EXECUTIVE SUMMARY

A comprehensive literature search for records of Southern California steelhead trout, *Oncorhynchus mykiss* was conducted for the following streams; Santa Margarita River, San Mateo, San Onofre, Las Flores, De Luz, Cristianitios, Talega, Pilgrim, Sandia, Rainbow, Murrieta, and Temecula creeks. Sufficient data exists to indicate southern steelhead populations historically occurred on San Mateo Creek through the late 1940's, and that the Santa Margarita River populations appeared to have declined prior to this. The best historical records for Base streams are from San Mateo Creek and its tributary Devils Canyon, followed by De Luz and San Onofre creeks. Steelhead populations in San Diego County have been extirpated and their known distributions in North America freshwaters have shifted northward from the Santo Domingo River in northern Baja California, to Malibu Creek in Los Angeles County.

An extended dry cycle from the mid 1940's through the late 1970's, and concurrent urban and agricultural growth in the lower alluvial valleys of the Santa Margarita River, San Mateo and San Onofre creeks, overtaxed the groundwater resources of these streams. There were extended periods in the mid 1950's, when stream flows were insufficient to reach the ocean during the historical wet months February through April. This severely limited the opportunity for upstream and downstream migration of adult and juvenile steelhead. Landlocked steelhead were likely extirpated due to competition, increased fishing pressure, disease, and/or predation following plants of hatchery trout for put and take fisheries, and the introduction of exotic predatory game fish. The introduction of exotic fish species in southern California started in the late 1940's, with the boom of dams and water diversions.

Based on the available literature, southern steelhead are relatively adaptable, able to survive in modest habitat and withstand higher stream temperatures and lower dissolved oxygen concentrations than their northern counterparts. Basic habitat requirements cited were adequate spawning gravel for adults, and areas of perennial flow or intermittent flow associated with pools and vegetative cover for over-summer juvenile rearing. Rainbow trout have been observed surviving water temperatures as high as 29^{o}C, but prolonged exposure to temperatures greater than 25 ^{o}C would likely be lethal. In intermittent streams, trout will tolerate low dissolved oxygen in order to escape high water temperatures. Large or deep thermally stratified pools likely provided the best opportunity for juvenile survival and growth, however, shallow pools associated with coldwater seeps or springs were also used. Adults spawned upstream soon after winter/spring flows breached the sand bar, and juveniles emigrated the following winter. Estuary/lagoon rearing was beneficial, but may not have been essential due to rapid in-river growth potential. The best steelhead habitat on Base occurs within the upper San Onofre Creek drainage. Roblar Creek, possesses spawning but limited rearing habitat. The Santa Margarita River and San Mateo Creek provide a corridor to upstream habitat off-Base. Spawning and rearing habitat occurs on San Mateo Creek and Devils Canyon within the Cleveland National Forest.

DISCUSSION:

The earliest historical records of steelhead occurring in Northern San Diego County were largely anecdotal, and from the neighboring San Luis Rey River. Historic population estimates for Base streams were not found in the reviewed literature, but steelhead runs on the San Luis Rey River were reportedly large enough to provide a major food supply for the Luiseno Tribe as late as the 1890's and 1900's (Shipek pers. comm. 1997). Kondolf and Karson (1995) described the natural conditions of the San Luis Rey River as probably perennial in most years; surface flow may have ceased in dry years, but the alluvial water table probably remained high, supporting riparian vegetation and maintaining deep pools as refugia for aquatic organisms. The natural conditions of the Santa Margarita River (SMR), San Mateo Creek (SMC) and San Onofre Creek (SOC) may have also resembled those described for the San Luis Rey River prior to urban development and subsequent alluvial groundwater withdrawals.

As with the San Luis Rey, the earliest documentation of steelhead within Camp Pendleton (Base) streams is anecdotal, however newspaper articles and early stream surveys have corroborated the historic presence of steelhead. The stream which has the best documentation is SMC and its tributary Devils Canyon dating back to the early 1900's. SMC data documents the use of the upper SMC within the CNF as spawning and over-summer rearing habitat. There was no documentation of adult steelhead spawning on the SMC within Base boundaries. The data indicates the presence of steelhead in the SMC through the mid to late 1940's, after which any trout observed may have been due to hatchery trout plants. The few post 1980 steelhead sightings on SMC are probably the result of straying from other systems.

The documentation of SMR steelhead populations is not as strong as for SMC and almost entirely anecdotal. We found documentation of adult steelhead in the SMR only during the 1940's, and it seems their numbers were already low. Hatchery trout were planted in De Luz Creek in 1941-42, and the SMR was heavily planted with trout throughout the 1960's and to a lesser degree in the 1970's and 1980's.

The accounts of steelhead on SOC are anecdotal and indicate the presence of steelhead at least through the late 1940's, with a few adult steelhead caught by fisherman in the surf zone at the mouth. In a 1950 California Dept. of Fish and Game (CDFG) survey of the SOC estuary, juvenile trout were considered the most abundant fish species (CDFG 1979). The only other information pertaining to steelhead in Base streams or the San Luis Rey were found in a compilation by CDFG, the San Diego Coast Regional Commission, and Charles Swartz of the University of California Sea Grant Program which stated:

> ...anadromous fish runs were observed in San Diego County as late as 1945-50. ... In San Diego County, steelhead (salmon trout) occurred in De Luz Creek in about 1950-52, and reports of steelhead in the lower San Luis Rey River as late as 1940-41. Steelhead trout were observed in pools below Lake Hodges, and commonly in San Onofre Creek and the Santa Margarita River before the 'dry cycle' began in the late 1940's. Offshore, steelhead and silver salmon appear intermittently in both partyboat and commercial fishing catches (SDCRC 1974).

In a separate document on California estuaries titled: California Coastal Plan, prepared by the California Coastal Zone Conservation Commission (CCZCC 1975), it was stated that “As late as 1958, steelhead trout were observed near the mouth of the Santa Margarita River”. Both of these citations were not included in our time-line tables because we were not able to obtain the original records. Records were not found for Cristianitios, Telega, Las Flores, or Pilgrim creeks which would have indicated the occurrence of historic steelhead runs in these streams.

Stream flow and precipitation in northern San Diego County fluctuates greatly from year to year. Precipitation is highly seasonal, falling primarily in the months of December through March. A dry cycle beginning in the late 1940's and continuing through the late 1970's , coincided with increases in urban development, stream diversions and the overdrafting of underground aquifers in the lower river valleys, resulting in southern California streams becoming dry much of the year (CCZCC 1975).

There were extended periods in the mid-1950's when surface flow did not reach the SMR estuary during the historically wet months of February-April. Likewise, stream flow records show the same trend on the SMC and SOC. Steelhead populations on Base streams have been extirpated and the known southern limit of steelhead in North American freshwaters has shifted northward from the Santo Domingo River in northern Baja California (Needham and Gard 1959), to Malibu Creek in Los Angeles County. Extirpation likely resulted due to an inadequate number of opportunities for adult steelhead in the ocean to ascend Base streams to spawn in riverine habitat located above the Base and for juvenile emigrations to reach the ocean. In addition, during extended drought, a greater proportion of water is taken for human use, leaving less for fish at a time when they need it the most. The native fishes are actually adapted for surviving extended periods of drought through a combination of life history strategies and physiological tolerances (Moyle et al. 1986 cited in Moyle 1995). Native trout would have had to contend not only with less water and habitat, but also increased inriver fishing pressure, disease transfer and/or predation following introduction of hatchery trout and predatory game fish.

Based on the available literature, adults spawned upstream soon after winter/spring flows breached the sand bar and juveniles emigrated the following winter. Between emergence and emigration, juveniles would require areas of perennial flow or intermittent flow associated with pools and vegetative cover for over-summer juvenile rearing. Rainbow trout have been observed surviving water temperatures as high as 29 ^{o}C, but prolonged exposure to temperatures greater than 25 ^{o}C would likely be lethal. In intermittent streams, higher water temperatures were avoided despite low dissolved oxygen levels. Large or deep thermally stratified pools likely provided the best opportunity for juvenile survival and growth, however shallow pools associated with coldwater seeps or springs were also used.

Roblar Creek, a tributary to De Luz Creek on Base, possesses spawning gravel, areas of perennial flow, and a diversity of aquatic insects that could be utilized as food items for southern steelhead. However, a barrier occurs 1.4 km from the confluence with De Luz Creek limiting the potential utilization of Roblar Creek to very few trout. Due to

the modification to the Lake O'Neill diversion weir, adult steelhead should now be able to get beyond the weir site, which was previously considered a barrier (Higgins 1991). Our survey of SMR above the Base was limited to the immediate area around Fallbrook from the De Luz Road. We do not know the current state of habitat on the SMR available to southern steelhead above the confluence of Rainbow Creek. Based on our surveys the SMR and its major tributary on Base, De Luz Creek contained the least quantity and quality of steelhead habitat. Ironically, De Luz Creek and its tributary Fern Creek were highly touted as trout streams in the literature we reviewed.

Beginning in the mid-1990's the Eastern Municipal Water District and the Rancho California Water District began live stream discharge into SMR providing year-around flow upstream of the Base. On Base surface flow occurs during the winter/spring before becoming intermittent and/or subsurface. Southern steelhead should benefit from live stream discharge on the SMR because the timing and amount of flow in recent years was adequate to support them. The Base benefits from the additional flow to recharge their groundwater supplies, which in turn could lead to reestablishing a riparian corridor which could eventually include a woodland community. The reestablishment of hardwoods would provide instream structure and scour points which promote the formation of pool habitat. Riparian habitat near Fallbrook scoured out by the 1993 flood improved each year during our surveys. The benefits of the improved riparian areas were evident in lower average stream temperatures and a shorter duration of higher water temperatures recorded near Fallbrook. Despite less flow, stream temperatures on average were cooler in 1996 than in 1995, which we attributed to the recovery of the riparian vegetation, primarily willow.

Based on only one continuous water quality monitoring station, the USGS gauge station 11046050, it appears the SMR estuary currently does not provide over-summer rearing conditions for southern steelhead. This may be due to the formation of a heat retaining saltwater lens which can cause anoxic conditions within its sphere of influence. There are few areas between the estuary and the diversion weir where juveniles could seek refuge from the high water temperatures and anoxic conditions from late spring through November, and within these areas steelhead would currently compete with green sunfish, and largemouth bass for resources.

With the exception of exotic fish not introduced directly into SOC, the combination of drought, groundwater pumping and fish introductions which occurred on the SMR, also occurred on SMC and SOC. These two streams currently possess the best steelhead habitat on Base. Unlike the SMR, urban and agricultural development has not occurred in the upper watersheds of these streams. The upper SMC watershed is protected within the CNF and the upper SOC is located in a remote location of the Base within the Whiskey Impact Zone.

Flow conditions post 1980 in the SMC and SOC drainage have been sufficient to support southern steelhead, although as has occurred historically, some water years have been better than others. SMC is basically a migratory corridor to habitat found off-Base, within the CNF. Within the CNF, there are areas of perennial flow and pool habitat in which juveniles could over-summer. The Base portion of the stream is intermittent and subsurface most years after May. Apart from

the migratory corridor, the San Mateo estuary/lagoon is the only other potential habitat available to steelhead on Base. The SMC lagoon is not tidally influenced after the formation of a sand bar. Based on our water temperature monitoring, water temperatures in the SMC lagoon are not conducive to over-summer rearing during dry years unless steelhead utilized the areas of cool groundwater upwelling. Such areas were located upstream of our TempMenter location. It was evident salinity concentrations remain low during the summer, based upon the presence of juvenile largemouth bass in September 1997. The use of estuaries by southern steelhead has been documented for central California coast streams, but not for streams further south. Steelhead would likely benefit from rearing in an estuarine environment. It has been shown that growth rates are greater for those fish able to rear in an estuary and that increased size upon ocean entry is positively correlated to ocean survival (Smith 1994). However, due to a longer inriver growing season, emigrating juveniles may obtain sufficient growth to enter directly into the ocean.

The mainstem SOC may have been a migratory corridor to habitat located on the Middle Fork SOC. Based on the size of the SOC basin and extent of perennial flow, the steelhead population on SOC was likely much smaller that of SMC or SMR. Relatively small quantities of spawning gravel were located in the Middle Fork SOC, with only one area with exceptional spawning potential noted. The Middle Fork possessed numerous shallow perennial pools and several thermally stratified deep pools. The steep canyon walls help limit the amount of time the stream is exposed to direct sunlight, and probably help keep water temperatures tolerable during the summer months. Woody riparian vegetation is abundant throughout the reach. Dominant vegetation consisted of willow, alder, sycamore, and oak. The fact that no fish were observed on the Middle Fork was actually a good indiction that exotics have not been able to establish themselves.

Conversely, the North Fork which receives flow from Case Springs and little Case Springs had multiple exotic species. The South Fork SOC had good riparian and canopy, however, flow was sustained by effluent from a wastewater treatment facility. The SOC estuary was small and shallow during the period of our surveys and probably does not afford juvenile steelhead rearing.

To help evaluate the habitat data collected on Base in the absence of steelhead, we reviewed the results of Carpanzano (1996). Carpanzano studied ten streams in Santa Barbara and Ventura Counties known to have had steelhead runs within the last hundred years. Methodologies of habitat evaluation were similar to ours. The study offers insight on rainbow trout and habitat associations during low summer flows and high water temperatures. Carpanzano found streams having no trout had similar characteristics, including deep silt deposits, seasonally variable flows, sandy stream bottoms, open canopy and warm stream temperatures. In contrast, the creek with the highest rainbow trout densities had perennial flow, low stream temperatures, dense canopy, and good spawning habitat. When water temperatures approached lethal limits, juveniles sought out areas of cooler water. These areas can be found at the intersection of tributaries, areas of perennial flow, pools deep enough to intersect cool subsurface flow and the bottom of thermally stratified pools due to springs and seeps (Woelfel 1991; Nielsen, Lisle and Ozaki 1994; Matthews and Berg 1996). Trout

preferred cool water despite low dissolved oxygen concentrations (Carpanzano 1996).

In conclusion, the best trout/steelhead habitat occurring on Base is within the upper SOC drainage. The remaining streams provide a corridor for upstream adult migration and downstream juvenile migration. With the exception of perennial flow occurring in the upper SOC, immediately below the Lake O'Neill diversion weir, and isolated areas below wastewater treatment facilities, areas of perennial flow adequate to support southern steelhead were not located on Base. Spawning and juvenile rearing can take place in the upper SOC, and SMC within the Cleveland National Forest (CNF). This includes the portion of Devils Canyon within Base boundaries. Spawning can also occur in Roblar Creek, but rearing is possible only during wet years.

Based on the available literature, southern steelhead seem very adaptable and able to survive in relatively modest habitat. Basic requirements are adequate spawning gravel, areas of perennial flow or intermittent flow associated with pools of sufficient depth to avoid lethal temperatures. Shallower pools can be kept below lethal levels if intersected by subsurface flow or if they occur in the vicinity of cold water seeps or springs. Fish in shallower pools likely have a higher mortality due to predation by birds and snakes. Deep pools able to thermally stratify likely provide the best inriver rearing potential in the absence of predatory fish. Based on this criteria, SMC should receive the highest consideration of all Base streams if restoration efforts are undertaken. SMC has the greatest quantity of suitable habitat. The majority of spawning and rearing habitat is upstream within the boundaries of the CNF and the portion within the Base boundaries was considered primarily a migratory corridor. The SOC should also be considered a candidate for any restoration efforts. However, due to the relatively small quantity of suitable habitat, it has should be secondary to SMC.

Maintaining/Restoring Steelhead Habitat on Base:

The largest area of steelhead habitat on Base occurs within the Middle Fork SOC. Small amounts of habitat also occur on Roblar Creek, a portion of SMC near the USGS gauge station, and the portion of Devils Canyon within the Base boundary. The primary concern for SOC would be to promote adult migration and juvenile emigration through the lower river. With the exception of SOC and Roblar Creek, the remainder of Base streams provide only a corridor to habitat off Base. The effectiveness of a migratory corridor leading to habitat on and off Base could be enhanced by the conservation of existing native riparian habitat. Native riparian habitats including scrubs and woodlands, affect a rivers shape and influence sediment transport, erosion, and bank stabilization (Warner and Hendrix 1984; Faber et al. 1989). Native riparian plant species also provide the best and most widely used habitat for many native wildlife. Riparian habitat along Base streams serve as refugia areas for sensitive wildlife species including the listed least Bell's vireo.

Areas of Base streams that are disturbed by human activities, vegetated with mainly non-native plant species and areas of native vegetation that have moderate levels of non-native plants or are devoid of

vegetation could be considered potential areas for restoration or enhancement. The Base has already initiated giant reed eradication. These efforts should continue for the conservation of surface and subsurface flow and promote the colonization by native willow species, mule fat, oak and sycamore trees. Existing sycamore and oak trees are beneficial to southern steelhead in that they contribute shade, large woody and organic debris and promote the formation of pools when they occur adjacent to the active channel. Additional pool habitat would benefit migrating southern steelhead, providing a place to rest and hold between storm freshets. However, enhancement of the riparian habitat would also be beneficial to exotic fish species.

If the current wet climatic cycle persists in southern California, and conservation efforts throughout the range of southern steelhead result in increased populations, the possibility that steelhead will attempt to re-colonize Base streams exists. Steelhead straying from other systems is a mechanism of expanding its range and re-colonization. If this were to come to fruition, success would be impeded if measures to control exotic species are not first addressed. Complete eradication would provide the most benefit to reestablishment efforts, but due to the numerous small lakes and ponds currently containing exotics and providing a recreational fishery, eradication seems an unrealistic goal. Containment and measures to control inriver propagation, especially in the early stages of any reestablishment effort would help promote steelhead reproductive success.

Initial methods of controlling inriver exotic fishes could include use of rotenone, explosives, electro-shocking or seining in perennial pools during summer low flow. However, efforts would need to be mindful of other species such as the arroyo toad, California newt, western pond turtle, and arroyo chub. Containment of exotics in locations of recreational fisheries by screening drainage outlets, i.e. Lake O'Neill, Case Springs and wastewater treatment facility ponds, would help curb escapees and subsequent competition with juvenile steelhead rearing in perennial stream reaches. Containment would also reduce the frequency and intensity necessary to control exotics which in turn would reduce adverse effects on arroyo toad, California newts, western pond turtles, and arroyo chub.

The Base in cooperation with upstream entities, could initiate periodic snorkel surveys and/or operate adult traps as a means of monitoring for the presence of southern steelhead. Adult monitoring would need to occur in the winter and spring months if flows permit. Snorkel surveys should occur during the summer or fall months in perennial pool habitats. Juvenile steelhead would be isolated in pool habitats during these months and survey crews could cover greater distances.

The Base has already modified the Lake O'Neill diversion weir which should help promote sediment transport and deepen the active stream channel. The diversion weir is no longer a barrier to the upstream migration of steelhead. However, in the future, if steelhead are found utilizing the SMR, installation of a fish screen at the diversion inlet is recommended.