley Hills Restoration Project: Quantification of Riparian Vegetative Cover, A GIS project for the Monterey Peninsula Water Management District.

Figure 5.5.1.6-K



Source: Adapted from Dettman, D. H. 1990. Spawning Habitat Mitigation Plans for Alternative Water Supply Project in the Carmel River Basin. Technical Memorandum 90-01. MPWMD. Based on measurements of surface substrate particle size in 18 potential spawning glides between the Narrows and Los Padres Dam (3,200 particles total, 1989-1991) and adjacent to 15 steelhead nests between Robinson Canyon and San Clemente Dam (1,300 particles total, 1982).

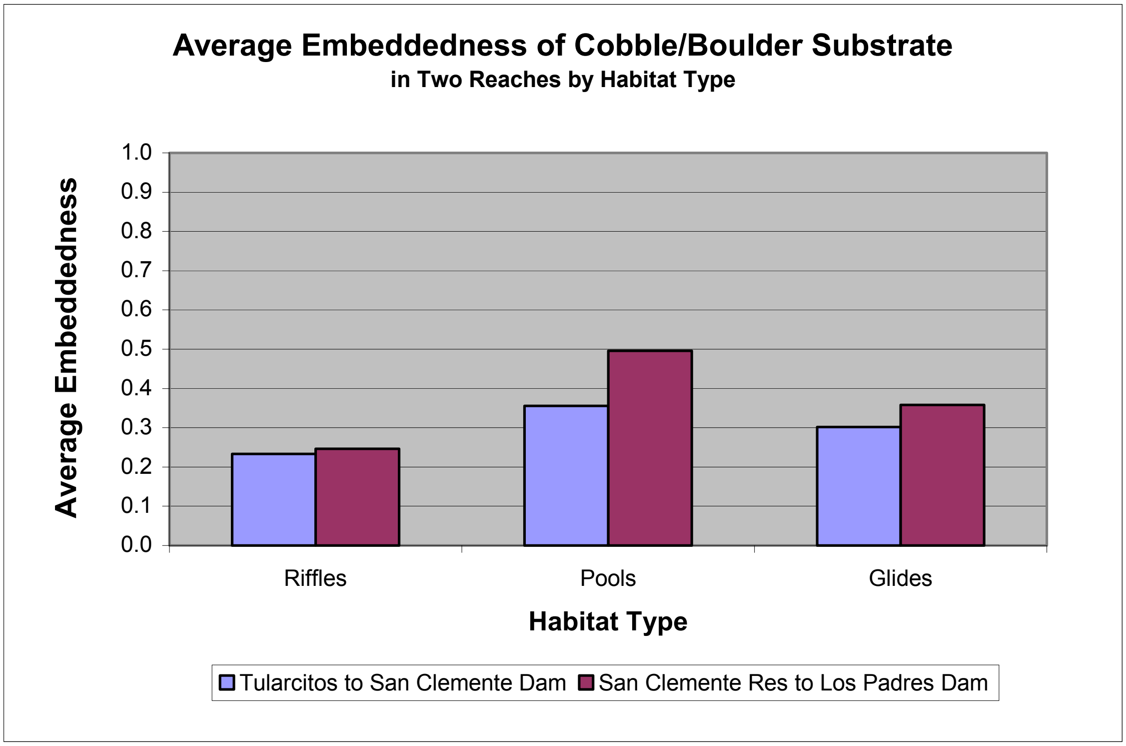
Figure 5.5.1.6-L. Photos of sediment deposition in riffle [upper right], run [upper left] and pool [lower right] habitats of the Carmel River, just upstream of the confluence with Pine Creek, July 1995.

Figure 5.5.1.6-M

San Clemente Dam Inundation Zone
July 13, 2004

Original Photos by David Norris, Cal Am Water
Mosaic by David H. Dettman, MPWMD

Figure 5.5.1.6-N



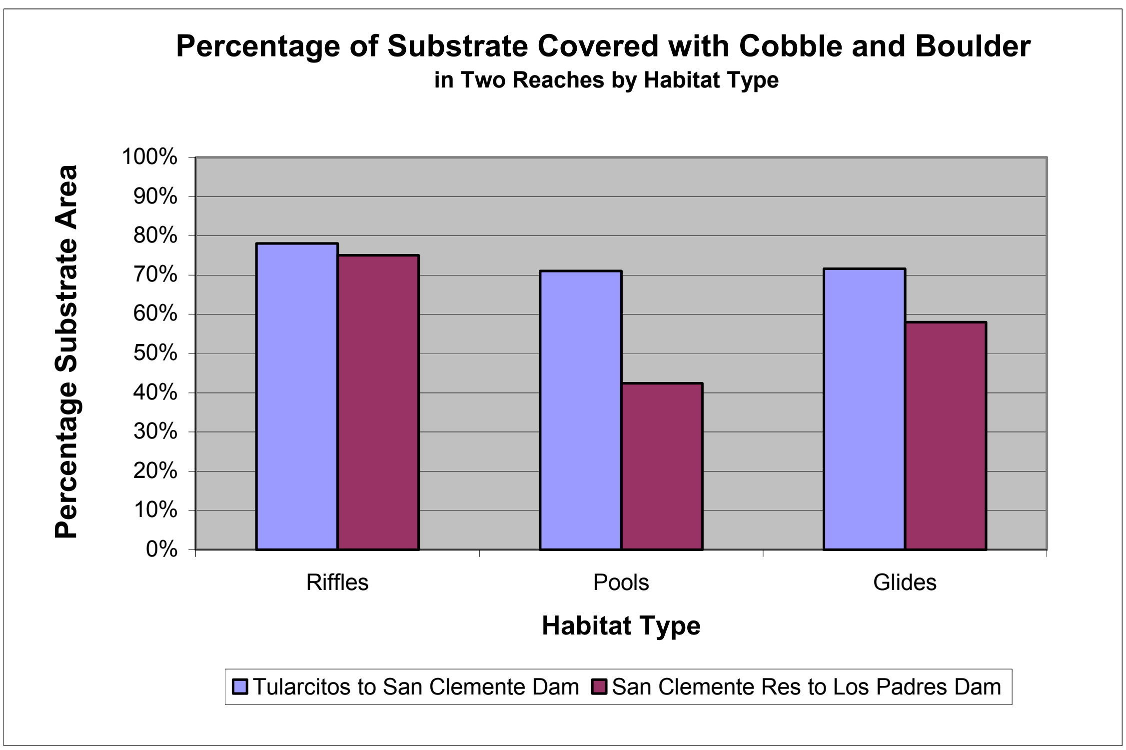
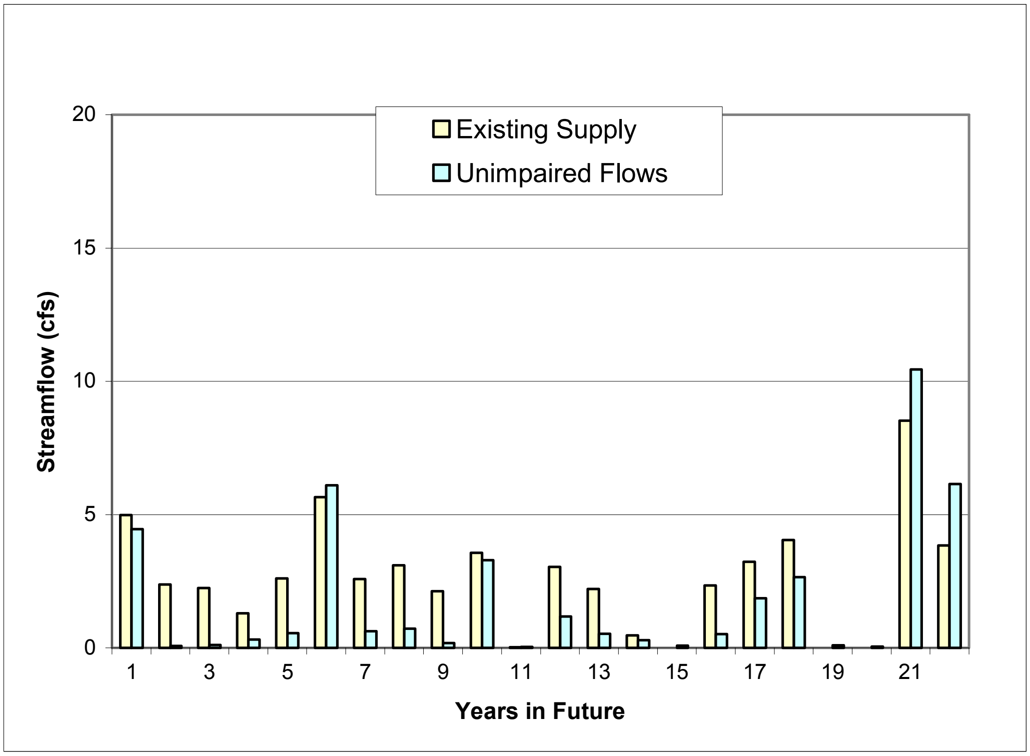
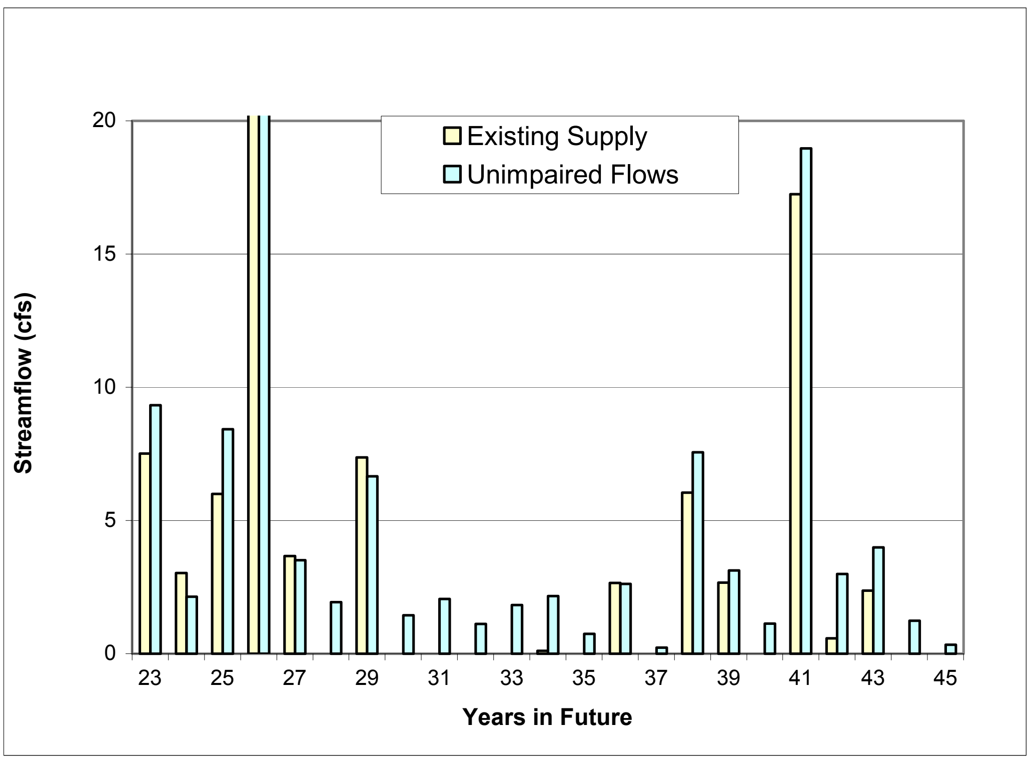


Figure 5.5.1.6-O





Seasonal Minimum 30-day Average Streamflow in the Carmel River at the Narrows with Natural Flows and the Existing Supply Development in the Carmel River Basin,
Years in Future: 1 to 22 (upper graph); 23 to 45 (lower graph).

SECTION 5.5.2.2

USING GIS TO DOCUMENT CALIFORNIA RED-LEGGED FROGS (*Rana aurora draytonii*) & THEIR REPRODUCTIVE HABITAT WITHIN THE CARMEL RIVER WATERSHED

SEPTEMBER 2004

PREPARED BY:
JESSICA WHEELER, FIELD BIOLOGY ASSISTANT

Objective

Geographic Information Systems (GIS) was used for the analysis of California red-legged frog (CRLF) (*Rana aurora draytonii*) locations and habitat characteristics to determine the CRLF population distribution, reproductive habitat, and potential reproductive habitat within the Carmel River Watershed. This GIS database will serve as a tool to enable the Monterey Peninsula Water Management District (MPWMD) to track the CRLF population in restoration projects and to evaluate how water resources affect CRLF habitat on the Carmel River, Monterey County, California. It will also serve as an educational tool for other public agencies and the community to gain understanding about the ecology of CRLF in our region.

Introduction

MPWMD has recorded sightings of CRLF along the Carmel River since 1989. On June 24, 1996, pursuant to the Endangered Species Act of 1973, CRLF were determined to be a "Threatened" species. The distribution of CRLF within California has been reduced. Therefore, the population of CRLF within our region becomes important for the recovery of the species within California (Map 5.5.2.2-1 historical and current CRLF range). Although the main goal of this report is to summarize information about CRLF reproductive habitat, adult CRLF distribution and movements throughout the entire watershed should be considered to understand CRLF ecology.

Many of the tributaries and adjacent ponds have not been surveyed and/or the survey data is outdated. There is a substantial survey bias for CRLF in the main stem of the Carmel River while the data is scant for the rest of the watershed. A summary of all surveyed areas included in this report is shown in Map 5.5.2.2-2. Map 5.5.2.2-3 summarizes reports of all CRLF sighting data (all life stages) that were gathered.

Methods

CRLF data for the Carmel River watershed were gathered and consolidated into databases and mapped using ArcView 8.3. This information follows in three sections below.

I. Data Sources
II. Data Organization
III. Data Analysis of Potential Reproductive and Reproductive Habitat (Mapping)

I. Data Sources

The data for this project came from five main sources:

A. CRLF survey data from the *Interim Draft of the Biological Assessment of CRLF for the Carmel River Dam and Reservoir Project, Monterey County* (Ecosystems West Consulting Group, 2001) was reviewed for all CRLF location and life stage references.

1. The above biological assessment was created from two data sets. A portion of the MPWMD data set was created from historical data that is summarized below (a). The 2000 data were collected by Ecosystems West Consulting Group(b).

a. MPWMD CRLF sightings from 1989 to 2000 were used to document existing conditions at the San Clemente Reservoir site and 18 miles of CRLF habitat between the San Clemente Dam and the Carmel River Lagoon.

b. GPS data collected in 2000 were used to define CRLF habitat along 11 miles of the main stem from the San Clemente Dam upstream through the proposed Carmel River Dam and Reservoir project area and ending one mile upstream of the proposed inundation zone.

These locations were plotted in digital format on orthophotographs from the hard copy of the report maps (annotated Power Point maps on scans of color aerial photographs). Digital raster graphs of USGS topographic maps were also used. The GPS data were not post-processed; however, all data point placement was corrected on the orthoimagery. These data sets were then reviewed by MPWMD staff and Dawn Reis, the principal investigator and author, to ensure positional accuracy.

B. Additional MPWMD historical records were summarized to complete the MPWMD data set.

1. MPWMD's incidental CRLF sighting data obtained during steelhead rescues (2000-present) and from river monitoring activities were incorporated into the database.

2. MPWMD's river restoration pre-project surveys were summarized and incorporated into the database. This included the *CRLF (Rana aurora draytonii) Monitoring Report for the Carmel River In-Stream Habitat Restoration Project at DeDampierre Park, Monterey, California (*Reis, 2002).

3. Data were used from a GIS class project done by Cameron Chabre at California State University Monterey Bay.

C. The Mullen data set was created from David Mullen's original survey notes and maps from his 1993 contract with MPWMD (Mullen, 1994). These notes were reviewed for information that was not included in the *Interim Draft of the Biological Assessment of CRLF for the Carmel River Dam and Reservoir Project, Monterey County* (Ecosystems West Consulting Group, 2001). Additional layers were created from Mullen's data that show the location of the tributaries and ponds that were surveyed. These layers are represented on Map 5.5.2.2-2.

D. The 2002 & 2003 datasets used in this report originated from two reports acquired from the U.S. Fish and Wildlife Service.

1. *2003 Annual Report for Permit #TE-057714-0 Under section 10(a)(1)(A) of the ESA* for submission to the United States Department of Interior Fish and Wildlife Service, (Reis, 2003) Note: This 2002 data summary has a 2003 date.

2. *California Red-legged Frog Tadpole Surveys and Translocations During the California-American Water Company 2003 Water Withdrawal in the Carmel River, Monterey County, CA: The United States Fish and Wildlife Service Biological Opinion (1-8-99-FW-7)*, (Reis, 2003).

The purpose of CRLF surveys in 2002 and 2003 was to identify and monitor potential CRLF tadpole habitat areas of the Carmel River that may be impacted by pumping water from the alluvial aquifer. The resulting dewatering of the river can occur before CRLF tadpoles complete metamorphosis (Reis, 2003 and Reis, 2003). The potential habitat surveys were conducted from Highway one to River Mile 17, which is approximately 1.6 miles downstream of the San Clemente Dam and near the California American Water Company's (Cal-Am) Carmel Valley Filter Plant.

E. Palo Corona CRLF locations were included in CRLF sightings Map 5.5.2.2-3.

Incidental sightings and reconnaissance survey data from the Palo Corona Ranch were used (Lynn Overtree and Dawn Reis unpublished data). These data were edited to include only those CRLF sightings that occurred in the Carmel River watershed with the exception of Animas Pond, which is not in the Carmel River watershed, but does fall within the MPWMD boundary.

F. Surveys have also been carried out at the Santa Lucia Preserve. These location data are included in Table 5.5.2.2-1; however, these data are not on the map as GPS locations were unavailable.

II. Data Organization

The data sets that were derived can be placed into two main categories. These data sets are summarized in Table 5.5.2.2-2.

A. Data that can be queried is one data set.
B. A supplemental or source information data set can be accessed if there are further questions.

A CD of this memorandum includes the ArcGIS 8.3 map documents, shapefiles and associated data sets used for this project. Additional information can be requested from MPWMD.

III. Data Analysis of Potential Reproductive Habitat and Reproductive Habitat (Mapping)

The data sets summarize CRLF habitat within the Carmel River Watershed although there is a substantial survey bias for CRLF in the main stem of the Carmel River. Analysis was done to identify reproductive and potential reproductive habitat. The data were then mapped. The table below summarizes which data sets were used to create each map. Three maps were created from the reproductive habitat data and two maps were created from the potential habitat data.

A. Reproductive habitat was defined by the presence of egg masses and/or tadpoles. The maps listed below identify sites where eggs or tadpoles were present.

Map	**Data Set**
Map 5.5.2.2-4	MPWMD_Hist_Query.dbf Mullen_Query.dbf
Map 5.5.2.2-5	2000PotentialHabitat_CRFLPresenceData.dbf (Queried for known habitat) 2002Tad_Monitoring_Query .dbf
Map 5.5.2.2-6	2003Tadpole_Monitoring_Query Data.dbf

B. Potential reproductive habitat was defined by the presence of substrate for CRLF egg-mass attachment and calm water between the months of March and June. Water velocity is important to consider when evaluating CRLF reproductive habitat. High flow conditions can flush eggs or tadpoles downstream. (Schmieder and Nauman 1994). The maps listed below identify sites that have the potential for egg and tadpole habitat.

Map	Data Set
Map 5.5.2.2-7	2000PotentialHabitat_CRFLPresenceData.dbf 2002Potential_Habitat_Query.dbf
Map 5.5.2.2-8	2003Potential_Habitat_QueryData.dbf

Results

Separation of the data sets for the mapping process was defined by how the data were collected. A discussion of this is included below.

Map 5.5.2.2-2 is a summary of all surveyed areas included in this report. Map 5.5.2.2-3 summarizes reports of CRLF sightings (all life stages) that were gathered. Data from the Santa Lucia Preserve are not on the map; however, it is included in Table 5.5.2.2-1 as GPS locations were not available.

The MPWMD and Mullen data sets represent incidental CRLF tadpole sightings and sightings of tadpoles during surveys for CRLF adults. These data sets show that there are higher concentrations of CRLF reproductive habitat in the areas upstream of San Clemente Dam and in the lower Carmel Valley from Robinson Canyon Road bridge downstream to the Highway One Bridge (Map 5.5.2.2-4).

The 2000, 2002 and 2003 CRLF data sets were collected using identical methodology. Comparative analysis of the 2002 and 2003 CRLF data sets was possible as the data sets were collected in the same area for two consecutive years. The 2000 data was included in this map; however, the data is not discussed in the analysis as only one year of data was available.

In 2002, 67 sites were identified as potential reproductive sites. Actual reproduction occurred in 25 (37%) of these predicted sites. Of the 25 reproductive sites only site (0.021B) occurred in an area that was not designated as a potential reproductive site (Reis, 2003) (Maps 5.5.2.2-5, 5.5.2.2-6, 5.5.2.2-7, and 5.5.2.2-8).

The 2002 survey shows that three reaches of the Carmel River had concentrations of CRLF reproductive habitat (Map 5.5.2.2-5).

1. Twelve sites were in the reach that extended from ~0.82 miles downstream of Schulte Road bridge to ~0.20 miles upstream of Robinson Canyon Road bridge (1.02 miles).
2. Three sites were in the reach that extended from ~0.38 miles downstream of Don Juan bridge to ~0.68 miles upstream of the Don Juan bridge (1.06 miles).
3. Seven sites were in the reach that extended from ~1.14 miles downstream of DeDampierre to ~0.58 miles upstream of deDampierre (1.72 miles).
4. Three additional sites were outside of these reaches.

In 2003, 54 sites were predicted to have potential for reproduction. Actual reproduction occurred in 28 (52%) of these predicted sites. Of the 28 reproductive sites only site G5 occurred in an area that was not designated as a potential reproductive site (Reis, 2003).

In the 2003 survey, three reaches of the Carmel River had concentrations of CRLF reproductive habitat (Map 5.5.2.2-4).

1. Seven sites were in the reach that extended from ~0.41 miles downstream of Schulte Road bridge to ~0.46 miles upstream of Schulte Road bridge (0.87 miles).
2. Six sites were in the reach that extended from Don Juan bridge downstream ~0.46 miles.
3. Eleven sites were in the reach that extended from ~0.89 miles downstream of the confluence with Garzas Creek to ~0.78 miles upstream of Garzas Creek (1.67 miles).
4. Four additional sites were outside of these reaches.

In 2002 and 2003, the potential reproductive habitat extended farther downstream than the actual reproductive habitat. In 2002 there were 13 sites in the reach extending from below Valley Greens Drive bridge to the Highway One bridge that were suitable as reproductive habitat, but where reproduction did not occur or was not successful (compare Maps 5.5.2.2-3 & 5.5.2.2-5). In 2003 there were 9 sites in the reach extending from ~0.33 mile below Schulte Road bridge to the Highway One bridge that were suitable as reproductive habitat, but where reproduction did not occur or was not successful (compare Maps 5.5.2.2-4 & 5.5.2.2-6). Note that the surveys in 2002 and 2003 did not include the Carmel River lagoon.

Discussion

It is likely that the adult CRLF presence is underrepresented in the data sets due to the lack of focused survey efforts for adults. Surveys for adults CRLF need to be conducted during nighttime hours during the spring, summer and fall.

Map 5.5.2.2-2 is a summary of all surveyed areas included in this report. This map may be used as a guide to aid in the determination of where CRLF surveys need to be conducted in the future. All waterways including ponds, tributaries, and vernal pools need to be considered when evaluating CRLF habitat parameters within the watershed. Mark Stromberg of Hastings Reserve recommended summarizing USGS 15 minute quad maps where vernal pools and ponds are brightly colored (1921 reprinted in 1940). Pool locations should be verified in the field and assigned coordinates using a GPS receiver or other similar method for determining location. To understand the CRLF populations, surveys must also be conducted within specific time frames for given life stages with seasonal hydrologic changes considered.

Analysis of the potential reproductive habitat locations and the actual reproductive locations indicated that there were differences. MPWMD historical data (Map 5.5.2.2-4) show that in 1997, 1998, 1999, and 2001 there were 7 CRLF reproduction sites in the lower Carmel Valley between the San Carlos Bridge and the Highway One Bridge. The 2002 and 2003 data (Maps 5.5.2.2-7 & 5.5.2.2-8) show that there was potential reproductive habitat in this reach of the river; however, evidence of reproduction was not observed in this reach (Maps 5.5.2.2-5 &

5.5.2.2-6). One possible explanation for the difference in these data sets is whether water was present dry season.

The hydrologic regime in the reach between the ocean and the Valley Greens Drive bridge affects CRLF reproduction. In most years, the lower six miles of river goes dry as a result of water extraction as early as June or July. Preliminary analysis of the hydrologic data showed significant variations in water quantity and duration of flow in CRLF reproductive habitat during 1995-99 and in 2001 at the Highway One Gage. Scouring during the flood events in 1995 and 1998 may have created a more complex river channel with more off channel pools. CRLF tadpole presence in this region may have been influenced by wet conditions during this period. In 1995, the Carmel River flowed to the lagoon for nearly the entire year and was continuous throughout 1998. The presence of frogs in the lower river may have been due to a longer duration of flow in 1998 that led to more suitable CRLF reproductive habitat. In addition, wetter conditions in 1995 and 1998 may have created more access overland and encouraged adult CRLF to move to the lower region of the Carmel River. Adult CRLF could also have moved upstream from the Carmel River lagoon or overland from upland areas such as the Palo Corona Ranch.

The timing and duration of peak flows and water availability in the river channel and in off channel pools are factors that should be considered for CRLF reproductive habitat. The timing and duration of high flow events affect successful CRLF egg attachment and development in the Carmel River watershed. Analysis of the Highway One gage in the lower Carmel River shows that the riverbed is usually dry until December or January and that there are generally high flushing flow events in January and February. In coastal systems in California, CRLF can begin breeding as early as November. However, as CRLF eggs can be washed away in high flow events (Schmeider& Nauman, 1994) it is likely that most CRLF in this watershed would lay their eggs during the month of March. Reis and Gunderson have observed CRLF egg masses in the Carmel River in February and March.

To understand the impact of drier years on habitat, the availability of water and the length of time needed for CRLF reproduction becomes important. In general CRLF tadpole eggs hatch 6-14 days after they are laid (Jennings 1988). CRLF eggs develop into tadpoles in 20-22 days and tadpoles usually complete development in 11-20 weeks (Bobzien et al. 2000, Storer 1925, Wright and Wright 1949). In rare instances, CRLF tadpoles will also over winter (Bobzien et al. 2000). To complicate matters, tadpole development is affected by water temperature and metamorphosis can be accelerated with higher temperatures, although temperatures exceeding 25 degrees Celsius can retard development or be lethal. In summary, CRLF development rates vary greatly but are usually between 15 to 25 weeks. Reproduction may depend on the availability of water throughout much of the dry season. CRLF tadpoles have been know to complete metamorphosis as late as early fall (October 22, 2003 in isolated pools of the Carmel River, Reis 2003).

Maps of CRLF locations are biased towards the main stem due to the lack of survey effort or reported surveys elsewhere in the watershed. In addition, maps of CRLF reproductive locations are biased toward the areas that have been systematically surveyed for CRLF as opposed to incidental sightings for adult frogs. MPWMD may have more incidental sightings in the lower six miles of the Carmel River as a result of steelhead rescue efforts and at steelhead population survey sites. The reach between San Clemente Dam and Los Padres Dam has been surveyed for reproduction and potential reproductive habitat as represented in the 2000 data set for the San Clemente Reservoir area.

The lack of data about egg mass presence in the Carmel River is due to the timing of surveys. CRLF egg masses can be present from November through April (USFWS, 2002). Most of the data collected on the Carmel River was done in June-October in 2000, 2002, and 2003. Therefore, egg masses were not detected.

The Carmel River is a dynamic system that is always changing. High flows each winter can alter pond and pool areas. Some areas may be scoured while others are filled. Water levels also fluctuate depending on the water year. Therefore, differences in the survey data from year to year can be expected. Some breeding habitat is lost in some years while other habitat is created. In 2003, seventeen of the known 2002 CRLF tadpole locations were not present and there were twenty new CRLF tadpole locations (Reis, 2003).

The data in this report concerning the upper reaches of the Carmel River Watershed serves as good base line information; however, the need for more current survey data exists. Mullen 1993 reported ~50 CRLF at a 2-3 acre man-made pond at the Tanbark settlement on the Miller fork. He felt that this population might have increased the population in the tributary below. He also surveyed Quail Lodge Golf Club, Carmel Valley Ranch and Golf Resort, and Rancho Cañada golf courses for CRLF presence in 1993. CRLF were found at one Quail Lodge Golf Club pond on the East side of the 15th fairway (Mullen, 1993)

Some of these ponds have served as habitat for CRLF in the past (Mullen, 1993). Ponds managed for vegetation, pesticide use, fertilizer minimization, and predator elimination, such as bullfrogs, could help to increase the reproductive sites for CRLF. Additionally CRLF can travel as far as 2 miles (3 kilometers) overland in wet weather outside of riparian corridors with no regard to topography or vegetation (Bulger *in litt.* 1998). Thus a buffer area should also be considered as an extension of CRLF general habitat.

The following private property interests may hold additional CRLF data that may be useful in the future: Palo Corona Ranch, Hasting Reserve, Rana Creek Ranch, Rancho San Carlos/Santa Lucia Reserve, Oak Ridge Ranch and others. Data from these properties could be useful in documenting CRLF in the Carmel River Watershed.

Peter Trenham, USGS, did one study concerning CRLF critical habitat and seasonality on Oak Ridge Ranch. This study is summarized in the California Natural Diversity Data Base. This database should also be searched for other CRLF studies done in the Carmel River Watershed.

Conclusions and Recommendations

In the *Recovery Plan for the California Red-legged Frog (Rana aurora draytonii*), the U.S. Fish and Wildlife Service recommends a population monitoring program that would consider four to five CRLF generations (a 15-year time frame) during an average precipitation cycle (USFWS, 2002). Nearly all CRLF sightings reported since 1989 for the Carmel River Watershed have been in the Carmel River main stem. However, it is likely that the adult CRLF presence is underrepresented in the data sets due to the lack of focused surveys. In addition, large areas of the watershed, including the Carmel River Lagoon, pond areas shown on USGS topographic maps, tributaries, and the upper reaches of the Carmel River have not been systematically surveyed for any life-stage of the frog. Until confirmed otherwise, all ponds within the Carmel River watershed should be considered potential CRLF habitat and surveys of presence/absence and the potential for reproduction should be carried out in these areas.

Maps showing reproductive habitat reflect data on the main stem of the Carmel River and do not show reproductive habitat in tributary drainages. Care must be taken not to assume that CRLF reproduction occurs only along the main stem of the Carmel River and to recognize that data sets in other areas of the watershed are missing. Maps derived from GIS layers for 2002 and 2003 show important areas of CRLF reproduction in the main stem near Schulte Bridge, Robinson Canyon Bridge, Don Juan Bridge, Garzas Creek, and in the vicinity of the deDampierre baseball fields. Data from the 2000 survey shows reproduction and a high concentration of potential reproductive habitat in the San Clemente Reservoir area. Additional 2003 data about CRLF reproductive habitat at the Santa Lucia Preserve, as well as for projects related to the San Clemente Dam, may be available through the USFWS. These data were not available during the construction of this GIS project.

Comparative analysis of the current population density in the Carmel River Watershed to other similar known CRLF populations would lend insight into the relative health of the population.

Future studies and surveys for CRLF should follow a study design aimed at documenting all life stages and reproductive habitat areas. Determining a consistent methodology and the timing for surveys will allow data collection that accurately portrays the CRLF population over time and will reduce the possibility of sampling bias. For example, day surveys for egg masses would need to be done earlier in the season, whereas repeated surveys for adult CRLF need to be conducted during nighttime hours in the spring, summer and fall. Also, any monitoring plan should account for habitat that is dynamic. For example, due to natural scour and the movement of sediment during winter storms, the river bottom changes nearly every year. Therefore, it would be incorrect to assume that reproductive sites remain in the same form or location from year to year. To fully understand CRLF population dynamics, night surveys for adult frogs, day surveys for reproduction (tadpoles), and reproductive habitat surveys should be carried out on a regular basis.

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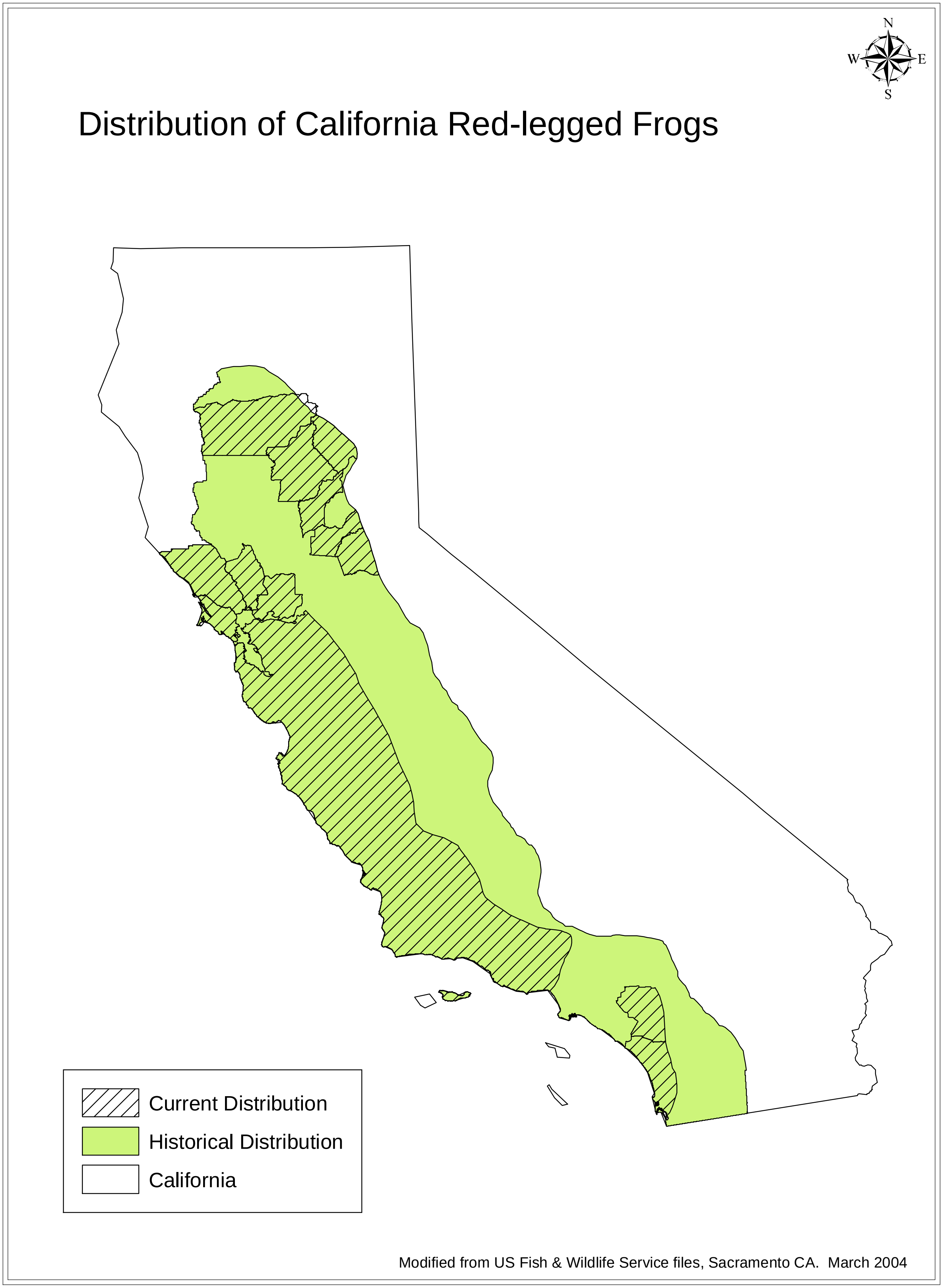
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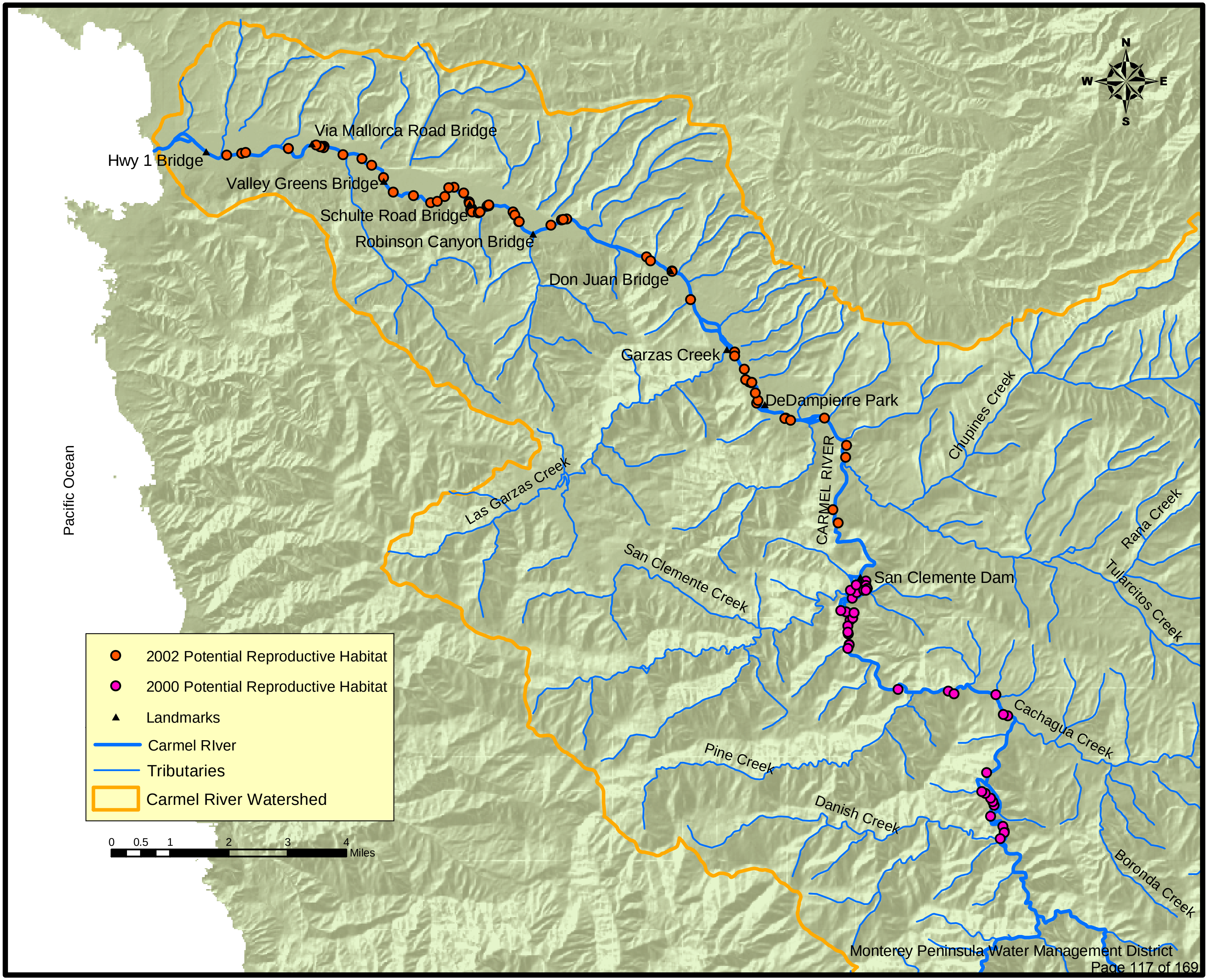
Distribution of California Red-legged Frogs
Current Distribution
Historical Distribution
California
Modified from US Fish & Wildlife Service files, Sacramento CA. March 2004

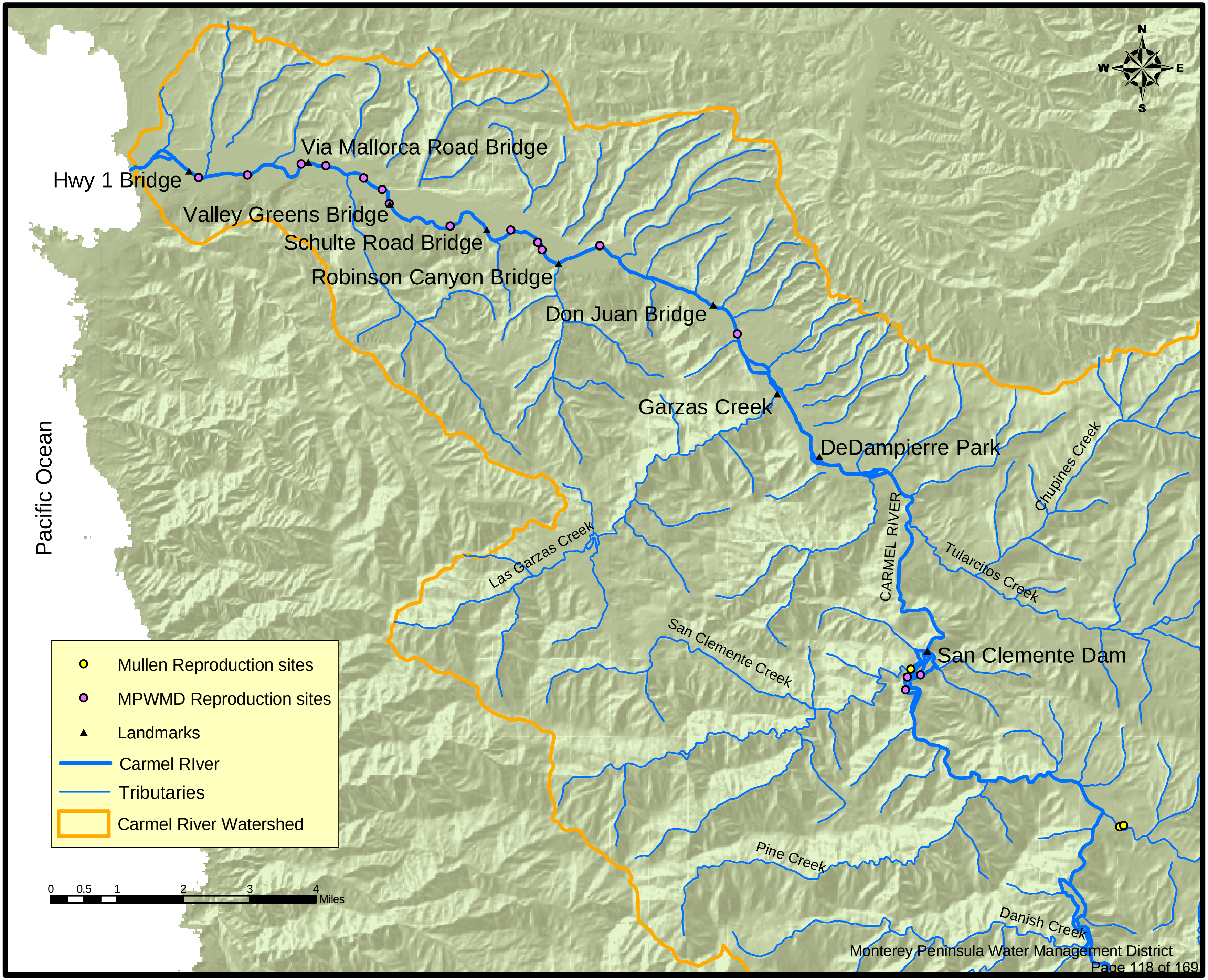
Map 5.5.2.2-1

2000 & 2002 CA Red-legged Frog Potential Reproductive Habitat Survey, Carmel River



Map 5.5.2.2-7

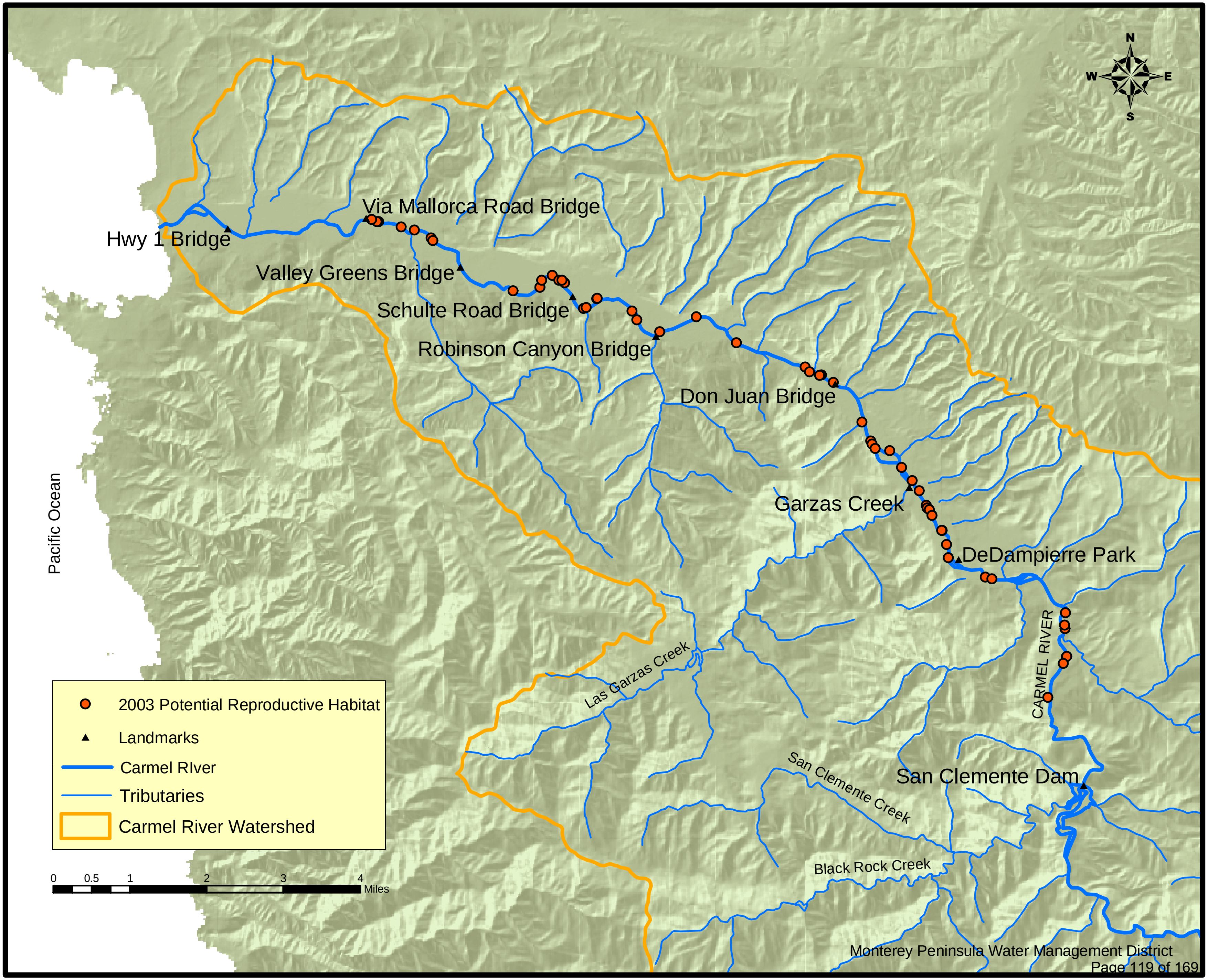
Mullen & MPWMD Records of CA Red-legged Frog Reproduction Sites, Carmel River Watershed



Monterey Peninsula Water Management District

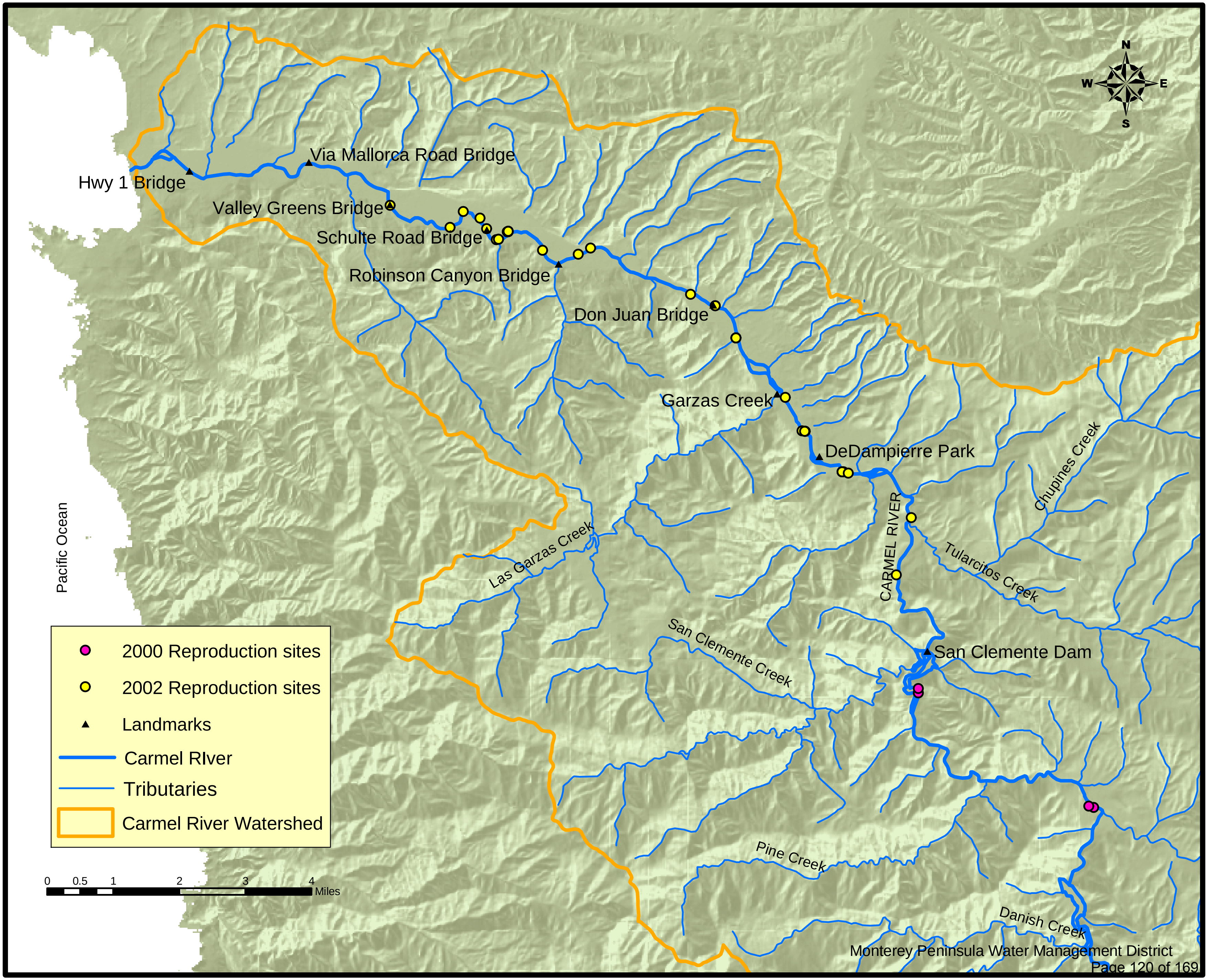
Map 5.5.2.2-4

2003 CA Red-legged Frog Potential Reproductive Habitat Survey, Carmel River



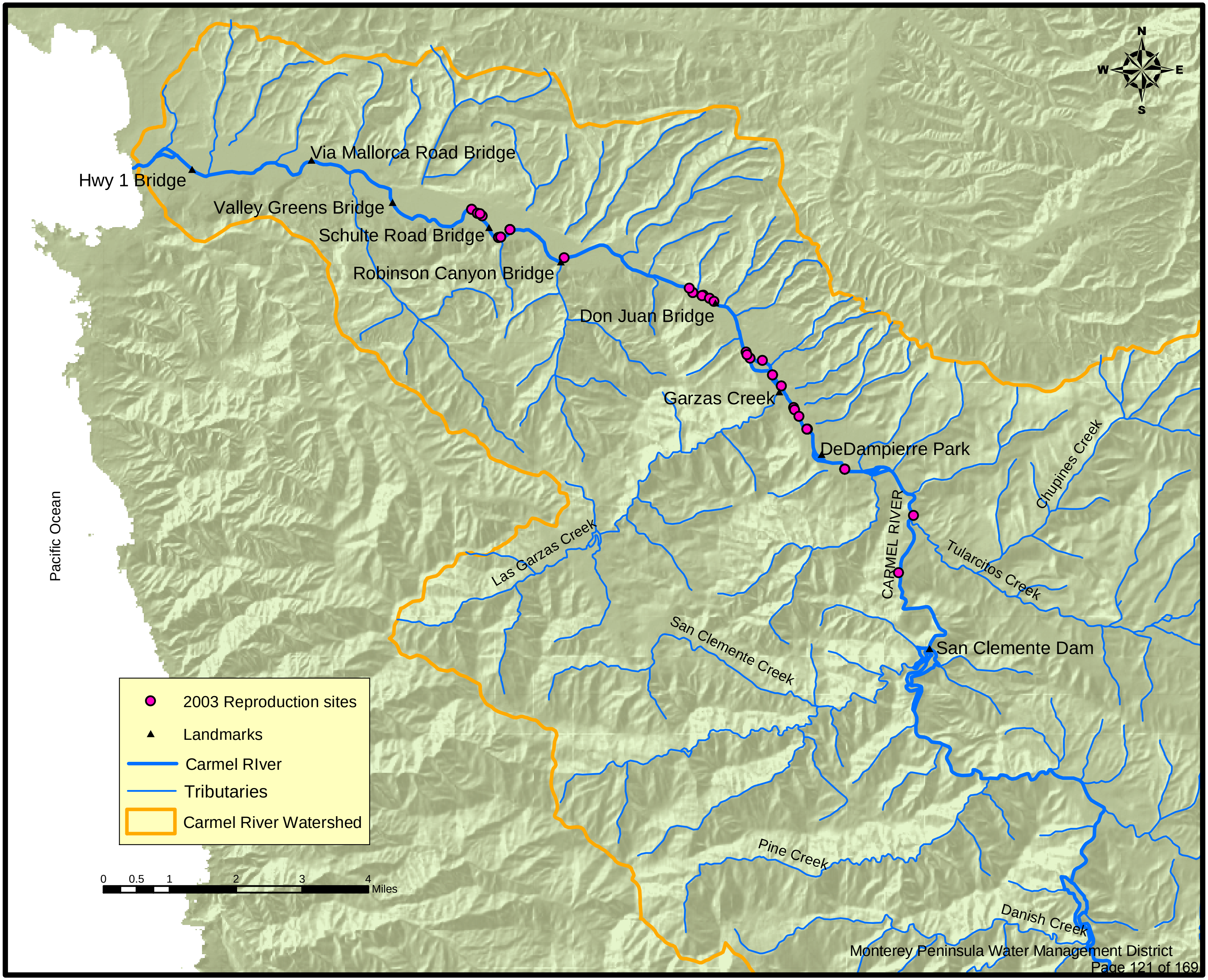
Map 5.5.2.2-8

2000 & 2002 CA Red-legged Frog Reproduction Site Surveys, Carmel River



Map 5.5.2.2-5

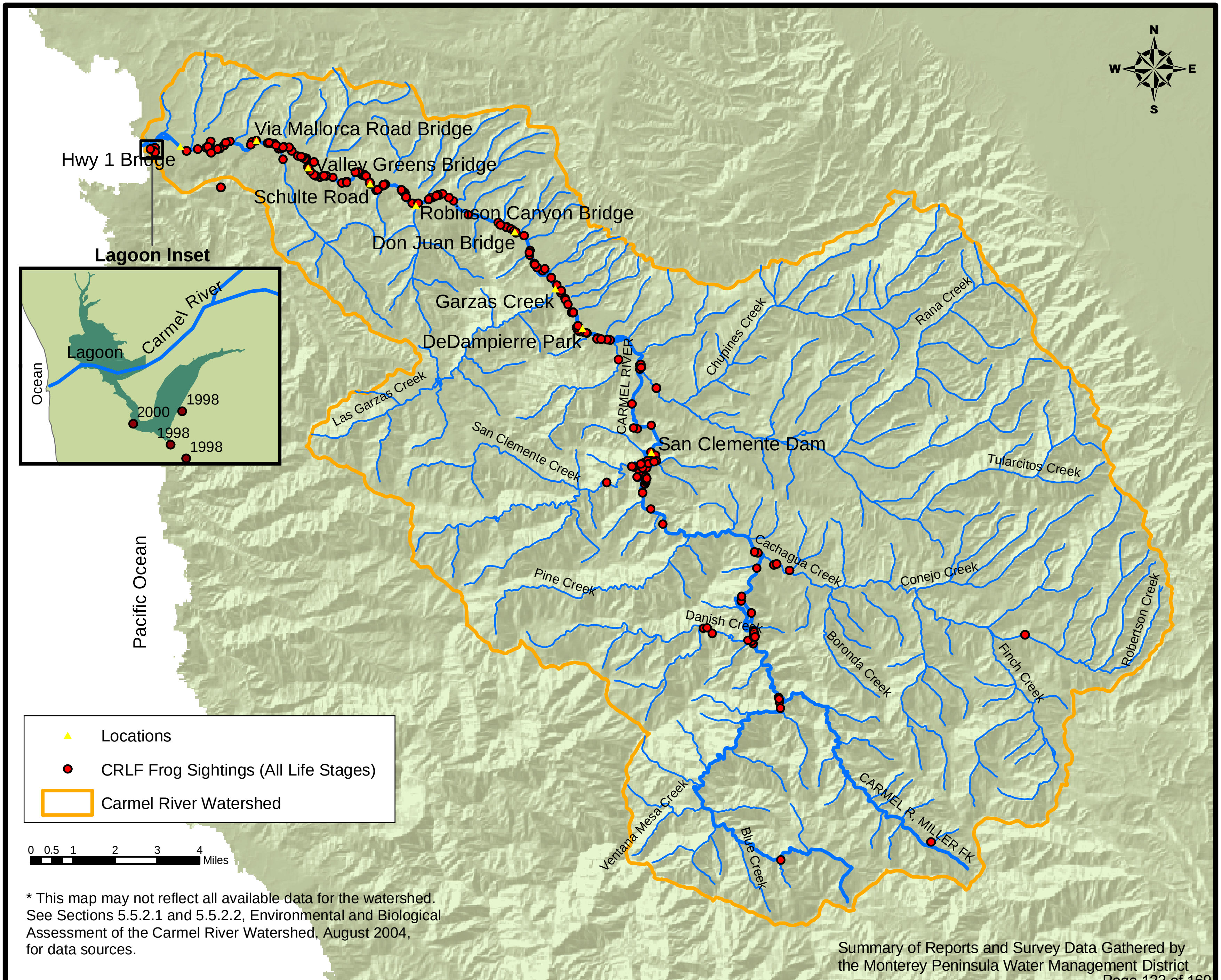
2003 CA Red-legged Frog Reproduction Site Survey, Carmel River



Monterey Peninsula Water Management District

Map 5.5.2.2-6

Summary of California Red-legged Frog Sightings in the Carmel River Watershed (1989-2003)*

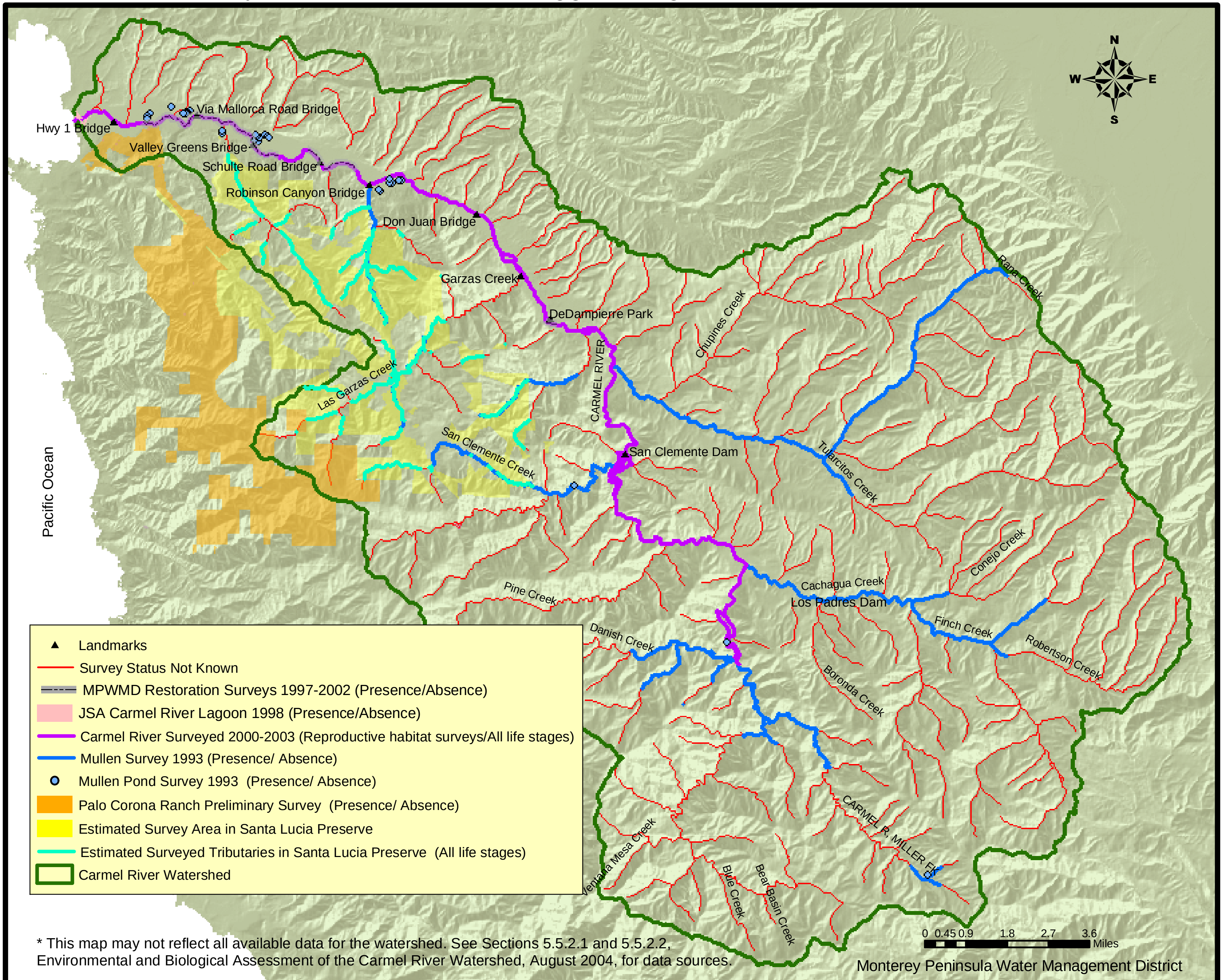


* This map may not reflect all available data for the watershed.
See Sections 5.5.2.1 and 5.5.2.2, Environmental and Biological
Assessment of the Carmel River Watershed, August 2004,
for data sources.

Summary of Reports and Survey Data Gathered by
the Monterey Peninsula Water Management District

Map 5.5.2.2-3

Surveyed Areas for CA Red-legged Frogs in the Carmel River Watershed *



* This map may not reflect all available data for the watershed. See Sections 5.5.2.1 and 5.5.2.2, Environmental and Biological Assessment of the Carmel River Watershed, August 2004, for data sources.

Map 5.5.2.2-2

SECTION 5.5.2.3 LIMITING FACTORS FOR CALIFORNIA RED-LEGGED FROG POPULATIONS

Introduction

The listing of California red-legged frog (CRLF) (*Rana aurora draytonii*) by the U.S. Fish and Wildlife Service (USFWS) as a "Threatened" species was effective on June 23, 1996 (61 FR 25813). The effect of this listing under the Federal Endangered Species Act (ESA) is to require formal consultation with the USFWS prior to carrying out any actions within the Carmel River Watershed that could harm CRLF. USFWS must issue a written biological opinion on proposed actions that contains steps to reduce the potential for harm. CRLF are found throughout the Carmel River Watershed and are a species of special focus regarding human impacts along the Carmel River.

At just over five inches long as an adult, the CRLF is the largest native frog in the western United States. The historic range of CRLF extends from the Sierra foothills to the coast, and from Shasta County to the boarder of Mexico, excluding the Coast Range north of Marin County. It is estimated that CRLF have disappeared from over 99 % of the inland and southern California localities within its historic range and have been extirpated from at least 70% of all localities within its entire historic range (Jennings, Hayes, and Holland 1992). CRLF occur throughout the entire Central Valley hydrographic basin, but the area from Ventura County south to the border of Mexico is the most depleted in California (Jennings, Hayes, and Holland 1993). Populations of CRLF in the Coast Range between Marin County south to Santa Barbara are more intact than populations in the rest of the state. The estimated disappearances of historical populations in the Coast Range are 50%. The Carmel River Watershed and the Santa Lucia mountain range have been identified as a core area (number 20), where recovery actions will be focused (USFWS, 2002).

It is thought that small coastal drainages contain the only remaining region in California where CRLF can still be found in significant numbers. In fact, when the CRLF were first protected under the ESA, only three localities were thought to support over 350 adult CRLF- Pescadero Marsh Natural Reserve in San Mateo County, Point Reyes National Seashore in Marin County, and Rancho San Carlos (now known as Santa Lucia Preserve) in Monterey County (Federal Register, 1996). Since that time, a fourth location, at the Elkhorn Slough National Estuarine Research Reserve, revealed 350 adult CRLF during a single night survey at ponds on the property.

The Carmel River Watershed meets the habitat requirements of CRLF, which have been observed in backwater and off-channel pools along the Carmel River and its tributaries (EcoSystems West Consulting Group 2001, Reis 2002, Reis 2003). These backwater and off-channel pools provide breeding habitat that is associated with still water. Emergent vegetation is also an important component in off-channel pools for egg mass attachment (S. Chubb, 1999). Upland habitat is important during periods of wet weather as refuge away from floods. Radio tagged frogs on the coast of San Luis Obispo County showed frog movement greater than one mile to upland areas (N. Scott and G. Rathbun, 1998). Frogs also spend considerable time in upland riparian areas resting and feeding in this moist foraging habitat (U.S. Fish and Wildlife Service, 2002).

In summary, with the known population at the Santa Lucia Preserve (formerly Rancho San Carlos) and recent data of CRLF reproduction along the Carmel River (EcoSystems West Consulting Group, MPWMD 1997 through 2003, Reis 2002 and Reis 2003), the Carmel River Watershed is extremely important to the current distribution of CRLF.

Limiting Factors

Many factors have contributed to the decline or loss of CRLF populations in their native range (Sierra Nevada foothills, central valley, and coastal areas all in California). Limiting factors include introduction of predators, loss of habitat and degradation from urbanization, agriculture, mining, overgrazing, recreation, timber harvesting, invasion from nonnative plants, impoundments, water diversion, and degraded water quality (65 FR 54893).

Introduced Predators

Many introduced predators such as bullfrogs, crayfish, bass, and mosquito fish impact CRLF in the Carmel Valley Watershed. Different life history stages of CRLF (adult, tadpoles, and eggs) have different predators.

Bullfrogs are consistently encountered in pools along the Carmel River during annual fish rescue operations. Mullen documented bullfrogs in the lower and upper Watershed up to Los Padres Reservoir and upper San Clemente Creek (Mullen, 1994). Research in California has shown cases where CRLF populations decline and eventually disappear after bullfrogs become established (Fisher and Schaffer, 1996). Bullfrogs have been known to prey on both CRLF adults and tadpoles and may have a competitive advantage for food, shelter, and reproductive space because of their larger size (Twedt, 1993). However, the CRLF tadpole life stage seems to experience the highest mortality rate. Lawler *et al.* (1999) found that the survival rate from hatching to metamorphosis is estimated to be less than five percent for CRLF tadpoles when bullfrog tadpoles are present.

The extent of mosquito fish (*Gambusia*) in Carmel Valley is unknown, but this species is known to occur in private ponds and in the Carmel River. Mosquito fish are sometimes used in water bodies to control mosquito larvae. Mosquito fish are non-native opportunistic feeders, are significant predators of CRLF eggs, and are known to cause physical harm to CRLF tadpoles (Schmieder and Nauman, 1994). Mosquito fish are also known to be a competitive disadvantage to CRLF larva in artificial ponds (Lawer, Dritz, and Holyoak, 1999). CRLF have been known to coexist with bullfrogs and mosquito fish, but the combined predatory effects may lead to extirpation (Kiesecker and Blaustein, 1998).

Native Predators

Native predators of CRLF include skunks, opossums, raccoons, great blue herons, American bitterns, red-shouldered hawks, and garter snakes (Jennings and Hayes, 1990). Although native predators have their place in the ecosystem, translocation of raccoons, skunks, and opossums from cities to National Forest or rural areas can concentrate their populations and impact CRLF.

Urbanization

Carmel Valley has been impacted by urbanization and increased traffic. Approximately 1,600 parcels have been identified as having residential use in the FEMA-defined 100-year Carmel River floodplain. The majority of these structures are located in the lower six miles of the river. Residential development and three golf courses contribute to the fragmentation of CRLF habitat. Development also is increasing in upland areas that may have been used by CRLF in wet years. Carmel Valley Road also carries a significant amount of traffic that can constitute a barrier to CRLF. Heine (1987) found as little as 26 cars per hour can reduce the survival of toads crossing a road to zero. Fragmentation of habitat areas can lead to the isolation of specific CRLF groups and the loss of access to reproductive or dispersal areas.

Although an argument can be made that some golf course ponds can serve as habitat for CRLF, this is dependent on proper management, which includes minimizing water quality impacts from fertilizers, herbicides, and pesticides known to harm CRLF. Golf ponds also need emergent vegetation for egg mass attachment and both emergent vegetation and upland vegetation for adult cover if they are going to provide productive CRLF habitat. Removal of bullfrog adults and draining ponds in late fall to eliminate bullfrog tadpoles is also an important management practice.

Agriculture

Commercial agriculture began in Carmel Valley in the 1870s when Edward Berwick introduced pear orchards. Clearing for orchards and row crops removed natural habitat and cover for CRLF. Much of the historical riparian habitat along the Carmel River was cleared for agriculture. Currently, only a thin, narrow, discontinuous band of riparian area exists in much of the lower valley. Upland areas have been impacted by conversion of native oak forest and chaparral to large commercial and private viticulture use. Although the scale of agriculture and use of chemicals in Carmel Valley is not the same as in the central valley of California, San Joaquin Valley experienced drastic declines in CRLF due in part to water bodies being contaminated with fertilizers and pesticides (Fish and Shaffer, 1996). Pesticides can cause deformities, disease, abnormal immune system functions, and death (Schneeweiss and Schneeweiss, 1997).

Livestock Grazing

CRLF have been known to co-exist with properly managed livestock grazing operations (Bobzien, 1998). Stock ponds have even greater value if they are managed to prevent bullfrog reproduction. However, poorly managed live stock operations can severely impact pond and creek habitats for CRLF. Animal waste can over nitrify ponds if large concentrations of waste flow into ponds during rainfall events. Unmanaged cattle can trample riparian vegetation and reduce or eliminate plant cover (Gunderson, 1968). Riparian and emergent vegetation in creeks are important for channel complexity, which helps form pools. The exclusion of cattle grazing from the Simas Valley resulted in riparian tree recruitment and the formation of pools, which led to the expansion of frog populations (Dunne, 1995).

Impoundments and Water Diversion

CRLF habitat has been fragmented in the Los Padres National Forest by dams that block or hinder dispersal (U.S. Fish and Wildlife Service, 2002). The Carmel River Watershed has two major reservoirs that impact the hydrologic regime of the Carmel River- San Clemente and Los Padres. The duration and extent of flow in the Carmel River to the lagoon is largely dependent on the amount of rainfall in the water year, groundwater pumping, and reservoir storage and release. In normal rainfall years, the Carmel River typically dries from above the Carmel River lagoon up to the Schulte Bridge area (River Mile 6.0 to 7.0) from mid-June to December.

San Clemente Dam, with an original reservoir storage capacity of 1,425 acre-feet, was constructed in 1921 and was the first major dam built on the main stem of the Carmel River. The 106-foot high and 300-foot long structure located in a steep canyon is a partial barrier to CRLF movement and to some extent isolates the CRLF population and prevents it from dispersing to downstream habitat. Currently, the reservoir is almost completely filled with sediment. This sediment has caused the Carmel River to braid behind the dam and has created favorable off-channel breeding sites within the reservoir area. Because of the coarse nature of the sand and gravel in these off-channel pools, they are hydraulically connected to the surface water. San Clemente Reservoir, which is operated by the California-American Water Company (Cal-Am), currently undergoes draw down during the spring to comply with orders from the California Division of Safety of Dams to meet seismic safety standards for the dam. Draw down can expose tadpoles and cause desiccation when done at a rapid rate. Several mitigation measures are carried out to help prevent the CRLF populations in and around the reservoir from being impacted by the draw down. Mitigations include tadpole relocation from areas that are projected to dry before metamorphosis is complete and CRLF adult relocation in order to protect them from bullfrog predation as deep water refuge areas are reduced by the draw down.

The second major dam and reservoir constructed along the main stem was Los Padres (original storage capacity of 3,030 acre-feet), built in 1948. Currently, more than one half of the 3,030 acre-foot reservoir is filled with trapped sediment. CRLF habitat in and around Los Padres Reservoir is not as well documented as at San Clemente Reservoir, but CRLF have been observed at the upstream end of the inundation zone. In this zone, summer draw down may also impact off-channel areas where the Carmel River enters the reservoir. However, summer releases from Los Padres Reservoir may contribute enough water to help prevent premature draw down of reproductive sites in the lower Carmel River.

Water diversion by well pumping can significantly impact CRLF by rapidly dewatering reaches of the Carmel River. The majority of wells capable of dewatering reaches of the Carmel River during the low flow season are Cal-Am production wells. In water year 2003 Cal-Am used 18 wells in Carmel Valley to produce at total of 11,076 acre-feet of water (MPWMD, 2003). Some of Cal-Am's lower valley wells are capable of pumping three to five cubic feet per second (cfs). During the low flow summer season the Carmel River may only be flowing 3-10 cfs so these wells can rapidly dewater off-channel pools where tadpoles are maturing. Cal-Am experienced one of these incidents in 1997 during late August – early September in a segment of the Carmel River near Cal-Am's Scarlett No. 8 well. This situation resulted from an unexpected shut down of the Cañada well, which automatically shifted pumping to the Scarlett well. This led to the stranding of many CRLF larvae.

In addition, Carmel Valley has approximately 561 private wells, including wells in the alluvial aquifer and upland areas. In water year 2003, production from these private wells equaled

2,475.8 acre-feet (MPWMD, 2003). The cumulative impact of these wells reduces the amount of water available for CRLF.

CRLF usually lay egg masses in the Carmel River main stem in February or March, after high winter flows (Reis and Gunderson pers. obs.). Eggs require around 20-22 days to develop into tadpoles and then, based on temperature, 11 to 20 weeks to develop into terrestrial frogs (Bobzien et al., 2000). Therefore, during summer months, it is critical for surface water to be present so CRLF frog larvae can complete metamorphosis. However, CRLF in the Carmel River usually metamorphose from tadpoles to terrestrial frogs by late August or early September (Dawn Reis, pers. comm.). Bullfrog tadpoles require two years for development. CRLF have an advantage if reproductive areas dry down in late October because this breaks the reproductive cycle of bullfrogs. These sites are more suitable for CRLF reproduction than for bullfrog reproduction.

Channelization

The Carmel River may not be thought of as a traditionally channelized river, however, levees and rip-rap bank protection structures along the river have reduced the natural floodplain width and ability of the river to meander and change course, therefore limiting off-channel pool development. Property owners and government agencies have traditionally used streambank hardening as a preferred method for preventing erosion associated with floods. In 2000, MPWMD estimated that 45 % of the streambanks in the alluvial portion of the Carmel River had received some kind of treatment. The historical incision and rip-rap bank protection may also increase main stem water velocities in certain reaches and prevent the use of these areas for CRLF egg attachment.

Water Quality and Temperature

Amphibians have complex life cycles, which subjects them to multiple routes of exposure to contaminants (U.S. Fish and Wildlife Service, 2002). The Carmel River is not known for having high levels of contaminants, but varying amounts of herbicides and pesticides enter the waterways from golf course ponds, sediment catch basins, adjacent agricultural areas, and urban development. There are a vast number of pesticides and herbicides used that can kill, paralyze, or mimic estrogen, which may impact reproduction (Berrill et al., 1993 and Jennings, 1996). It is not clear how many of these are used in Carmel Valley, but common herbicides containing surfactants such as Roundup® have severe negative effects on amphibians when used close to water. The USFWS addresses the toxicity of a number of potential herbicides and pesticides in their Recovery Plan for the California red-legged frog.

Mineral fertilizers used on crops, lawns, and golf courses also impact CRLF. Schneeweiss and Schneeweiss (1997) found up to 100 percent of amphibians dead in pitfall traps located on fertilized fields, but no dead amphibians on fields not fertilized during simultaneous monitoring. Nitrate levels below the standard for drinking water were found to increase mortality to Northern red-legged frog larvae (Marco et al., 1999).

Although warmer water can help tadpoles mature at a faster rate, studies of Northern red-legged frog tadpoles have shown critical maximum water temperature near 25°C and adult CRLFs have been shown to die of heat exposure at 29.0 °C (Calef, 1972 and Jennings and Hayes, 1990).

Water temperature in the Carmel River is seldom a limiting factor for CRLF based on data; however, as water depth is reduced in summer months, areas that lack vegetative cover for shade could potentially reach critical maximums (Ecosystems West, 2001). Reis (2003) reported that water temperatures came close to critical maximums in 2002 and 2003 in the Carmel River between the Carmel River RV Park and Schulte Road Bridge, and upstream of the footbridge at the DeDampierre Ball Park.

Conclusion

Many factors in combination can lead to declines in CRLF populations. In general, CRLF are threatened by more than one factor in streams (U.S. Fish and Wildlife Service, 2002). The upper Carmel River Watershed (above Los Padres Reservoir) is not impacted by urbanization, agriculture, and water extraction. CRLF reproduction locations occur upstream of and around Los Padres Reservoir and in Cachagua Creek. However, urbanization, agriculture, channelization, bullfrogs, and water extraction are factors that can damage habitat in the lower Carmel River. Groundwater extraction and reservoir operations are currently being managed to reduce the threat to CRLF. Bullfrog control and urbanization are more tenuous problems.

CRLF would benefit from a management plan that addresses: pond management, water quality, non-native predators, habitat fragmentation, and water diversion. The Carmel River Watershed Council could help CRLF by educating private landowners on issues such as pesticide residues, fertilizer contamination, and non-native predator control. Although CRLF are found throughout the whole watershed, **Table 1** summarizes some of the top limiting factors for defined reaches on the main stem of the Carmel River.

Table 1. General Reach-by-Reach Assessment of Limiting Factors for CRLF on the Carmel River

Subreach Number	Upstream Station	Downstream Station	Limiting Factors
1	Upstream limit of Carmel River Watershed	Confluence with Miller Fork	Native predators and bullfrogs
2	Confluence with Miller Fork	Danish Creek	Native predators and bullfrogs
3	Danish Creek	Los Padres Dam	Reservoir operations, bullfrogs, and dam dispersal barrier issues
4	Los Padres Dam	Cachagua Creek	Reservoir operations, bullfrogs, dam dispersal barrier issues, and urban run-off
5	Cachagua Creek	Upstream end of San Clemente Reservoir	Native predators and bullfrogs
6	Upstream end of San Clemente Reservoir	San Clemente Dam	Reservoir operations, bullfrogs, and dam dispersal barrier issues
7	San Clemente Dam	Sleepy Hollow	Native predators and bullfrogs
8	Sleepy Hollow	Tularcitos Creek	Native predators and bullfrogs
9	Tularcitos Creek	Hitchcock Canyon Creek	Native predators, bullfrogs, and stock pond management
10	Hitchcock Canyon Creek	Garzas Creek	Bullfrogs, Carmel Valley Road, and urbanization
11	Garzas Creek	Randazzo bridge	Bullfrogs, Carmel Valley Road, and urbanization
12	Randazzo bridge	Robinson Canyon Road bridge	Bullfrogs, Carmel Valley Road, and urbanization
13	Robinson Canyon Road bridge	Schulte Road bridge	Bullfrogs, Carmel Valley Road, urbanization, agriculture, private and commercial well pumping
14	Schulte Road bridge	Valley Greens Drive bridge	Bullfrogs, Carmel Valley Road, urbanization, agriculture, private and commercial well pumping
15	Valley Greens Drive bridge	Highway 1	Bullfrogs, Highway 1, Rio Road, urbanization, agriculture, private and commercial well pumping, channelization
16	Highway 1	Pacific Ocean	Bullfrogs, Highway 1, Rio Road, urbanization, agriculture, channelization

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SECTION 5.6.1 MAIN STEM CARMEL RIVER WATER QUALITY

Since 1991, the MPWMD has collected surface water quality data at two locations on the Carmel River (**Appendix 5.6**). Sampling stations are located below Los Padres Dam and below San Clemente Dam. Specific locations and descriptions of sampling stations can be found in **Appendix 5.6**. Data were collected for the following chemical and physical parameters: temperature (°F), dissolved oxygen (mg/L), carbon dioxide (mg/L), pH, specific conductance (uS/cm), and turbidity (NTU). The emphasis for this suite of parameters is on the suitability for rearing juvenile steelhead.

Favorable water quality conditions for rainbow trout/steelhead culture are listed in **Table 5.6.1-A** (Piper et al., 1982). Also listed below is the Central Coast Basin Plan water quality objectives set by the California State Water Resources Control Board (SWRCB).

Table 5.6.1-A. Suggested chemical criteria for trout hatchery water supply and Central Coast Basin Plan water quality criteria for cold freshwater habitat.

Parameter	***Hatchery water supply****	***Central coast basin plan *****
Temperature range	33-78°F	never 5°F above natural receiving water temp.
Optimum temperature range	50-60°F	N/A
Dissolved oxygen	5 mg/l -saturation	not less than 7.0 mg/L
pH	6.5-8.0	7.0-8.5
Carbon dioxide	0-10 mg/l	N/A

* Piper et al. 1982
** SWRCB, 1994

WATER TEMPERATURE

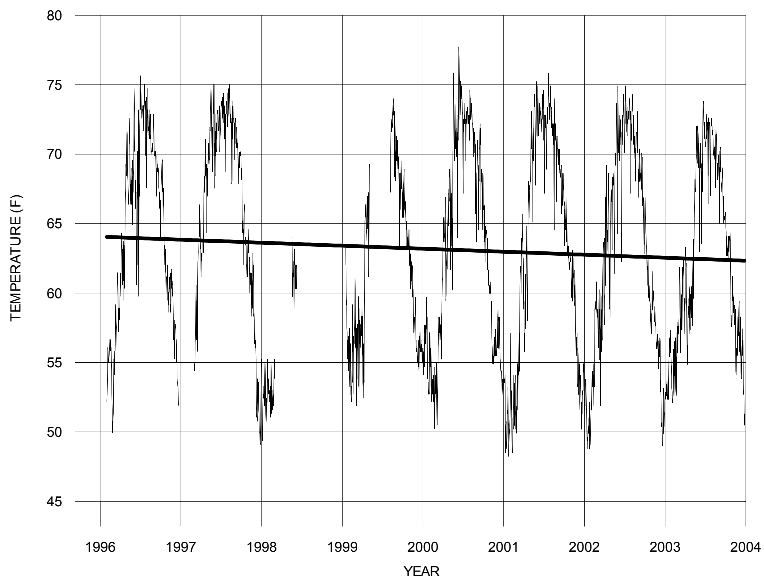
Water temperature has been measured at a total of 11 locations including the Lagoon (two sites), the Narrows, Garland Park, Sleepy Hollow weir, San Clemente Reservoir (three sites), San Clemente Creek, and Los Padres Reservoir (two sites). One of the Lagoon sites has been discontinued due to vandalism.

Water temperature in the main stem Carmel River (excluding the Lagoon and two main stem reservoirs) has been monitored at six different locations, since 1996. For a complete record of sampling dates, and locations refer to **Appendix 5.6**. Generally, water temperatures in the main stem Carmel River are satisfactory for aquatic life during the winter and spring months. Typically this is the period when there is adequate flow and cooler air temperatures. However, water temperatures reach threatening levels for aquatic life during the summer and fall months. This is due to the reduction of flow and warmer air temperatures. Maximum daily water temperature commonly exceeds 70°F during the summer and fall months. Linear trend analysis of data from the eight-year period between 1996 and 2004 at the Garland Park station (see **Figure 5.6.1-A)**, where water temperature annually exceeds 70°F, shows a slight downward trend in maximum daily water temperature.

This may be due to the recovery of the riparian zone upstream and the shade it provides along the river. However, maximum water temperatures remain within the stressful range during the summer and fall months. The optimum water temperature range for steelhead growth is 50-60°F (Piper et al. 1982). During the summer and fall period, average daily water temperature commonly exceeds the range for optimum growth (**Figure 5.6.1-B**).

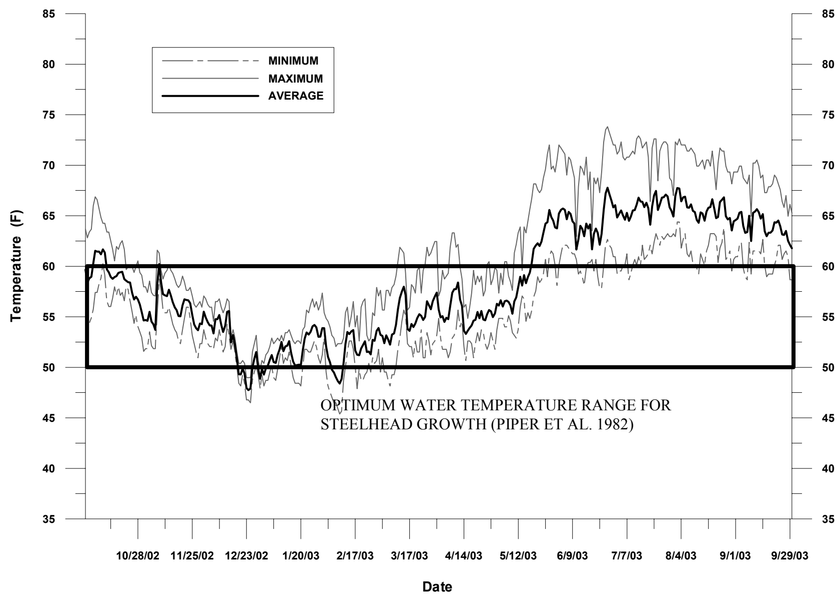
All six main stem monitoring stations exhibit stressful temperature conditions during the summer and fall months. Potential factors affecting water temperature in the main stem Carmel River include rainfall, air temperature, reservoir water temperatures, reservoir flow releases, tributary inflow, water diversions, canopy cover, and septic effluent.

Figure 5.6.1-A. Maximum daily water temperature at Garland Park Station during CY 1996-2003.



Note: Data for 1998 and 1999 years are incomplete

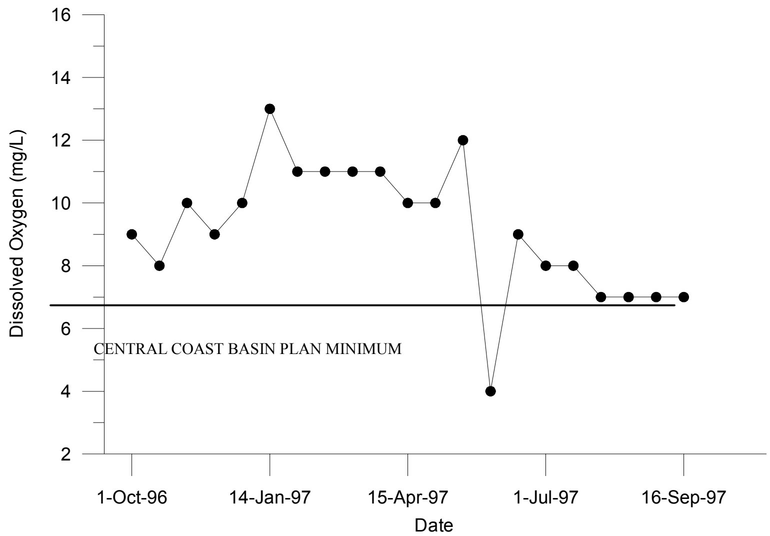
Figure 5.6.1-B. Daily water temperature at Garland Park station during WY 2003.



DISSOLVED OXYGEN

Generally, dissolved oxygen levels observed by MPWMD between 1991 and 2004 have met the Central Coast Basin Plan objectives of 7 mg/L or higher. There has been one recorded violation of this objective, which occurred below the Los Padres Dam on June 3, 1997 (**Figure 5.6.1-C**). During the spring and summer months the reservoir stratifies, creating a bottom layer of cold, low-oxygenated water and a top layer of warmer and more oxygenated water. At the time, the reservoir was nearly full and releases were being made primarily from the lower outlet. Under these stratified conditions, the dissolved oxygen in the lower outlet release can fall below the saturation level. This is believed to be the reason for the observed violation of the objective. This is further evidenced by the fact that an additional measurement made approximately 200 ft downstream showed that the dissolved oxygen level was at or near saturation level.

Figure 5.6.1-C. Dissolved oxygen measurements recorded below Los Padres during WY 1997.



pH

The pH measurements observed at the sampling stations in the Carmel River always were within the Central Coast Basin Plan recommended range of 7-8.5. For example, **Figure 5.6.1-E** shows the pH measurements recorded at the Los Padres sampling station for the past thirteen years.

CARBON DIOXIDE

Carbon dioxide levels ranging from 0-10 mg/L are recommended for salmonid hatchery water sources (Piper et al. 1982). Carbon dioxide in excess of 20 mg/L may be harmful to fish (Piper et al. 1982). The most detrimental influence of carbon dioxide results when concentrations increase during periods of critically low dissolved oxygen. Dissolved oxygen concentrations at the sampling stations never fell below 7.0 mg/L at times when the carbon dioxide concentrations were above 10 mg/L. For example, carbon dioxide measurements recorded below Los Padres during the last thirteen years are shown in **Figure 5.6.1-F**.

Figure 5.6.1-E. The pH measurements recorded at below Los Padres sampling station from WY 1991-2003.

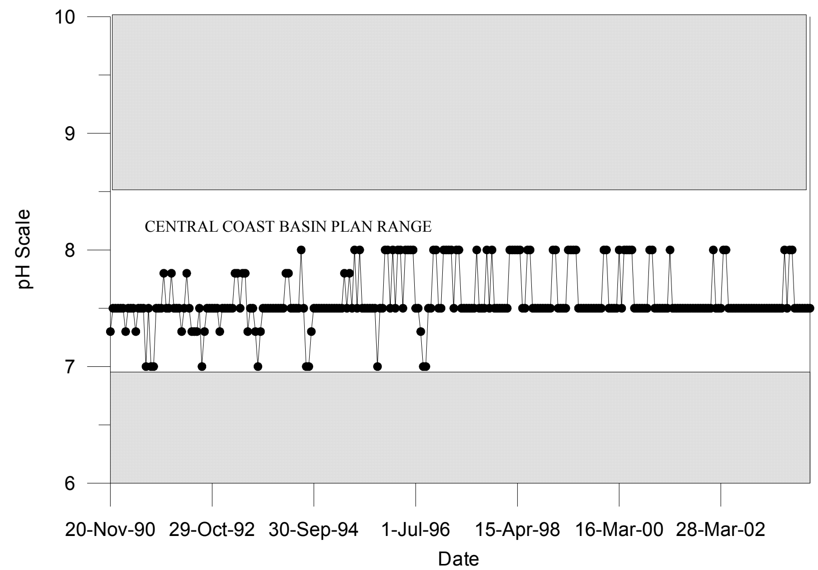
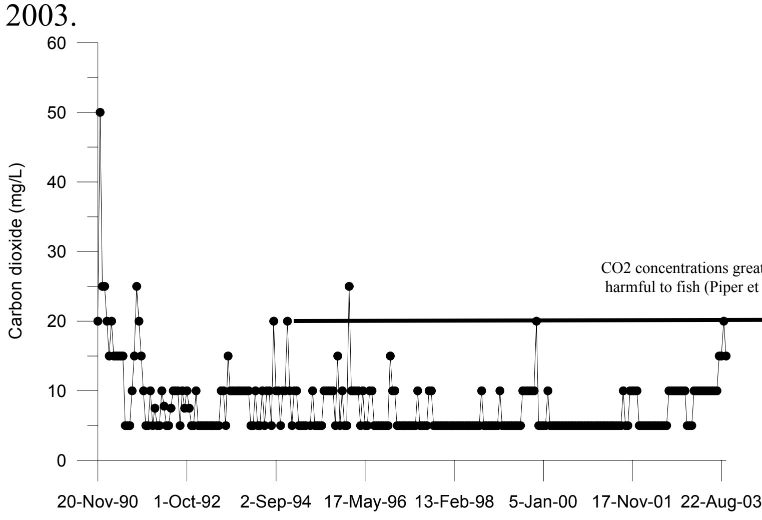


Figure 5.6.1-F. Carbon dioxide measurements recorded below Los Padres during WY 1991-2003.



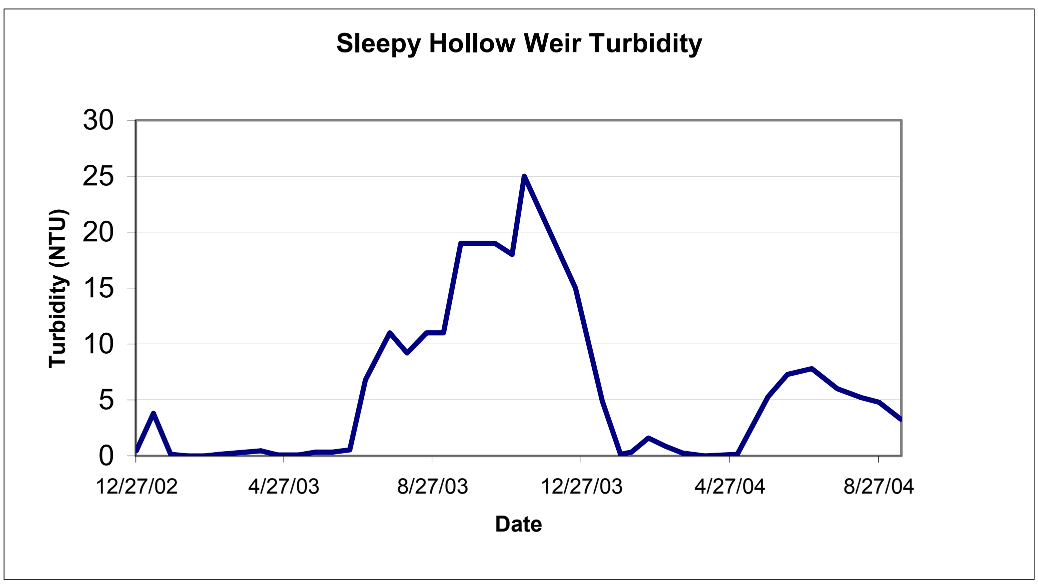
SPECIFIC CONDUCTANCE

Specific conductance at the sampling stations ranged from 129-550 umhos. The average specific conductance over the thirteen-year monitoring period is 267 umhos.

TURBIDITY

Turbidity in the main stem is normally low, except during winter when storm runoff events can elevate turbidity for several days during and after a storm event. Very wet years, such as in 1998, can cause extensive landslides and bank erosion, which can increase turbidity in the main stem for up to several months. In June 2003, Cal-Am was ordered by the State of California's Department of Water Resources, Division of Dam Safety to lower the water elevation of San Clemente Reservoir for safety precautions. The lowering caused a large amount of sediment that was historically trapped behind the dam to move downstream. The turbidity below the San Clemente Dam during this process increased to 25 NTU as shown in **Figure 5.6.1-G**. Sigler et al. (1984) found that turbidity levels of 25 NTU caused a reduction in growth of steelhead. Other effects of elevated turbidity levels on steelhead include disruptions in physiological functions, emigration, decreased foraging ability, damage to redds, reduction in spawning and benthic macro-invertebrate habitat. The Central Coast Basin Plan objectives for turbidity state that levels should not exceed 20% or 10 units above natural levels. Based on the limited amount of data available, it appears that turbidity levels have increased above background levels since the draw down of San Clemente Dam was initiated.

Figure 5.6.1-G. Turbidity measured at the Sleepy Hollow Weir from December 2002 to September 2004.



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SECTION 5.6.2 CARMEL RIVER LAGOON WATER QUALITY

Since 1991, the MPWMD has collected surface water quality data at the Carmel River Lagoon (**Appendix 5.6**). Location and description of sampling stations can be found in **Appendix 5.6**. Data were collected for the following chemical and physical parameters: temperature (°F), dissolved oxygen (mg/L), carbon dioxide (mg/L), pH, specific conductance (uS/cm), salinity (ppt), and turbidity (NTU). The emphasis for this suite of parameters is on the suitability for rearing juvenile steelhead.

Water quality in the Carmel River Lagoon is dependent on freshwater inflow from the Carmel River, tidal levels, and ocean waves over topping the sandbar from the Pacific Ocean. It is typical to observe a decline in water quality during the late summer, fall and early winter months. This is due primarily to a lack of freshwater input and inflow of seawater. For example, during Water Year 2003, there was no freshwater inflow until December 15, 2002 (**Figure 5.6.2-A**). During the time before December 15, 2002, ocean waves over topped the sandbar and added salt water and marine organic material to the lagoon. As shown below, the salinity within the lagoon increased. The marine organic material entering the lagoon causes an increase in decomposition. As shown in **Table 5.6.2-A**, November 2002, this resulted in an increase in carbon dioxide and a decrease in dissolved oxygen. This is a common scenario in the lagoon. Timing of inflows and amount of marine organic material entering the lagoon varies from year to year. The severity of water quality degradation that occurs due to these factors also varies from year to year.

Figure 5.6.2-A. Freshwater inflow and salinity measurements at the Carmel River Lagoon during WY 2003.

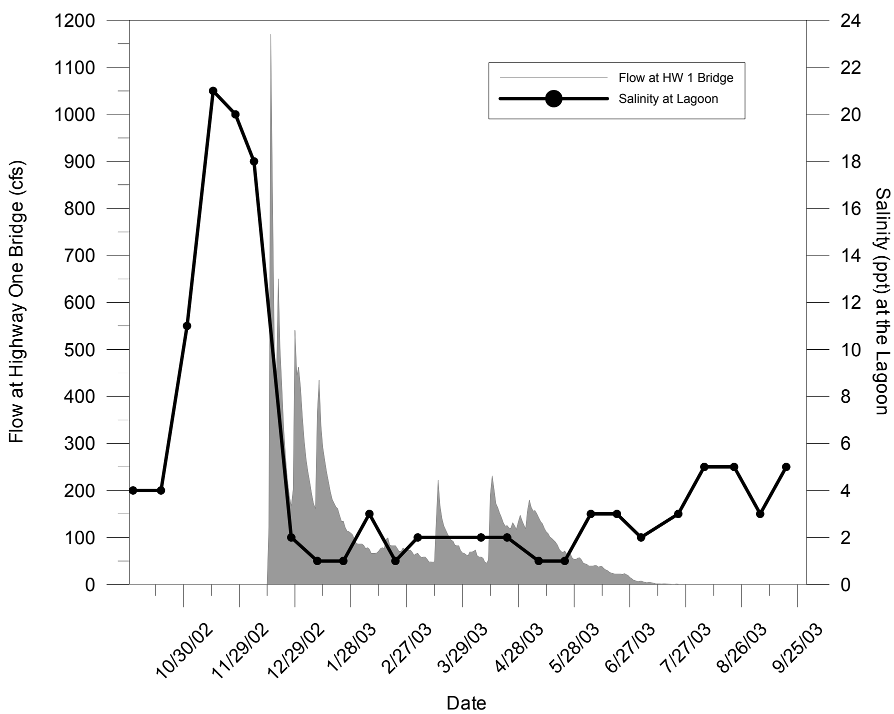
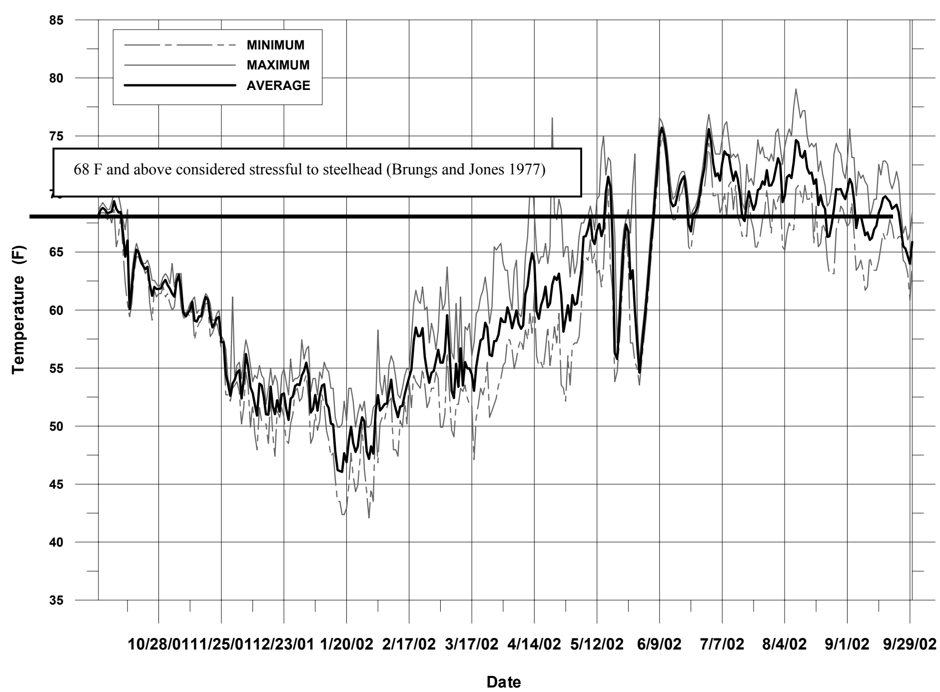


Table 5.6.2-A. Water quality data collected during WY2003 at Carmel River Lagoon.

Date	Time (24 hr)	Temperature (F)	Dissolved Oxygen (mg/L)	Carbon Dioxide (mg/L)	pH	Conductivity (uS/cm)	Nacl (ppt)	Turbidity (NTU)
03-Oct-02	13:13	66.0	11.0	10.0	8.0	9650	4	N/A
18-Oct-02	13:10	63.0	10.0	10.0	8.0	4780	4	N/A
01-Nov-02	12:10	55.0	10.0	10.0	8.0	15160	11	N/A
15-Nov-02	12:15	56.0	2.0	40.0	6.5	>19999	21	N/A
27-Nov-02	11:20	55.0	2.0	35.0	7.5	>19999	20	N/A
12-Dec-02	11:45	53.0	7.0	35.0	7.5	>19999	18	N/A
27-Dec-02	12:30	54.0	9.0	5.0	7.5	437	2	1.5
10-Jan-03	12:25	56.0	10.0	10.0	7.5	283	1	55.0
24-Jan-03	12:50	57.0	10.0	10.0	7.5	1447	1	1.0
07-Feb-03	13:45	52.0	11.0	10.0	7.5	788	3	0.4
21-Feb-03	12:45	58.0	11.0	10.0	8.0	601	1	0.5
05-Mar-03	13:45	60.0	11.0	5.0	8.0	1093	2	0.4
08-Apr-03	14:30	67.0	9.0	10.0	8.0	1324	2	1.2
22-Apr-03	13:35	61.0	10.0	10.0	7.5	1321	2	1.2
09-May-03	12:30	61.0	10.0	10.0	7.5	779	1	1.2
23-May-03	12:25	64.0	9.0	10.0	8.0	565	1	0.7
06-Jun-03	11:40	66.0	9.0	10.0	7.5	1628	3	2.2
20-Jun-03	12:00	69.0	8.0	10.0	8.0	3190	3	1.2
03-Jul-03	12:35	70.0	10.0	15.0	8.0	3320	2	0.7
23-Jul-03	15:10	72.0	11.0	15.0	8.0	5080	3	0.6
06-Aug-03	11:10	75.0	10.0	25.0	8.0	10940	5	1.5
22-Aug-03	13:15	72.0	11.0	25.0	8.0	7160	5	1.0
05-Sep-03	13:05	71.0	12.0	25.0	8.0	6130	3	3.0
19-Sep-03	12:45	70.0	11.0	30.0	8.0	8660	5	5.2
Minimum		52.0	2.0	5.0	6.5	283.0	1.0	0.4
Maximum		75.0	12.0	40.0	8.0	>19999.0	21.0	55.0
Average		62.6	9.3	16.0	7.8			

Lagoon water temperature commonly exceeds 70 degrees Fahrenheit (°F) during the late summer and early fall period. An example of lagoon water temperature in the south arm for WY 2002 is shown in **Figure 5.6.2-B**. Constant water temperature over 68°F is considered to be stressful on steelhead (Brungs and Jones 1977). Factors affecting water temperature within the lagoon are surface water elevation, air temperature, wind, and water temperature of inflow (freshwater and/or sea water). Water temperature graphs for two sampling stations within the lagoon are presented in **Appendix 5.6**.

Figure 5.6.2-B. Water temperature for the South Arm Lagoon during WY 2002.



Favorable water quality conditions for rainbow trout/steelhead culture are listed in **Table 5.6.2-B** (Piper et al., 1982). Also listed below is the Central Coast Basin Plan water quality objectives set by the California Regional Water Quality Control Board. This criteria states that the minimum dissolved oxygen be 7.0 mg/L and the pH range between 7-8.5 at any given time (SWRCB, 1994).

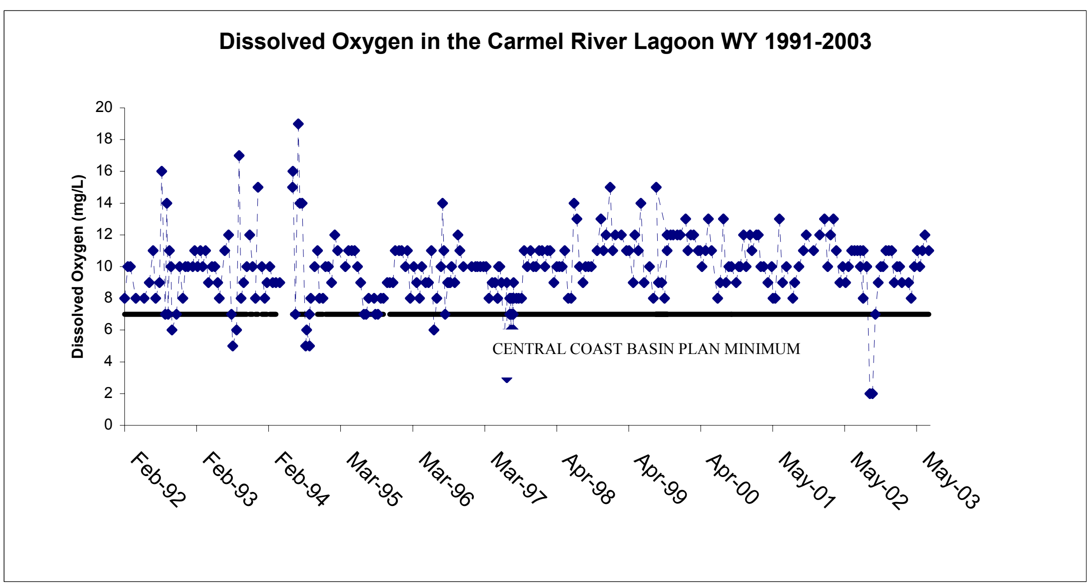
Table 5.6.2-B. Suggested chemical criteria for trout hatchery water supply and Central Coast Basin Plan water quality criteria for cold-water estuaries.

Parameter	***Hatchery water supply****	***Central coast basin plan *****
Temperature range	33-78°F	never 5°F above natural receiving water temp.
Optimum temperature range	50-60°F	N/A
Dissolved oxygen	5 mg/l -saturation	not less than 7.0 mg/L
pH	6.5-8.0	7.0-8.5
Carbon dioxide	0-10 mg/l	N/A

* Piper et al. 1982
** SWRCB, 1994

Dissolved oxygen in the Carmel River Lagoon periodically violates Central Coast Basin Plan water quality guidelines. For example, in six of the last twelve years, dissolved oxygen measurements have been recorded below 7.0 mg/L (**Figure 5.6.2-C**). This is usually observed in the late summer and fall months and is primarily due to increasing water temperature and/or an inflow of large amounts of marine organic material.

Figure 5.6.2-C. Dissolved Oxygen measurements recorded from the Carmel River Lagoon during WY 1991-2003.



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5.7 Conduct Assessment of Benthic Macroinvertebrate Community

5.7.1. Review existing information

Historic Information

The importance of aquatic benthic macroinvertebrates (BMI) as the major food source to a stream's native fish population has been well documented (Cummins 1975). The concept of using BMI as an indicator of water quality and stream health is relatively new with most of the literature on this topic coming from the past 20 years.

In 1997, the United States Environmental Protection Agency (EPA) developed a Rapid Bioassessment Protocol that used BMI as indicators of stream health. In 1999, the California Department of Fish and Game (CDFG) approved the California Stream Bioassessment Procedure (CSBP) based on the EPA protocol (Harrington 1999). CDFG has recommended the use of bioassessment techniques for determining the condition of streams. Further, monitoring of BMI using the CSBP has been required by the State Water Resources Control Board - Division of Water Quality, and the California Regional Water Quality Control Board (RWQCB) for National Pollutant Discharge Elimination System (NPDES) discharge permits, enforcement cases, storm water discharge, and for Agricultural and Timber Harvest Waivers.

On the Carmel River, there has been a limited amount of work done to date with BMI as either a water quality indicator or as they relate to the steelhead population. Three major studies have been completed, or are being worked on now in the Carmel River drainage: (1) the Central Coast Ambient Monitoring Program (CCAMP), 2000 to present; (2) the 1984, W. C. Fields studies, "Invertebrate Fauna of the Carmel River System" and "Food Habits of Fish in the Carmel River System"; and (3) the Monterey Peninsula Water Management District Bioassessment Program, 2000 to present.

Central Coast Ambient Monitoring Program (CCAMP)

As part of its Central Coast Ambient Monitoring Program, the Central Coast Regional Water Quality Control Board (CCRWQCB) has developed three regionally scaled water quality monitoring and assessment programs: (1) *Watershed Rotation Monitoring*, (2) *Coastal Confluence Monitoring and Assessment*, and (3) *Nearshore Monitoring*. The purpose of the program is to provide scientific information to CCRWQCB staff and the public, to protect, restore, and enhance the quality of the waters of Central California. Program data and information can be viewed on the CCAMP web site**:** **http://www.ccamp.org**.

The Watershed Rotation Monitoring Program divides the Region into five watershed rotation areas. Over a five-year period all the Hydrologic Units in the Region are monitored and evaluated. Within each rotation area, 30 permanent sites are established where CCAMP conducts monthly monitoring for conventional water quality parameters. Additional data, including benthic invertebrate community assessment, is collected at a subset of these sites twice every five years. On the Carmel River, two sites have been included in the BMI monitoring: Esquiline Road (River Mile, [RM, measured from the ocean] 14.45), in Carmel Valley Village (data is available over the web at http://www.ccamp.org/ca/3/Sites/307cmu/307CMU.htm), and

Highway 1 (RM 1.09) (for information available on the web, see http://www.ccamp.org/ca/3/Sites/307cml/307CML.htm). BMI data were collected in March 2002 and in April 2003 at Esquiline Road, and in April 2001 and April 2003 at Highway 1 **(Appendix 5.7.1- A)**. Not surprisingly, the BMI assemblages at the Esquiline site were of generally higher quality compared to those at the Highway 1 site where the substrate is very sandy and the river dries up in most years.

The Esquiline Road site had a higher EPT Index percentage[1], a greater number of EPT taxa, more species that are intolerant of poor water quality, and fewer species that are tolerant of poor water quality than the Highway 1 site. Numerically dominant BMI taxa sampled by CCAMP from the Carmel River Esquiline Road site included (in order of decreasing numerical dominance): Simulium (black fly larva), *Baetis* (mayfly), *Orthocladiinae,* and *Chironomidae* (midges). Numerically dominant BMI taxa sampled from the Carmel River Highway 1 site included: Simulium, *Baetis,* and *Orthocladiinae.*

In the Coastal Confluence Monitoring and Assessment Program, water quality is assessed at the confluence of freshwater streams within the central California coast region. The CDFG's Aquatic Bioassessment Laboratory participated in this effort by conducting a pilot study to evaluate the value of BMI bioassessment for monitoring water quality in these coastal lagoon environments. The objectives of the pilot study were to determine a chemical contaminant gradient for fourteen coastal lagoons; collect BMI samples using a standardized procedure to determine a biological gradient; assess whether the biological gradient correlated with the contaminant gradient; and provide recommendations for incorporating biological assessment data into the Coastal Confluence Monitoring and Assessment Program.

For each of the fourteen lagoon sites, biological metrics (numerical attributes of BMI assemblages) were integrated into a site score, which provided a relative assessment of site quality as a function of BMI assemblage quality (see the CCAMP web site for more information). Also, organic chemical constituents (pesticides and PCBs) extracted from sampled sediments at the fourteen lagoon sites were analyzed. Resultant organic chemical values were integrated into a mean Sediment Quality Guideline Quotient (SQGQ). Results of the biological and chemical integrative indices were plotted to explore possible relationships.

One of the fourteen sites was located at the mouth of the Carmel River. Based on the CCAMP data, the Carmel River Lagoon appears to be healthy with a relatively high BMI metric score and a low SQGQ. The BMI metric site score for the Carmel River Lagoon site was above average when compared to the other sites; five sites ranked higher and eight sites ranked lower than the Carmel River Lagoon site. The SQGQ determined for the Carmel River Lagoon site was lowest when compared to the SQGQs determined for the other lagoon sediment samples. There was not a strong relationship determined for biological metric scores and SQGQs. The authors of the study suggested that factors associated with local habitat condition might have had a stronger influence on biological metric scores.

[1] EPT index measures the percentage of the Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies), taxa generally considered to be of high value, in a sample.

Numerically dominant BMI taxa sampled from the Carmel River lagoon included (in order of decreasing numerical dominance): *Corophium*, Gnorimosphaeroma, Cyprididae, *Gammarus* (all amphipods) and Oligochaeta (worms).

1982 Invertebrate Fauna of the Carmel River System

As part of an assessment of Carmel River steelhead resource, a report by Hydrozoology (Fields 1984) was prepared for MPWMD. Fields' report on the Carmel River comprised elements associated with BMI including:

1. Benthic sampling (March and May) and diel drift on the lower river,
2. Terrestrial drift in open versus canopied stream reaches,
3. Benthic sampling on the river reach and tributaries between the San Clemente and Los Padres Reservoirs,
4. Food habits of trout in San Clemente and Los Padres Reservoirs, and
5. Food habits of steelhead for various river reaches including the lagoon.

For element 1, above, black fly (simuliids) and midge larvae (Chironomids) were the most numerically dominant BMI groups for both months but the benthic fauna was less diverse with fewer individuals in March than benthic fauna sampled in May. Although the mayfly *Baetis tricaudatus* was common in March, their abundance in May was much greater. In March, average BMI density at the sites was 1,800 BMI per m^2 (range 510 to 3,000); in May, average BMI density was 3,300 (range 620 to 5,500). There were fewer differences in abundance and composition of benthic fauna in March and May samples at sites where the substrate was relatively stable. Diel drift was highest in areas where substrate consisted of gravel and cobble and was approximately one-quarter as high in areas dominated by sand substrate. Chironomids, simuliids, baetid mayflies and oligochaetes comprised over 93 percent of drifting organisms.

For element 2, above, contributions of terrestrial organisms to drift as a food resource for steelhead was considerably higher (numerical abundance and biovolume) in canopied river reaches when compared to river reaches with no or little canopy cover.

For element 3, above, Fields reported the BMI assemblages of Pine Creek to be the most diverse and attributed the high diversity to the "unperturbed" condition of the site where samples were collected. Fields also found that while there was ample BMI drift downstream of San Clemente Reservoir, species diversity was low and almost all the food available as drift to steelhead consisted of black fly larvae.

For element 4, above, Fields found that trout inhabiting both San Clemente and Los Padres Reservoirs fed on invertebrates from three sources, in order of decreasing relative importance: riverine, lacustrine and terrestrial. By far, the terrestrial component was the least important food source to trout. Of the lacustrine food source, benthic invertebrates were more important than planktonic invertebrates.

MPWMD Carmel River Bioassessment Program (CRBP)

Among other responsibilities, MPWMD fishery personnel regularly monitor surface water quality parameters that affect steelhead (i.e., dissolved oxygen, carbon dioxide and temperature) at stations along the Carmel River. Other staff and contractors monitor the effects of water production on the status of riparian and wetland vegetation along the river. However, other than the 1984 Fields investigation of the invertebrate fauna and feeding requirements of steelhead on the Carmel River, there was limited information available about the aquatic macro invertebrates (BMI) until MPWMD implemented a bioassessment program in the year 2000 (BioAssessment Services. April, 2004).

MPWMD staff recognized that monitoring of BMI could supplement and complement their ongoing surface water quality sampling. Reasons cited to implement a BMI monitoring program (Peckarsky 1997) include:

- BMI are relatively easy to collect and identify.
- BMI have cosmopolitan distribution (are present in a wide variety of habitats).
- BMI have a diversity of species that are responsive to conditions ranging from healthy to degraded.
- BMI are abundant enough that reasonable sampling does not deplete the overall population.
- Many BMI have well-documented natural histories and tolerances to environmental conditions.
- Many have limited mobility, so BMI do not move in and out of habitats seasonally, or in response to degradation.
- Some BMI are relatively long-lived, so chronic degradation can be detected.

Conventional water quality programs focus on chemical contamination, but degradation often stems from other factors, such as sedimentation. In some cases, BMI provide a more effective analytical tool. MPWMD staff also recognized that they had primarily been managing the watershed for a single species (i.e., steelhead), but individual species do not thrive outside of a sustaining biological context.

The objectives of the Bioassessment Program were to:

- Document biological integrity of the Carmel River using BMI assemblages at selected stream locations;
- Consolidate existing BMI data and associated information for the Carmel River;
- Establish a baseline data set using a standardized procedure from which future biological assessments may be compared;
- To contribute data to a Monterey region-wide data set intended to characterize watershed “health” and development of an Index of Biological Integrity (IBI).

Monitoring Sites

In fall of 2000, MPWMD established four sites on the Carmel River to conduct the CRBP. Two additional sites were each sampled once (SHRC in 2000 and CRDD in 2001). A summary of all BMI sites monitored by MPWMD is provided in **Table 5.7.1-A**. The site locations are shown on **Figure 5.7.1-A**, along with the approximate location of sampling sites used by other investigators. The four original sites were selected because they were established steelhead population survey sites and they were representative of most reaches of the Carmel River. The CRRW site was added in 2002 to determine if detrimental effects were occurring as a result of the operation of MPWMD's Sleepy Hollow Steelhead Rearing Facility, and to better detect anticipated effects of sedimentation from Tularcitos Creek. This site may also provide information on the effects of sedimentation and turbidity associated with the lowering of the elevation of San Clemente Reservoir, which began in June 2003, in response to an order from the State Department of Water Resources, Division of Safety of Dams.

Site locations are summarized below:

- Cachagua: between Los Padres Dam and Cachagua Creek;
- Sleepy Hollow: about one mile downstream from San Clemente Dam;
- Sleepy Hollow Rearing Channel: artificial off-channel steelhead rearing facility (sampled once in Fall 2000);
- Russell Wells: added in 2002, between Sleepy Hollow and Stonepine;
- Stonepine: just below confluence with Tularcitos Creek;
- DeDampierre: sampled once in Spring 2001, prior to a restoration project that installed large-woody debris (LWD) in channel;
- Red Rock: Mid-Valley, below the Narrows; channel dries up here some years.

Table 5.7.1-A Carmel River monitoring locations including year and season of sampling for benthic macroinvertebrates (BMI) and habitat assessment (HAB).

Site Name	Site Code	River Mile	GPS Location UTM (10S)	Site Elev. (ft)	2000	2001		2002		2003
					Fall	Spring	Fall	Spring	Fall	Spring
Monitoring Sites										
Cachagua	CRCA	23.5	0619965 4028670	820	BMI/ HAB	BMI/ HAB	BMI/ HAB	BMI/ HAB	BMI/ HAB	BMI/ HAB
Sleepy Hollow	CRSH	17.6	0615287 4034061	380	BMI/ HAB	BMI/ HAB	BMI/ HAB	BMI/ HAB	BMI/ HAB	BMI/ HAB
Russell Wells	CRRW	16.2	0615228 4035817	360					BMI/ HAB	BMI/ HAB
Stonepine	CRSP	15.7	0615162 4036428	280	BMI/ HAB	BMI/ HAB	BMI/ HAB	BMI/ HAB	BMI/ HAB	BMI/ HAB
Red Rock	CRRR	7.7	0605866 4042701	200	BMI/ HAB	BMI/ HAB	BMI/ HAB	BMI/ HAB	BMI/ HAB	BMI/ HAB
Other Sites										
DeDampierre	CRDD	13.9		250		BMI				
SHSRF Channel	SHRC	17.5		380	BMI/ HAB					

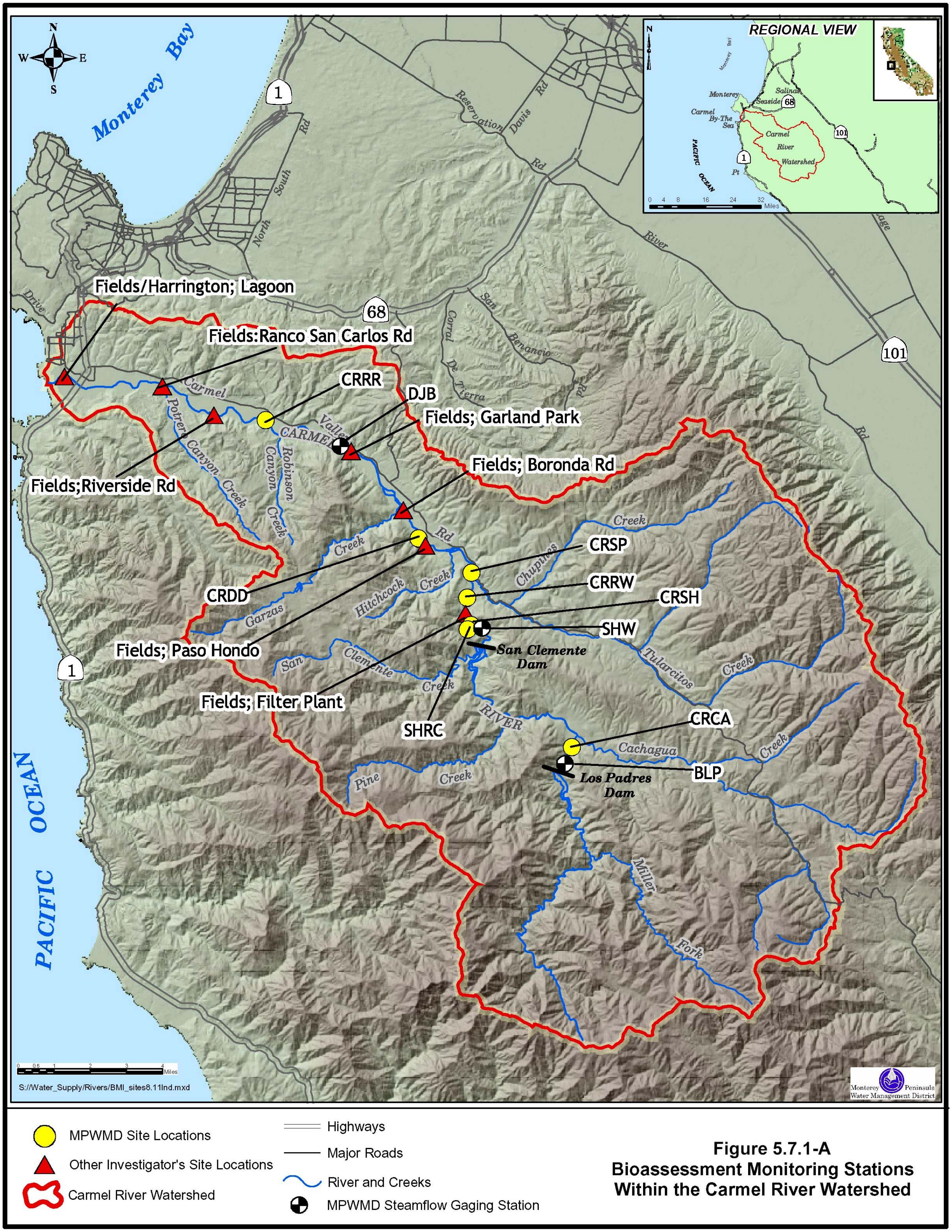


Figure 5.7.1-A
Bioassessment Monitoring Stations Within the Carmel River Watershed

Macroinvertebrate Metrics
BMI taxa and the numbers of BMIs comprising each taxonomic group were entered into a Microsoft Access® database. A taxonomic list and a table of the five most numerically abundant (dominant) taxa for each site were generated using Microsoft Excel®. Cumulative site totals were determined by pooling the BMIs from the three replicate samples collected at each site.

Biological metrics (numerical attributes of biotic assemblages) suggested by the CDFG were generated using Excel® and are described in **Appendix 5.7.1-B**. Tolerance values and functional feeding group designations were obtained from the California Macroinvertebrate Laboratory network (CAMLnet) short list of taxonomic effort, January 2003 revision. Biological metric values were tabulated by sample and summarized by site using mean, standard error and cumulative site totals.

The various metrics can be categorized into five main types:

- Richness Measures (reflects one component of diversity);
- Composition Measures (reflects the relative contribution of individual taxon to the total benthic fauna);
- Tolerance/Intolerance Measures (reflects the relative sensitivity of the assemblage to disturbances such as sediment loading/transport, water quality, and floods);
- Functional Feeding Groups (shows the balance of feeding strategies in the aquatic assemblage);
- Abundance (estimate total number of organisms in sample based on a six square foot sampling area)

Composite Metric Score
To assess the biological integrity of the sites, seven metrics were integrated into a single score for each site. The seven metrics, developed by Ode et al. (2003; in review), were a product of analysis and screening of a large suite of sites and biological metrics for the development of a central coast region Index of Biological Integrity (IBI [P. Ode, personal communication]). The purpose of a regional IBI is to incorporate metrics that are the most responsive and selective for assessing anthropogenic stress on benthic fauna that inhabit wadeable stream systems within a region with similar ecological attributes.

While the development of the central coast region IBI is incomplete, the seven metrics used to develop the IBI have already been evaluated and were thus integrated into composite metric scores for each of the Carmel River monitoring sites using cumulative site totals (metrics based on 900 individuals instead of 300). The seven metrics used to develop the composite metric scores were:

1. Percent Intolerant Individuals
2. Percent Collector-Gatherer + Collector-Filterer Individuals
3. Percent Non-Insect Taxa
4. Percent Tolerant Taxa
5. Coleoptera Richness
6. Predator Richness
7. EPT Richness (includes the Ephemeroptera, Plecoptera and Trichoptera taxonomic orders)

Sites that score high in this integrative index have better than average scores for most or all of the metrics, while sites that score low have poorer scores for most or all of the component metrics **(see section 5.7.3)**. Average ranking sites either have average scores for the component metrics or have a combination of high and low scores[2].

In addition to plotting composite metric scores by site, composite metric scores determined for each sample were plotted against mean substratum particle size **(see section 5.7.3)**. Mean substratum particle size was assessed using substrate composition estimated visually at each sampling location: boulder (phi –8), cobble (phi –7), gravel (phi –4) and sand (phi –1). The phi values ($-\log_2$) were weighted by percent substrate composition at each location where benthic samples were collected.

Benthic Macroinvertebrates

From the 86 samples collected, 25,603 BMIs were processed comprising 87 total taxa, 31 EPT taxa, nine mayfly taxa, two stonefly taxa and 20 caddisfly taxa **(Table 5.7.1-B)**. Tolerance and Shannon Diversity for the pooled samples was 4.9 and 2.7, respectively. Median sample Taxa Richness was 18 (range 8 - 32), median EPT Richness was 7.1 (range 2 – 12), median mayfly richness was 1.9 (range 1 – 5), median stonefly richness was 0.2 (range 0 – 2) and median caddisfly richness was 5.1 (range 1 – 9). Median Tolerance of the samples was 5.0 (range 3.5 – 6.8) and median sample Shannon Diversity was 2.0 (range 0.5 – 2.7).

A project taxa list indicating California Tolerance Values (CTV) and Functional Feeding Group designations is shown in **Appendix 5.7.1-C**; taxonomic lists by season and year are shown in **Appendix 5.7.1-D**. Biological metric values are presented by sample and summarized by site as site mean, standard deviation and cumulative site totals in **Appendix 5.7.1-E**.

Table 5.7.1-B. Commonly reported biological metric values including cumulative project totals and sample statistics for the Carmel River Bioassessment Program.

Metric	Project Totals	Sample Statistics (n = 86)		
		Median	Min	Max
Taxa Richness	87	17	8	32
EPT Taxa	31	7	2	12
Ephemeroptera (mayflies)	9	2	1	5
Plecoptera (stoneflies)	2	0	0	2
Trichoptera (caddisflies)	20	5	1	9
Tolerance Value	4.9	4.9	3.5	6.8
Shannon Diversity	2.7	2.0	0.5	2.7

[2] The formula for computing the composite metric score is as follows: **Composite Metric Score** = $\sum \pm(\mathbf{x}_i - \mathbf{x}_i)/\mathbf{sem}_i$ where: $\mathbf{x}_i$ = sample value for the i-th metric; x_i = overall mean for the i-th metric; sem_i = standard error of the mean for the i-th metric; ±: a plus sign denotes a metric that decreases with response to impairment (e.g. Taxonomic Richness) while a minus sign denotes a metric that increases with response to impairment (e.g. Tolerance Value).

Dominant Taxa

Numerically dominant BMI taxa sampled at the monitoring sites in the spring and fall seasons are presented in **Table 5.7.1-C.** Black flies (*Simulium/Prosimulium*) were by far the most numerically dominant at all sites for both seasons, but with somewhat inconsistent seasonal representation. Percentages of black flies at sites CRSH, CRRW and CRSP were similar for both seasons but their percentages were seasonally variable at sites CRCA and CRRR. The mayfly *Baetis* was consistently dominant at all sites during both seasons. Other taxa were either more seasonal or site specific. Seasonal taxa included the hydroptilid caddisfly *Leucotrichia pictipes*, which was dominant only in fall samples at all sites except site CRRR. The fixed-retreat making caddisfly, *Wormaldia*, was dominant at the three middle sites (CRSH, CRRW and CRSP), but only in the spring. With the exception of *Leucotrichia pictipes*, there did not appear to be a strong and consistent seasonal component influencing composition of dominant taxa.

Several taxa were site specific or specific to groups of sites. The amphipod *Hyalella*, was sampled only from spring season samples at site CRCA, the mayfly *Tricorythodes*, was dominant only at site CRRR and the caddisfly *Cheumatopsyche*, was dominant in fall samples at site CRSP. The portable case making caddisfly *Micrasema*, was most abundant at the two lowermost sites: CRSP and CRRR. *Micrasema* was the most dominant taxon in spring samples at the lowermost site (CRRR). Midges within the subfamily Orthocladiinae and tribe Tanytarsini were consistently more abundant at the three uppermost sites (CRCA, CRSH and CRRW) when compared to the two lowermost sites (CRSP and CRRR).

Intolerant Taxa

Entomologists have developed tolerance values for many common aquatic macroinvertebrate species, based on their abilities to thrive in disturbed conditions. Generally, BMIs that require well oxygenated, cool, flowing water are assigned low values while BMIs that are less sensitive to low dissolved oxygen and elevated temperature are assigned higher tolerance values. The assignment of tolerance values is complicated by potential variation in tolerance of the life stages of any given BMI taxon and by potential variation exhibited at the species level.

BMI taxa with tolerance values less than three are shown for the monitoring sites in **Table 5.7.1-D.** There were two intolerant taxa within the Diptera (true flies) insect order but most taxa were within the insect orders usually associated with intolerance: Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies). The mayflies, *Ephemerella* and *Serratella* were most abundant within the lower elevation sites (CRSP and CRRR). A baetid mayfly, *Centroptilum* (one individual) was sampled from site CRSP. Stoneflies were scarce at the Carmel River monitoring sites; the only individuals sampled are shown in Table 5.7.1-D (*Malenka* and *Isoperla*). The three *Isoperla* individuals were collected in the first sample set from the fall of 2000. Most intolerant taxa were sampled from site CRSP but site CRRR had by far the most individuals represented by sensitive groups.

Tolerant Taxa

There were seventeen BMI taxa sampled with tolerance values greater than 7 as shown in **Appendix 5.7.1-C,** but only a few of these were members of the seven numerically dominate taxa for any of the five main sites **(Table 5.7.1-C)**. The amphipod *Hyalella*; the tubifida worm, Naididae; and the seed shrimp, Ostracoda all have tolerance values of eight and are part of the collector-gatherer feeding group. None comprised more than 14% of any sample (CRRW Fall), and were generally less than 5% of the total sample.

Table 5.7.1-C. Numerically dominant benthic macroinvertebrate taxa sampled from the Carmel River in the fall season (years 2000 to 2002 and in the spring season (years 2001 to 2003). Also shown is the percentage of individuals subsampled that comprised the seven most dominant groups.

		Dominant Taxa							
Site	**Season**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Total**
CRCA	Spring	*Simulium/ Prosimulium* 30%	*Baetis* 22%	Orthocladiinae 12%	*Hyalella* 11%	Tanytarsini 6%	*Hydropsyche* 4%	Naididae 4%	89%
	Fall	*Baetis* 20%	*Leucotrichia pictipes* 17%	*Hydropsyche* 14%	Orthocladiinae 10%	Tanytarsini 10%	*Argia* 6%	*Simulium/ Prosimulium* 5%	82%
CRSH	Spring	*Simulium/ Prosimulium* 32%	*Baetis* 30%	Orthocladiinae 14%	Naididae 5%	*Antocha* 4%	Tanytarsini 2%	*Wormaldia* 2%	89%
	Fall	*Simulium/ Prosimulium* 31%	*Baetis* 26%	*Leucotrichia pictipes* 14%	Orthocladiinae 8%	*Hydropsyche* 3%	*Argia* 3%	*Antocha* 3%	71%
CRRW	Spring	*Baetis* 35%	*Simulium/ Prosimulium* 33%	Orthocladiinae 12%	*Wormaldia* 4%	*Antocha* 4%	*Micrasema* 3%	*Hydropsyche* 3%	94%
	Fall	*Simulium/ Prosimulium* 23%	*Baetis* 21%	Orthocladiinae 18%	Ostracoda 14%	*Leucotrichia pictipes* 5%	*Hydropsyche* 4%	*Ochrotrichia* 3%	67%
CRSP	Spring	*Baetis* 40%	*Simulium/ Prosimulium* 19%	*Hydropsyche* 12%	*Micrasema* 6%	*Wormaldia* 6%	Orthocladiinae 5%	*Antocha* 2%	89%
	Fall	*Hydropsyche* 26%	*Baetis* 22%	*Simulium/ Prosimulium* 13%	*Cheumatopsyche* 6%	*Micrasema* 6%	*Leucotrichia pictipes* 4%	Naididae 3%	72%
CRRR	Spring	*Micrasema* 22%	*Baetis* 15%	*Hydropsyche* 11%	Tanytarsini 8%	*Simulium/ Prosimulium* 5%	Ostracoda 5%	*Tricorythodes* 5%	72%
	Fall	*Simulium/ Prosimulium* 20%	*Tricorythodes* 12%	*Hydropsyche* 10%	*Baetis* 8%	*Micrasema* 8%	Tanytarsini 5%	Orthocladiinae 4%	66%

Table 5.7.1-D. Intolerant benthic macroinvertebrate taxa sampled from Carmel River monitoring sites. CTV=California Tolerance Value.

Taxa	CTV	Sites				
		CRCA	CRSH	CRRW	CRSP	CRRR
Diptera (true flies)						
Dixidae						
Dixa	2	1	4		2	
Psychodidae						
Maruina lanceolata	2				1	
Ephemeroptera (mayflies)						
Baetidae						
Centroptilum	2				1	
Ephemerellidae						
Ephemerella	1			2	4	50
Serratella	2	1	1		12	77
Plecoptera (stoneflies)						
Nemouridae						
Malenka	2	2	1	2	10	
Perlodidae						
Isoperla	2				3	
Trichoptera (caddisflies)						
Brachycentridae						
Micrasema	1	167	35	37	316	814
Glossosomatidae						
Agapetus	0				9	
Glossosoma	1				2	
Glossosomatidae (pupae)	0					3
Lepidostomatidae						
Lepidostoma	1	2			5	12
Psychomyiidae						
Tinodes	2				3	38
Rhyacophilidae						
Rhyacophila	0	1	15	2	31	
Total Taxa:		6	5	4	13	6
Total Intolerant Individuals:		174	56	43	399	994

5.7.2 ANALYSIS OF MACROINVERTEBRATE FUNCTIONAL GROUPS

5.7.2a Functional Feeding Groups

Functional feeding groups (FFG) are a classification approach that is based on morpho-behavioral mechanisms of food acquisition rather than taxonomic group. The same general morpho-behavioral mechanisms in different species can result in the ingestion of a wide range of food items (Merritt and Cummins, 1996). The benefit of this method is that instead of hundreds of different taxa to be studied, a small number of groups of organisms can be studied collectively based on the way they function and process energy in the stream ecosystem. Individuals are categorized based on their mechanisms for obtaining food and the particle size of the food, and not specifically on what they are eating. Thus, the functional feeding group method of analysis avoids the relatively non-informative necessity to classify the majority of aquatic insect taxa as omnivores and it establishes linkages to basic aquatic food resource categories (coarse particulate organic matter [CPOM, particles >1mm], fine particulate organic matter [FPOM, particles <1 mm and >0.45 µm], periphyton, and prey) requiring different adaptations for their exploitation.

The major functional feeding groups are 1) ***scrapers/grazers*** which consume algae and associated material; 2) ***shredders***, which consume leaf litter or other CPOM, including wood; 3) ***collector-gatherers***, which collect FPOM from the stream bottom; 4) ***collectors-filterers***, which collect FPOM from the water column using a variety of filters; and 5) ***predators***, which feed on other consumers (Naiman and Bilby, 2001). A sixth category, ***other***, includes species that are omnivores, or simply do not fit neatly into the other categories.

Functional feeding group analyses support the notion that linkages exist in riparian-dominated headwater streams between CPOM and shredders, and FPOM and collectors, and between primary production (e.g., periphyton in midsized rivers) and scrapers. The feeding of shredders on riparian litter affects detrital processing in aquatic systems. About 30% of the conversion of CPOM leaf litter to FPOM has been attributed to shredder feeding (Petersen and Cummins 1974), and this can affect the growth of FPOM feeding collectors (Short and Maslin 1977). In addition, shredder feeding enhances the release of dissolved organic matter (DOM; Meyer and O'Hop 1983). Such analyses link the balance between food resource categories and the predictable response of aquatic insect assemblages.

<u>Functional Feeding Groups in the Carmel River 2000 - 2003</u>

Samples collected during the fall season from mid-Carmel Valley at the CRRR site (see Fig. 5.7.1-A) had the most functionally balanced BMI assemblages (diverse feeding groups), while spring samples collected at Cachagua from the CRCA site had the least functionally balanced BMI assemblages. The higher percentage of scrapers and shredders in the fall season at all sites is likely an indicator of the greater amounts of algal growth on rocks and more leaf litter available in the stream.

A consistent pattern in the distribution of BMIs among the functional feeding groups was not evident for the five primary sites, with the possible exception of higher percentages of BMIs in the “other” FFG category sampled from site CRRR **(Figure 5.7.2a-A)**.

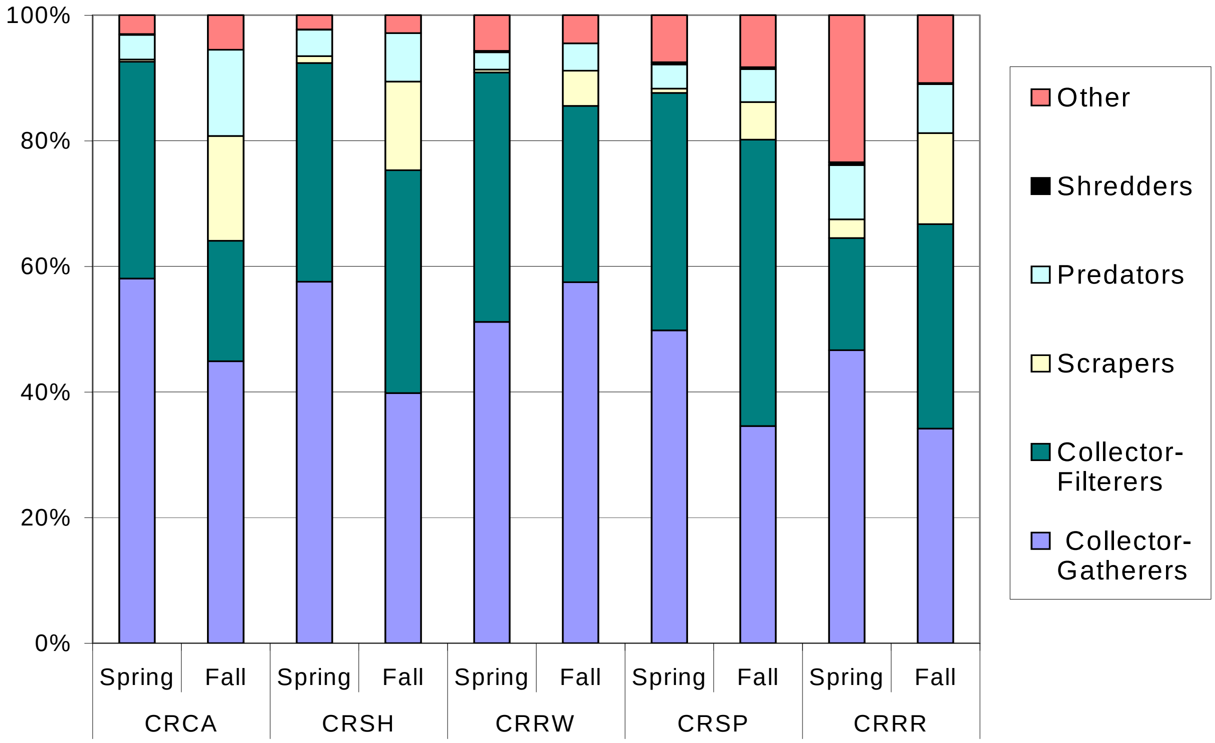


Figure 5.7.2a-A. **Percentages of benthic macroinvertebrate functional feeding groups (FFG) sampled from Carmel River monitoring sites 2000 - 2003.**

High numbers of individual *Baetis* mayflies, and the midges Orthocladiinae and Tanytarsini contributed to the numerical dominance of the collector-gatherer FFG at each site, except for Stonepine (CRSP) in the fall **(Appendices 5.7.1-C and 5.7.1-D)**. This feeding group typically comprised 35 to 55 percent of the BMI in all samples.

Black flies and hydropsychid caddisflies were the most important contributors to the collector-filterer FFG.

The hydroptilid *Leucotrichia pictipes* was the primary contributor to the scraper FFG but other BMI taxa such as the water penny *Psephenus falli*, the heptageniid mayfly *Ironodes*, and the riffle beetle *Optioservus*, also contributed to the representation of the scraper FFG. There was a trend of higher percentages of scrapers in the fall season when compared to the percentage of scrapers in the spring season.

Several BMI taxa contributed to the predator FFG including the damselfly *Argia*, water mites comprising several genera (mostly *Sperchon*), flatworms, and at some sites dance flies (several genera within the family Empididae).

Shredders were scarce in the samples, comprising between zero and two percent of the FFGs.

Several of the shredders that were present in the samples had low tolerance values, perhaps indicating that a water quality issue may be cause of the scarcity since there did not appear to be a lack of leaf litter in the fall sampling season. The shredding caddisfly, *Lepidostoma*, was the most abundant shredder in the samples but was not numerically dominant at any of the sites.

FFGs listed as "<u>other</u>" include omnivore, xylophage, parasite, macrophyte-herbivore and piercer-herbivore. Localized abundance of the caddisfly *Micrasema*, an omnivore, present in samples collected from site CRRR contributed to the relatively high percentage of the "other" FFG category.

5.7.2b Analysis of Drift Feeders

As Outlined in Merritt and Cummins (1996)

Downstream drift is a characteristic phenomenon of invertebrates in running waters. Despite the adaptations for maintaining their positions in the current or avoiding it, occasional individuals could be expected to lose attachment or orientation and be transported downstream. However, the large numbers of some taxa that drift indicate that this is more than a passive activity. Waters (1965) divided drift into three categories: (1) ***catastrophic***, resulting from physical disturbance of the bottom fauna, e.g., by floods, high temperatures, and pollutants, (2) ***behavioral***, indicated by characteristic behavior patterns resulting in a consistent diel periodicity (usually at night), and (3) ***constant***, the continual occurrence of low numbers of most species. Mayflies of the genus *Baetis* consistently exhibit high behavioral drift rates with a night active periodicity. Other mayflies, stoneflies, caddisflies, black flies, and the amphipod *Gammarus* sp. are frequently abundant in drift. Drift is important to stream systems in the recolonization of denuded areas, as a dispersal mechanism, and particularly as a food source for visual predators. Many fish, especially salmonids and in particular juvenile steelhead, select and defend territories best suited for the interception of drift (Waters 1972).

Drift propensity is related to behavioral habits, which are reflected by body shape and vary with functional feeding group. For example, many of the active (behavioral) drifters are swimmers, well adapted to their collector-gather lifestyle and swim frequently between food patches. They have a cylindrical, streamlined body shape with a height to width ratio near 1. Almost all of the filtering-collectors and scrapers cling to surfaces. Scrapers and predators that are clingers have a flattened body (low height to width ratio) that avoids the main thrust of the current. These are normally accidental drifters that are dislodged into the current from their high-risk locations on exposed, periphyton-rich surfaces. Burrowers generally have a cylindrical body shape (high ratio), such as many shredders, that live concealed in their plant litter food resource and are accidentally introduced into the drift when the litter accumulations they inhabit are disturbed. Sprawlers may have low height to width ratios, but the adaptation is largely for wide bodies to maintain position on top of flocculant substrates in depositional areas. Their appearance in the drift is normally accidental occurring at times when depositional areas are scoured. Some shredders are sprawlers living and feeding on litter accumulations and woody debris and occasionally drift between food patches. (Wilzbach *et at.* 1988).

A survival advantage for generalists may accrue during unpredictable changes in environmental conditions when resources are unavailable. Predictably, such generalists are often pioneer colonists performing better than specialists in newly available aquatic habitats following disturbance, but are outperformed by obligate specialists in mature systems.

Distribution of an aquatic insect population is ultimately set by the physical-chemical tolerance of the individuals in the population to an array of environmental factors. Within its range of occurrence, population abundance is regulated through interactions between habitat and food suitability and availability (Merritt and Cummins, 1996).

Relationship Between Drift Insects and Steelhead (Fields, 1984)

Studies of the food habits of juvenile steelhead in 1982 documented the relative contribution of food from three sources, including drifting insects, terrestrial insects, and benthic invertebrates (Fields, 1984) (**Figure 5.7.2b-A**). Approximately 96 percent of the food consumed by smolts originated from drift and terrestrial sources. The tendency for young-of-the-year fish to consume drifting insects was more pronounced with drift insects comprising more than 99 percent of the food. While juvenile steelhead feed on drifting insects, much of this food originates from the benthic environment. Consequently, the proportion of food comprising drift species is correlated to the proportion of these species in the benthos (**Figure 5.7.2b-B**). An adequate food supply depends upon maintenance of populations of insects that exhibit drifting behavior. Rader (1997) rated 95 taxa of stream invertebrates on their tendency to drift and developed an index for rating the availability of these taxa as food resources for salmonids. He compared this index with the percentage contribution of taxa in stomach samples and found good correlations. Based on this study, it appears that the availability of drifting insects is a key component of energy transfer from lower trophic levels to juvenile steelhead populations. Predicting that the food supply for juvenile steelhead will be adequate and sufficient is reasonable if the benthic community is dominated by abundant numbers of drifting insects.

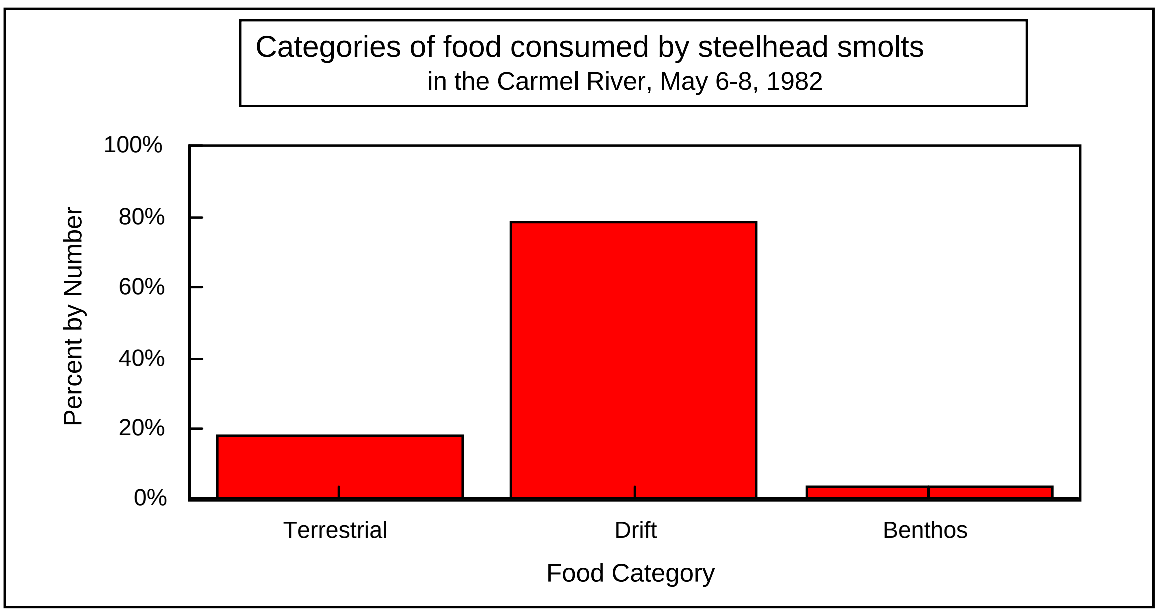
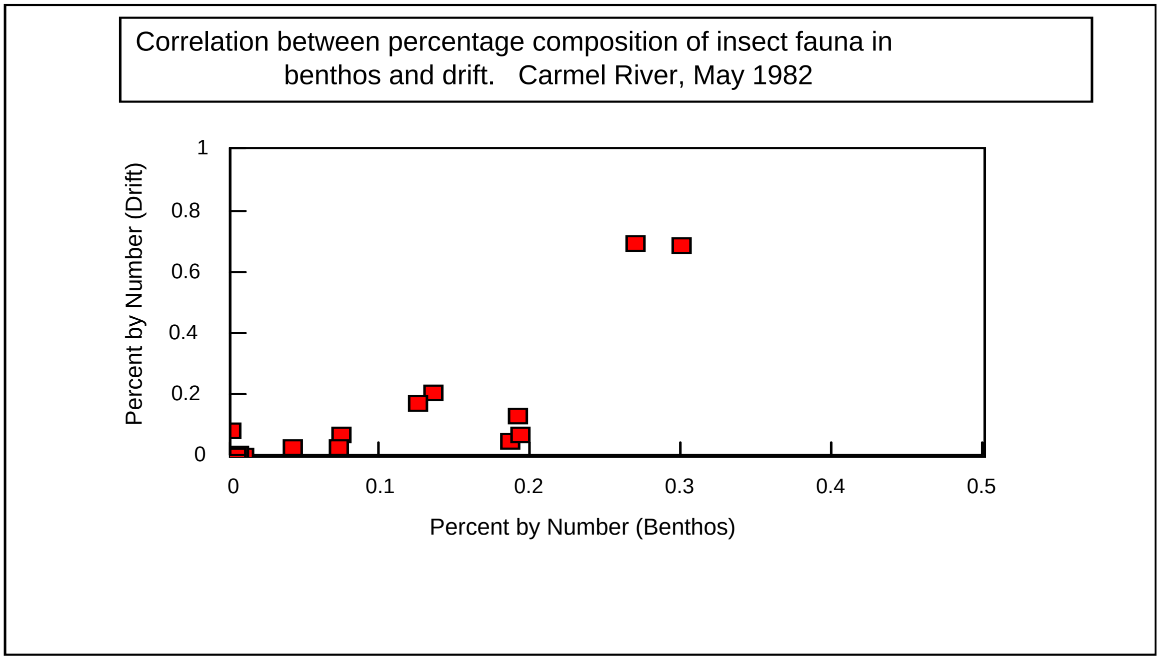


Figure 5.7.2b-A. Categories of food consumed by steelhead smolts.



Note: Data shown for most important food items in stomachs of steelhead smolts
Source of primary data: Fields (1984)

Figure 5.7.2b-B. Correlation between percentage composition of insect fauna in benthos and drift.

As suggested by Wooton, Parker and Power (1996), the dominance by drifting insects may be associated with occurrence of high flows, which mobilize coarse sediment and dislodge the benthic fauna, including mobile and sessile species. The drift propensity for BMI in three reaches on the Carmel River were analyzed using data from Field's 1984 report:

(1) *Cachagua Creek to Los Padres Dam* - Based on 1982 surveys, the aquatic insect biota in this reach is rich (38 species), highly diverse (Shannon-Weaver Diversity Index [SWDI] = 3.58), and moderately abundant (insect density = 4,400 individuals/square meter [No/m^2]). More important, the assemblage of insects is dominated by drifting insects, including Chironomid and Simulid flies and Baetid mayflies, which are readily consumed by juvenile steelhead. Based on the drift rating system proposed by Rader (1997), the drift propensity in this reach is high for 33 of the insect species (87% of the total) (**Figure 5.7.2b-C**). The drift propensity is low or negligible for only two species, representing less than 1 percent of the total number of insects in the benthos.

(2) *Tularcitos Creek to San Clemente Dam* - The aquatic insect biota in this reach is characterized by lower species richness (average 31 species), lower diversity (average SWDI = 3.06), and low abundance (insect density = 2,265 No/m^2). As in the reach above Cachagua Creek, the assemblage is dominated by drifting insects, with high rate drifters comprising 84 percent of the species (average of 24.5 of 29 total species) and about 92 percent of the organisms (**Figure 5.7.2b-D**). Only three species with low or negligible drift propensities were noted, representing less than 1 percent of the number of insects.

(3) *Narrows to Tularcitos Creek* - The aquatic insect biota is characterized by lower species richness (averaging 29 species), variable diversity (SWDI ranging from 1.83 to 3.26), and low to abundance populations (average insect density = 4,115 No/m^2 and ranging from 2,146 - 5,182 No/m^2). As in other reaches, species with low or negligible drift propensities comprised no more than 1 percent of the total number of insects (**Figure 5.7.2b-D**). A summary of the species composition in 1982, including: Order, Family, Genus and Species, and ranking by number are shown in **Appendix 5.7.2b-A**.

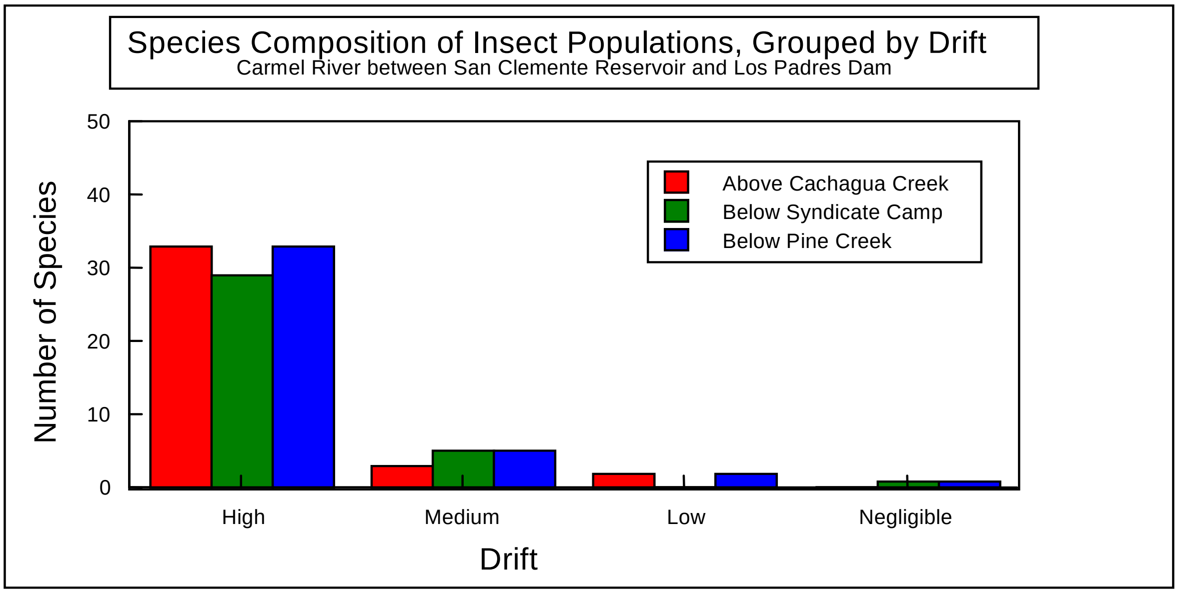


Figure 5.7.2b-C. 1982 species composition and drift propensity in the reaches between Los Padres and San Clemente dams.

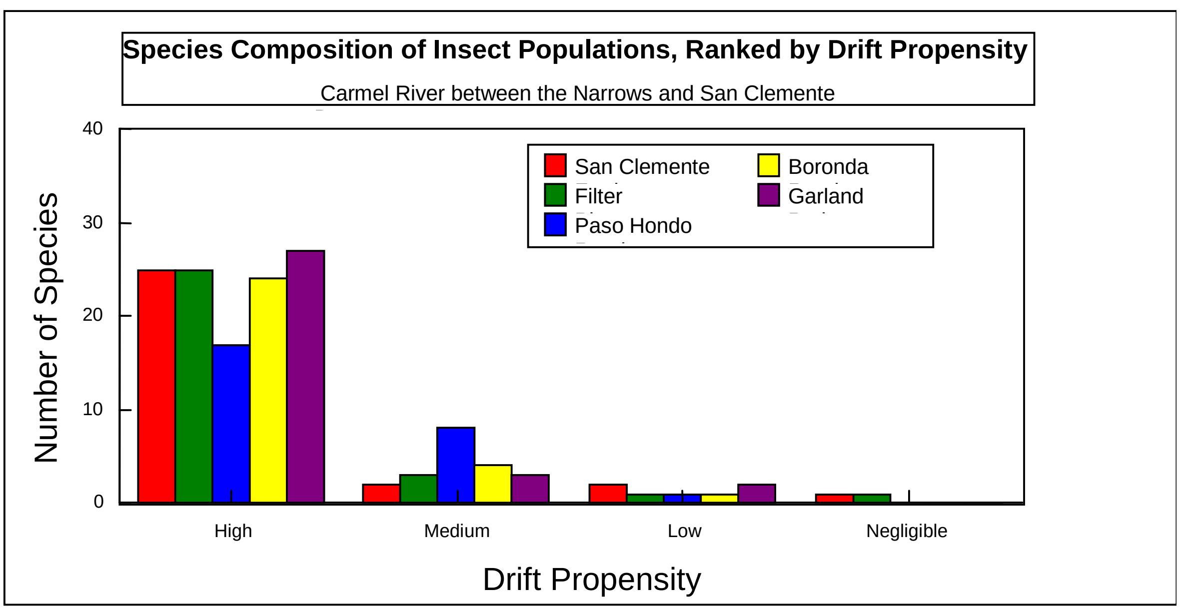


Figure 5.7.2b-D. 1982 species composition and drift propensity between the Narrows and San Clemente Dam.

5.7.3 FACTORS LIMITING BENTHIC INVERTEBRATE PRODUCTION

There are many factors that can limit BMI composition and abundance. Physical characteristics include substratum, current velocity, food availability, water temperature, dissolved oxygen concentration, and water chemistry. On the local level, substrate size and current velocity are often the most important factors affecting the types of BMI present (Naiman and Bilby, 2001). Factors contributing to streams with productive and diverse benthic fauna include mixtures of loosely consolidated coarse substrate, abundant CPOM and LWD, a natural hydrograph, consistent gravel inputs with retention, and good water quality (e.g. Alan 1995, Petts 1984).

These conditions become altered in urban areas where upstream impervious landscape surfaces alter the natural hydrograph and interfere with the production, transport and retention of suitable material (Williams and Feltmate 1992, Schueler 1995, and Karr and Chu 1999). While bank sloughing is a natural phenomenon of stream systems, urban streams are characterized as having higher peak discharges, which contribute to reduced bank stability, increased channel cross-sectional area and higher sediment discharge (Trimble 1997). Excessive sediment fills the interstitial spaces, decreasing the area within the substrate available for colonization of benthic fauna (Allan 1995). Often, a shift in benthic fauna occurs with increases in sedimentation resulting in increases in burrowing forms such as oligochaetes and clams and potentially contributes to lower richness and diversity. Furthermore, altered hydrographs resulting from instream impoundment may affect benthic fauna that are dependent on cyclic thermal cues for their development (Ward and Stanford 1979). Benthic fauna of urban streams may also be affected by constituents from storm water runoff such as petroleum hydrocarbons, fine sediment, pesticides, fertilizers and detergents (Schueler 1987) as well as discharge from septic systems.

While the primary objective of the three-year Carmel River Bioassessment monitoring program (2000 to 2003) was to establish a baseline of data, several interim results of the program are worth noting. First, there was a trend of higher quality BMI assemblages sampled from the lowest elevation site in the drainage at Red Rock (CRRR, near mid-Carmel Valley) when compared to the other sites (BioAssessment Services, 2004) **(Figure 5.7.3-A)**. This was demonstrated by the composite metric scores but was also supported by CRRR's relatively high Taxa Richness values, and higher abundance values for the two lower elevation sites, CRSP (at the confluence of Tularcitos Creek with the main stem) and CRRR **(Appendix 5.7.1-E)**. Second, the highest elevation site at Cachagua had consistently lower quality macroinvertebrate assemblages when compared to the other sites in both the spring and fall season samples. Third, there was a trend of decreasing BMI assemblage quality during the three-year monitoring period. Finally, there was a weak relationship between substrate size class and macroinvertebrate assemblage quality. Samples collected in substrate consisting of boulder and large cobble had generally lower quality macroinvertebrate assemblages when compared to macroinvertebrate assemblages sampled in substrate consisting of mixtures of gravel and cobble.

Site **CRRR**'s relatively high BMI assemblage quality is important because the site receives a more urbanized flow from the Carmel Valley downstream of River Mile 15 when compared to sites upstream of Carmel Valley Village, especially site CRCA (immediately downstream of Los Padres Dam). In addition to more of an urbanized flow, site CRRR also receives more flow from un-regulated tributaries, such as Pine, San Clemente, Tularcitos, and Garzas creeks. Sensitive taxa were also better represented at both downstream sites (CRRR and CRSP) as well as longer-lived taxa such as elmid beetles. Long-lived taxa that use cyclic thermal cues for their development are more sensitive to alterations in annual temperature regime.

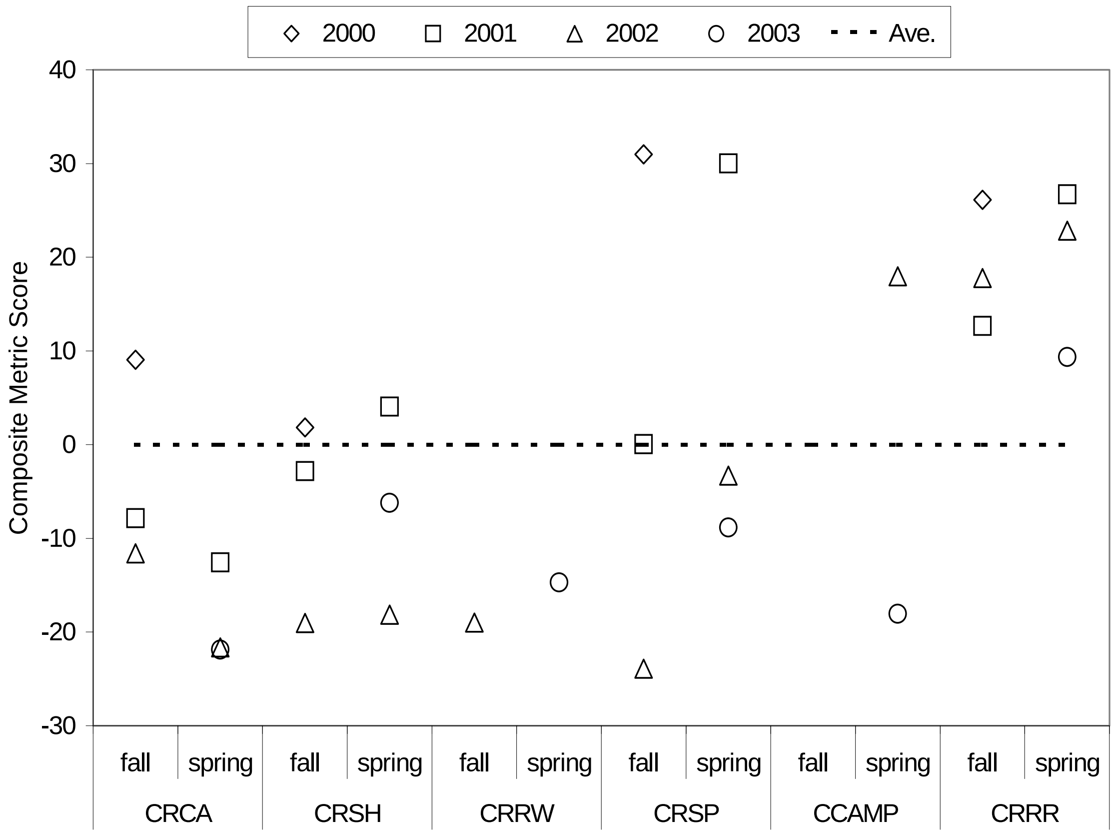


Figure 5.7.3-A. Composite metric scores for benthic macroinvertebrates collected from monitoring sites within the Carmel River. Sampling was initiated at site CRRW in the fall season of 2002. Data for composite metric scores for site CCAMP were derived from taxonomic lists provided by the Central Coast Regional Water Quality Control Board.

Conversely, site **CRCA**, which receives a regulated flow regime from Los Padres Dam with no influence from unregulated tributaries had a relatively poor BMI assemblage quality. This preliminary result suggests that the influence of Los Padres Dam may have had more of an effect on BMI assemblages than the more urbanized flow occurring lower in the watershed. The weak relationship between substrate size class and composite metric scores suggested that larger substrate at site CRCA may have contributed to lower quality of BMI assemblages **(Figure 5.7.3-B)**. Although inconclusive, other studies have suggested that while substrate consisting of gravel and cobble are optimal for colonization, diversity begins to decline when substrate composition shifts to large cobble and boulder (Alan 1995). Impoundments on main stem rivers, such as at Los Padres Dam and Reservoir, frequently block passage of bed material that would otherwise replenish the substrate downstream of the dam. Because the reservoir has little effect on peak flows, material downstream of the dam is scoured out, resulting in channel degradation and a substrate that coarsens over time. As the substrate coarsens, progressively higher flows are required to disturb the bed material. This armoring effect is common on main stem dams.

However, the weak relationship between substrate composition and BMI assemblage quality suggests that other factors may have contributed to the poorer relative quality of BMI assemblages at site CRCA. Other factors associated with the impoundment including alterations in temperature and flow regimes could have contributed to poor quality BMI assemblages. Fields (1984) documented poorer BMI assemblages at sites between San Clemente and Los Padres dams when compared to BMI assemblages sampled from unregulated tributary streams draining into the Carmel River, particularly Pine Creek.

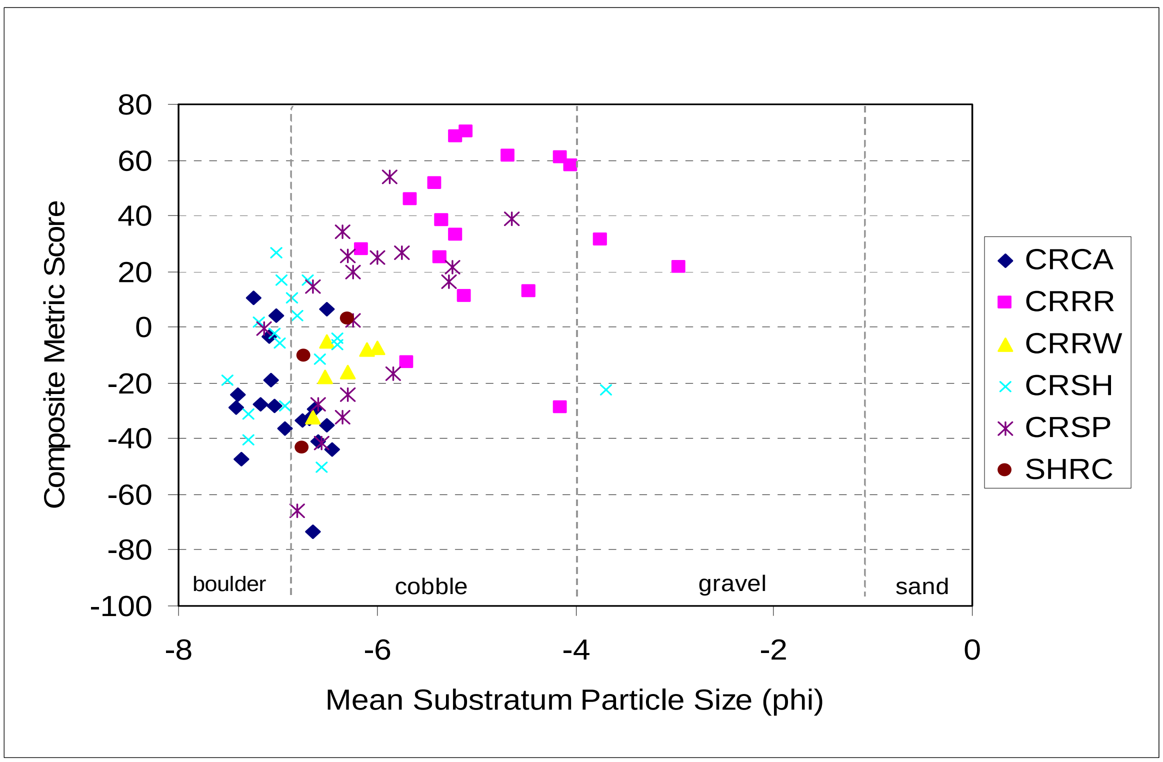


Figure 5.7.3-B. Benthic macroinvertebrate composite metric scores vs. weighted mean substratum size class for Carmel River samples collected at indicated sites

<u>Potential BMI Limiting Factors By Reach:</u>

(1) *Carmel River Lagoon to Valley Greens Drive Bridge* (RM 4.8) – This reach has two major constraints to BMI production. The most serious of these is the annual summer drying up of the river by pumping. In the past 40 years, the river has flowed year-round

to the lagoon only twice, in 1983 and 1998. The sandy substrate also limits the quality of the BMI assemblage due to the constant shifting of the bed material and the lack of habitable surface area.

(2) *Valley Greens Drive Bridge to Schulte Road Bridge* (RM 6.7) – As in the previous reach, this section dries up during most years, but the riffle substrate consists of more gravel and less sand.

(3) *Schulte Bridge to Esquiline Road Bridge* (RM 14.5) – This reach is highly influenced by urban activities such as channelization and bank hardening, vegetation removal, street runoff, and septic system drain fields. Despite these problems, the BMI assemblages are surprisingly healthy here. Consistent year-round flow, a good gravel/cobble substrate mix, combined with the influence of several tributaries make this reach highly productive.

(4) *Esquiline Bridge to San Clemente Dam* (RM 18.6) – The dam is the biggest factor influencing BMI in this reach. Built in 1921, the reservoir has been trapping sand, gravel and cobble for over 80 years. The result is a substrate consisting mostly of boulders and large cobbles that lack the interstitial space required for many BMI taxa to thrive. The MPWMD has been adding 2 – 4 inch gravel to this reach the past 10 years as part of its steelhead spawning habitat restoration project. The continuation and expansion of this program would help improve BMI habitat. Ironically, the reservoir is now nearly full of sand, which may begin spilling over the dam in the near future. This fine material will likely fill the remaining, limited interstitial spaces between the cobbles and boulders leading to additional scour of existing BMI and less habitat space for BMI.

(5) *San Clemente Reservoir to Cachagua Creek confluence* (RM 23.8) - This reach has few apparent constraints to BMI production. Its relative isolation and pristine condition, good mix of substrate size classes, and year-around flow should make this section of river one of the best for BMI production. No BMI survey work has been done in this reach since 1982 when Fields found both a high number of species and very high population densities.

(6) *Cachagua Creek to Los Padres Dam* (RM 24.8) – Like San Clemente Dam, Los Padres Dam, built in 1948, blocks the downstream passage of cobble and gravel, leaving boulders as the primary substrate below the dam. In addition, the reservoir increases stream temperatures, and reduces the water quality downstream.

(7) *Above Los Padres Reservoir to the Head Waters* – This reach is within the Los Padres National Forest and is in generally pristine condition. BMI production and assemblage quality should be in a natural state with very few constraints.

5.7.4. CONSTRAINTS TO POPULATION OF BENTHIC POPULATIONS AND FUNCTIONAL GROUPS

Based on the findings of MPWMD's bioassessment program (2000 – 2003), the primary five functional feeding groups (FFG) were ranked by abundance at the five sampling sites **(Figure 5.7.2a-A)**. The most numerous species in each of these groups are listed. Probable constraints to the population size of each group and some potential restoration projects to overcome these constraints are discussed.

(1) Collector-Gatherer FFG (collect fine particulate organic matter [FPOM] from the stream bottom):

Most numerous species: High numbers of individual *Baetis* mayflies, and the midges Orthocladiinae and Tanytarsini contributed to the numerical dominance of this group. This feeding group typically comprised 35 to 55 percent of the BMI in all samples.

Probable constraints: This group does not appear to be constrained in the Carmel River, but according to Petersen and Cummins (1974) and Short and Maslin (1977), about 30% of the conversion of coarse particulate organic matter (CPOM) leaf litter to FPOM has been attributed to shredder feeding and this can affect the growth of FPOM feeding collectors. So by increasing the abundance of shredders to help break down CPOM (leaves and LWD), the collector-gatherers would also benefit.

Abundant interstitial spaces are also important for this group. The release of large amounts of sand from San Clemente Reservoir or from bank failure along the river that cause interstitial space filling would be detrimental.

Potential restoration projects to overcome constraints: Any project that contributes to the overall health of the river with improved water quality, stable banks, and abundant gravel will help this group. Planting more native riparian trees would help by increasing the abundance of shredders.

(2) Collector-Filterer FFG (collect FPOM from the water column using a variety of filters):

Most numerous species: Black flies (*Simulium*), and hydropsychid caddisflies. This feeding group typically comprised 20 to 45 percent of the BMI in all samples.

Probable constraints: This group relies on remaining stable and attached to the substrate to facilitate their filtering behavior. They need a constant flow of fresh water that contains FPOM. High flushing flows that cause scour and bedload movement could result in a reduction of this group.

Potential restoration projects to overcome constraints: While important to the overall health of the stream, this group is less important as a food source to steelhead since they are infrequent drifters. They thrive in many stream conditions, including those that may be less favorable to other groups, such as downstream of a dam.

(3) **Scraper FFG** (consumes algae and associated material):

Most numerous species: The hydroptilid *Leucotrichia pictipes* was the primary contributor to the scraper FFG but other BMI taxa such as the water penny *Psephenus falli*, the heptageniid mayfly *Ironodes*, and the riffle beetle *Optioservus*, also contributed to the representation of the scraper FFG. There was a trend of higher percentages of scrapers in the fall season when compared to the percentage of scrapers in the spring season. This feeding group typically comprised 2 to 15 percent of the BMI in all samples.

Probable constraints: This group is dependant on a rocky substrate that supports algal growth. Dense overhead growth of trees and shrubs that shade the stream may reduce the abundance of this FFG as would turbid water that prevents sunlight from penetrating the water column. The presence of moving sand or silt that scours the cobble surfaces would also be detrimental. Water that is high in organic nutrients, such as from septic drain-fields or agricultural runoff, may be beneficial for this group since algal production would be increased.

Potential restoration projects to overcome constraints: This group is also an important component of drift food for steelhead. Individuals BMI crawl on the surface of the rocks and may get swept away by the current. Projects that stabilize the stream banks to prevent siltation and turbidity of the river would benefit this group.

(4) **Predator FFG** (feed on other consumers):

Most numerous species: The damselfly *Argia*, water mites comprising several genera (mostly *Sperchon*), flatworms, and at some sites dance flies (several genera within the family Empididae) were the main contributors to this FFG. This feeding group typically comprised 5 to 10 percent of the BMI in all samples.

Probable constraints: This group depends on vigorous populations of the other feeding groups.

Potential restoration projects to overcome constraints: Any restoration project that provides for a healthy stream would benefit this group. Excellent water quality, including cool water temperatures, abundant cobble and gravel substrate, stable stream banks, and a natural flow regime would promote an increased population of all BMI taxa.

(5) **Shredder FFG** (consume leaf litter or other CPOM, including wood):

Most numerous species: The shredding caddisfly, *Lepidostoma*, was the most abundant shredder in the samples but was not numerically dominant at any of the sites. This rare group comprised less than 2 percent of the BMI in most samples.

Probable constraints: The lack of LWD and the somewhat limited riparian cover in some sections of the river likely contribute to the lack of CPOM and the near absence of shredders on the Carmel River. Ironically, the CRCA and CRSH sites had the fewest shredders of any of the sites even though there is abundant leaf litter in the fall in these locations.

Potential restoration projects to overcome constraints: Continue with stream bank restoration projects that include vegetation planting and irrigation. Strive to complete more LWD installment projects.