CENTER FOR BIOLOGICAL DIVERSITY

CALIFORNIA AND PACIFIC OFFICE

*protecting and restoring natural ecosystems and imperiled species through science, education, policy, and environmental law*

**VIA U.S. MAIL**

January 11, 2005

Robert L. Reiter
General Manager and Chief Engineer
San Bernardino Valley Municipal Water District
1350 South "E" Street
POB 5906
San Bernardino, CA 92412-5906
(909) 387-9200

Re: Draft EIR for the Santa Ana River Water Right Applications for Supplemental Water Supply

Dear Mr. Reiter:

These comments are submitted on behalf of the Center for Biological Diversity ("Center") for 1
the Draft Environmental Impact Report ("EIR") for the Santa Ana River Water Right Applications for Supplemental Water Supply ("the project"). The Center is a non-profit environmental organization dedicated to the protection of native species and their habitats through science, policy, and environmental law. The Center has over 11,000 members throughout California and the western United States, including Riverside and San Bernardino Counties. As described below, the Center objects to approval of the project based on the inadequacy of the current environmental documents.

The Draft Environmental Impact Report has been prepared pursuant to the California Environmental Quality Act ("CEQA") to evaluate the potential environmental impacts associated with water right applications filed by the San Bernardino Valley Municipal Water District ("Muni") and Western Municipal Water District of Riverside County ("Western"). Muni/Western have jointly filed two applications with the State Water Resources Control Board ("SWRCB") to appropriate 200,000 acre feet per year ("afy") of water from the Santa Ana River.

In 1989 (WR 89-25) and again in 1998 (WR 98-08), the SWRCB issued a declaration that the Santa Ana River was considered fully appropriated year-round. In 1989, the state Water Code prevented the SWRCB from accepting any new applications to appropriate water from watercourses considered fully appropriated. Muni/Western subsequently submitted a petition to revise the Declaration of Fully Appropriated Stream Status for the Santa Ana River ("SAR"), together with an application to appropriate 100,000 afy from the SAR. Muni/Western provided evidence which

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represented that flows in the SAR watershed had increased due increased runoff and releases of treated wastewater resulting from urbanization, and increased availability of water during wet years due to the subsequent operation of the Seven Oaks Dam.

2 The project also includes the following construction related activities: modification of the intake structure and access roads at Seven Oaks Dam; creation of the Plunge Pool Pipeline, Low Flow Connector Pipeline, and Morton Canyon Connector II Pipeline; modification of the Devil Canyon area, including State Water Project Afterbays, to accommodate the Devil Canyon By-Pass Pipeline; and creation of the Lower Lytle Creek Pipeline and Cactus Basin Pipeline.

3 The direct and indirect effects of the project will impact a host of rare, sensitive, threatened and endangered species, but not limited to, the following: Marsh Sandwort *(Arenaria paludicola),* Gambel's Water Cress *(Rorippa gambelii),* Stephen's Kangaroo Rat (*Dipodomys stephensi),* Arroyo Toad (*Bufo californicus),* California Red-Legged Frog (*Rana aurora draytonii),* Western Yellow-billed Cuckoo *(Coccyzus americanus occidentalis),* Southwestern Willow Flycatcher (*Empidonax trailii extimus),* Coastal California Gnatcatcher (*Polioptila californica californica),* Least Bell's Vireo (*Vireo bellii pusillus),* Santa Ana Sucker *(Catostomus santaanae),* The Santa Ana River Woolly-Star
4 (*Eriastrum densifolium* ssp. *sanctorum),* Slender-Horned Spineflower (*Dodecahema leptoceras),* San Bernardino Kangaroo Rat *(Dipodomys merriami parvus),* Nevin's barberry (*Berberis nevinii),* SAR woolly star (*Eriastrum densifolium ssp. sanctorum),* Swainson's hawk *(Buteo swainsoni),* Plummer's mariposa Lily (*Calochortus plummerae),* Robinson's peppergrass *(Lepidium virginicum* var. *robinsonii),* Arroyo Chub (*Gilia orcutti),* Santa Ana speckled dace *(Rhinichthys osculus* ssp. 3), Western spadefoot toad (*Scaphiopus hammondii),* Southwestern pond turtle *(Clemmys marmorata pallida),* San Diego horned lizard *(Phrynosoma coronatum blainvillei),* Sharp-shinned hawk *(Accipiter striatus),* Burrowing owl *(Athene cunicularia*), Coastal cactus wren *(Campylorhynchus brunneicapillus couesi),* and California thrasher *(Toxostoma redivivum).* Draft EIR Table 3.3-2, 3.3-3, E5-1, E5-2.

5 Many localities, agencies and organizations, including the Center, commented on the project when the Notice of Preparation was released. The Center herein incorporates by reference comments made by those organizations listed in the Draft EIR, Appendix D at 2-3, 54-101. The comments referenced herein include, but are not limited to, those referenced in the list in Exhibit 1, App. D, NOP comment list and references.

6 I. THE DRAFT EIR'S ANALYSIS OF IMPACTS TO BIOLOGICAL RESOURCES IS INADEQUATE

The Biological Resources section of the Draft EIR fails to adequately disclose, analyze, minimize, and mitigate impacts to the biological resources of the project site. While the Draft EIR discloses that the endangered threatened Santa Ana sucker (*Catostomus santaanae*, "sucker"), as well as a host of other state-listed and sensitive species, will be impacted by the project, the Draft EIR fails to adequately analyze the significance of the project to these species.

7 The project represents three of the four main threats contributing to the decline of the sucker: 1) direct loss of suckers due to water divesions; 2) loss of connectivity; 3) destruction and degredation of habitat through urbanization, channelization and other flood control structures, water diversion and

withdrawl, reductions in water quality; and 4) competition and predation from introduced non native 7
competitors. 65 Fed. Reg. 19696 (April 12, 2000). As a threat contributing to the decline of the sucker population the project must be analyzed critically within the DEIR.

Contrary to CEQA guidelines and relevant case law, the Draft EIR erroneously concludes that 8
the impacts the Santa Ana sucker will be less than significant. The project will have significant impacts on sucker habitat. The Legislature and the Secretary of Resources have determined that certain kinds of impacts are necessarily significant. "Mandatory findings of significance" are required for the following circumstances:

> The project has the <u>potential</u> to… substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, [or] reduce the numbers or restrict the range of an endangered, rare or threatened species.

CEQA Guidelines § 15065; see also Pub. Resources Code § 21083 [emphasis added]. Additionally, the State CEQA Guidelines Appendix G defines an impact significant if it would "interfere substantially with the movement of any native resident or migratory fish or wildlife species."

Section 15065 applies "to the contents of an EIR once it is determined an EIR must be 9
prepared." *Los Angeles Unified School Dist. V. City of Los Angeles* 58 Cal.App.4th 1019, 1024, fn.6. The mandatory findings of significance control "the identification of effects to be analyzed in depth in the EIR, the requirement to make detailed findings on the feasibility of alternatives and mitigation measures to reduce or avoid the significant effects, and when found to be feasible, the making of changes in the project to lessen the adverse environmental impacts." Discussion following CEQA Guidelines § 15065. The drafters of the guidelines realized that this section was necessary to assure
agencies follow the concerns of the Legislature to determine whether effects are significant. Id. 10
Courts have determined that impacts to aquatic habitat for rare flora and fauna are significant under section 15065 and require full evaluation and recirculation prior to approval. *Mira Monte Homeowners Association v. Ventura County* 165 Cal.App.3d 357, 363-364.

The project has the potential to reduce the numbers or restrict the range of an endangered 11
species. The Project would decrease flows in the Santa Ana River on non-storm days between Seven Oaks Dam and Riverside Narrows, and no feasible mitigation measures were identified to alleviate that impact. Draft EIR at S-3. Sucker habitat is present above the Riverside narrows and would be impacted by the reduction in flows. Draft EIR 3.3-63. There is no analysis of how the impacts will affect aquatic habitat for the species. The Draft EIR simply concludes that the impact is less than significant. This analysis is contrary to federal agency opinions on the importance of flow for aquatic
species. For example, the United States Fish and Wildlife Service emphasizes that the temporary 12
reduction of flows can significantly reduce the amount of habitat for suckers and could potentially strand them in dewatered sections of the stream. Exhibit 2, *Biological Opinion for the Prado Dam Water Conservation and Supply Study, Orange, Riverside, and San Bernardino Counties, California*, at 13. The reduction and quantification of cfs is not a valid indicator, by itself, of the effects on sucker numbers and habitat. In order for the analysis to be valid the Draft EIR must assess how the reduction
in flow will affect the minimum viable population and the amount of occupied habitat. Studies on 13
sucker reintroduction have shown that the establishment of multiple independent, viable populations or subpopulations of a species is an effective buffer against species extinction and is a frequently used measure of species recovery. Exhibit 3, *Results of the Year 3 Implementation of the Santa Ana Sucker*

13 *Conservation Program For the Santa Ana River, Final Report*, at 4. The Draft EIR must analyze the impacts of reduced flows on the minimum viable population and habitat in order to determine the level of significance.

14 Further, the Draft EIR concludes that the loss of critical habitat for a federally endangered species will be less than significant. Draft EIR at Table 3.3-2 (page 5 of 5). Nevertheless the Draft EIR dismisses these impacts as insignificant. *Id.* Regardless of the adequacy of these conclusions, this analysis is invalid as a matter of law. The impacts must be analyzed in depth, as a significant impact, because of their potential to reduce the numbers and restrict the range of the sucker.

15 The Draft EIR does not discuss the impacts on potential movement of the Santa Ana sucker upstream to reproduce in critical habitat within the project area. The Santa Ana sucker belongs to the family Castostimidae. Other species in the Castostimidae family are known to undertake spawning migrations. Tyrus and Karp 1990. Although it is not known whether the Santa Ana sucker follows similar reproductive behavior, Swift reported that Santa Ana sucker juveniles detected downstream of River Road in the Santa Ana River were likely the progeny of adults reproducing upstream. Swift 2000. These suckers may need to return upstream to spawn. The Draft EIR does not analyze the impacts to sucker reproduction or fecundity due to the decreased flows in the Santa Ana.

16 The Draft EIR also fails to address the impacts to other rare aquatic species. The arroyo chub (*Gila orcutti*) and Santa Ana speckled dace (*Rhinichthys osculus* ssp.) are both state and federal species of special concern that exist within the project area between Seven Oaks Dam and the Prado Flood Control Basin. Draft EIR at 3.3-5, Table E5-2 (page 2 of 7). The Draft EIR admits these species exist within the project area, yet neglects to analyze the impacts to these species. As rare species, per CEQA Guidelines § 15065, the project's impacts to these species must be addressed.

17 The project will negatively impact habitat and populations of the Arroyo Chub. The primary water quality threat to the arroyo chub in the Santa Ana River in western Riverside County is the long-term security of base flows within the river downstream of the Rapid Infiltration and Extraction Plant (RIX) outlet. Exhibit 4, *Final Multiple Species Habitat Conservation Plan. Volume II-B* F-13. The flow within the river is subject to frequent drops downstream of the Rialto Drain and the RIX plant, which are the origination sources of flow for the river below the Seven Oaks Dam in San Bernardino County. Id. Swift indicates that every few weeks the flow drops by more than 50 percent for a few hours or more during maintenance and Clean Water Act (CWA) requirements, dramatically reducing the shallow water habitats favored by native fishes downstream to Riverside Avenue and potentially limiting the number of fish that may inhabit the upstream areas of the river. Swift 2001. A portion of these flows may be subject to sale in the future, potentially reducing the flow volume available to the
18 arroyo chub in the river. Exhibit 4. In addition, water pollution from non-point sources including heavy metals, high-levels of bacteria, and low levels of protozoa and viruses has been identified as a potential threat. Egan *et. al.* 1992. These factors are not mentioned, analyzed or addressed in the Draft EIR. The project's impacts on a State Species of Special Concern must be analyzed for the EIR to be valid.

19 The project's threats on the Santa Ana speckled dace were not addressed or analyzed. The Santa Ana speckled dace occupies only remnants of its native range because of water diversions, urbanization of watersheds, introduction of nonnative species, and a myriad other factors associated

with expanding human populations in the Los Angeles region. Exhibit 5, *Fish Species of Special Concern in California, Santa Ana Speckled Dace*. It is considered to be one of the rarest native fishes in coastal southern California. Id. The remaining populations of Santa Ana speckled dace in the Los Angeles River were extirpated during the past ten years and dace in the Santa Ana River system are in 19
imminent danger of extinction. Id. In order to maintain the remaining dace population the California Department of Fish and Game recommends that immediate steps should then be taken to protect the remaining habitats in all the San Gabriel and Santa Ana drainages, including measures to secure enough water for the fish to live in. Id. The appropriation of water from the Santa Ana river will reduce flows between the Seven Oaks dam and the Riverside narrows. The elimination of water from speckled dace habitat must be analyzed in the Draft EIR. 20

The Draft EIR states negative surveys for rare, sensitive, threatened and endangered species in viable habitat constitute a less than significant impact because the species do not exist on the project site. Draft EIR 3.3-21, 3.3-22, 3.3-24, 3.3-26. This is simply incorrect. Negative surveys do not mean that the species does not utilize the habitat on the project site; it simply means that the species was not present at the time of the survey. The project will eliminate suitable habitat for sensitive species and contribute to continued habitat fragmentation, and destruction. The elimination of marginal or immature habitat because it presently does not meet the ideal habitat for sensitive species will prevent the species from ever using that habitat in the future during dispersal and/or colonization. These impacts must be addressed and mitigated. 21

Impacts to sensitive species and their habitat should be fully analyzed and mitigated. Species are categorized as sensitive because of their potential to become threatened or endangered in the future. Impacts from human development, urbanization, habitat alternation and fragmentation, are some of the biggest threats to fish and wildlife. As discussed above CEQA requires a mandatory finding of significance if a project has the potential to reduce the numbers or restrict the range of an endangered, rare or threatened species. CEQA Guidelines § 15065. Direct mortality of sensitive species is a 22
significant impact and must be analyzed in depth as a significant impact. The Draft EIR repeatedly claims that impacts to sensitive species resulting from habitat loss, disturbance and direct mortality are less than significant. Draft EIR 3.3-48, 3.3-50, 3.3-51. In order to determine the significance of the impact to sensitive species, the EIR should disclose a quantified analysis of impacts to species populations resulting from project activities. Additionally, the results of numerous individual projects eliminating small habitat fragments are cumulatively considerable. The project cannot rationalize impacts to sensitive species and their habitat as insignificant without mitigation. The Draft EIR must mitigate the impacts of habitat destruction. 23

In general, the Draft EIR fails to disclose or minimizes the impacts to the endangered, threatened, and sensitive species that will be impacted by the project. Having done so, the Draft EIR then fails to propose adequate avoidance or mitigation measures. 24

## II. THE DRAFT EIR'S ANALYSIS OF GROWTH INDUCING AND GROWTH RELATED IMPACTS IS INADEQUATE

CEQA requires complete analysis of a project's growth inducing and cumulative impacts. The Draft EIR's treatment of these vitally important topics is inadequate. The Draft EIR admits that the 25

25 project will remove an obstacle to population growth by providing additional water supplies for the area. Draft EIR at 4-2. This availability of additional water will inevitably facilitate and fuel further sprawl style development with all of its attendant environmental impacts. These impacts must be disclosed, quantified, avoided where possible, and mitigated.

26 The Draft EIR repeatedly refers to the County of San Bernardino General Plan Final EIR and the County of Riverside General Plan Draft EIR instead of fully analyzing the growth related impacts resulting from the project. The lead agencies rely on CEQA Guidelines Section 15091(a)(2) "to find that mitigation for growth related impacts is the responsibility of other public agencies, which either have adopted or should adopt such mitigation during the course of project-specific CEQA analysis." Draft EIR at 4-2. Unfortunately, the lead agencies interpretation is contrary to the legislative intent of
27 the governing guidelines. The lead agencies combined with the local municipalities share the burden of addressing growth related impacts. The guidelines clearly state the legislature intended CEQA to address "the problem of agencies deferring to each other, with the result that no agency deals with the problem." Discussion following CEQA Guidelines § 15091. Shifting the responsibility for analysis and mitigation of environmental impacts is contrary to the purpose of CEQA that "*all* agencies... which are found to affect the quality of the environment, *shall* regulate such activities so that major consideration is given to preventing environmental damage, while providing a decent home and satisfying living environment for every Californian." Pub. Resources Code § 21000 [emphasis added].

28 The lead agencies' reliance on the EIRs drafted by San Bernardino and Riverside counties compounds the problem because the counties' underlying EIRs declare significant unavoidable impacts, i.e., impacts unable to be mitigated to a less than significant level, are identified for the following resources: Air Quality; Agricultural Resources; Biological Resources; Cultural and Paleontological Resources; Geology, Soils and Mineral Resources; Hydrology and Water Quality; Noise; and Public Services, Utilities and Transportation. The EIR must identify potential mitigation measures to reduce the project's impacts.

29 The problem of shifting mitigation responsibilities is exemplified by Muni's failure to adopt adequate water conservation measures. To date Muni has not implemented conservation measures comparable to Western. Draft EIR at 5-14. Muni fails to address conservation related alternatives that would result in less adverse impacts by shifting the responsibility to localities that have demonstrated they are unwilling to presently address the issue. Id. Shifting the responsibility of addressing conservation related activities to the localities perpetuates "the problem of agencies deferring to each
30 other, with the result that no agency deals with the problem." Yet alternative 2 considers conservation related activities representing that the agency itself can and has considered conservation related concerns. Muni/Western cannot simultaneously analyze the viability of conservation related alternatives, and dismiss those alternatives as beyond their jurisdiction. Mitigation in the form of contractual requirements for conservation related activities could be included in agreements between lead agencies and the localities they service, in consideration for the services that Muni/Western provide.

31 In addition, the Draft EIR fails to adopt binding mitigation for the growth related impacts resulting from the project as required by CEQA section 21081. CEQA requires the adoption of binding mitigation in order to reduce a project's environmental impacts. "Passing references to the mitigation measures are insufficient to constitute a finding," because nothing binds the agency "to

follow these measures." *Citizens for Quality Growth v. Mount Shasta* 198 Cal.App.3d 433, 442. The Draft EIR continually makes a passing reference to non-binding mitigation: "impacts... *would* be reduced *should* local governments implement the following policies of the San Bernardino County and Riverside County General Plans." Draft EIR at 4-9, 4-11, 4-13, 4-14, 4-16, 4-19, 4-20, 4-21, 4-24, 4-25 [emphasis added]. This type of non-binding boilerplate analysis violates the spirit and letter of CEQA. The agency is required to adopt mandatory mitigation for significant environmental impact through the EIR process-- not simply defer to alternative potential mitigation. The Draft EIR should analyze environmental effects with, and without, mitigation. 31

## III. THE DRAFT EIR'S ANALYSIS OF AIR QUALITY IMPACTS IS INADEQUATE

The Draft EIR's air quality section falls far short of CEQA's requirements. The Draft EIR does not address the project's impacts on existing levels of non-attainment for criteria pollutants in the South Coast Air Basin. The project will lead to significant growth inducement. Draft EIR at 4. The area served by Muni/Western is experiencing severe air quality problems. The growth inducement resulting from the project will exacerbate air quality problems in the community. The project's indirect impacts to decreasing air quality should be fully evaluated and disclosed within the EIR. Without proper analysis of air quality the Draft EIR is invalid. A revised EIR is required to properly analyze the projects' direct, indirect, and cumulative contribution to deteriorating air quality. 32

### 1. SIGNIFICANT AIR QUALITY PROBLEMS IN SAN BERNARDINO AND RIVERSIDE COUNTY

The project lies within the South Coast Air Basin ("SCAB") in San Bernardino and Riverside County. The 2003 Air Quality Management Plan produced by the South Coast Air Quality Management District ("SCAQMD") lists the South Coast Air Basin as the U.S. location with the highest number of days exceeding the federal ozone standard. Exhibit 6, *Final 2003 AQMP Appendix II- Current Air Quality*, II-S-1. In addition the Basin also continued to rank among the areas of the U.S. with high carbon monoxide (CO) and particulate matter concentrations. *Id.* The federal ozone standard was exceeded most frequently in the SCAB (36 days), and the more stringent state standard was exceeded on 121 days. *Id* at II-2-3, II-2-4. The significance of this problem was not properly addressed within the Draft EIR. Avoidance of an issue of significance is a violation of CEQA. The increased mobile source emissions from construction and operation facilities will increase ozone pollution in the South Coast Air Basin, further violating the non- attainment status for the SCAB. 33

Ozone ($O_3$) is the chief component of the common pollutant known as "smog." Ozone is formed when emissions including reactive organic gases (ROG) and oxides of nitrogen (NOx) undergo photochemical reactions in sunlight and are transformed to $O_3$. Ozone irritates lung airways and causes inflammation much like a sunburn. Ozone causes wheezing, coughing, pain when taking a deep breath, and breathing difficulties during outdoor activities. The American Lung Association focuses on ozone as one of the most hazardous of the common air pollutants. American Lung Association, 2002 at 18. Repeated exposure to ozone pollution for several months may cause permanent lung damage. Children, the elderly, and those with respiratory problems are most at risk, but anyone who spends time outdoors may be affected. Even at very low levels, ozone triggers a variety of health problems including aggravated asthma, reduced lung capacity, and increased susceptibility to 34

34 35 pneumonia and bronchitis. Ozone also interferes with the ability of plants to produce and store food, which makes them more susceptible to disease, insects, and weather, and damages the leaves of trees and plants, ruining the appearance of cities, national parks, and recreation areas. Ozone also reduces
36 crop yields, and is, in fact, responsible for 98% of air quality related crop damage in California. A revised EIR must discuss the proposed project's production of ozone precursor emissions and the direct, indirect, and cumulative impact both on human health and on vegetation and wildlife habitat, especially habitat for threatened, endangered, and sensitive species.

37 Particulate matter (PM) is a category of pollutant which includes the respirable particles suspended in the the air. PM is classified into "coarse" particles, $PM_{10}$, or those under 10 microns in diameter, and "fine" particles, $PM_{2.5}$, or those under 2.5 microns in diameter, and comes from a variety of sources including diesel exhaust, windblown dust from agriculture and construction and motor vehicles. Because the human respiratory system's ability to filter out harmful particles decreases as particles size decreases, the smallest particles lodge deepest in the lungs and are especially dangerous. PM can contain at least 40 toxic chemicals including heavy metals, nitrates, sulfates, and aerosols, as well as soot, soil, and dust.

38 PM is associated with extreme health consequences. PM causes premature death, aggravates asthma, increases coughing, painful breathing, and chronic bronchitis, and decreases lung function. Lung inflammation caused by inhaling PM can also lead to changes in heart rhythm, constriction of blood vessels, blood coagulation, and increased risk of heart attacks. Unlike what is believed about some other air pollutants, there is no "safe" level of PM pollution: even very low levels of PM lead to health impacts, as described in more detail in *Particle Civics, How Cleaner Air in California Will Save Lives and Save Money* at 25.

39 A wealth of information on the environmental and health ramifications of the SCAB's poor air quality is readily available. These reports and others contain critical information on the health and environmental impacts of air quality. One study found that in San Bernardino County alone, 486 deaths per year are due to current $PM_{2.5}$ levels, and 231 deaths and 34,127 asthma attacks per year are
40 due to current $PM_{10}$ levels. Environmental Working Group at 19. The Draft EIR's conclusion that air quality impacts cannot be mitigated without including any basic information on the link between air quality, health impacts, and impacts to biological resources render it inadequate. This and other information must be analyzed in a revised EIR so that the project's air quality impacts can be analyzed in the full environmental context.

41 The Air Quality Section of Appendix G of the CEQA Guidelines (Environmental Checklist Form) specifically calls out a project's potential to conflict with or obstruct implementation of any applicable air quality plan as an impact to be discussed. The Draft EIR contains no discussion of the proposed project's contribution to this problem. Failure to meet regulatory deadlines have serious economic, environmental, and health ramifications for the SCAB, all of which should be discussed.

42 The Draft EIR has also omitted an adequate discussion of the project's cumulative air quality impacts. Air quality is an area where the always important cumulative impacts analysis is particularly crucial, because major air quality problems are created by a vast number of small sources which may appear individually insignificant. A revised EIR must be prepared to discuss the project's cumulative impacts to air pollution, including impacts to human health and impacts to biological resources.

## III. THE DRAFT EIR'S ANALYSIS OF CUMULATIVE IMPACTS IS INADEQUATE

The cumulative impacts analysis in the Draft EIR is inadequate and requires further analysis and 43
recirculation. Courts have emphasized that the cumulative impacts analysis is an integral part of the EIR process.

> [It] is vitally important that an EIR avoid minimizing the cumulative impacts. Rather, it must 44
> reflect a conscientious effort to provide public agencies and the general public with adequate and relevant detailed information about them. [Citation.] A cumulative impact analysis which understates information concerning the severity and significance of cumulative impacts impedes meaningful public discussion and skews the decisionmaker's perspective concerning the environmental consequences of the project, the necessity for mitigation measures, and the appropriateness of project approval. An inadequate cumulative impact analysis does not demonstrate to an apprehensive citizenry that the governmental decisionmaker has in fact fully analyzed and considered the environmental consequences of its actions.

*Citizens to Preserve the Ojai v. County of Ventura*, 176 Cal. App. 3d 421, 431. A proper cumulative impacts analysis must be prepared "before a project gains irreversible momentum." *City of Antioch v. City Council*, 187 Cal.App.3d 1325, 1333. The cumulative impacts analysis does not address all 45
additional projects which will impact the Santa Ana river, and does not adequately address the cumulative impacts on flows, habitat and species.

In order for the cumulative impacts analysis to be valid the lead agencies must evaluate all 46
reasonably foreseeable projects and their synergistic impacts on the environment in relation to the project. The Draft EIR does not even contain a valid list of cumulative projects, as required by CEQA. All reasonably foreseeable projects with similar impacts must be listed, their impacts briefly summarized, and the cumulative impacts analyzed, avoided, and mitigated. The cumulative impacts section of the Draft EIR does not even approach this standard. As a starting point, all Santa Ana river- 47
related projects by other water agencies in the region, and all other agencies (including, but not limited to flood control districts), that undertake projects that impact the Santa Ana River and its watershed must be compiled in a list of cumulative projects and addressed. The Draft EIR does not address all reasonably foreseeable projects. For example, the Draft EIR makes no mention of the Prado Basin Water Supply Feasibility Study ("Prado Basin project") by the United States Army Corps of Engineers and Orange County Water District. The Prado Basin project will impact the Santa Ana River downstream of the project area. Notice for the availability of Prado Basin project Draft EIR was released in August of last year. 69 Fed. Reg 51639 (Aug. 20, 2004). The Draft EIR cumulative impacts analysis must include the Prado Basin project.

The Draft EIR concludes, without justification or analysis, that the cumulative impacts on riparian 48
habitat, acquatic habitat, and aquatic species would be less than significant. This conclusory analysis violates CEQA. A lead agency "shall briefly describe its basis for concluding that the incremental effects is not cumulatively considerable." CEQA Guidelines § 15130(a). Courts have upheld this standard to find that where an EIR concludes that cumulative impacts are not significant, it should explain the basis for that conclusion. *Citizens to Preserve the Ojai v. County of Ventura*, 176 Cal. App. 3d 421, 432. The Draft EIR does not meet this standard in determining the effects on riparian habitat, aquatic habitat, and aquatic species downstream of Seven Oaks Dam. The Draft EIR states:

49 "The RIX Water Recycling Project would reduce flows by approximately 30 to 35 cfs. However, the impact analysis [RIX impact analysis] for that project did not identify significant impacts on biological resources. The Project would add an increment to the reduction caused by the RIX Water Recycling Project, but cumulative impacts in this reach would remain less than significant. Cumulative impacts on aquatic species, riparian habitat, and sensitive riparian plants and animals in the SAR downstream of Project diversions are expected to be less than significant. No mitigation is required."

Draft EIR at 6-34.

50 This analysis is wholly inadequate. First, the Draft EIR cannot rely on the RIX impact analysis for a justification that the cumulative impacts from this project would not be significant. The RIX impact analysis did not consider the current project. The Draft EIR admits that the "Project would *add* an increment of reduction." Id. The Draft EIR cannot justify a less than significant impact upon an analysis that did not even consider the impacts resulting from the project. Relying upon another impact analysis without addressing the current project's impacts turns the cumulative impact analysis
51 on its head. Secondly, the EIR must describe the basis for determining that a cumulative impact is less than significant. The EIR provides no such basis but simply concludes "cumulative impacts in this reach would remain less than significant." Id. Finally, even incremental increases to existing problems can be significant and must be analyzed. Where a current project would add only a small increment to an existing problem, the current project's effects may nonetheless be considered significant. *Los Angeles Unified School District v. City of Los Angeles* 58 Cal.App.4th 1019, 1025-1026. Consulting agencies recognize the dire situation of the Santa Ana's reduced flows for aquatic
52 species. The United States Fish and Wildlife Service emphasizes that the temporary reduction of flows can significantly reduce the amount of habitat for suckers and could potentially strand them in dewatered sections of the stream. Exhibit 2, *Biological Opinion for the Prado Dam Water Conservation and Supply Study, Orange, Riverside, and San Bernardino Counties, California* at 13 The lead agencies must fully consider the cumulative impacts resulting from this and other projects on riparian and aquatic species, and their attendant habitat.

53 The Draft EIR inadequately analyzes the cumulative impacts resulting from water diversion applications pending on the Santa Ana River. The following water right applications and projects will impact flow within the Santa Ana: San Bernardino Valley Water Conservation District Water Right Application (Conservation District Application) requests 174,545 af in any year, Draft EIR at 6-13; City of Riverside Water Right Application (Riverside Application) requests to 41,400 afy, Draft EIR at 6-14; Chino Basin Watermaster Water Right Application (Chino Application) up to 97,000 afy, Draft EIR at 6-15; Orange County Water District Water Right Application (OCWD Application) 42,000 afy baseflow plus any additional storm flows reaching Prado Dam, Draft EIR at 6-15; RIX Facility Recycled Water Use Project (RIX Water Recycling) approximately 18,000 afy of tertiary effluent would be eliminated from discharge into the Santa Ana river, Draft EIR at 6-16; Pilot Dewatering Program for the Bunker Hill Basin Area of Historic High Groundwater (Pilot Dewatering) pumping a maximum of 25,000 afy out of existing groundwater basins that could affect flow in the Santa Ana river, Draft EIR at 6-17.

These applications and projects have the potential to eliminate 597,945 afy from a fully 54 appropriated river.[1] The combined total diversions exceed both the median and maximum flows that exist within the Santa Ana river. Draft EIR at 3.1-3. Indeed, the total diversions are 74 times greater than the annual median annual flow. The potential impacts from the cumulative impacts are not 55 addressed in the Draft EIR. The Draft EIR only addresses the cumulative impacts to flows from the project and Conservation District Application. Draft EIR at 6-22. There is no analysis of the cumulative impacts of the 5 other projects on flows, habitat, ground water and riparian resources within the Santa Ana. The Draft EIR must account for the cumulative impacts that may potentially result from these reasonably foreseeable projects. The Santa Ana River is dying from a host of projects and impacts, many of which might be considered individually insignificant but which cumulatively are destroying the river environment. CEQA explicitly requires that a Draft EIR vigorously explore these issues. The Draft EIR fails to do so.

## IV. THE DRAFT EIR'S ANALYSIS OF UNAVOIDABLE SIGNIFICANT IMPACTS IS INVALID

A draft EIR must describe those significant adverse environmental impacts that cannot be 56 avoided because there are not feasible mitigation measures or because feasible mitigation measures cannot mitigate the impacts to a less than significant level. CEQA Guidelines §§ 15126(b); 15126.2(b). The Draft EIR lists numerous significant unavoidable impacts to air quality, public safety, hydrology and water quality, groundwater hydrology, and biological resources. Draft EIR at 3.8-12, 3.13-27, 4-8, 6-28, 6-32, 6-36. If the lead agency nevertheless decides not to require such design 57 changes, then the EIR must describe the "implications" of impacts involved and the agency's reasons for choosing to tolerate them rather than requiring an alternative design." CEQA Guidelines §15126.2(b); Pub. Resources Code § 21100(b)(2)(A). These issues must be addressed in an EIR section that also addresses significant effects "that would be irreversible if the project is implemented." Pub. Resources Code § 21100(b)(2). The implications and reasoning for the acceptance of significant unavoidable impacts is noticeably absent. The Draft EIR's omission of the required analysis of unavoidable significant impacts makes it deficient.

## V. THE DRAFT EIR SHOULD BE RECIRCULATED FOR PUBLIC REVIEW AND COMMENT

A lead agency must recirculate an EIR for further public comment under any of four 58 circumstances:

(1) When the new information shows a new, substantial environmental impact resulting either from the project or from a mitigation measure;
(2) When the new information shows a substantial increase in the severity of an environmental impact, except that recirculation would not be required if mitigation that reduces the impact to insignificance is adopted;

[1] The combined application and diversions can be calculated for the five 174,545 (Conservation District Application), + 41,400 (Riverside Application), + 97,000 (Chino Application), +42,000 (OCWD Application), +18,000 (RIX Water Recycling), + 2,000 (Pilot Dewatering), + 200,000 (Project Application) = 597,945 afy

58 (3) When the new information shows a feasible alternative or mitigation measure that clearly would lessen the environmental impacts of a project and the project proponent declines to adopt the mitigation measure; or
(4) When the draft EIR was "so fundamentally and basically inadequate and conclusory in nature" that public comment on the draft EIR was essentially meaningless.

CEQA Guidelines §15088.5.

59 Based on the comments above, it is clear that the EIR must be re-drafted and recirculated. Conditions (1), (2), and (3) above will be met by meaningful and adequate discussion of the project's impacts to biological resources, as well as a discussion of growth inducing and cumulative impacts. The combined effect of these omissions makes it clear that the fourth condition has also been met.

## VI. THE PROJECT MUST COMPLY WITH THE ENDANGERED SPECIES ACT

60 The project is subject to the Endangered Species Act ("Act"), and must fully comply with the Act's provisions. Section 9 of the Endangered Species Act of 1973, and Federal regulations issued pursuant to section 4(d) of the Act, prohibit take of endangered and threatened species without a special exemption. 16 U.S.C. 1531 *et seq*. Section 7 of the Act requires Federal agencies to consult with the United State Fish and Wildlife Service ("USFWS") should it be determined that their actions may affect federally listed threatened or endangered species. Take is defined as harass, harm, pursue,
61 hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct. Harm is further defined by USFWS to include significant habitat modification or degradation that actually kills or injures a listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by USFWS as an action that creates the likelihood of injury to a listed species by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), such incidental taking is not considered to be a prohibited taking under the Act provided that such taking is in compliance with the Incidental Take Statement.

62 The project is subject to the Endangered Species Act, and consultation with the USFWS, regarding impacts to threatened and endangered species, must occur. The project requires approval from the U.S. Army Corps of Engineers for the following activities: approval for any alterations to Seven Oaks Dam and its operations; approval for new pipelines to connect to facilities of Seven Oaks Dam; permits/approvals per Section 404 of the Clean Water Act (for the discharge of dredged and fill material into waters of the United States); and permits/approvals per Section 10 of the Rivers and Harbors Act (for construction in waterways) The project also requires approval from the U.S. Forest Service for access agreements/permits for construction within the San Bernardino National Forest. Draft EIR at 2-9.

63 The project will harm and harass listed species including, but not limited to: Marsh Sandwort *(Arenaria paludicola)*, Gambel's Water Cress *(Rorippa gambelii)*, Stephen's Kangaroo Rat (*Dipodomys stephensi)*, Arroyo Toad (*Bufo californicus)*, California Red-Legged Frog (*Rana aurora draytonii)*, Southwestern Willow Flycatcher (*Empidonax trailii extimus)*, Coastal California Gnatcatcher (*Polioptila californica californica)*, Least Bell's Vireo (*Vireo bellii pusillus)*, Santa Ana

Sucker *(Catostomus santaanae),* The Santa Ana River Woolly-Star (*Eriastrum densifolium* ssp. 63
*sanctorum),* Slender-Horned Spineflower (*Dodecahema leptoceras),* and San Bernardino Kangaroo Rat *(Dipodomys merriami parvus).* The construction related activities and removal of additional water from the Santa Ana river will negatively impact delicate desert ecosystems, riparian habitats and streambed ecosystems. Consultation with the USFWS must occur as soon as possible to identify and mitigate any potential take of all federally threatened and endangered species impacted by the project.

VII. CONCLUSION

In summary, the current Draft EIR has not adequately disclosed, analyzed, minimized, and 64
mitigated the environmental impacts of the proposed project. Because of the document's shortcomings, the public and decision makers cannot make informed decisions about the proposed project's costs in areas including biological diversity, cumulative impacts and growth inducement.

We appreciate the several extensions granted by your agencies of the draft EIR comment period 65
which have enabled us to provide you with these comments in a timely fashion. The magnitude and complexity of this project is immense, and we encourage your agencies to provide adequate time for the public to review and comments on projects of this nature. Due to the importance and complexity of the issues, we request a minimum 60 day public comment period on the FEIR.

Should your agencies wish to move forward with the proposed project, the Center hopes to 66
receive a revised Draft EIR. Please add the Center for Biological Diversity, P.O. Box 493, Idyllwild, CA 92549, Attn: Kassie Siegel, to all mailing lists for all information about this project. If you have any questions please do not hesitate to contact Peter Galvin, Conservation Director, at (415) 436-9682. Thank you very much for your consideration of these comments.

Sincerely,

/s/
Jonathan Evans
Legal Fellow
Center for Biological Diversity

CC without exhibits:

John V. Rossi
General Manager
Western Municipal Water District of Riverside County
450 Alessandro Blvd.
Riverside, CA 92508
(951) 789-5000

USFWS- Ecological Services
Carlsbad Field Office
2730 Loker Avenue West

Carlsbad, CA 92008
Attn: Karen A. Evans, Assistant Field Supervisor

State Water Resources Control Board
Division of Water Rights
P.O. Box 2000
Sacramento, CA 95812
Attn: Jane Farwell

California Department of Fish and Game
Eastern Sierra – Inland Deserts Region
4775 Bird Farm Road
Chino Hills, CA. 91709
Attn: Terry Foreman, Senior Biologist – Supervisor, Region 6

## LIST OF EXHBITS AND REFERENCES

### EXHIBITS

Exhibit 1: Draft EIR Appendix D, NOP comment list and references, at 2-3, 54-101.

Exhibit 2: United States Fish and Wildlife Service, *Biological Opinion for the Prado Dam Water Conservation and Supply Study, Orange, Riverside, and San Bernardino Counties, California*. July 1, 2002.

Exhibit 3: Baskin, Jonathan N., Haglund, Thomas R. and Swift, Camm C. 2003. *Results of the Year 3 Implementation of the Santa Ana Sucker Conservation Program For the Santa Ana River, Final Report.* Prepared for: Santa Ana Sucker Conservation Team. San Marino Environmental Associates.

Exhibit 4: Riverside County Integrated Project. *Final Multiple Species Habitat Conservation Plan. Volume II-B*. June 2003. F-1 – F-18.

Exhibit 5: California Department of Fish and Game. *Fish Species of Special Concern in California, Santa Ana Speckled Dace*. 1995.

Exhibit 6: South Coast Air Quality Management District, *Final 2003 AQMP Appendix II- Current Air Quality.*

**REFERENCES:**


American Lung Association. *American Lung Association State of the Air: 2002.*

Egan, J.T., S.P. Canton, T.F. Moore, G.Y. Michael, M.M. Grimes, and A.P. Rochette. 1992. *Tailoring Requirements to reality: The Santa Ana River Use Attainability Analysis*. Water Environment Federation, Alexandria, VA. AC92-036-006.

Tyus, H. M. and Karp, C.A. 1990. *Spawning and movement of razorback sucker in the Green River, Utah, 1979-1986.* Southwestern Naturalist 35:427-433

Environmental Working Group. Sharp, Renee and B. Walker. *Particle Civics: How Cleaner Air in California Will Save Lives and Save Money.*

Swift, C.C. 2000. *Informal data report on Santa Ana sucker surveys and reproduction by suckers in spring, 2000: activities and update since 22 April meeting.* Report submitted to Ad-Hoc Santa Ana discussion team, May 23, 2000.

Swift, C. C. 2001. *The Santa Ana sucker in the Santa Ana River: distribution, relative abundance, spawning areas, and impact of exotic predators*. Submitted to the Santa Ana Water Project Authority, Riverside CA. 94 pp.

# Exhibit 1

The following listed comments letters are incorporated, in their entirety, herein by reference. SANTA ANA RIVER WATER RIGHT APPLICATIONS FOR SUPPLEMENTAL WATER SUPPLY DRAFT ENVIRONMENTAL IMPACT REPORT. APPENDIX D: NOTICE OF PREPARATION AND INITIAL STUDY, October 2004 at 2-3, 54-101

1. Center for Biological Diversity, Monica Bond (comment card received August 6, 2002).
2. County of Orange, Public Facilities and Resources Department, Flood Control Division, H.I. Nakasone, Manager (letter dated August 8, 2002).
3. Brunick, Battersby, McElhaney and Beckett, General Counsel to East Valley Water District (letter dated August 7, 2002).
4. United States Department of Agriculture, Forest Service, San Bernardino National Forest Supervisor's Office, Gene Zimmerman, Forest Supervisor (letter dated August 8, 2002).
5. City of Redlands, Office of the City Attorney, Daniel J. McHugh, City Attorney (letter dated August 9, 2002).
6. City of Riverside, Public Utilities, Thomas P. Evans, Director (letter dated August 9, 2002).
7. County of San Bernardino, Economic Development and Public Services Group, Department of Public Works, Environmental Management Division, Naresh P. Varma, Division Chief (letter dated July 31, 2002).
8. City of Fontana, Community Development Department, Planning Division, Debbie M. Brazill, Deputy Director (letter dated July 25, 2002).
9. South Coast Air Quality Management District, Planning, Rule Development and Area Sources, CEQA Section, Steve Smith, Program Supervisor (letter dated July 23, 2002).
10. Native American Heritage Commission, Rob Wood, Environmental Specialist (letter dated July 19, 2002).
11. City of Rialto, Donn Montag, Principal Planner (letter dated July 25, 2002).
12. State of California, Department of Water Resources, State Water Project Analysis Office, David M. Samson, Project Coordinator (letter dated August 8, 2002).
13. City of San Bernardino, Municipal Water Department, Bernard C. Kersey, General Manager (letter dated August 9, 2002).
14. San Bernardino Valley Water Conservation District, D. Burnell Cavender, General Manager (letter dated August 12, 2002).
15. California Department of Fish and Game, Eastern Sierra – Inland Deserts Region, Terry Foreman, Senior Biologist – Supervisor (letter dated August 12, 2002).
16. County of Orange, Planning and Development Services, Environmental Planning Services Division, Timothy Neely, Manager (Letter dated August 12, 2002).
17. Southern California Association of Governments, Intergovernmental Review, Jeffrey H. Smith, Senior Regional Planner (Letter dated August 13, 2002).
18. California Department of Toxic Substances Control, Haissam Y. Salloum, P.E., Unit Chief (letter dated August 21, 2002).

19. Felger & Associates, Counsel to the City of Redlands, Warren P. Felger, (letter dated September 6, 2002).
20. U.S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office, Karen A. Evans, Assistant Field Supervisor (letter dated September 12, 2002).

# Exhibit 2

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Ecological Services
Carlsbad Fish and Wildlife Office
2730 Loker Avenue West
Carlsbad, California 92008

In Reply Refer To:
FWS-WRIV-2102.3

JUL 0 1 2002

Colonel Richard G. Thompson
District Engineer
U.S. Army Corps of Engineers, Los Angeles District
P.O. Box 532711
Los Angeles, California 90053-2325

Attn: Alex Watt, Environmental Coordinator

Re: Biological Opinion for the Prado Dam Water Conservation and Supply Study, Orange, Riverside, and San Bernardino Counties, California

Dear Colonel Thompson:

This document transmits our biological opinion based on our review of the proposed Prado Dam Water Conservation and Supply Study and its effects on federally threatened and endangered species and their critical habitats, in accordance with section 7 of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq*.). The biological opinion considers the possible effects of the proposed action on the federally endangered least Bell's vireo (*Vireo bellii pusillus*, "vireo") and its designated critical habitat, endangered southwestern willow flycatcher (*Empidonax traillii extimus*, "flycatcher"), and threatened Santa Ana sucker (*Catostomus santaanae*, "sucker"). Your July 3, 2001, letter requesting the initiation of formal consultation on the revised project was received by us on July 10, 2001.

This biological opinion is based on information provided in the May 2001, *Draft Biological Assessment for the Prado Dam Water Conservation and Supply Study* (Draft BA), site visits, and correspondence, notes and information compiled during the course of our consultation with your agency (Corps) and the project proponent, Orange County Water District (District). This information and other references cited in this biological opinion constitute the best available scientific information on the status and biology of the species considered. The complete administrative record for this consultation is on file at the Carlsbad Fish and Wildlife Service Office (CFWO).

Consultation History

We have consulted informally with the Corps since November 1998 and provided draft and revised draft Fish and Wildlife Coordination Act Reports (dated November 18, 1999, and March

22, 2001, respectively) for use in planning for this project. Meetings attended by the Corps, District and CFWO to discuss the project and measures to offset project-related effects to federally listed species and their habitats were held in 1999 on July 1 and December 12; in 2000 on April 25, August 2, August 9, August 19, October 11, November 21; and in 2001 on January 9 and October 24. Since many of our biological concerns with this water conservation project were related to our concerns with the Santa Ana River Mainstem Project (Mainstem), we encouraged the Corps to postpone consultation on this project until the issuance of the biological opinion on Mainstem. However, the Corps requested initiation of formal consultation, which was begun on July 10, 2001, prior to issuance of the Mainstem biological opinion on December 5, 2001. We requested an extension of formal consultation to allow time for completion of the Mainstem biological opinion and review of requested biological and hydrological information. We provided a draft project description of the proposed action to the Corps and District on January 10, 2002, and held a telephone conference call on Janaury 29, 2002, to discuss the proposed conservation measures outlined in the draft project description. We held a telephone conference call with the District on February 5, 2002, to further discuss proposed conservation measures, and a second draft project description was provided to the Corps and District on February 11, 2002. The District responded to the second draft project description by telephone on February 19, 2002. Formal consultation was extended to Friday, April 19, 2002, by agreement of the Corps via electronic mail on March 27, 2002. We provided our draft biological opinion on Monday, April 22, 2002. We received your response to the draft and request for a final biological opinion on June 26, 2002.

## BIOLOGICAL OPINION

### DESCRIPTION OF THE PROPOSED ACTION

The general area of the Prado Basin is divided by the Riverside and San Bernardino county lines, while the Orange County line is downstream of the Basin. Prado Dam was built just downstream of the confluences of Chino, Mill, and Temescal creeks with the Santa Ana River. The water flow in much of the Santa Ana River is perennial due to inputs of stormwater, urban runoff, and treated wastewater discharge into the river and several tributaries. The area immediately surrounding Prado Basin is a matrix of agriculture, residential and commercial development, and open space.

Prado Dam is a 106-foot-high rolled-earthfill structure with a current crest elevation of 566 feet above mean sea level. Its detached concrete spillway crests at 543 feet. When constructed, the dam provided flood protection for a 100-year flood event. However, with increased urban runoff from the surrounding area and accumulated sediment behind the dam, the flood control capacity of the dam has been reduced. In 1988, the Corps issued a Main Report and Supplemental Environmental Impact Statement of the Phase II General Design Memorandum for the Santa Ana River Mainstem Project (Corps 1988) that outlined construction plans, including increasing the dam height by about 28 feet and spillway height by 20 feet and other improvements to the dam outlet structures and spillway that would improve the dam's capacity to control flooding in a 190-year flood event. The dam and spillway-raising portion of the project has not yet been built, but in Reach 8 downstream of the dam, concrete drop structures and bank protection have been completed.

Water conservation, in addition to flood control, has taken place at Prado Dam since at least the late 1960s. Water conservation retains excess water behind the dam for regulated release that allows the District to percolate the discharge in their downstream spreading basins. Water retention levels and impact minimization measures associated with current water conservation practices were outlined in biological opinions issued by the U.S. Fish and Wildlife Service (Service) in 1993, 1995, and 2000 (Biological Opinion 1-6-93-F-7 dated February 25, 1993, Biological Opinion 1-6-95-F-28 dated April 20, 1995, and Biological Opinion 1-6-99-F-75 dated February 10, 2000). Current agreements permit water to be pooled to an elevation of 494 feet during the flood season (October 1 through the end of February) and to 505 feet during the non-flood season (March 1 to September 30). During the non-flood season, the District must release a flow equal to the maximum recharge capacity of the downstream basins or a running average of 500 cubic feet per second (cfs), whichever is greater. Water must be released at a greater flow rate if the water level exceeds 505 feet, to get the water's elevation back at or below 505 feet as quickly as possible.

Impact minimization measures by the District and Corps for currently implemented water conservation included monetary contributions to establish a conservation fund used to remove the non-native invasive plant *Arundo donax* ("arundo") from the Santa Ana River watershed, the creation of riparian habitat, establishment of a vireo and flycatcher monitoring program, and implementation of brown-headed cowbird (*Molothrus ater*, "cowbird") trapping in Prado Basin. These measures were to offset the anticipated loss of half the function and value to habitat between 494 and 505 feet. In addition, the consultation required that, if vireo or flycatcher nests were imperiled by impounded water up to 505 feet, District personnel would relocate nests to higher elevations to prevent loss of eggs or nestlings. Incidental take for the vireo from the current water conservation project included harm to 90 pairs from alteration to habitat from impounded water. Impacts to the sucker, which was federally listed on April 12, 2000 (65 FR 19686), were not addressed in previous biological opinions.

This opinion addresses the incremental effects from additional water conservation during the flood season for vireo and flycatcher and the full project effects on the sucker. All conservation measures and terms and conditions of previous biological opinions on water conservation (i.e., Biological Opinion 1-6-93-F-7 dated February 25, 1993, Biological Opinion 1-6-95-F-28 dated April 20, 1995, and Biological Opinion 1-6-99-F-75 dated February 10, 2000) remain in effect and are not superceded by this opinion.

The proposed Prado Dam Water Conservation and Supply Study would implement changes to the current water conservation practices. The Corps examined eight project alternatives that proposed holding water at differing levels depending on time of year and whether Mainstem construction to raise Prado Dam had been completed. The Corps asked CFWO to examine two proposed alternatives; one for operation prior to dam-raising construction and the Corps' National Economic Development (NED) post-construction alternative.

The pre-construction alternative would permit water elevation levels to 498 feet (a 4-foot increase from the current 494 foot level) during the flood season and to 505 feet (the current level) during the non-flood season. This inundation at 498 feet is an annual average increase of 13.8 percent over the current water conservation practice. Water release rates from the dam for 5-year to 50-year floods would be 5,000 cfs, which is the current capacity of the outflow structures. The life of this alternative is anticipated to be 2 to 3 years; that is, until Mainstem construction is completed.

The Corps' NED post-construction alternative would allow a maximum pool level during the flood season of 498 feet and 505 feet during the non-flood season, the same levels as in the pre-construction alternative above. However, water release rates with the upgraded outflow structures in the dam would be 5,000 cfs during a 5-year to 10-year flood; 8,760 cfs during a 25-year flood; and 18,500 cfs during a 50-year flood. Maximum release through the gates will be 30,000 cfs. The life of this alternative is anticipated to be 50 years, once Mainstem construction is completed.

Both of these alternatives would increase inundation at the 498 foot level by an annual average of 13.8 percent (a 4-day increase over the current 29 days of inundation). The acreage between 494 and 498 feet is 219.6 acres, of which one-half of the value and function has been offset under prior water conservation agreements; thus, 109.8 acres may be additionally affected by increased inundation from this project. A 13.8 percent increase in effects to 109.8 acres equates to 15.2 acres of additional inundation effects within the Basin that were not offset through prior water conservation agreements. In addition, 22 acres of riparian habitat will be affected downstream of the Basin through water releases necessitated by the increased elevation. Therefore, a total of 37.2 acres of riparian habitat will be affected by either alternative.

The following conservation measures have been proposed to offset project-related effects to vireo and its critical habitat, flycatcher, and sucker:

1. With concurrence from CFWO, the Corps and/or District will acquire and protect in perpetuity via a conservation easement 37.2 acres within Prado Basin for restoration of riparian habitat prior to implementation of either alternative. This acreage is calculated from 37.2 acres of impact at a 1:1 ratio. The restoration will be done outside of areas that are already mitigation areas. A detailed map that delimits the restoration area will be provided to CFWO. To accomplish restoration of the acquired acreage:

a. Compensation to the Santa Ana River Conservation Trust Fund (SARCTF) for restoration, maintenance, and management in perpetuity of the 37.2 acres will be made in the amount of $25,000 per acre for a total of $930,000. This compensation will be made on or before the time of implementation of the habitat restoration plan. SARCTF will provide a detailed report to CFWO annually on the use of these funds for this restoration area.

b. A detailed habitat restoration plan for the 37.2-acre restoration site will be submitted to CFWO and California Department of Fish and Game (CDFG) for review and concurrence within three months of implementation of either the pre- or post-construction project alternative. The Corps will notify CFWO in writing of the date of implementation of either the pre- or post-construction project alternative and identify the date that the restoration plan will be submitted to CFWO and CDFG. The habitat restoration plan implementation will begin as soon as possible after CFWO and CDFG concurrence on the plan, with restoration activities conducted between September 15 and March 15 of each calendar year unless specifically authorized to do otherwise by CFWO and CDFG.

If it is necessary to conduct weeding or other restoration and/or creation activities outside of this period, then authorizations from CFWO and CDFG will be obtained in advance to preclude the unauthorized take of federally listed species which is increasingly likely as the restored/created habitat matures. The restoration plan must, at a minimum, include the following components: 1) plant material and seed mix; 2) planting and seeding methods; 3) salvage methods for vegetation and topsoil; 4) preparation of sites and implementation of planting; 5) a proposed monitoring and reporting schedule; and 6) remediation measures to be implemented if initial restoration efforts are unsuccessful.

c. The Corps and/or the District will notify CFWO and CDFG via written report when restoration and/or creation efforts in a given area are deemed successful by your agency based on the success criteria in the restoration plan. Each report must include quantitative evidence that the structure and composition of the revegetated area is statistically similar (i.e., not significantly different) to habitat occupied by vireos in the vicinity or other willow woodland habitats with understory as characterized by Zembal *et al.* (1985) and Zembal (1986). If the success criteria have been completely satisfied, then CFWO will concur in writing that restoration and/or creation requirements for that given area have been successfully attained.

d. The Corps and/or the District will ensure that all lands in the designated restoration area are not used for any purpose that would change or otherwise interfere with their value as wildlife habitat or a wildlife corridor (e.g., erect permanent or temporary structures, night lighting, or facilitate the ingress of domestic animals, exotic animals, or non-native plants).

e. The taking and use of cuttings from willow riparian, riparian scrub, marsh, or aquatic habitats will be prohibited except with the prior approval of CFWO and CDFG. Also, all water conveyance infrastructure in restoration areas and adjacent areas will be constructed and operated to avoid the flooding of vireo habitat in the action area. Imported water, including water used for irrigation, will not be allowed to flood or otherwise degrade existing or replacement habitats.

f. The use of rodenticides, herbicides, insecticides, or other chemicals that could potentially harm federally listed species will be prohibited.

2. The Corps and/or District will monitor vireo territories in Prado Basin within the 498 to 505 foot elevation for a 5-year period beginning with implementation of either project alternative. The baseline number of vireo territories within this area will be submitted to CFWO for review and concurrence at the beginning of project implementation. Should the number of vireo nesting territories show a statistically significant ($\alpha \le 0.05$) decline over the 5-year period within these elevations, then the Corps and/or District will restore and protect in perpetuity an additional 37.2 acres of riparian habitat within Prado Basin and provide funding at a level to adequately implement, monitor, manage and assure success of that restored habitat area.

3. The Corps and District will commit to ongoing vireo and flycatcher population monitoring within the Prado Basin for the life of the project. Termination of monitoring will be subject to mutual agreement by the Corps, District, and CFWO. The District will make available one

existing vireo monitor to aid in population research on the flycatcher. As part of the commitment to population monitoring, historical and current vireo and flycatcher locations in Prado Basin will be digitally mapped. Digital mapping will be done annually for the life of the project. The District will submit an annual work plan for both vireo and flycatcher research to CFWO for review and concurrence.

4. A detailed eradication plan for Prado Basin for the removal of exotic, invasive animals that are competitors or predators on the sucker will be submitted to CFWO for review and concurrence within three months of implementation of either alternative. The plan will include goals and objectives, methods, efficacy assessment, reporting requirements and funding assurances. Funding for this plan's development and implementation will be assured by the Corps and/or District at the level required to achieve the plan's goals and objectives.

## STATUS OF THE SPECIES

### *Least Bell's vireo*

The least Bell's vireo is a neotropical, migratory, insectivorous songbird that nests and forages almost exclusively in riparian woodland habitats in California and northern Baja California, Mexico (Garrett and Dunn 1981, Gray and Greaves 1981, Miner 1989, AOU 1998). Vireos generally begin to arrive from their wintering range in southern Baja California and, possibly, mainland Mexico to establish breeding territories by mid- to late-March, though a singing vireo was detected on territory on March 2, 1994 (Garrett and Dunn 1981; Salata 1983a, b; Hays 1989; Pike and Hays 1992; Service, unpublished data). The large majority of the breeding vireos typically depart their breeding grounds by the third week of September, and only a few vireos are found wintering in California or the United States as a whole (Barlow 1962; Nolan 1960; Garrett and Dunn 1981; Ehrlich *et al.* 1988; Salata 1983a, b; Pike and Hays 1992).

Vireo nesting habitat typically consists of riparian woodlands with well-developed overstories, understories, and low densities of aquatic and herbaceous cover (Zembal 1984; Zembal *et al.* 1985; Hays 1986, 1989; Salata 1983a; RECON 1988). The understory frequently contains dense subshrub or shrub thickets. These thickets are often dominated by sandbar willow (*Salix hindsiana*), mule fat (*Baccharis salicifolia*), young individuals of other willow species, such as arroyo willow (*S. lasiolepis*) or black willow (*S. gooddingii*), and one or more herbaceous species (Salata 1983a, b; Zembal 1984; Zembal *et al.* 1985). Significant overstory species include mature arroyo willows and black willows. Occasional cottonwoods (*Populus* spp.) and western sycamore (*Platanus racemosa*) occur in some vireo habitats, and there additionally may be locally important contributions to the overstory by coast live oak (*Quercus agrifolia*).

Though the vireo occupies home ranges that typically range in size from 0.5 to 4.5 acres (RECON 1988), a few may be as large as 7.5 acres (Service 1998). In general, areas that contain relatively high proportions of degraded habitat have lower productivity (hatching success) than areas that contain high quality riparian woodland (Jones 1985, RECON 1988, Pike and Hays 1992).

The vireo was historically described by multiple observers as common to abundant in the appropriate riparian habitats from as far north as Tehama County, California, to northern Baja California, Mexico (Grinnell and Storer 1924, Willett 1933, Grinnell and Miller 1944, Wilbur 1980). The past, unparalleled decline of this California landbird species (Salata 1986, Service 1986) has been attributed, in part, to the combined, perhaps synergistic effects of the widespread destruction of riparian habitats, habitat fragmentation, and brood-parasitism by cowbirds (Garrett and Dunn 1981).

Reductions in vireo numbers in southern California and the San Joaquin and Sacramento valleys were evident by the 1930s and were "apparently coincident with increase of cowbirds which heavily parasitize this vireo" (Grinnell and Miller 1944). Widespread habitat losses fragmented most remaining populations into small, disjunct, and widely dispersed subpopulations. The historic loss of wetlands (including riparian woodlands) in California has been estimated at 91 percent (Dahl 1990). Much of the potential habitat remaining is infested with alien plants (e.g., arundo) and exotic animals (e.g., cowbirds).

During the past decade, the vireo has begun to recover at several locations (e.g., Prado Basin) within its range due to relatively intensive recovery efforts. Approximately 2,000 vireo territories were detected within California during 2000 (Service, unpublished data). The largest population of vireos continues to be located on Marine Corps Base, Camp Pendleton in San Diego County. In recent years, the populations of vireos at Camp Pendleton and the Prado Basin collectively represented approximately 60 percent of all known territories within California and the United States as a whole.

Habitat fragmentation negatively affects abundance and distribution of neotropical migratory songbirds, in part by increasing incidence of nest predation and parasitism (Whitcomb *et al.* 1981, Small and Hunter 1988). Also, vireos are sensitive to many forms of human disturbance including noise, night lighting, and consistent human presence in an area. Excessive noise can cause vireos to abandon an area. Greaves (1989) hypothesized that the lack of breeding vireos in apparently suitable habitat was due to human disturbances (e.g., bulldozers, off-highway vehicles, and hiker travel) and further suggested that buffer zones between natural areas and surrounding degraded and disturbed areas could be used to increase the suitability of some habitat for vireos.

Habitat destruction and brood-parasitism by the cowbird continue to be the primary threats to the survival and recovery of this species. Riparian woodland vegetation containing both canopy and shrub layers, combined with adjacent upland habitats, are essential to the conservation of the vireo. The following activities continue to destroy or degrade habitat for vireos: 1) removal of riparian vegetation; 2) invasion of exotic species (e.g., arundo, cowbird); 3) thinning of riparian growth, especially near ground level; 4) removal or destruction of adjacent upland habitats used for foraging; 5) increases in human-associated or human-induced disturbances; and 6) flood control activities, including dams, channelization, water impoundment or extraction, and water diversion. The draft recovery plan for the vireo identified two major causes of vireo population decline as cowbird-nest parasitism and habitat loss and degradation. Recovery efforts are focused on addressing these two issues.

Because of the documented, drastic decline in abundance and distribution, the vireo was listed as an endangered species by the State of California in 1980. The vireo was listed as a federally endangered species by the Service on May 2, 1986 (51 *Federal Register* 16474). Critical habitat for this species, which includes all riverine and flood plain habitats with appurtenant riparian vegetation in the Prado Basin below the elevation of 543 feet upstream on the Santa Ana River to the Norco Bluffs area and beyond to the vicinity of the Van Buren Boulevard crossing, was designated on February 3, 1994 (59 *Federal Register* 4845).

*Southwestern willow flycatcher*

The southwestern willow flycatcher is a relatively small, insectivorous songbird that is one of five subspecies of the willow flycatcher (Hubbard 1987, Unitt 1987, Browning 1993). Although previously considered conspecific with the alder flycatcher (*Empidonax alnorum*), the willow flycatcher is distinguishable from that species by morphology (Aldrich 1951), song type, habitat use, structure and placement of nests (Aldrich 1953), eggs (Walkinshaw 1966), ecological separation (Barlow and MacGillivray 1983), and genetic distinctness (Seutin and Simon 1988).

The breeding range of the flycatcher includes southern California, southern Nevada, Arizona, New Mexico, and western Texas (Hubbard 1987, Unitt 1987, Browning 1993). The species may also breed in southwestern Colorado, but nesting records are lacking. Past records of breeding in Mexico are few and confined to extreme northern Baja California and Sonora (Unitt 1987, Howell and Webb 1995). Flycatchers winter in Mexico, Central America, and northern South America (Phillips 1948, Ridgely 1981, AOU 1983, Stiles and Skutch 1989, Ridgely and Tudor 1994, Howell and Webb 1995).

Breeding flycatchers are often present and singing on territories in mid-May (rarely in late April in southern California). Flycatchers are generally gone from breeding grounds in southern California by late August (The Nature Conservancy 1994) and are scarce in the United States after mid-October (Garrett and Dunn 1981).

The flycatcher breeds in riparian habitats along rivers, streams, and other wetland habitats where dense growths of willows (*Salix* spp.), coyote-bush (*Baccharis* spp.), arrowweed (*Pluchea sericea*), buttonbush (*Cephalanthus occidentalis*) [not found in southern California], or other plants of similar structure and configuration are present. The flycatcher nests in thickets of trees and shrubs approximately 13 to 23 feet or more in height with dense foliage from approximately 0 to 13 feet above ground. Overstories are often present in occupied habitats and composed of willows or cottonwoods or, in some portions of the species' range, tamarisks (*Tamarix* spp.) (Phillips 1948; Grinnell and Miller 1944; Whitmore 1977; Hubbard 1987; Unitt 1987; Whitfield 1990; Service 1993, 1995). Nesting flycatchers generally prefer areas with surface water nearby (Bent 1960, Stafford and Valentine 1985, Harris *et al.* 1986).

All three resident subspecies of the willow flycatcher (*E. t. extimus*, *E. t. brewsteri*, and *E. t. adastus*) were once considered widely distributed and common within California wherever suitable habitat existed (Grinnell and Miller 1944). The historic range of *E. t. extimus* in California apparently included all lowland riparian areas of the southern third of the State. Nest and egg collections indicate the bird was a common breeder along the lower Colorado River near

Yuma in 1902 (T. Huels, University of Arizona, *in litt.*). Willett (1933) considered the bird to be a common breeder in coastal southern California. Most recently, Unitt (1987) concluded that *E. t. extimus* was once fairly common in the Los Angeles basin, the San Bernardino/Riverside area, and San Diego County.

Throughout the known range of the flycatcher, occupied riparian habitats have been, and remain, widely separated by vast expanses of relatively arid lands. However, the species has suffered the extensive loss and modification of these cottonwood-willow riparian habitats due to grazing, flood control projects, and other water or land development projects (Klebenow and Oakleaf 1984, Taylor and Littlefield 1986, Unitt 1987, Dahl 1990, Service 1995). Changes in riparian plant communities have resulted in the reduction, degradation, and elimination of nesting habitat for the flycatcher, curtailing the ranges, distributions, and numbers of western subspecies, including *E. t. extimus* (e.g., Klebenow and Oakleaf 1984, Taylor and Littlefield 1986, Unitt 1987, Ehrlich *et al.* 1992).

The species is also impacted by a variety of other factors, including brood parasitism by cowbirds (Unitt 1987; Ehrlich *et al.* 1992; Service 1995). Parasitism rates of flycatcher nests have ranged from 50 to 80 percent in California (Whitfield 1990; M. Whitfield and S. Laymon, unpublished data) to 100 percent in the Grand Canyon in 1993 (Service 1993). Mayfield (1977) concluded that a species or population might be able to survive a 24 percent parasitism rate but that much higher losses "would be alarming." In any case, a composite of all current information indicates continuing declines, poor reproductive performance, and continued threats to most of the extant populations of flycatchers (e.g., Whitfield and Laymon (Kern River Research Center, *in litt.*, 1993); Service 1993, 1995, unpublished data).

Available information suggests that the abundance and distribution of breeding flycatchers in California have declined substantially, such that only small, disjunct nesting groups remain (e.g., Unitt 1987, Service 1995). Status reviews or analyses conducted before the listing of the flycatcher considered extirpation from California to be possible in the foreseeable future (Garrett and Dunn 1981, Harris *et al.* 1986). Unitt (1987) reviewed historical and contemporary records of the flycatcher throughout its range and determined that the species had declined precipitously during the last 50 years. He argued that the flycatcher was faring poorly throughout much of its breeding range and postulated that the "total population of the subspecies is well under 1,000 pairs; I suspect that 500 is more likely" (see also Monson and Phillips 1981, Garrett and Dunn 1981, Service 1995). Despite recent, relatively intensive surveys in much of the historic range of the species, the United States population is now estimated at 900 to 1,100 pairs (Service, unpublished data, 2001). The species is apparently extirpated or exceedingly rare in Mexico (Howell and Webb 1995).

Only six permanent breeding sites for the flycatcher remain in California. Only the populations along the Kern and San Luis Rey rivers contain 20 or more nesting pairs. Despite the virtual elimination of impacts from livestock grazing to the large and important flycatcher population on the south fork of the Kern River (Harris *et al.* 1986, Whitfield 1990), numerical declines in the population levels were observed in 1991 and 1992. Fortunately, increases in nesting success were realized in 1992 and 1993. These increases were attributed to removing cowbird eggs or nestlings found in southwestern willow flycatcher nests and cowbird trapping (Whitfield and

Laymon, Kern River Research Center, *in litt.*, 1993). The Kern River population consisted of 23 pairs in 1999 (U.S. Geological Survey, Biological Resources Division [USGS/BRD], unpublished data). Forty-seven pairs were detected along the upper San Luis Rey River in 1999 where cowbird numbers have also been reduced by trapping (USGS/BRD, unpublished data).

Although four other nesting groups were known in southern California in 1996, all but one of these consisted of four or fewer nesting pairs in recent years (Service, unpublished data). A total of 104 pairs of flycatchers were recorded in California in 1996, and the available data indicate that approximately 100 pairs were present in the state in 1998 (Service, unpublished data). More intensive survey efforts in 1999 resulted in the detection of 160 territories that contained 117 confirmed pairs (Service and USGS/BRD, unpublished data).

The southwestern willow flycatcher was listed as a federally endangered species throughout its range on February 27, 1995 (59 *Federal Register* 10693). Breeding flycatchers are listed as state endangered by California and Arizona. As identified in the draft recovery plan for the southwestern willow flycatcher (Service 2001), the conservation needs of the species include preventing the loss of flycatcher habitat, habitat restoration, cowbird trapping, and research designed to evaluate the efficacy of measures intended to minimize or reduce impacts.

*Santa Ana sucker*

The Santa Ana sucker is a small, short-lived member of the Catostomidae family that is endemic to the Los Angeles, San Gabriel, and Santa Ana rivers. Historically, the sucker occupied the Los Angeles, San Gabriel, and Santa Ana rivers from near the Pacific Ocean to their uplands (Swift *et al.* 1993). Although the sucker was described as common in the 1970s (Moyle 1976), recent surveys indicate that the species has experienced declines throughout most of its range (Moyle *et al.* 1995, Swift *et al.* 1993) and persists in isolated, remnant populations. Approximately 70 to 80 percent of the sucker's historic range in the Los Angeles, San Gabriel, and Santa Ana rivers has been destroyed or altered to such an extent to make it unsuitable for occupation.

The sucker only occupies portions of Big Tujunga Creek between the Big Tujunga and Hansen dams along the Los Angeles River. Recent surveys indicate that the sucker is relatively rare downstream of the Big Tujunga Dam, including the vicinities of Delta Flat and Wildwood but relatively abundant near Stoneyvale (Wickman 1996).

The sucker is found only in the west, east, and north forks of the San Gabriel River above the Morris Dam. In the west fork, Haglund and Baskin (1992, 1995, 1996) found the sucker from the Cogswell Reservoir to the confluence of the north and west forks. In the east fork, the sucker was observed during surveys by Saiki (2000) and Knowles (1999). The California Department of Fish and Game detected suckers in the north fork just above its confluence with the west fork, sections of the west fork, and one section of the east fork (Deinstadt and Ally 1997). The east fork appeared to have the highest relative abundance, followed by sections of the west and north forks. The population of suckers in the north fork is small, and the population in the west fork appears to be declining.

The sucker occupies reaches of the Santa Ana River between the City of San Bernardino and the vicinity of Anaheim. During 1999 and 2000, the sucker was collected between the Rapid Infiltration and Extraction (RIX) facility in Colton and Prado Dam and was relatively abundant in the upstream portions of this reach (Swift 2001). Baskin and Haglund (2001) detected eight adult and two juvenile suckers downstream of Prado Dam between Weir Canyon Road and the Imperial Highway. Chadwick and Associates (1996) hypothesized that tributaries are the primary source of suckers for the Santa Ana River population because abundances were highest in these areas during their surveys. However, Swift (1999) detected a relatively low abundance of suckers in only four tributaries (i.e., Rialto Drain, Sunnyslope Creek, Evans Lake Drain, and Anza Park Drain).

There is a population of suckers in the Santa Clara River that is thought to be introduced, although this presumption is based on the absence of the species from early collections rather than any documented records of introduction (Bell 1978). Portions of this population have apparently hybridized with the Owens sucker (*Catostomus fumeiventris*; Hubbs *et al.* 1943) and, as a result, this population is not included within the range of the native sucker.
The sucker is fairly general in its habitat requirements, occupying both low-gradient, lowland reaches and high-gradient, mountain streams where water temperatures are less than 22° Celsius. However, the sucker appears to fare best in small to medium streams with higher gradients, clear water, and coarse substrates, such as the East Fork of the San Gabriel River. Flowing water is essential, but flows can range from slight to swift. The sucker can tolerate seasonal turbidity, but Saiki (2000) found that their relative abundance is negatively correlated with turbidity.

The sucker is typically associated with gravel, cobble, and boulder substrates, although it is also found over sand and mud substrates. *Catostomus* spp. produce demersal, adhesive eggs that are thought to be adapted to spawning habitat with boulders, cobble, and gravel rather than shifting sands or mud (Moyle 1976). Saiki (2000) found the sucker to be most common near cobble, boulders, and man-made structures in the San Gabriel River. During sampling in the Santa Ana River, Swift (1999) found that suckers comprised 38 percent of the catch in a habitat dominated by gravel and cobble, but only 2 percent of the catch in a habitat dominated by shifting sands. Conversely, no suckers were present in the Chino Creek, a tributary of the Santa Ana River, where gravel and cobble comprised a majority of the substrates. Water quality may have been reduced at that site, thus accounting for the lack of the sucker (Swift 1998).

The sucker feeds mostly on algae, diatoms, and detritus scraped from rocks and other hard surfaces. Aquatic insects comprise only a small component of their diet (Greenfield *et al.* 1970). They have a relatively short life span of three to four years but reach sexual maturity in one year and have high fecundity. For example, the fecundity of 6 females, ranging in size from 3.1 inches (78 millimeters) to 6.2 inches (158 millimeters), was 4,423 to 16,151 eggs (Greenfield *et al.* 1970). Spawning generally occurs from late March to early July, with the peak occurring in late May and June (Greenfield *et al.* 1970, Swift 2001).

Although little is known about sucker movements, other species in the Catostomidae family are known to be highly vagile and undertake spawning migrations (Tyus and Karp 1990). For example, juveniles of the mountain sucker, *Catostomus platyrhynchus,* swim downstream and then move back upstream to spawn (Moyle 1976). It is not known if the Santa Ana sucker follows this pattern; however, Swift (2000) reported that juveniles detected downstream of River Road in the Santa Ana River were likely the progeny of adults reproducing upstream. These suckers may need to return upstream to spawn.

Information on population dynamics of the sucker is lacking. However, frequent fluctuations between periods of low and high abundance may be characteristic of their populations due to the unpredictable fluvial systems they inhabit. Arid regions of California are subject to considerable environmental variation, particularly in year-to-year precipitation that occurs primarily as winter rains. Unpredictable flood events may contribute to catastrophic decreases in abundance by transporting suckers downstream past barriers to movement that essentially preclude any future contribution to the breeding population. Conversely, unpredictable droughts may contribute to decreases in abundance by stranding suckers in isolated pools where ambient conditions become unsuitable or they can be extirpated by predation. Although the sucker's high intrinsic reproductive rate should enable it to quickly repopulate once environmental conditions become more favorable (Moyle 1976), rapid decreases in abundance render small populations even more susceptible to chance extinctions, especially if unfavorable environmental conditions persist or reoccur before the populations can recover.

Few estimates of age-specific survival rates, age structures, sex ratios, or dispersal rates are available for populations of the sucker. Age classes of suckers in the San Gabriel River were normally distributed between zero and four years old during 1984 and 1994. In 1987 and 1995, however, young-of-the-year were preponderant and older age classes were lacking (Haglund and Baskin 1995, 1996). Density estimates in the Santa Ana River during winter of 1999 and 2000 were 0.02 to 1 fish per meter (Swift 2001). Density estimates in the San Gabriel River during 1997 were 0.03 to 0.13 fish per meter (Hernandez 1997).

Threats that may have contributed to the decrease in the status of the sucker include the following: 1) direct loss of suckers due to water diversions; 2) competition and predation from introduced non-native competitors and predators; 3) loss of connectivity; and 4) destruction and degradation of habitat through urbanization, channelization and other flood control structures, water diversion and withdrawal, suction dredging, reductions in water quality, and other activities (65 *Federal Register* 19686).

The construction of flood control and water diversion structures associated with urbanization has resulted in conversion of sucker habitat to unsuitable concrete-lined storm drains in the lower-most reaches of the Los Angeles, San Gabriel, and Santa Ana rivers (Moyle *et al.* 1995) and a substantial loss of habitat in the upper portions of these rivers and their tributaries. These structures have also contributed to the dewatering of extensive reaches of these rivers and their tributaries, thereby eliminating additional habitat for the sucker. For example, the Big Tujunga Creek Dam has eliminated flows along most of the Big Tujunga Creek during late summer and autumn of dry years. During these periods, the sucker is restricted to an approximate one mile stretch of the creek.

Historically, the Los Angeles, San Gabriel, and Santa Ana rivers flowed perennially throughout their length (McGlashan 1930). However, the withdrawal of ground and surface water has de-watered extensive portions of these rivers that now remain dry during non-flood periods, unless the discharge of treated wastewater effluent sustain flows (e.g., Santa-Ana River downstream of the RIX facility). For example, surface flows along the Santa Ana River upstream of the City of Riverside have long been diverted to provide water for communities in western San Bernardino and Riverside counties. Although records from the 1940s (Anonymous 2000) indicate that the sucker was once a common resident in this reach, no suckers have been detected within the upper Santa Ana River in recent years (Jones & Stokes Associates 1997).

Remaining habitat for sucker is often degraded by a variety of factors, including sedimentation, ephemeral water flow, reduced water quality, and the presence of invasive species. Degraded habitat conditions may contribute to reduced growth, fecundity, and survival of suckers due to loss of prey items, reduction in foraging efficiency, and lack of nursery areas (Gibson 1994). High turbidity is strongly correlated with lower relative abundance of suckers, possibly due to a reduction in the availability of prey (e.g., loss of light for algal photosynthesis) and/or the inability of suckers to detect prey items in turbid waters (Saiki 2000).

Most of the existing flow in the lower Santa Ana River during the summer months is derived from treated wastewater discharged into the stream channel, primarily from the RIX treatment facility in Colton. Flows from this facility are reduced or terminated periodically when malfunctions cause reductions in discharge quality that exceed standards required by the State Regional Water Quality Control Board. The temporary reduction or termination of flows significantly reduce the amount of habitat available to suckers and could potentially strand them in dewatered sections of the stream. Also, because much of the Santa Ana River is maintained through treated water, contaminants within the treated water may adversely affect the sucker. Saiki (2000) reported that suckers inhabiting the Santa Ana River had significantly higher concentrations of dichlorodiphenyltrichloroethylene (DDT) and trans-Nonachlor than those in the San Gabriel River. Conversely, concentrations of arsenic and mercury were significantly higher in suckers inhabiting the San Gabriel River. However, all of these concentrations were lower than those found in a variety of freshwater species throughout the United States (Saiki 2000).

Recreational activities have contributed to the degradation of habitat for the sucker via erosion of stream banks, destruction of vegetation, and release of untreated human waste and other refuse. Off-highway vehicle activity may physically increase erosion and sedimentation and alter channel morphology. In addition, recreational suction dredging occurs in all counties occupied by the sucker. Suction dredging removes all substrates smaller than the diameter of the intake nozzle and deposits them as large, unstable piles just downstream from the dredge. As a result, suction dredging can locally increase turbidity, change channel topography, and decrease the abundance of aquatic insects (Harvey and Lisle 1998). Also, suction dredging appears to have significant negative effects to the early life stages (i.e., eggs, larvae, fry) that could pass through a suction dredge and be killed or injured (Harvey and Lisle 1998). For example, Griffith and Andrews (1981) found mortality rates of up to 100 percent for eggs and fry of cutthroat trout (*Oncorhynchus clarki*) and rainbow trout (*O. mykiss*) that passed through a suction dredge.

The introduction of exotic species may eliminate or reduce the abundance and distribution of native species via predation, competition, and ecosystem alteration (Moyle and Light 1996). Infestations of the invasive arundo have degraded extensive areas of habitat for the sucker by forming monotypic stands of marsh and slow-moving aquatic habitats. Although arundo may provide cover and a possible source of food for the sucker, its overall effects are likely more detrimental than beneficial (Baskin and Haglund 1999).

Moyle and Yoshiyama (1992) concluded that introduced brown trout (*Salmo trutta*) contributed to the extirpation of the sucker from the upper Santa Ana River in the San Bernardino Mountains. In addition, flood control and water diversion structures have contributed to conditions that are favorable to many predators and competitors of the sucker, including the common carp (*Cyprinus carpio*), largemouth bass (*Micropterus salmoides*), channel catfish (*Ictalurus punctatus*), green sunfish (*Lepomis cyanella*) and tilapia (*Oreochromis mossambicus*). Saiki (2000) reported that the relative abundance of the sucker was negatively correlated with the relative abundances of common carp and largemouth bass. Hence, the ponding of water (e.g., settling ponds, inundation pools for dams) essentially creates areas that are unsuitable for the sucker and serve as population sinks.

Flood control and water diversion structures on the Los Angeles, San Gabriel, and Santa Ana rivers have also reduced the status of the sucker by imposing barriers that preclude or impede movements within populations. Within the Santa Ana River, the sucker population is bisected by Prado Dam, which effectively blocks the movement of fish upstream. Hence, adults, larvae or juveniles that move downstream of Prado Dam are lost from the upstream portion of the breeding population. Hansen Dam on Big Tujunga Creek and the San Gabriel River Dam may contribute to similar effects. Smaller barriers such as gauging stations, culverts and drop structures also impede movements of suckers along each of these rivers. For example, suckers washed downstream of the Weir Canyon drop structure along the Santa Ana River during high flows are effectively removed from the breeding population. The importance of upstream migration for the sucker is not known at this time. However, it is apparent that spawning is rare below Prado Dam and appears to be concentrated between Mission Boulevard and Rialto Drain, well upstream of Prado Dam. Therefore, providing upstream passage to the sucker may be important to improving reproduction for this species.

All remaining populations of the sucker are at risk due to their small size. Most of the lowland river habitats have been destroyed, and the remaining populations of the sucker are low in numbers, with the exception of the population in the San Gabriel River. Although the sucker is, in places, locally common in what remains of their native range, the total population size of any one of these remaining populations is still relatively small. Small populations have a higher probability of extinction than larger populations because their low abundance renders them susceptible to stochastic (random, naturally occurring) events such as inbreeding, the loss of genetic variation, demographic problems like skewed variability in age and sex ratios, and catastrophes such as floods, droughts, or disease epidemics (Lande 1988, Saccheri *et al.* 1998).

Another factor that renders populations of the sucker vulnerable to stochastic events is isolation, which often acts in concert with small population size to increase the probability of extinction for populations. Altered fluvial processes and impediments to movement have fragmented the historic range of the sucker such that remaining reaches of occupied habitat now function independently of each other. Isolated populations are more susceptible to extirpation by accidental or natural catastrophes because their recolonization has been precluded. Hence, the extirpation of remnant populations during local catastrophes will continue to become more probable as development and barriers further constrict remaining populations.

The sucker was listed as a federally threatened species on April 12, 2000 (65 *Federal Register* 19686). Critical habitat was not designated at that time because the biological needs of the sucker were not sufficiently known to identify areas essential for conservation. The sucker is designated a "species of special concern" by the State of California.

ENVIRONMENTAL BASELINE

Regulations implementing the Act (50 CFR § 402.02) define the environmental baseline as the past and present effects of all Federal, State, or private actions and other human activities in the action area. Included in the environmental baseline are the anticipated effects of all proposed Federal projects in the action area that have undergone section 7 consultation and the effects of State and private actions which are contemporaneous with the consultation in progress.

The action area encompasses areas that would either be directly or indirectly affected by the proposed action, and not merely the immediate area involved in the action. Subsequent analyses of the environmental baseline, effects of the action, and levels of incidental take are based upon the action area as determined by our agency. We have described the action area in this consultation to include the Prado Flood Control Basin upstream of the dam and Reach 9 of the Santa Ana River downstream of the dam. Because our action area is a biological determination that must incorporate direct, indirect, and interrelated/interdependent effects to listed species and their habitats, our action area may differ from the scope of analysis used by your agency under the National Environmental Policy Act.

*Least Bell's vireo*

The vireo population in the Prado Basin and contiguous reaches of the Santa Ana River and Mill and Chino creeks has been actively studied and managed since 1986. Annual monitoring is conducted to estimate abundance and distribution, breeding chronology, reproductive success, and nest site preferences. Also, cowbirds present in vireo home ranges were routinely monitored, and modified Australian crow traps were deployed throughout the basin and the adjacent Santa Ana River in an attempt to control this brood-parasitic species.

Vireos nesting in the Prado Basin area demonstrate a strong preference for nesting and foraging in willows and mule fat (The Nature Conservancy 1997, Pike and Hays 2000). Fifty-four percent of all nests in 1997 for which data were available ($n = 239$) were placed in various willow species, while 40 percent were found in mule fat (The Nature Conservancy 1997).

Surveys indicate that the vireo population in the Prado Basin area has increased significantly from approximately 164 pairs in 1995 to a minimum of 336 pairs during the 2001 breeding season. This population continues to be the second largest overall and the largest north of San Diego County. Preliminary data from the 2001 breeding season suggest that there were a minimum of 444 vireo territories that contained approximately 336 mated pairs within the Prado Basin study area (Pike *et al.* 2001). Hoffman (2001) reported a total of 61 additional territories containing 44 pairs at select areas within the remainder of the Santa Ana River Watershed. Data for the 2000 breeding season in Prado Basin indicated the presence at least 357 territorial male vireos, 281 of which were paired (Pike and Hays 2000). Of the 336 territorial male vireos detected in the area in 1999, 224 were paired (Pike and Hays 1999). By contrast, 270 pairs were recorded in 1998, 195 pairs were detected in 1996, and 164 pairs were located in 1995 (Pike and Hays 1998). The reason for the decrease in the number of breeding pairs from 1998 to 1999 remains unknown.

A minimum of 714 known fledged young was detected within the Prado Basin study area during the 2001 breeding season, which was a 10 percent increase over the 1999 total of 649 (Pike *et al.* 2001). Nesting success in recent years has been relatively high; the data for 1999 (57 percent) and 2000 (71 percent) both exceeded the figures for 1997 (50 percent) and 1998 (41 percent) Pike and Hays 1999, 2000). By contrast, the average number of fledglings per breeding pair from 1999 to 2001 (2.2) remained well below the average (3.1) for the breeding seasons from 1988 to 1991. In recent years significantly fewer pairs have renested after successfully fledging young on their first attempt (Pike and Hays 1999, 2000; Pike *et al.* 2001).

The primary threats to the vireo in the Prado Basin area are habitat loss and degradation and nest parasitism by cowbirds. Recovery objectives and current range-wide management efforts are focused on addressing these two issues (Service 1998). For example, 2,785 cowbirds were trapped and removed from habitats for the vireo and flycatcher within the Prado Basin area during 2001, 2,587 cowbirds were removed in 2000, and 2,300 cowbirds were removed in 1999. Nest parasitism was at 13 percent in 2001, while in 2000 the rate had decreased to an all-time low of 8 percent (Pike and Hays 2000), likely due to the cowbird trapping efforts in riparian habitat and at adjacent cattle farms; parasitism rates had been as high at 39 percent in 1986 and 57 percent in 1993.

Vireo researchers at Prado Basin area have detected several apparently well-incubated clutches of vireos that failed to produce a single viable nestling (Hays 1989). Entire clutches failed to hatch in three cases, and all vireo nestling young failed to survive in two other instances during the early part of the 1988 breeding season. In 1994, four full clutches failed to hatch; one apparently infertile female is thought to be responsible for two of these clutches.

In 1997, a vireo nestling with a deformed upper mandible was observed (Pike and Hays 2000). Such abnormalities are often the expressed result of exposure to environmental contaminants. Abnormalities that often are attributable to toxic levels of various pollutants were detected in invertebrate specimens collected within the Prado Basin. Specifically, crayfish (*Procambius clarkii*) with abnormal appendages have been found, and several Chinese river clam (*Corbicula fluminea*) specimens exhibited shell ring patterns that indicated irregular growth (Service, unpublished data). Also, several age classes of Chinese river clams appeared to be missing from the aquatic habitats that were surveyed. This phenomenon may be the result of episodic, lethal exposures to toxic substances. Most importantly, preliminary data derived from the toxicological testing of abandoned vireo eggs from the Prado Basin have revealed the presence of dichlorodiphenylethylene (DDE), a metabolite of DDT, in concentrations that could cause eggshell thinning (Service, unpublished data).

The draft recovery plan for the vireo (Service 1998) calls for the protection and management of riparian and adjacent upland habitat in each identified population/metapopulation site (including the Santa Ana River) and a reduction of threats to the extent that: 1) the species no longer needs significant human intervention to survive; or 2) if human intervention is necessary, "... perpetual endowments are secured for cowbird trapping and exotic plant (*Arundo*) control in riparian habitat occupied by least Bell's vireos."

Critical habitat for the vireo includes all riverine and flood plain habitats with appropriate riparian vegetation in the Prado Basin below the elevation of 543 feet and upstream along the Santa Ana River through the Norco Bluffs area to the vicinity of the Van Buren Boulevard crossing. The action area contains a minimum of 3,500 acres of riparian habitats supporting the primary constituent elements of critical habitat. This critical habitat functions as a core area for vireos that is essential for the conservation of this species. Activities that could adversely affect these primary constituent elements include removal of riparian vegetation, thinning of riparian growth, especially near ground level, the invasion of exotic species (e.g., arundo), removal or destruction of adjacent upland habitats used by vireos for foraging, and flood control activities, including dams, channelization, water impoundment or extraction, and water diversion.

*Southwestern willow flycatcher*

The Prado Basin population is one of only six permanent southwestern willow flycatcher breeding sites that now exist in California. In 2001, the first flycatcher of the breeding season at the Prado Basin was detected on May 3 and the last (two juveniles) were noted on August 28 (Pike *et al.* 2001). Seven flycatcher home ranges were detected during the 2001 breeding season. Pike *et al.* (2001) indicate that three of the territorial birds paired and nested. A total of three young were fledged from two nests, the third nest was unsuccessful. Only one pair of flycatchers was detected during the 2000 breeding season; apparently only two young were fledged in the Prado Basin at that time (Pike and Hays 2000). By contrast, five flycatcher home ranges were detected within the Prado Basin during the 1999 breeding season. Pairs were eventually found in three of these home ranges; two of the three pairs produced a total of five fledglings (Pike and Hays 1999).

Flycatchers in the Prado Basin virtually always nest near surface water or saturated soil (The Nature Conservancy 1994). All known territories have been situated in relatively close proximity to water-filled creeks or channels. Nests have been placed as low as two feet above ground level. Of the five flycatcher nests found in 1996, two were placed in arroyo willow, one was found in a red willow (*Salix laevigata*), one was placed in a sandbar willow, and one was placed in a tamarisk. Both nests discovered during the 1997 season were in arroyo willows. In 2001, two nests were in arroyo willow and one in tamarisk.

Although flycatcher home ranges have been detected throughout much of the surveyed portions of the Prado Basin, successful breeding prior to 1996 had been detected only in North Basin and West Basin (Chino Creek). From 1996 to 1998 and again in 2000 and 2001, however, the only successful breeding occurred in the South Basin. No flycatcher home ranges have been detected in Reach 9 of the Santa Ana River (Service, unpublished data). Although trapping and removal of cowbirds have reduced nest parasitism and increased reproductive success of vireos in the

Prado Basin, similar results have not been seen for the flycatcher. The lack of a demonstrated relationship may reflect the low abundance of flycatchers in the area or that some other factor(s) are limiting the population.

While the unauthorized destruction of habitat within the action area has largely been curtailed, it has not completely ceased. During 1998, 1999, and 2000, property lessees of the Corps apparently mowed or cleared more than three acres of riparian habitat suitable for the vireo and flycatcher within the basin adjacent to Chino Creek. In addition, operations and maintenance work completed for the Corps in late 1998 resulted in the clearing of less than one acre of riparian habitat suitable for the vireo and flycatcher. Also, during autumn of 1999 approximately two acres of vireo habitat was destroyed or degraded in conjunction with the construction of roads, apparently on District property, in the western portion of the Basin. Most recently, seven ponds in the lower basin were created without apparent authorization. Staff in the Corps' Operations and Regulatory branches are currently working with CFWO to address these issues.

The primary threats to flycatcher within the action area essentially are the same as those identified affecting the vireo. The draft recovery plan for the flycatcher (Service 2001) calls for a minimum of 50 territories within the designated Santa Ana management unit and protection from identified threats to assure maintenance of the population over time.

*Santa Ana sucker*

The sucker has lost approximately 70 percent of its native range in the Santa Ana River; the portions of the Santa Ana River occupied by the sucker constitute approximately 60 percent of the entire remaining native range of the species. In the mid-1980s, Fisher (1999) reported observing numerous suckers at Imperial Highway. In Reach 9, researchers caught five suckers in 1991, one sucker in 1996, and five suckers in 1998 (Chadwick and Associates 1996, Swift 1998). The area downstream of the first drop structure downstream of Prado Dam contained appropriate habitat for sucker, including rocky to gravelly substrate, slow to moderate flowing water, and a mean depth of about 20 inches (Swift 1998). Thus, the relatively low density of suckers is apparently not due to a lack of habitat. In recent surveys, ten adult suckers were caught between Weir Canyon Road and Imperial Highway (Baskin and Haglund 2001).

Between the Hamner Avenue crossing of the Santa Ana River and Prado Dam, researchers caught 3 suckers in 1991, 76 in 1997, 22 in 1998, 5 in 1999, and 3 in 2000 (Chadwick and Associates 1996; Swift 1997, 1998, 1999, 2001). All 76 suckers caught in the Norco Bluffs area in 1997 were between 0.8 to 2.8 inches in length. Therefore, Swift (1997) hypothesized that this area was a nursery for the sucker. However, the substrate was mostly shifting sand and provided low food resources. Additionally, the presence of invasive competitors such as fathead minnow may limit the availability of diatoms and epiphytic green algae to the sucker. The fish caught in this area during other years were adults or the length information was not provided. It appears that this area may provide appropriate habitat to the sucker in some years.

The causes of sucker decline in the proposed project area are attributed to habitat degradation and destruction, increase in invasive species and loss of connectivity in recent years. Habitat quality and quantity have been reduced by increased turbidity and sedimentation upstream of the Prado

Dam and the construction and maintenance of flood control structures. Increased turbidity reduces the available light needed for photosynthetic processes for algae and visibility for prey searching. Sedimentation reduces available spawning habitat and food sources by covering favorable cobble and gravel substrate. The installation of hard bank stabilization structures along various areas of the Santa Ana River has also contributed to losses of habitat. These hard bank stabilization structures reduce habitat quality and quantity by reducing bank vegetation and increasing flow, thus encouraging the removal of larger-sized substrate. Habitat quality is further reduced by bank stabilization structures that remove pool-riffle complexes.

The status of the sucker in the action area has likely been adversely affected by increased predation and competition from invasive species. Banks stabilization structures, the Prado Dam reservoir, and the construction of wetlands have provided excellent habitat for invasive predatory and competitive species such as largemouth bass, channel catfish, carp, bluegill, green sunfish and mosquitofish (*Gambusia affinis*). Swift (2001) reported that carp and channel catfish were most common downstream of the Prado Dam, and green sunfish and largemouth bass rarely strayed from deep pools and slow-moving aquatic habitats. However, Baskin (2001) hypothesized that large numbers of mosquitofish observed in the mouth of the Sunnyslope Creek may be preying on recently spawned larval suckers.

As suckers are washed downriver, they are unable to return upstream due to the presence of several barriers. Four existing drop structures are present downstream of Prado Dam that probably prevent suckers from passing upstream due to their height and design. Additionally, Prado Dam almost certainly impedes passage, especially during low flows in the dry season, and during high flows and subsequent ponding upstream of the dam during flood seasons. Upstream of Prado Dam, the diversion at River Road provides another barrier. This diversion is a 12 to 36-inch earthen dam that diverts 70 percent of the water to wetlands managed by the Orange County Water District. The remaining water is diverted through culverts beneath the dam to the main river channel. Upstream of the culverts, water is ponded and provides habitat for exotic predators and competitors. Suckers are likely not able to swim upstream through the fast flowing water exiting the culverts and, should they succeed, then they must pass through ponds. The importance of upstream migration has been demonstrated for several species of lake suckers, including the cui-ui sucker (*Chasmistes cujus*), Sacramento sucker (*Catostomus occidentalis*), and Modoc sucker (*Catostomus microps*) (Moyle 1976; S. Reid, Service, Klamath Falls, OR, personal communication to L. Caskey, CFWO, April 2001). Where fish passage has been constructed for the lake suckers, fish locks have been successful in passing 150,000 to 700,000 suckers per day (B. Mefford, Bureau of Reclamation, Denver, CO, personal communication to L. Caskey, CFWO, March 2001).

The relatively low density of suckers downstream of Prado Dam may be due to several factors, including a lack of recruitment due to the small amount of suitable spawning habitat, relatively high density of exotic predators, and loss of habitat from the installation of flood control features (e.g., drop structures, bank stabilization, and low flow channels).

Because the status of the sucker is precarious and declining, long-term conservation depends on the implementation of the following conservation measures: 1) protection of remaining populations to ensure that they are independently viable with stable or increasing abundance and recruitment; 2) maintenance or restoration of adequate perennial flows necessary to support and create viable habitat in each river and tributary occupied by the sucker, including reaches that are currently dewatered; 3) maintenance or restoration of connectivity of habitat in each river and tributary occupied by the sucker, including the removal or modification of existing barriers to movement; 4) maintenance of water quality suitable for the sucker; and 5) removal of exotic species that degrade habitat and/or reduce the status of the sucker through predation or competition.

Habitats that are currently degraded could be improved in a number of ways. Naturally sinuous river channels should be encouraged throughout the historic range of the sucker, and ponded water should be reduced to a minimum and/or managed in such a way as to discourage entry by the sucker. In addition, water management plans and/or legal agreements should be developed to maintain adequate perennial flows in all rivers, particularly in the Santa Ana River where RIX facility shutdowns could strand the sucker in shallow pools. Furthermore, restoring flow to dry reaches with appropriate substrate could provide adequate habitat to support the reintroduction of suckers. In addition to flow, turbidity should be reduced through appropriate dam modifications, and the scope and intensity of recreational activities that adversely affect the sucker and its habitat should be limited. Habitat for sucker may also be improved by adding coarse material and boulders to the substrate. In areas where other listed species are not present, nursery habitats should be created and maintained by clearing emergent non-native vegetation and, if necessary, modifying stream banks to create shallow stream bank areas. Once habitat is created, it should be protected from human-induced high flows (e.g., dam releases) that could scour gravel and cobble substrate. One possible measure that could dissipate these high velocity flows is the installation of relief channels. Relief channels are constructed to divert high flows away from the main channel. An example of a relief channel is at the confluence of Sespe Creek and Santa Clara River. This relief channel appears to support a population of suckers, arroyo chubs and sticklebacks (Baskin and Haglund 1999).

An exotic species program should be implemented to remove vegetation such as arundo and competitors and predators of the sucker such as green sunfish, largemouth bass, carp, and channel catfish. Such a program would improve habitat for the sucker by reducing the amount of slow moving or standing water created by large stands of arundo and by decreasing the presence of exotic fish. Removal of invasive fish species is usually completed by chemical or mechanical means such as the use of seines, nets, and traps. Mechanical means would be the most effective and least harmful to the native fish species in the Santa Ana River.

Barriers that preclude or impede the movements of suckers should be removed or modified (e.g., installation of fish passage structures) so that individuals are no longer lost to the breeding population and can colonize currently unoccupied areas. Several types of fish passage are available including fish locks, vertical slot structures, and fish rock passageways. Vertical slot structures have been successful for the cui-ui sucker in the Truckee River, and natural fish passageways are being constructed for the Modoc sucker in a Pit River tributary (S. Reid, Service, personal communication to L. Caskey, CFWO, April 2001). The darting speed of small suckers is estimated to be 4 body lengths per second (e.g., a 6-inch-long sucker would have darting speed of 2 feet per second) (S. Reid, Service, personal communication to L. Caskey, CFWO, April 2001). However, the swimming speed and affinities of the sucker and other similar species should be examined more closely so that appropriate passageways can be constructed.

Because few specifics are known about the life history strategies, population dynamics, and habitat affinities of the sucker, research and monitoring should be initiated immediately. The Santa Ana Sucker Discussion Team has funded initial studies of the distribution, habitat affinities, and potential effects of contaminants, turbidity, and exotic species on the sucker population in the Santa Ana River. Additional studies should be funded to investigate additional areas and variables. Also, goals should be clearly defined for all measures implementing conservation needs, and the success of conservation efforts must be assessed through quantitative and qualitative monitoring.

EFFECTS OF THE ACTION

Effects of the action refer to the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated and interdependent with that action, that will be added to the environmental baseline. Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration. Indirect effects are those that are caused by or result from the proposed action, and are later in time, but are still reasonably certain to occur.

Activities associated with, or resulting from, the proposed action could adversely affect the vireo and its critical habitat, flycatcher, and/or sucker in the following manner: 1) increased degradation of riparian and stream habitat in the reservoir pool due to more frequent, higher elevation pooling of water and, in turn, inundation effects to habitat; 2) increased degradation of habitat downstream of the dam due to potentially more frequent, higher rate discharges; 3) increased invasion of exotic species due to disturbance of habitats within the expanded reservoir pool area that are favorable to these species; and 4) effects to sucker from water conservation structures and diversions. Each of these categories of adverse effects are discussed in detail in the following sections.

*Effects to sucker*

Increased degradation of riparian and stream habitat in the reservoir pool due to more frequent, higher elevation pooling of water and, in turn, inundation effects to habitat: Impounding water and creating a larger reservoir behind Prado Dam would have adverse affects on the sucker. Approximately 2.2 to 4.8 acres of river habitat would be lost, at least temporarily, to impounded water (Table 8, draft BA). As flowing water reaches the conservation pool, its velocity drops and suspended sediment settles out; fines that settle create unsuitable bottom habitat for sucker. Freshwater aquatic habitat consisting of pooled, non-flowing water decreases the extent of natural stream habitat for sucker. Pooled, standing water has increased stagnation, accumulation of nutrients, eutrophication, elevated temperature, and decreased dissolved oxygen, which are conditions unsuitable for native fish.

While specific river enhancements to benefit sucker are not proposed as part of the conservation measures of this project, some habitat restoration for the sucker is being addressed through implementation of conservation measures under the Mainstem consultation. In addition, the District is a member of the Santa Ana Sucker Discussion Team (Sucker Team), which is developing a conservation program that will identify scientific study needs and species management options and work to implement a suite of activities, including habitat enhancement, to benefit the sucker.

Increased degradation of habitat downstream of the dam due to potentially more frequent, higher rate discharges from the dam: Scour of the downstream channel will contribute to the degradation of habitat for sucker. Suckers depend on gravel substrate because they scrape algae off of rocks for food and use these types of substrate for spawning. Although it is not known if suckers spawn in Reach 9, they have been detected in that area. It is reasonably certain that discharges in the range of 5,000 to 10,000 cfs will mobilize gravels, alter the river substrate, and decrease the availability of spawning habitat and food resources for the sucker downstream of Prado Dam. This substrate is unlikely to be replaced at a rate commensurate with its loss due to the barrier to gravel transport imposed by the dam. The loss of any spawning habitat downstream of the Prado Dam could limit reproduction by the sucker because there is little possibility for these fish to return to upstream spawning sites due to the barrier imposed by the dam. Even an infrequent, high-rate discharge event that reduces available spawning or larval habitat and, thereby, contributes to a decrease in recruitment could decrease the status of the species for years due to persistent effects (i.e., time lags) on local population dynamics.

Impacts to sucker from the increased flow and frequency include sweeping suckers from areas where there is great constriction and no refugia past Weir Canyon Bridge into Reach 8 and beyond of the Santa Ana River, loss of spawning habitat, and loss of food resources. Since there are no known spawning locations between Prado Dam and Weir Canyon Bridge, it is difficult to assess impacts to reproduction. Survival could be significantly reduced for any existing sucker population as food resources would be anticipated to decrease. Additionally, any suckers swept past the drop structure downstream of Weir Canyon Bridge would be moved to habitats that are less conducive to their survival. For example, between Weir Canyon Bridge and Imperial Highway Bridge, there is less canopy and refugia, and the river is highly fragmented by three drop structures. After Imperial Highway Bridge, water flow is extremely reduced, and little or no canopy and habitat, including appropriate substrate, exists. Therefore, it is likely any suckers swept below Weir Canyon would be lost to the known sucker populations.

Increased discharge rates may wash suckers past Weir Canyon, where they would not be able to return upstream past the several existing drop structures. These suckers would be lost to any breeding population downstream of Prado Dam because there is no known spawning habitat downstream of Weir Canyon. No specific measures under this proposed water conservation project are being proposed to address effects to sucker from being passed downstream in high flows; however under the Mainstem consultation, the Corps will design and implement an efficient, cost effective trap and haul program in coordination with the Service, CDFG and other experts. This program should reduce the number of suckers that would be permanently lost from the breeding population. In addition, the Sucker Team is working to initiate an intensive study of the species' status and distribution downstream of Prado Dam.

Increased invasion of exotic species due to disturbance of habitats within the expanded reservoir pool area that are favorable to these species: Increasing the water conservation pool will increase habitat for exotic animal species such as bass, carp, green sunfish, bullfrog, and crayfish, all of which are competitors with or predators on native fish, such as the sucker. The conservation measure proposed by this project to develop and implement an effective exotic animal species control program within the Basin will reduce the negative effects that these species have on sucker and other native fish.

Effects to sucker from water conservation structures and diversions: Under current water conservation practices, approximately 50 percent of the river is diverted into a channel just downstream of the River Road bridge for delivery to water quality ponds (polishing ponds). That diversion channel has good quality habitat and sucker have been found in it. However, in its current configuration, the diversion channel does not allow sucker to pass back into the main river, and the outflow of the diversion ends at the polishing ponds. The polishing ponds are areas of still water that contain species which are predators and/or competitors of the sucker. It is unlikely that sucker survive if they pass into the polishing ponds. In addition, the main river channel has culverts near the diversion channel that have a significant drop, preventing sucker that pass through the culvert from being able to move back upstream. Sucker that pass through the culverts there are effectively removed from any upstream breeding population. Conservation measures to be implemented under the Mainstem project include providing for year-round, bidirectional passage of suckers in both the main river channel and the diversion channel.

*Effects to vireo and flycatcher*

Increased degradation of riparian and stream habitat in the reservoir pool due to more frequent, higher elevation pooling of water and, in turn, inundation effects to habitat: Our agency voiced concerns about increased inundation effects not only due to higher levels of water conservation but also due to the ability of the dam to hold water more frequently and at a higher level once the new dam outlet gates are installed during Mainstem. With and without the Mainstem project inundation levels and durations were compared to determine if that project would result in prolonged inundation of vireo critical habitat or an increased potential for flooding of vireo nests following rare late spring storms. Your agency has maintained that the Mainstem project would not cause significant increases in inundation elevations or dwell times within habitat for vireos behind the dam due to the increased discharge capacity of the outlet works (Corps 2001a). Also, your staff has indicated that the dam will continue to be operated primarily for flood control purposes and that during late winter water will not be held longer or at higher elevations behind the dam in anticipation of water control activities up to 505 feet elevation following March 1. In addition, your agency maintains that any increases in inundation under future conditions will be the result of parameters (e.g., sedimentation and watershed development) not related to Mainstem or increased water conservation.

While we agree that the increased discharge capacity of the reconstructed dam could, under certain circumstances, reduce both the elevation and dwell time of water pooled behind the dam, it is evident that the inundation of wetland, riparian and upland habitats up to an elevation of 566 feet will be enabled by Mainstem, and therefore, the dwell time of impounded waters at all elevations, including those for water conservation, could be increased. As an example, the current water control manual (Corps 1994) provides for a range of release rates at all elevations from the debris pool to the elevation of the spillway (and above). Given that a stated objective of the manual is to accommodate water conservation whenever possible, the much larger post-Mainstem potential reservoir pool, and resulting decreased flood risk associated with storing water at higher elevations, it is reasonable to conclude that Mainstem will induce incremental damage to habitats occupied by the vireo and, possibly, the flycatcher, at the current winter water conservation 494 foot elevation and that same type of incremental damage will take place at the higher proposed water conservation level of 498 feet. The increased storage of water during the later winter could result in the degradation of riparian habitat and the understory that vireos require for nesting.

Although the effects of inundation on riparian habitat are relatively difficult to quantify, water conservation efforts may result in the following effects: 1) vegetation mortality that reduces the areal extent of willow riparian habitat; 2) reduction in species diversity, as plants intolerant of inundation are reduced within the basin; and 3) structural changes within the habitat, especially a loss of shrubby understory. Persistent water will have an effect out some distance beyond its immediate edge due to soil saturation, capillary action, and microclimate alteration. In some areas, only the most inundation tolerant plants would persist, potentially expanding the existing monotypic black willow forest to a higher contour level, with concomitant shifts of other vegetation communities also to higher contours or resulting in their direct loss. These losses or changes to the plant community depend on a variety factors including the elevational gradient, soil type, and current plant community. The border of much of Prado Basin has a steep elevational gradient; therefore, plant community changes in these areas will be more abrupt, while within the Basin and riverbed, changes would occur over a wider area where the elevation change is more gradual.

The primary effects to the vireo and flycatcher include a reduction in the carrying capacity of the area due to decreased availability of habitat and a reduction in recruitment due to decreased foraging and nesting locations. Since monitoring for the vireo began, there has been a shift in the distribution of vireo nesting territories from lower elevations in the southern basin to more eastern and higher elevation areas due to habitat changes, particularly the loss of shrubby understory, from current water conservation practices (Biological Opinion 1-6-95-F-28 dated April 20, 1995). This shift has moved a large portion of the breeding population nearer to the Corona Airport, increasing the number of vireos subject to potentially adverse noise effects and closer to dairies, agricultural and ruderal habitats, which could subject breeding vireos to increased nest parasitism by cowbirds.

We anticipate that the increased pooling of water during winter months when Prado Dam is operated for flood control (October 1 to February 28) is not likely to directly threaten individual vireos or flycatchers because these species are typically not present in the project area during this time period. Vireos typically arrive in the Prado Basin and southern California from their wintering grounds in mid- to late March, with territory establishment and nesting taking place from March through late July (Pike and Hays 1999). Dispersal of fledglings and mature adults typically occurs in August and September. Flycatchers typically arrive in the Prado Basin later than vireos and leave earlier. As a result, vireos and flycatchers are only rarely detected in the Basin during October 1 to March 15 (Pike and Hays 1999). The biological opinion for the current water conservation activities anticipated the harm of 90 pairs of vireos or 180 individual vireos over the life of the project due to the periodic, temporary flooding, destruction or degradation of occupied habitat; no harm was anticipated for flycatchers. Since the proposed project's water conservation elevation of 505 feet during summer months is the same as the current water conservation activities, all measures outlined in previous formal consultations for avoidance and minimization to vireo and flycatcher nests and young, including any necessary relocation of nests subject to flooding to a higher elevation, will continue to be implemented by the Corps and/or District for the life of the project. In addition, one conservation measure to be implemented with this proposed project would create at least 37.2 acres of riparian habitat that, over time, would become suitable for occupation by the vireo and, potentially, the flycatcher. This created area would provide nesting area for vireos that may be displaced by the increased water conservation activities between 494 and 498 feet and for the general vireo population, that has grown substantially.

Increased degradation of habitat downstream of the dam due to potentially more frequent, higher rate discharges from the dam: The upsizing of the dam outlet works from Mainstem will increase the capacity for discharges from 5,000 cfs to 8,760 cfs for a 25-year flood, from 5,000 cfs to 18,500 cfs for a 50-year flood, and from 22,200 cfs to 30,000 cfs for a 100-year flood (Corps 2001a, b). Your agency maintains that significant damage to riparian habitat downstream from the dam would occur only rarely because sustained discharges exceeding 10,000 cfs would be rare. However, the draft BA (page 33) states that a release of 7,400 cfs with velocities from 4 to 14 feet per second can cause considerable scouring of the channel. Your agency estimates that 22 acres of downstream habitat will be affected by discharges due to water conservation activities.

Scour of the downstream channel will contribute to the degradation of habitat for vireo. Release at high rates erodes soil, removes vegetation, moves cobble, rock and boulders, and can cause armoring of the channel. High rates of discharge can be a significant factor in causing streambank erosion resulting in loss of riparian vegetation. Water released from Prado Dam, while containing a load of suspended fines, in nearly free of coarser sediments. Thus, the natural dynamics of deposition replacing sediment scoured by large flow rates are highly altered. Vegetation would be unable or take longer to reestablish in areas scoured of soil. The loss of vegetation due to higher velocity flows facilitated by the upsized outlet structures will reduce the extent of suitable overstory and understory riparian downstream of the dam that vireos depend upon for nesting and foraging.

The Habitat Management Plan prepared for these public lands has not been completed or adopted. However, the Corps and District have agreed to finalize the proposed plan or equivalent within one year of the initiation of Mainstem construction in coordination with our agency and, subsequently, obtain approval from our agency and implement the plan immediately thereafter to appropriately conserve listed species within Reach 9 of the River. The local sponsors have indicated that, under any circumstances, the approved Habitat Management Plan will be implemented in full upon the conclusion of construction in the Santa Ana River Canyon (County of Orange 2001). In the interim local sponsors have committed to maintain open space that is under their direct control in a manner that is consistent with the intent of the Habitat Management Plan (County of Orange 2001). We anticipate that the purchase and management of the Santa Ana River flood plain and other habitat restoration measures within the action area will be implemented over time to moderate any damage incurred by higher release flows.

Increased invasion of exotic species due to disturbance of habitats within the expanded reservoir pool area that are favorable to these species: Any project-related creation and maintenance of conditions that favor exotic plants and animals could decrease the status of the vireo and flycatcher. The increase and spread of alien plants such as arundo is continuing in the Santa Ana River watershed, including the Prado Basin. Undisturbed areas vegetated with native species are much more resistant to invasion by this and other alien plants. The alteration of the landscape within the project area and associated establishment and dispersal of select non-native plants likely will impact, and could overwhelm, native habitats in the project area. Invasive exotic plants could be established in riparian habitat impacted by activities associated with the project. Stands of arundo, castor bean (*Ricinus communis*), and other invasive, noxious non-native plants provide little habitat for the vireo and flycatcher. The vast majority of vireo nests within the Prado Basin and elsewhere have been placed in native trees and shrubs (Pike and Hays 2000).

The disturbance or removal of existing riparian can result in the creation of cowbird foraging habitat or increase cowbird parasitism events due to the fragmentation of nesting habitat (Askins 2000). Cowbirds prefer feeding in open areas such as those created by human alterations of the landscape (Garrett and Dunn 1981). There is a relatively high density of cowbirds in the Prado Basin and contiguous reaches of the Santa Ana River, possibly due to the rather close juxtaposition of host-rich riparian habitats and expansive feeding areas in and around nearby dairies, livestock operations, urban, and agricultural fields (Zembal *et al.* 1985, Hays 1987, Lowther 1993, Pike and Hays 1999).

Because the rate of parasitism of vireo nests in the Prado Basin was as high as 100 percent prior to the inception of current management efforts (Zembal *et al.* 1985), any project-related feature that creates conditions favorable to cowbirds in the project area would likely decrease the reproductive success of vireos in the absence of management. However, the cowbird trapping and removal efforts that are part of ongoing efforts by the District should effectively reduce the incidence of parasitism to the vireo or flycatcher in the Prado Basin, based on the results of several recent publications that demonstrated the efficacy of cowbird trapping programs at increasing the reproductive success for the vireo (Kus 1999, Whitfield and Sogge 1999, Whitfield *et al.* 1999, Pike and Hays 2000, Powell and Steidl 2000).

*Effects to designated critical habitat for vireo*

Within Prado Basin, 15.2 acres of designated vireo critical habitat will be affected by increased inundation. Inundation effects include vegetation mortality that reduces the areal extent of willow riparian habitat and structural changes within the habitat, especially a loss of shrubby understory. These effects to vireo critical habitat will be offset by the creation of 37.2 acres of riparian habitat.

## CUMULATIVE EFFECTS

Cumulative effects include the effects of future State, tribal, local or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act.

We are unaware of any future, non-Federal actions that are reasonably certain to occur within the action area that could adversely affect the vireo and its critical habitat, flycatcher, or sucker.

## CONCLUSION

Measures to offset effects to vireo and flycatcher from prior water conservation projects include species monitoring and reporting, cowbird trapping, and habitat restoration. Measures to offset effects to sucker from the Mainstem project include habitat restoration and continued development and implementation of a sucker management plan. After reviewing the current status of the vireo and its critical habitat, flycatcher, and sucker, the environmental baseline for the action area, effects of the proposed action including conservation measures, and the cumulative effects, it is our biological opinion that the proposed action is not likely to jeopardize the continued existence of the vireo, flycatcher, or sucker or adversely modify critical habitat for the vireo. Our conclusion is based on the following findings:

1. Adequate conservation measures have been implemented from prior consultations to minimize project-related effects during non-flood season at elevations between 498 and 505 feet, and adequate conservation measures will be implemented for project-related effects during flood season between 494 and 498 feet, thus maintaining the baseline of habitat, abundance, and distribution for the vireo and flycatcher within the project action area;

2. Implementation of the proposed habitat creation efforts, plus remedial measures if necessary, will ensure that habitat function for the vireo and flycatcher is maintained within the action area;

3. Adequate conservation measures will be implemented for project-related effects to the sucker, thus maintaining the baseline of habitat, abundance and distribution of sucker within the project action area; and,

4. Implementation of the proposed exotic predator/competitor eradication plan will ensure that project-related effects to sucker are minimized.

## INCIDENTAL TAKE STATEMENT

Section 9 of the Act, and Federal regulations issued pursuant to section 4(d) of the Act, prohibit take of endangered and threatened species without a special exemption. Take is defined as harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that actually kills or injures a listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the Service as an action that creates the likelihood of injury to a listed species by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), such incidental taking is not considered to be a prohibited taking under the Act provided that such taking is in compliance with this Incidental Take Statement.

The measures described below are non-discretionary and must be implemented by the Corps or the District in order for the exemption in section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activity that is covered by this incidental take statement. If the Corps (1) fails to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document, and/or (2) fails to retain oversight to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse.

AMOUNT OR EXTENT OF TAKE

We anticipate no additional incidental take of vireo from this proposed project over that assessed in Biological Opinion 1-6-99-75 for prior water conservation activities that are still in effect during the life of this project, that is, the harm of 90 pairs of vireos or 180 individual vireos over the life of the project due to the periodic, temporary flooding, destruction or degradation of occupied habitat.

We anticipate no incidental take of flycatchers.

We anticipate incidental take of an unquantifiable number of suckers in the form of harm due to loss of breeding habitat downstream of Prado Dam and inundation effects to 2.2 to 4.8 acres of stream habitat behind the dam in the reservoir pool.

EFFECT OF TAKE

In the accompanying biological opinion, we determined that the level of anticipated take is not likely to result in jeopardy to the vireo, flycatcher and/or sucker, or adverse modification of vireo critical habitat.

REASONABLE AND PRUDENT MEASURES

The Corps shall implement the following reasonable and prudent measure.

1. Your agency or the District will ensure that adverse effects to the vireo, flycatcher and sucker resulting from the implementation of the proposed action are minimized to the maximum extent practicable.

TERMS AND CONDITIONS

To be exempt from the prohibitions of section 9 of the Act, your agency and/or the project proponents and their agents must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are nondiscretionary.

1.1 The Corps and the District shall implement the project minimization measures for vireo, flycatcher and sucker as described in the section entitled "Description of the Proposed Action."

1.2 The Corps, District, or their agents shall obtain all necessary local, State, and Federal permits to implement the project. In particular, the Corps and District must obtain any necessary permits from California Department of Fish and Game. The incidental take authorization in this biological opinion is not in effect in the absence of any or all such permits.

The reasonable and prudent measures, with their implementing terms and conditions, are designed to minimize incidental take that might otherwise result from the proposed action. If, during the course of the action, the level of incidental take is exceeded, such incidental take represents new information requiring reinitiation of consultation and review of the reasonable and prudent measures provided. Your agency must immediately provide an explanation of the causes of the taking and review with this office the need for possible modification of the reasonable and prudent measures.

## CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to use their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information. We recommend your agency consider implementing the following recommendations to further the conservation of the vireo, flycatcher, and sucker:

1. A long-term plan for restoring sucker habitat within the Santa Ana River, including Reach 8, should be developed and implemented to address the creation of stream meanders, pool-riffle complexes, upstream and downstream fish passage throughout the reach, reestablishment of riparian vegetation, and other conservation needs. Your agency should regularly participate in the monthly meetings of the Santa Ana Sucker Discussion Team.

2. The installation of low-flow rock passageways, vertical slot structures, fish locks, or other similar methods that provide fish passage through or around drop structures in the Santa Ana River should be developed and implemented. The velocity of flow in which the sucker can maintain direction and movement should be investigated so that appropriate

fish passage systems could be established at each of the drop structures between Prado Dam and Imperial Highway.

3. Conduct an annual assessment of the effects of inundation (e.g., dwell time and elevation) to the vireo, sucker, and their habitats for the life of the dam. This assessment should include baseline information such as the distribution and elevation of all vireo nests during each monitoring season for which data has been collected (i.e., approximately the past 16 years).

4. To the extent practicable, remove all invasive/exotic biota from riparian habitats in the Prado Basin. The existing cowbird management program should be continued and expanded to maximize the reproductive success of the vireo, flycatcher, and other sensitive avian species. Also, the control of invasive, exotic plants such as arundo and castor bean must continue if riparian habitats are to provide the elements necessary to accommodate the vireo, flycatcher, and a large variety of other sensitive animal taxa over time.

5. A sediment transport study should be developed and implemented in cooperation with other local, State, and Federal agencies. The sediment transport study should incorporate historical and current data and evaluate the effectiveness of the Santa Ana River as a sediment transport system. The study should address the excess sedimentation that occurs upstream of Prado Dam and the sediment deficit downstream of Prado Dam. The results of this study would be used to develop measures that would attempt to return the Santa Ana River to a fully functioning sediment transport system.

## REINITIATION NOTICE

This concludes formal consultation on the proposed action as specified in your request for formal consultation. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: 1) the amount or extent of incidental take is exceeded; 2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; 3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (4) a new species is listed or critical habitat designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation. Any questions or comments should be directed to Jill Terp of my staff at (760) 431-9440.

Sincerely,

Karen A. Evans

Karen A. Evans
Assistant Field Supervisor

cc: Orange County Water District, C. Miller and D. Zembal

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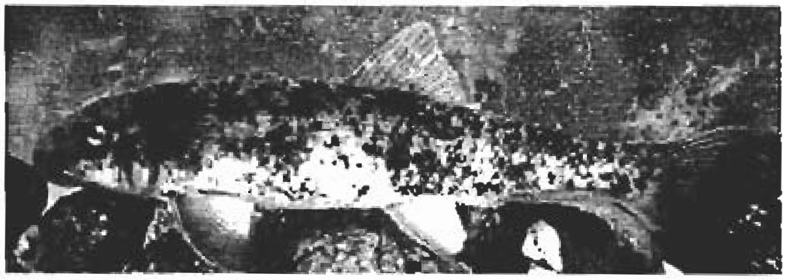
# Exhibit 3

# *San Marino Environmental Associates*

REVISED DRAFT



# Results of the Year 3 Implementation of the Santa Ana Sucker Conservation Program For the Santa Ana River


**Thomas R. Haglund, Ph.D.**
**Jonathan N. Baskin, Ph.D.**
**Camm C. Swift, Ph.D.**


**Prepared for the Santa Ana Sucker Conservation Team**
**SAWPA Task Order SMEA 370-03**

# San Marino Environmental Associates

# Results of the Year 3 Implementation of the Santa Ana Sucker Conservation Program For the Santa Ana River

## Final Report

Prepared For:
**Santa Ana Sucker Conservation Team**
Composed of:
City of Riverside (Regional Water Quality Control Plant)
City of San Bernardino Municipal Water Department
Orange County Flood Control District
Orange County Water District
Riverside County
Riverside County Flood Control and Water Conservation District
San Bernardino County Flood Control District

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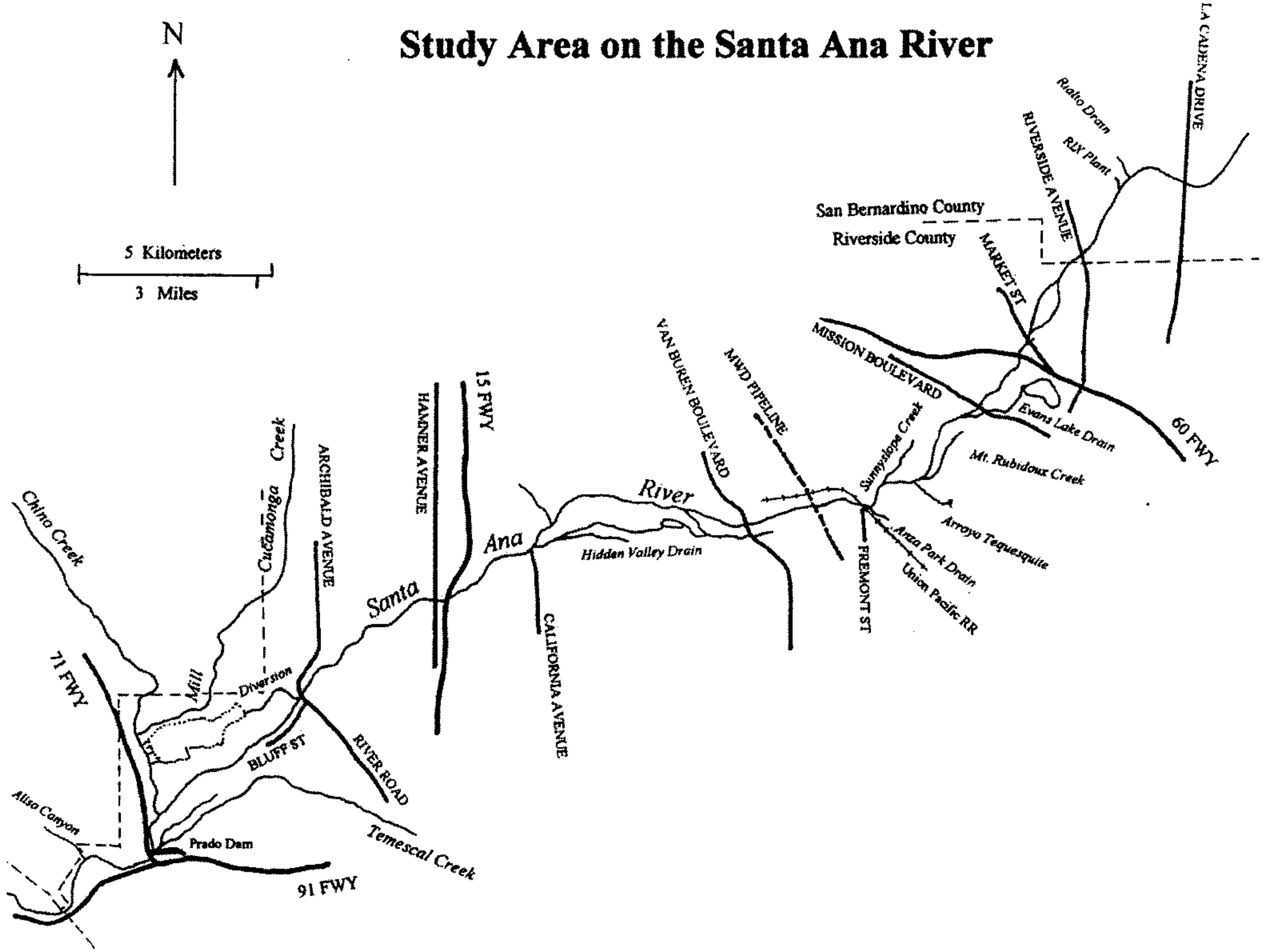
**2003**

# Study Area on the Santa Ana River



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# I. BACKGROUND.

## A. Introduction.

In the spring of 1999, an informal group of concerned local, regional, State and Federal agencies formed the Ad Hoc Santa Ana Sucker Discussion Team (now called the Santa Ana Sucker Conservation Team) to identify and implement conservation measures that would contribute to the survival and recovery of the sucker within the watershed of the Santa Ana River. Research priorities and funding sources were identified, and a three-phase, coordinated effort was initiated and completed during the year 2000. The first phase of the initial scientific studies concentrated on physiochemical variables, including organic and inorganic tissue analysis, and was performed by the U.S. Geological Survey (Saiki 2000). The second phase, which studied migration patterns, predatory fish relationships and reproduction of Santa Ana suckers in tributaries, was conducted by Larry Munsey International (Swift 2001).

### 1. Saiki (2000) Study.

Saiki (2000) conducted a study of Santa Ana suckers in the Santa Ana River and in the San Gabriel River. In his study he specifically examined fish condition, gut contents (diet), fish-tissue contaminant levels, water quality and environmental measures associated with fish capture.

Saiki (2000) measured length and weight of suckers captured between December 1998 and December 1999. Suckers were captured in the East Fork of the San Gabriel River and at MWD Crossing in the Santa Ana River. Attempts to capture suckers at Imperial Highway failed. The data were used to estimate relative weight, an index of fish body condition (Bagenal and Tesch 1978). These data suggested that the geometric means of relative weight were typically higher in the San Gabriel River; however, the differences were only significant in three of five cases (Saiki 2000). Furthermore, the geometric means for various size classes of Santa Ana suckers were also typically higher in the San Gabriel River than in the Santa Ana River, but again these differences were only statistically significant among intermediate-sized fish, 40-119 mm SL (Saiki 2000). Saiki concluded that these data when combined with abundance data supported the premise that the San Gabriel River supports a healthy population of Santa Ana suckers while the Santa Ana River supports a marginal population of suckers. However, Saiki collected suckers near the downstream boundary of their continuous distribution in the Santa Ana River, clearly not in the area where suckers are most abundant in the Santa Ana River. Also the data suggest only occasionally a statistically significant higher index of fish body condition. Saiki interpreted the length data to indicate that only two distinct size classes were present in the Santa Ana River while three size classes were present in the San Gabriel River. Again the importance of the pattern observed by Saiki can only be determined by studying the Santa Ana sucker where it is abundant in the Santa Ana River. It will be important to determine if Saiki (2000) is correct in suggesting that there are only two age classes representing 0+ and 1+ aged individuals. Based on the detailed study of

Santa Ana suckers in the Santa Clara River by Greenfield *et al* (1970), suckers first reproduce at 1+, which would mean that the suckers in the Santa Ana River only have one reproductive season. Data from the Santa Clara River suggest that suckers in this system typically reproduce at 1+, 2+, and some at 3+ (Greenfield *et al* 1970). The San Gabriel River may even contain individuals of age 4+ (Drake and Sasaki 1987), and even Saiki's data indicate at least 1+ and 2+. Haglund and Baskin (1997) analyzed data from the West Fork of the San Gabriel River, and based on five years of data the population contained 2+, 3+ or 4+ as the maximum age class in different years.

The contaminant studies performed by Saiki (2000) indicate that Santa Ana suckers in the Santa Ana River do not possess persistent environmental contaminants at levels which exceed the average concentrations reported for freshwater fish from throughout the United States.

Saiki also proposed that reproduction occurred earlier in the Santa Ana River than in the San Gabriel River based on the time of initial appearance of fry and observations of breeding tubercles. Saiki did not provide data which were sufficiently specific to actually determine reproduction time during 1999, but his general observations are consistent with those of Haglund and Baskin (unpubl. data from San Gabriel River).

Gut contents of suckers were analyzed from both the San Gabriel River and the Santa Ana River. In both cases the gut contents consisted almost entirely of organic detritus. Insect material was slightly more common in fish from the San Gabriel River than in fish from the Santa Ana River. These data are consistent with the results of Greenfield *et al*'s (1970) study of Santa Ana suckers and what is known about *Pantosteus* suckers in general (Smith 1966).

**2. Swift (2001) Study.**

Swift's (2001) study had three major goals:

1. Document possible migration or movement of suckers with reference to the potential impacts of a stream diversion below River Road, Norco.
2. Document areas and timing of spawning in the main river and its tributaries.
3. Assess the impact of exotic predators on the sucker.

As a result of these studies, Swift (2001) reached a series of conclusions with respect to the primary goals of the study.

Despite significant attempts to capture fish in the study area below River Road, Swift was only able to capture 11 sub-adult suckers. The captures were scattered throughout the year and no seasonal pattern of migration was detected (Swift 2001). A small number of young-of-the-year (YOY) suckers (17 individuals) were captured between May and August, which Swift (2001) attributed to downstream dispersal of YOY from upstream spawning areas. This work was unlikely to be able to determine the presence or absence of migration due to the rarity of adult fish in this stream reach. Furthermore, migration in other sucker species is associated with movement to and from spawning areas, and there was no suspected spawning area in this reach. Swift's (2001) capture of YOY in May through August suggests that the downstream post-spawning dispersal of YOY needs to be investigated. Again the capture of 17 YOY over a four-month period is insufficient to establish downstream movement of juveniles as a major life history phenomenon. The results of this portion of Swift's study are more likely to have a bearing on the potential significance of the diversion on the take of suckers, than to provide significant insights into the importance of movement (adult migration, YOY downstream dispersal) in the life history of Santa Ana suckers in the Santa Ana River.

Swift (2001) examined eight tributaries as potential reproductive sites: Rialto Drain, Rapid Infiltration and Extraction Plant (RIX) outlet, Evans Lake Drain, Mount Rubidoux Creek, Arroyo Tequesquite, Sunnyslope Creek, Anza Park Drain and Hidden Valley Drain. Of these potential tributary spawning sites, Swift (2001) only found larvae in Rialto Drain and Sunnyslope Creek, and concluded that reproduction was only occurring in these two tributaries. Swift also found fry in the mainstem and concluded that there was significant mainstem spawning. Swift (2001) found fry from late March until the first week of May. Based on the assumption that Santa Ana sucker's reproductive habits would mirror that of other suckers (larval emergence one to two weeks following egg-laying), Swift (2001) concluded that sucker spawning had occurred from mid-March through mid-April in 2000, a period of approximately one month. The mainstem distribution of larvae was primarily from Rialto drain downstream to about 600 meters downstream of Mission Boulevard. Larvae were rare to absent from this point downstream with the exception of the occurrence of larvae in Sunnyslope Creek (Swift 2001).

The gut contents of 121 predatory fish were examined; however, only 79 of these exotics were captured when YOY suckers were known to be present in the vicinity. The gut contents of largemouth bass, green sunfish and bullhead catfish were primarily examined. These comprised about 75% of the exotics captured. Fish were an important component of the diet of largemouth bass and green sunfish. This is consistent with what is known of the diet of these fishes in their native habitat. Largemouth bass feed primarily on fish larvae and insects by the time they reach 50-60 mm SL (Keast 1966), and by the time they exceed 100-125 mm SL they subsist primarily on fish (Lewis *et al* 1961). Black bullhead and "Tilapia" gut contents were dominated, volumetrically, by algae and non-insect invertebrates. Fish and insects were minor components (Swift 2001). Again, these finding are consistent with the literature on the diets of these fishes within their native habitats (black bullhead, Applegate and Mullan 1967; Mozambique tilapia, Bruton and Boltt 1975). Among the bullheads (*Ameiurus*) that occur in the Santa Ana River, the yellow bullhead is probably slightly more piscivorous than the black bullhead (Miller 1966). As noted by Swift (2001), the "Mozambique type" cichlid and mosquitofish are the two most common exotics where suckers are abundant. As Swift (2001) recognized, the cichlid could be a food competitor. Studies (Bruton and Boltt 1975, Man and Hodgkiss 1977) indicate that diatoms are a major dietary component to fry and juvenile cichlids, but slightly less important to adults. This ontogenetic dietary pattern is the same in Santa Ana suckers (Greenfield *et al* 1974). The mosquitofish is an omnivorous, opportunistic feeder, which will often feed on the most abundant food source, including fish larvae (Harrington and Harrington 1961, Greenfield and Deckert 1973). Despite Swift's (2001) relatively small sample size, when he combined these data with the distributional data, Swift suggested that exotic predators do not currently have a very significant impact on Santa Ana suckers (except potentially mosquitofish). Baskin and Haglund have argued that the data are not sufficiently robust to support such a conclusion. Further data is needed on the potential predation by various exotics on different life stages of the Santa Ana sucker, including the potential for mosquitofish to act as a larval predator. The potential impact of the Mozambique-type cichlids as a food competitors and other exotic interactions such as habitat modification and space competition need to be examined before a conclusion can be reached on the impact of exotics on the Sana Ana sucker population.

As a further outgrowth of the phase one and two studies discussed above, the Participants funded phase three, the development of a Conservation Plan for the Santa Ana sucker in the Santa Ana River. The Conservation Plan was developed by San Marino Environmental Associates (SMEA – Baskin and Haglund). The Conservation Program was developed based on SMEA's Conservation Plan, with an initial term of five-years. The Program will promote the conservation of the Santa Ana sucker by implementing necessary research, restoring and creating habitat, and instituting avoidance and minimization measures during "Covered Activities" by the Participants along the Santa Ana River. [Information modified from the U.S. Fish and Wildlife Service Draft Environmental Assessment, 4 October 2001]

**B. Conservation Plan.**

A Conservation Program for the *in situ* recovery of a population of any fish species requires that two basic life history phenomena take place: successful breeding and successful recruitment (maturing of young into the adult reproductive population). If the success of these two features of the fish's life history can be enhanced there will be an increase in the effective population size and genetic heterozygosity can be maintained. This will, in turn, reduce the chances of extirpation, which is the goal of species recovery. The establishment of multiple independent, viable populations or subpopulations of a species is an effective buffer against species extinction and is a frequently used measure of species recovery when only one or a very few populations existed prior to the initiation of recovery efforts. In the case of the Santa Ana sucker, populations exist in all of the drainages within its historic range: Los Angeles River (Big Tujunga), Santa Ana River (lower portion of the drainage) and San Gabriel River (subpopulations in each of the West, North and East forks of the upper San Gabriel River) (Swift *et al* 1993). In addition, the Santa Ana sucker occurs in the Santa Clara River. This may be an introduced population. However, the conclusion that the Santa Ana sucker is introduced into the Santa Clara River is based entirely on negative evidence. It was absent from incidental field collections in the early part of this century, but it appeared in collections later. No records of an introduction are known. Although the sucker continues to survive within each of the drainages of its historic range, its distribution in each of the drainages to which it is native has become significantly reduced. It was this reduction in the species historic distribution that has led the U.S. Fish and Wildlife Service to propose listing the Santa Ana sucker as threatened under the Endangered Species Act (*Federal Register*, Vol. 64, No. 16, 50 CFR Part 17, RIN 1018-AF34, 26 January, 1999).

The presence of the sucker within each of its historical drainages means that the typical recovery strategy of creating more independent populations will not be as important as the *in situ* enhancement, expansion, and protection of existing populations. The implementation of the Conservation Program for the Santa Ana sucker in the Santa Ana River is the first step in the overall recovery of the species.

**C. Conservation Agreement.**

The U.S. Fish and Wildlife Service is preparing an Environmental Assessment pursuant to the National Environmental Policy Act (NEPA) to analyze the effects of its proposal to execute (Proposed Action) a Conservation Agreement (Agreement) with various public and private sector agencies and interests (Participants). The agreement would implement the Santa Ana Conservation Program dated 1 September 2000, pursuant to NEPA and the Endangered Species Act of 1973 (ESA), as amended.

While the EA is being completed, and prior to the signing of the Conservation Agreement, the Participants have opted to fund the Conservation Program in order to initiate the Program and begin the recovery of the Santa Ana sucker in the Santa Ana River.

**1. Summary of the Results of the Year 1 Conservation Program.**

- SMEA's data support the importance of Sunnyslope Creek and Rialto Drain as reproductive sites for the Santa Ana sucker.

- Our work also supports Swift's (2001) assertion that the Santa Ana River from just downstream of Mission Boulevard upstream to Rialto Drain holds the largest, most continuously distributed deme of Santa Ana suckers.

- Suckers in the Santa Ana River breed from mid-March through late April based on the appearance of larvae (Swift 2001, Haglund *et al.* 2001).

- Santa Ana suckers can be successfully tagged with PIT tags.

- SMEA's population estimate for Santa Ana sucker from about 600 meters downstream of Mission Boulevard upstream to Rialto Drain is 6,500-6,800 fish. However, we do not have any idea of the degree of fluctuation in this number.

- Suckers spawn over medium gravel in water approximately 0.5 meters in depth with a flow of 0.20-0.24 m/sec.

- Sucker spawning habitat must contain a deeper, more protected area adjacent to the spawning area for fish to utilize when not spawning or between spawning bouts.

- Larval suckers utilize shallow (5-10 cm) water in low flow areas with a silt bottom. Emergent or aquatic vegetation does not appear to be a requirement but is commonly present.

- Larval suckers are only present for approximately 1.5 months.

- Based on Saiki's (2000) data, and SMEA's data, most suckers may not survive past 1+, meaning that they have only a single reproductive season. Due to annual variability in year class composition in Santa Ana sucker from the San Gabriel River, more data are needed.

  These results are presented in more detail in Haglund *et al.* (2001).

This document is a report on the activities carried out and the data collected during the second year (2001/2002) of the Conservation Program.

**D. Santa Ana Sucker.**

The biology of the Santa Ana sucker (*Catostomus* santaanae Snyder) is poorly documented. The only substantial study on the life history of this species was done on the lowland population in the Santa Clara River (Greenfield *et al* 1970). Studies are underway which will improve the understanding of this species, but much of the current knowledge is based on the anecdotal observations of a few biologists that have spent many years studying the fishes of southern California. Preliminary results from Haglund and Baskin (2002) on habitat preferences of the Santa Ana sucker in the upper San Gabriel River are presented later in this report. Implementation of this Conservation Program will significantly improve the knowledge of this fish's life history and the parameters that impact population size variation in this species.

*Catostomus santaanae* was originally described as *Pantosteus santa-anae* by Snyder in 1908, based on specimens collected from the Santa Ana River, Riverside, California. The hyphen was dropped from the specific name, and the species was assigned to the genus *Catostomus* by Smith in 1966. Smith considers *Pantosteus* to be a subgenus of *Catostomus*. The older literature uses the name assigned by Snyder. A complete synonymy is provided in Smith (1966).

The Catostomidae are all freshwater fish found in China, northeastern Siberia and North America. The family has thirteen genera and 68 species (Nelson 1994). North America is the center of catostomid diversity. Santa Ana suckers are small catostomids with adults commonly less than 175mm SL (standard length). Their gross morphology (Photo 1) is generally similar to that of mountain suckers (*C. platyrhynchus*) and they possess notches at the junctions of the lower and upper lips as do mountain suckers (Photo 2). Large papillae are found on the anterior of the lower lip but papillae are poorly developed on the upper lip. The jaws have cartilaginous scraping edges inside the lips. There are 21-28 gill rakers on the external row of the first arch and 27-36 on the internal row. This species has 67-86 lateral line scales; 9-11 dorsal fin rays, usually 10; and 8-10 pelvic fin rays. The axillary process at the base of the pelvic fins is represented only as a simple fold. They possess a short dorsal fin and a deep caudal peduncle. The fish are silver ventrally while the dorsal surface is darker with irregular blotching. The degree of dorsal darkening and blotching is variable. Breeding males develop breeding tubercles over most of the body, but the tubercles are most dense on the caudal and anal fins and the caudal peduncle. Reproductive females possess tubercles only on the caudal fin and peduncle (Moyle, 1976).

Photo 1. A large Santa Ana sucker.

Photo 2. Note the distinctive morphology of the lips of the Santa Ana sucker.

Santa Ana suckers are endemic to the Los Angeles basin. Their original range included only the Los Angeles, Santa Ana and San Gabriel river systems (Smith, 1966). Today small populations are still found in the Santa Ana River (Photo 4), Tujunga Wash in the Los Angeles River system, and in the upper San Gabriel River system (Figure 5) (Swift *et. al.*, 1993). The Santa Ana sucker is presently listed as a Threatened Species under the federal Endangered Species Act. Large populations are found only in the San Gabriel River (Haglund and Baskin, unpubl. data). For this reason Swift *et al.* (1990) suggested that the East, West and North Forks of the San Gabriel River be considered for status as a Native Fish Management Area for this species. A potentially introduced population exists in the Santa Clara River (Photo 3); however, this population is in decline and throughout the lower portion of the drainage has hybridized with another introduced sucker, the Owens River sucker, *Catostomus fumeiventris* (Haglund, unpubl. data).

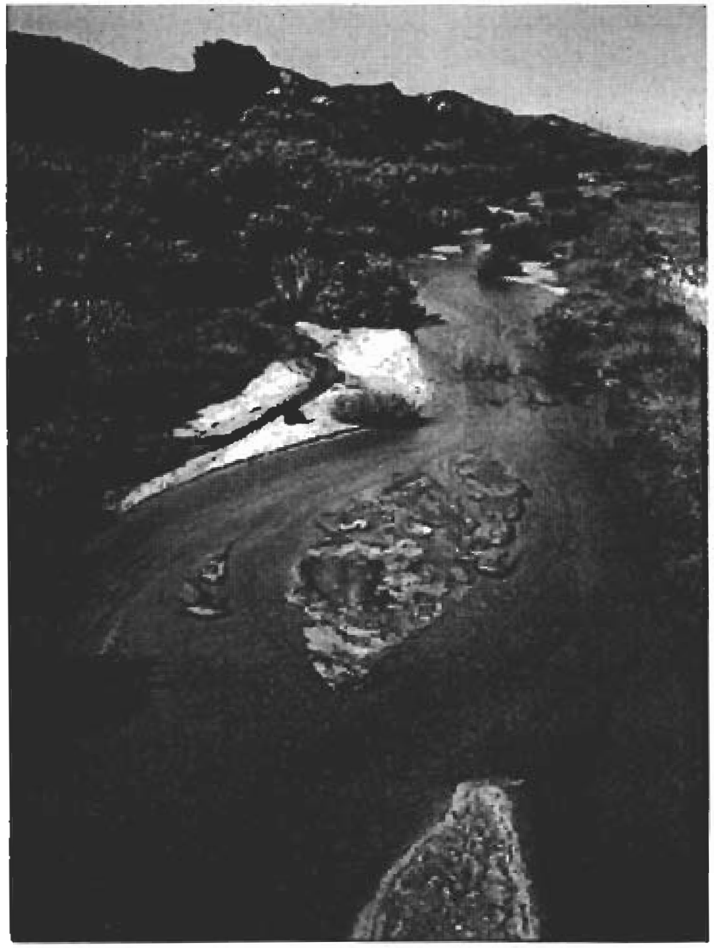


Photo 3. Sucker habitat in the Santa Clara River near the Los Angeles/Ventura County line.

Note the similarity between the sucker habitat in the Santa Clara River (Photo 3) and in the Santa Ana River (Photo 4) compared to the San Gabriel River (Photo 5).

Photo 4. Santa Ana sucker habitat in the Santa Ana River at Mission Bridge.

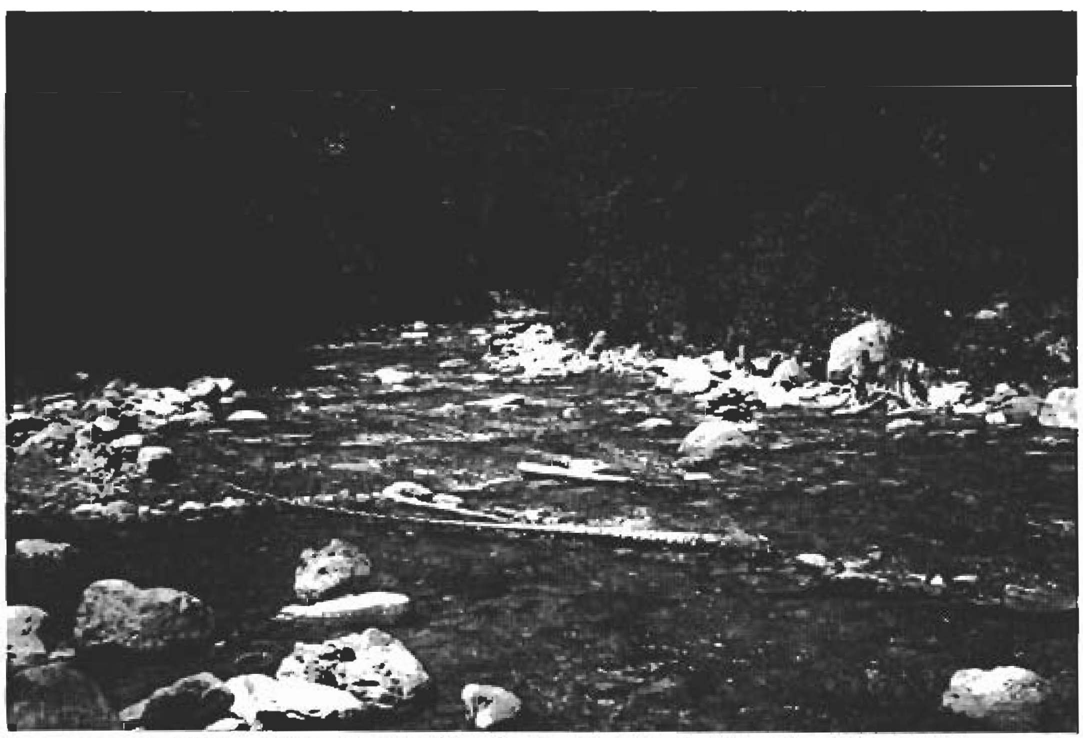


Photo 5. Santa Ana sucker habitat in the East Fork of the San Gabriel River.

Collection of data on the Santa Ana sucker population in the Santa Clara River could, as suggested in SMEA's Conservation Plan (Baskin and Haglund 2000), provide some insights into the Santa Ana River population. Such data might be particularly useful in understanding the carrying capacity for suckers in the Santa Ana River and their population structure.

Santa Ana suckers are typically found in small to medium-sized streams, usually less than 7 meters in width, with depths ranging from a few centimeters to over a meter (Smith 1966; Deinstadt *et al.* 1990). Flow must be present, but it can range from slight to swift. The native streams were all subject to severe periodic flooding; thus, suckers prefer clear water but can tolerate seasonal turbidity. The preferred substrates for adults are gravel and cobble but may also include sand. Although the exact habitat of the juveniles has not been systematically documented, field observations in the Santa Clara River indicate that they are commonly found over sandy substrate and in shallower water than the adults if a choice of such habitats is available (Baskin and Haglund, unpubl. data). During surveys in the San Gabriel River, sucker fry were observed in very shallow water (less than 5 cm) at the very edge of streams (Baskin and Haglund, unpubl. data). This is a microhabitat commonly exploited by very young stream fishes, where they are less vulnerable to larger piscivorous predators and, possibly, where exposure to slightly elevated water temperatures can accelerate development. Santa Ana suckers are associated with algae but not macrophytes. Although the sucker seems to be quite generalized in its habitat requirements, they appear intolerant of highly polluted or highly modified streams.

Spawning in this species occurs from April until early July but peaks in late May/early June in the Santa Clara River (Greenfield *et al.* 1970). The eggs are demersal and are spawned over gravel. Fecundity is high for such a small sucker species, ranging from 4,423 eggs in a 78mm SL (standard length) female to 16,151 in a 158mm SL female. The species is more fecund than most other catostomids. The Santa Ana sucker is relatively short-lived: few individuals survive beyond their second year and none beyond the third year in the Santa Clara River. They are reproductively mature in their first year and thus will typically spawn for two years. Growth rates in the Santa Clara River suggest first year individuals reach 61mm, second years 77-83mm and by the third year 141-153mm SL. Data from the West Fork of the San Gabriel River suggest a similar pattern of growth, but the fish in the West Fork live longer. Aging of Santa Ana suckers from the West Fork of the San Gabriel River by the California Department of Fish and Game (Drake and Sasaki 1987) led to the recognition that Santa Ana suckers could Reach 4+ years in the West Fork. The study suggested the following growth pattern for Santa Ana suckers in the West Fork of the San Gabriel River, young-of-the-year, 0-70mm; 1+, 71-130mm; 2+, 131-160mm; 3+, 161-185mm; and 4+, over 186mm (total length). Development of the eggs and larvae is described by Greenfield *et al.* (1970).

The only substantial life history study done on this species studied the, potentially, introduced Santa Clara River population (Greenfield *et al.* 1970). Greenfield *et al.* (1970) found that detritus, algae and diatoms comprised 97% of the stomach contents while aquatic insect larvae, fish scales and fish eggs accounted for the remaining 3%. Larger specimens usually had an increased amount of insect material in their stomachs. The herbivorous trophic status of the Santa Ana sucker is substantiated by it's long intestine with up to 8 coils.

**E. General Distribution of the Santa Ana Sucker in the Santa Ana River.**

The Santa Ana sucker is found in the Santa Ana River from about Imperial Highway bridge upstream to the Rialto Drain. However, within the river the fishes are not evenly distributed. Below Prado Dam, suckers currently are rare. Swift's (2001) surveys in 2000 failed to produce any suckers below Prado Dam, and Saiki's (2000) team never captured any suckers during their work at Imperial Highway. However, work by SMEA for the U.S. Army Corps of Engineers (ACOE)(outside the Scope of the SAWPA contract) from 21-28 September located 8 suckers, six adult fish and two fish, which may have been young-of-the-year (YOY). SMEA conducted the surveys in conjunction with ACOE's diversion of the river between Weir Canyon and Imperial Highway (Baskin and Haglund 2000). The diversion affected about 3 miles of river. Thus, not many suckers were located given the length of stream surveyed. This has been the pattern recently. Surveys find a few fish or none, and the individuals captured are adults or YOY.

Surveys sponsored by the California Department of Fish and Game in 1994 located a moderate number of YOY and a few adults in the first 3 miles of stream below Prado Dam. In the early 1990s adult suckers could regularly be taken just upstream of Imperial Highway (Haglund unpubl data), and on one occasion, in excess of 100 adult suckers were trapped by a diversion immediately downstream of Imperial Highway (R. Fisher pers comm.). Although no recent, thorough surveys exist for the river below Prado Dam, in general, Santa Ana suckers appear to have declined in recent years in the river below Prado Dam.

The river immediately below Prado Dam is different from the river reaches upstream of the dam. Much of the river is deeper, more slowly flowing with a siltier bottom (Photo 6), and the reach around Imperial Highway has been significantly impacted by construction (Photo 7).

It is not known whether there was recently or is a self-sustaining population of Santa Ana suckers downstream of Prado Dam. No reproduction has been documented below Prado, and the population may be sustained solely by immigration from the upstream population.

Photo 6. Habitat in the Santa Ana River near the mouth of Aliso Creek. Juvenile suckers have been collected from this river reach.

Photo 7. Santa Ana River at Imperial Highway.

From the MWD crossing downstream to Prado Dam, fish are widely scattered and not very abundant. Swift's (2001) work in 2000 yielded only 11 adult suckers by trapping about 4 days per month for the entire year downstream of River Road. His seining surveys yielded one adult sucker downstream of River Road in 2000. SMEA conducted a one-time, intensive survey upstream and downstream of Van Buren Street bridge (Photo 8) in June of 2001 (outside of SAWPA contract, Baskin and Haglund 2001) and failed to locate any suckers. Swift reported visual sighting of suckers at Hamner Avenue Crossing and upstream almost to California Avenue. Suckers do occur downstream of MWD crossing, but the numbers are low and the fish scattered. The only place where fish may be reliably found is in the vicinity of the Riverside Water Reclamation facility (Chadwick 1991, Susan Ellis (CA DFG) pers comm.; Chadwick 1996, Mike Giusti (CA DFG) pers comm.; Swift 2000).

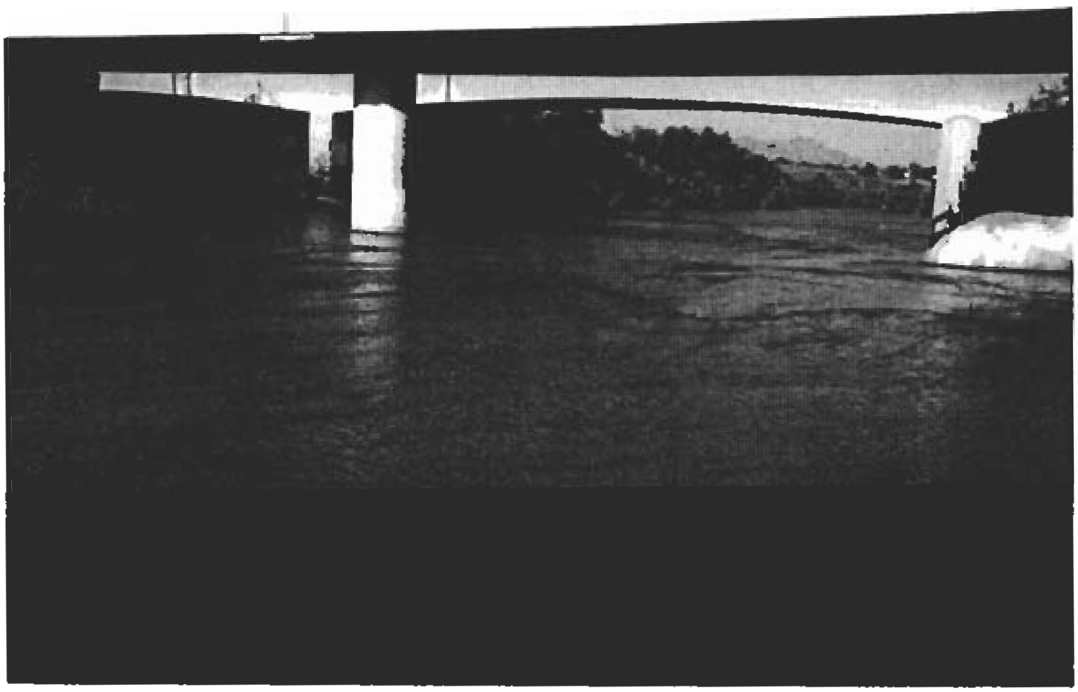


Photo 8. The Santa Ana River at the Van Buren Street bridge.

Suckers regularly occur at MWD crossing. This was one of Saiki's (2000) study sites, and he found fish in both 1998 and 1999. USGS collections for the NAQUA program captured suckers at MWD crossing in July 2001 (previously in 1999 and 2000), and SMEA had collected suckers at MWD crossing earlier in the year, March 2001.

The river reach upstream of MWD crossing to Mission Boulevard consistently contains fish, but the numbers are relatively low. Swift was able to find adult suckers in the vicinity of Arroyo Tequesquite in both February and June 2000, but no suckers were captured in the Arroyo itself. This stream reach also contains Anza Park Drain and Sunnyslope Creek. Suckers are found in both of these tributaries (Chadwick 1991, Susan Ellis (CA DFG) pers comm., Chadwick 1996, Mike Giusti (CA DFG) pers comm., Swift in 2000 (2001), Haglund *et al.* this report). Sunnyslope Creek is a well-documented reproductive site for the Santa Ana sucker.

The river reach from just downstream of Mission Boulevard upstream to Rialto Drain contains the greatest number of suckers (Photo 9) (Swift 2001, Haglund *et al.* this report).

Photo 9. The Santa Ana River upstream of Market Street.

## II. STUDY PLAN FOR YEAR 3 OF THE IMPLEMENTATION OF THE SANTA ANA SUCKER CONSERVATION PROGRAM.

The work plan submitted by SMEA identified the tasks listed below. These tasks continue to be based to a large extent on the original tasks for a Conservation Program which were suggested in the Conservation Plan prepared by SMEA (Baskin and Haglund 1999). Modifications are primarily due to results of the year 1 and 2 implementation of the Santa Ana sucker conservation program and to a reduced budget compared to that envisioned in the Conservation Plan.

Task 1. Prepare to Enhance Sucker Breeding/Spawning Habitat in Sunnyslope Creek during the 2003/2004 field season.

Subtask 1A. Obtain approval from USFWS
Subtask 1B. Obtain approval from California Department of Fish and Game
Subtask 1C. Obtain approval from County Parks
Subtask 1D. Determine measures of success

This task responds to Item II-A-2 of the USFWS Draft Conservation and Recovery Needs of the Santa Ana Sucker in the Santa Ana River.

This task is the precursor to the first attempt to actually improve sucker habitat in the Santa Ana River. In addition to obtaining the requisite permission, the project must be carefully designed in order to facilitate an accurate assessment of the success of the enhancement. The enhancement will be based on data collected at observed reproductive sites in the Santa Ana River.

What do we know? – Based on the two previous field seasons SMEA has been able to collect structural data at two separate reproductive sites in the Santa Ana River Drainage (habitat type, current velocity, substrate, adjacent habitat, depth *etc.*). These data will be used to select the enhancement site and design the enhancement.

Task 2. Studies of Larval Suckers

Subtask 2A. Determine movement of larvae particularly downstream drift

Subtask 2B. Characterize habitat of larval suckers

Subtask 2C. Determine the diet of larval suckers

This task responds to Items II-A-2 and II-C-3 of the USFWS Draft Conservation and Recovery Needs of the Santa Ana Sucker in the Santa Ana River.

To the extent that habitat needs must be defined prior to any attempt at enhancement this task will collect the data necessary to define potential habitat enhancement for larval suckers and define habitat that must be restored following perturbation. Data on larval drift will begin to provide insight into the connectivity of different portions of the stream. Dietary data will be a precursor to looking at dietary overlap between Santa Ana suckers and non-native fishes of the Santa Ana River.

What do we know? – Based on preliminary data collected during the 2001/2002 field season, larval suckers are selecting a stream margin site, with particular structure, and substrate characteristics, these data a somewhat preliminary but will be firmed up during the current field season. Diets of the various life stages of Santa Ana sucker have only been generally characterized, and the data may not be applicable to the Santa Ana River. Downstream drift is known to be an important life history characteristic for other sucker species.

Task 3. Studies of Young-of-the-Year (YOY) Suckers

Subtask 3A. Determine movement of YOY suckers particularly downstream drift

Subtask 3B. Characterize habitat of YOY suckers

Subtask 3C. Determine the diet of YOY suckers

This task responds to Items II-A-2 and II-C-3 of the USFWS Draft Conservation and Recovery Needs of the Santa Ana Sucker in the Santa Ana River.

To the extent that habitat needs must be defined prior to any attempt at enhancement this task will collect the data necessary to define potential habitat enhancement for YOY suckers and define habitat that must be restored following perturbation. Data on YOY drift will begin to provide insight into the connectivity of different portions of the stream, and may help understand occurrences such as the apparently unusually large number of YOY suckers that were found at River Road last summer. Dietary data will be a precursor to looking at dietary overlap between Santa Ana suckers and non-native fishes of the Santa Ana River.

What do we know? – Currently we know very little about these tasks. Preliminary data and anecdotal data from the 2001/2002 field season suggest that YOY may show considerable downstream movement. Our understanding of their habitat preference is very limited. However, studies by SMEA on the San Gabriel River have devised a methodology which proved to be successful in characterizing YOY habitat in the upper San Gabriel River. Diets of the various life stages of Santa Ana sucker have only been generally characterized, and the data may not be applicable to the Santa Ana River.

Task 4. Studies of Adult Suckers

Subtask 4A. Determine movement of adult suckers (placed under tagging also)
Subtask 4B. Characterize habitat of adult suckers
Subtask 4C. Determine the diet of adult suckers
This task responds to Items II-A-2 and II-C-3 of the USFWS Draft Conservation and Recovery Needs of the Santa Ana Sucker in the Santa Ana River.
To the extent that habitat needs must be defined prior to any attempt at enhancement this task will collect the data necessary to define potential habitat enhancement for adult suckers and define habitat that must be restored following perturbation. Data on adult sucker movement will begin to provide insight into the connectivity of different portions of the stream. Dietary data will be a precursor to looking at dietary overlap between Santa Ana suckers and non-native fishes of the Santa Ana River.

What do we know? – Currently we know very little about these tasks. Preliminary data and anecdotal data from the last two field seasons suggest that adult suckers may show little movement. Our understanding of their habitat preference is very limited. However, studies by SMEA on the San Gabriel River have devised a methodology which proved to be successful in characterizing adult habitat in the upper San Gabriel River. Diets of the various life stages of Santa Ana sucker have only been generally characterized, and the data may not be applicable to the Santa Ana River.

Taken together tasks 2, 3, and 4 will determine the habitat preferences of the various life stages of the Santa Ana sucker in the Santa Ana River, which will allow future attempts at habitat enhancement and restoration. Thus, this information can be used in the future to perform habitat enhancement/restoration experiments/tasks analogous to that proposed in Task 1. The "A and C" components of these tasks begins to address the importance of downstream movement of larva/YOY and adult movement, while the dietary data will provide the groundwork for future tasks which examine dietary overlap between the Santa Ana sucker and non-native fishes..

Task 5. Population Estimate/Tagging

Subtask 5A. Estimate population size at the three standard sites
- Mission Boulevard
- Highway 60
- Riverside Avenue

Subtask 5B. Estimate population size at River Road
Subtask 5C. Tag all fish captured during population estimates
Subtask 5D. Use tagged fish to determine movement patterns of adult suckers
This task responds to Items II-A-2, II-C-1 and II-A of the USFWS Draft Conservation and Recovery Needs of the Santa Ana Sucker in the Santa Ana River.

What do we know? – SMEA currently has two years of population data. Population trends cannot be reliably determined from two data points. In fact, the two years of data that we do have suggest significant differences in population structure have occurred. This year's data will begin to provide an insight into the result of such a demographic change, but only long term monitoring will allow an accurate assessment of population trends and population dynamics. Initial recovery of tagged adult Santa Ana suckers suggest some form of site fidelity. The data do not currently allow us to distinguish seasonal site fidelity from the potential that the adults do not move very much within the mainstem. We do possess some data suggesting that adults do move up creeks such as Sunnyslope Creek during reproductive season.

Task 6. Snorkeling Surveys

Subtask 6A. Snorkeling survey of Sunnyslope Creek

Subtask 6B. Snorkeling survey of mainstem

This task responds to Items II-C-1 and II-A of the USFWS Draft Conservation and Recovery Needs of the Santa Ana Sucker in the Santa Ana River.

What do we know? – The snorkeling data provide the broadest coverage of the suckers in the Santa Ana River. These data allow SMEA to determine overall patterns of occurrence/density, and provide another semi-quantitative dataset on the status of the sucker. The snorkeling of Sunnyslope Creek allows SMEA to ascertain the degree to which adults migrate into the creek or are year-round residents (another way of looking at adult movement).

Task 7. Determine the Diet of the Adult Stages of Exotic Fishes

Subtask 7A. Determine the importance of predation on larvae

Subtask 7B. Determine the importance of predation on YOY

This task responds to Item II-B of the USFWS Draft Conservation and Recovery Needs of the Santa Ana Sucker in the Santa Ana River.

What do we know? – Non-native fish species are still considered a threat to the Santa Ana sucker. In other systems where interactions between native fishes and non-natives have been studied, declines in the natives have been attributable to the presence of the non-natives. Preliminary data collected by Swift did not show evidence of predation on the sucker by non-natives, but the dataset was relatively small. The sample size needs to be increased. Gut content analysis will also broadly determine the diets of non-native fish, these data will provide the an initial dataset , which will subsequently be expanded to examine dietary overlap between various life stages of the non-natives and the life stages of the Santa Ana sucker. Exotic control programs are typically time-consuming and costly. Before making exotic fish control a priority, it will be important to try and ascertain the importance of such a program compared to other management alternatives.

Modifications and finalization of the work plan were done through negotiations with SAWPA and in consultation with Jim Van Haun. The final Tasks are summarized below.

Task 1. Enhancement of Breeding Habitat

Move forward on the permitting process.

Task 2. Studies of Larval Suckers.

Attempt drift netting to begin determining how important downstream larval drift is to the Santa Ana sucker life cycle.

Task 3. Studies of Juvenile and Adult Sucker.
This task is the initiation of studies to determine the habitat utilization of juvenile and adult Santa Ana suckers in the Santa Ana River.

Task 4. Population Studies.
This task includes the sequential depletion population estimates, tagging studies, searching for tagged fish, and the snorkeling survey.

Task 5. Determination of the Diets of Exotic Fishes.
This task has no budget, but exotics will be collected as they are encountered. No gut content analysis is planned for this year.

Task 6. Project Management and Administration.
This task includes meeting attendance, preparation of updates, preparation of the annual report, and agency coordination.

All work conducted as part of the third year implementation of the Santa Ana sucker Conservation Program was done under USFWS permit TE781377-3, as amended issued to SMEA (Baskin, Haglund and employees) and USFWS permit TE793644-4 issued to Camm Swift.

## III. TAGGING OPTIONS.

In the Conservation Plan, Baskin and Haglund (2000) had recommended tagging suckers. The benefits of tagging to the study of the Santa Ana sucker in the Santa Ana River are extensive. In order to recover the sucker, we need to understand patterns of movement/migration, determine age class survival, document reproductive habitat use and estimate population size. Tagging should be useful in the study of all these parameters.

Prior to initiating the tagging during the year 1 implementation of the Santa Ana sucker Conservation Program, SMEA investigated alternative tagging technologies. Specifically, SMEA examined:

- Decimal Coded Wire Tag
- Soft Visible Implant Alphanumeric
- Passive Integrated Transponder (PIT) Tag
- Photonic Marking

The following table (Table 1) summarizes the advantages and limitations of the four technologies.

Table 1. Summary of the advantages and limitations of four tagging technologies.

| ADVANTAGES | LIMITATIONS |
|---|---|
| **Decimal Coded Wire Tag** | |
| Can be used on small animals | Capital equipment is expensive |
| Minimal biological impact | Tags are not externally visible |
| High retention rate | Tags must be excised (lethal) |

| | |
|---|---|
| Enormous code capacity | |
| Inexpensive tags | |
| **Soft Visible Implant Alphanumeric** | |
| High retention rate | Unsuitable for small fish |
| Low capital costs | Requires suitable tissue |
| Readable in live specimens | Can become occluded |
| Minimal biological impact | |
| **Passive Integrated Transponder (PIT) Tag** | |
| Positive identification | Moderate cost |
| Easy field identification | Requires injection |
| Biologically safe | Learning curve on injection |
| Passive operation | |
| Easily injected | |
| **Photonic Marking** | |
| Non-invasive | For placement beneath translucent skin |
| Externally visible | Difficult to mark individuals |
| Easily injected applied | |
| High retention | |
| Ideal for batch marking | |

Based on the table above, it can be easily discerned that PIT tags offered the greatest potential for studies of the Santa Ana sucker. It should also be noted that SMEA investigated the potential use of telemetry to follow fish movement, but determined that sufficiently small transmitters were not available.

The work done by SMEA in 2000-2002 has validated the use of pit tags on the Santa Ana sucker. Photos 10 and 11 show the equipment SMEA used during the sucker tagging.

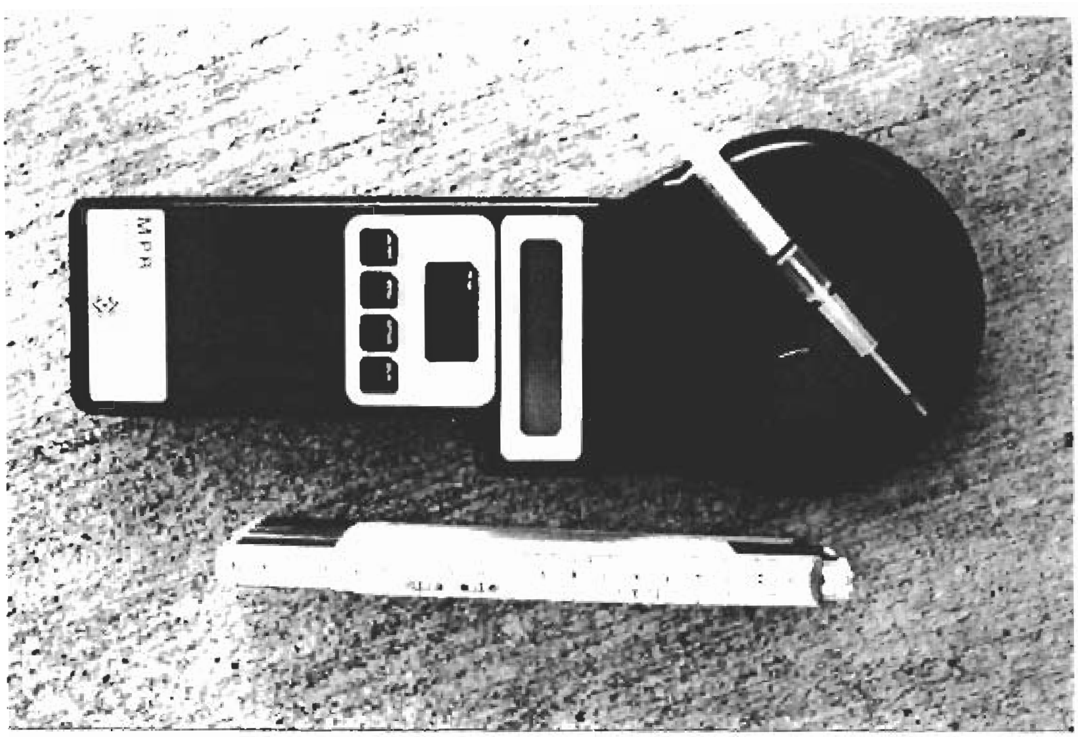



Photo 10. The PIT tagging equipment, including the reader, injector with needle and a PIT tag. A folding meter stick is provided for scale.

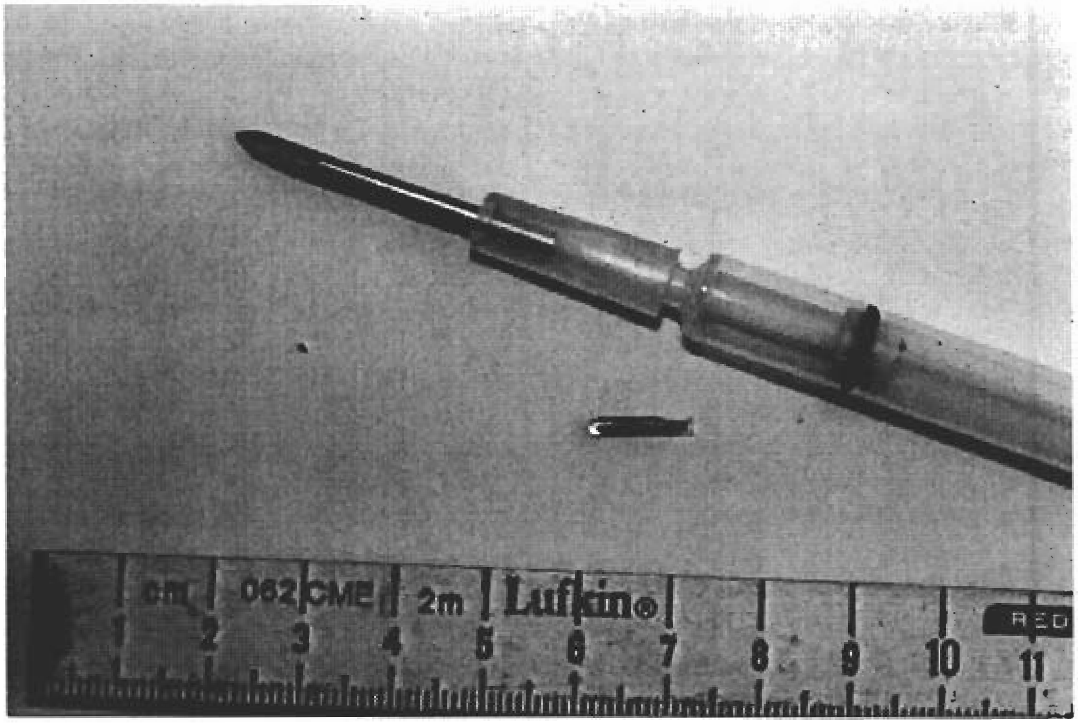



Photo 11. Close-up of PIT tag and injector needle. Notice the bevel on the injector needle. A folding meter stick is provided for scale.

## IV. TAGGING FEASABILITY STUDY.

In 2000, once SMEA had determined the optimal tagging technology, it was decided to conduct a study to ascertain the effect of the tagging on Santa Ana suckers, since no such data existed. Specifically, SMEA wanted to determine if the tagging caused any significant mortality.

PIT tagging methods were described for salmonids based on work by the U.S. National Marine Fisheries Service (Prentice *et al* 1990a, 1990b). The techniques described in these papers combined with a protocol supplied by Howard Burge of the U.S. Fish and Wildlife Service were used to establish a protocol for tagging Santa Ana suckers. Burge indicated that he had found two sources of mortality in PIT tagging fish: 1) inexperienced personnel, and 2) anesthesia and handling. Therefore, a preliminary study served the additional benefit of gaining experience tagging, particularly Baskin, Swift, and Bryant. Only Haglund had previously PIT tagged suckers. SMEA also eliminated the use of MS-222 as an anesthetic, and used $CO_2$ from Alka Seltzer tablets instead.

SMEA used the following techniques during the experimental fish tagging. Because of the success of the experiment, the same techniques were used during the tagging of fish on the Santa Ana River.

As suckers were captured, they were placed in buckets containing fresh river water. After several fish were captured they were transferred to coolers containing clean river water and polyaqua (slime stimulant). Coolers were maintained in the shade, and the water was refreshed as necessary. Fish were removed from the holding coolers about 4-6 fish at a time and transferred to an anesthetizing bucket to which Alka Seltzer had been added. No attempt was made to inject fish until they had slowed down. Prior to use and following each use, needles and injectors were soaked in 70% ethanol. Tags were stored in ethanol prior to their injection. A recorder noted the number of each tag and passed the tag to the individual doing the injection. The individual doing the injection measured (standard length) and weighed the fish prior to injection. The fish were injected to the left of the ventral midline, just posterior of the pectoral girdle. The needle was inserted at a low angle to the body. When the needle opening was just occluded by the fish's tissue, the plunger was pushed. As the plunger was depressed, the needle was withdrawn so that the tag would just slide into the abdomen. The position and low angle insertion were designed to prevent damage to the fishes' visceral organs. Following tagging, the fish were placed into a recovery cooler with fresh river water and polyaqua. The water was refreshed as necessary. Once fish were recovered, they were returned to the stream (At the Santa Ana River fish are returned to the stream when collection is complete). Fish were returned to the entire stream reach from which they had been captured. Temperature was constantly monitored, and all coolers were oxygenated using bubblers.

The Santa Ana suckers from the Santa Clara River provided the perfect surrogates for the Santa Ana River suckers. They are the same species, but as previously mentioned, are specifically excluded from the federal listing.

On 9 December 2000, 24 suckers were collected upstream of the Interstate 5 bridge over the Santa Clara River. The fish were split into two groups, a control group, and a group to be PIT tagged. All fish were relaxed with Alka Seltzer then 12 fish were tagged, and the untagged fish were handled to simulate tagging. Tag insertions were performed by Haglund, Baskin and Swift. The fish were tagged in this preliminary experiment and the subsequent experiment with BioMark PIT tags (11.5 mm) in the abdominal cavity. All 24 fish were placed in coolers containing a slime stimulant and transported to the Robinson Ranch golf course. The creek on the golf course was selected as an experimental site because it was thought to be secure. The fish were placed in artificial enclosures (boxes). The boxes had holes drilled in all sides in order to allow the water to flow relatively freely through the boxes. Cobbles were placed in the bottom and the boxes were wired to two pieces of rebar (on either side of the container) that had been driven into the substrate (Photo 12). The boxes were weighted with cobbles from the river in order to help stabilize the boxes and provide a food source for the suckers. Tops were "snap on" tops, which were further secured with bungee cords. Plant debris was used to cover the boxes to make them less obvious to a casual observer.

Photo 12. Notice the two boxes in the center of this photograph; these are the sucker enclosures. This photo was taken at the Robinson Ranch golf course creek.

The fish were first checked on 12 December and it was discovered that the boxes had been tampered with, and 15 of the fish were missing. Nine fish remained in the boxes. 3 PIT tagged fish and 6 untagged fish. These fish were maintained in the golf course creek until 24 December when they were transported to the Santa Clara River and placed in the river just upstream of the Interstate 5 bridge. These fish suffered no mortality following the disturbance of the boxes. On 11 January a large flow in the Santa Clara River washed the box away terminating the experiment. Therefore, the known results are shown in the following table. This experiment lasted 27 days.

Table 2.

| | Initial Number | Mortality | Surviving Number |
|---|---|---|---|
| PIT Tagged Fish | 3 | 0 | 3 |
| Fish Not PIT Tagged | 6 | 0 | 6 |

The success of this experiment with respect to the apparent survival of the PIT tagged fish encouraged SMEA to expand the experiment.

On 29 December 2000, Haglund, Baskin and Bryant of SMEA began a second phase of the tagging trial. The purpose of the second phase was to repeat the tagging experiment with a larger sample size.

93 suckers were collected upstream of the Interstate 5 bridge during 27 minutes of shocking. Sixty fish ranging in size from 59 mm SL to 113 mm SL were used in the experiment. The

other 33 suckers were released. Twenty-three suckers were released after having been held for slightly over 2 hours, and all individuals appeared "healthy" when they were released.

For the experiment, 30 fish were tagged and 30 fish were used as a control group. All fish were relaxed with Alka Seltzer then some fish were tagged, and the untagged fish were handled to simulate tagging. All 60 fish were placed in a cooler containing a slime stimulant. All tag insertions were performed by Haglund and Baskin. An attempt was made to utilize samples (tagged and untagged fish) with equal size distributions.

The fish were placed in artificial enclosures (boxes). It took approximately an hour to place the boxes in the river. The boxes were weighted with cobbles from the river in order to help stabilize the boxes and provide a food source for the suckers. Fifteen fish were placed in each of 4 boxes with tagged/untagged ratios as follows:

Box 1 - 8 tagged, 7 untagged
Box 2 – 8 tagged, 7 untagged
Box 3 – 7 tagged, 8 untagged
Box 4 – 7 tagged, 8 untagged

Box 1 was the downstream-most box and Box 4 was the furthest upstream. Box 1 was placed in the same pool as the old experimental box containing the nine fish from the first experiment.

The boxes had holes drilled in all sides in order to allow the water to flow relatively freely through the boxes. Rocks were placed in the bottom and the boxes were wired to two pieces of rebar (on either side of the container) that had been driven into the substrate. Tops were "snap on" tops, which were further secured with bungee cords. Plant debris was used to cover the boxes to make them less obvious to a casual observer.

The old experimental box was checked at time of installation of the other boxes, all nine fish were present and appeared fine. Two new cobbles, covered with algae, were placed in the box.

Once the experiment had been completely set up, the remaining 10 suckers were released. All suckers had recovered and appeared to be swimming normally. There was no apparent damage as a result of electroshocking. All fish placed in the boxes appeared to be swimming normally and no fish were in obvious distress.

The experiment was first checked following the set up on 1 January 2001. All the fish in the old experimental box were fine. There were two dead fish in the new experiment, one each in boxes 2 and 3. The dead fish were removed, and the boxes secured. The boxes were checked again on 2 and 7 January, there was no additional mortality. On 10 January flows were high when SMEA personnel went to check the boxes, and it was decided that the boxes shouldn't be opened. On 11 January there was a very high flow that washed away the boxes, terminating the experiment.

The results of the experiment after 10 days are summarized in the table below.

Table 3.

| | Initial Number | Mortality | Surviving Number |
|---|---|---|---|
| PIT Tagged Fish | 30 | 2 | 28 |
| Fish Not PIT Tagged | 30 | 0 | 30 |

The null hypothesis is that there was no association between PIT tagging and death. The null hypothesis is rejected if $P<0.05$. In a Fisher's exact test, $P = 0.25$; so the null hypothesis is accepted.

Based on the data presented above, SMEA determined that they could PIT tag Santa Ana suckers and not affect their survival.

## V. PIT TAGGING

On 19 and 21 July 2002, SMEA personnel shocked three 100-meter sections of stream in order to capture and tag the Santa Ana suckers from these stream reaches. These same three stream reaches had been shocked and the captured fish tagged on 15 and 16 June 2001 (Data from the 2001 shocking collections are presented in Appendix 1). The primary goals of these collections were: (1) to provide population estimates of Santa Ana sucker from these three stream sections, (2) to begin to develop a population of tagged suckers, so that their movement/migration in the stream can be recognized and documented, and (3) to examine the population structure of the Santa Ana sucker. Discussion of the data relevant to each of the primary goals is given below.

Three 100-meter stream reaches were chosen at random upstream of Mission Boulevard. The three sites are designated as: Site 1, upstream of Mission Boulevard; Site 2, upstream of Highway 60, and Site 3, downstream of Riverside Avenue. The stream sections are shown in Photos 13-15.

Photo 13. A photograph of the tagging site just upstream of Mission Boulevard.

Photo 14. A photograph of the tagging site upstream of Highway 60.

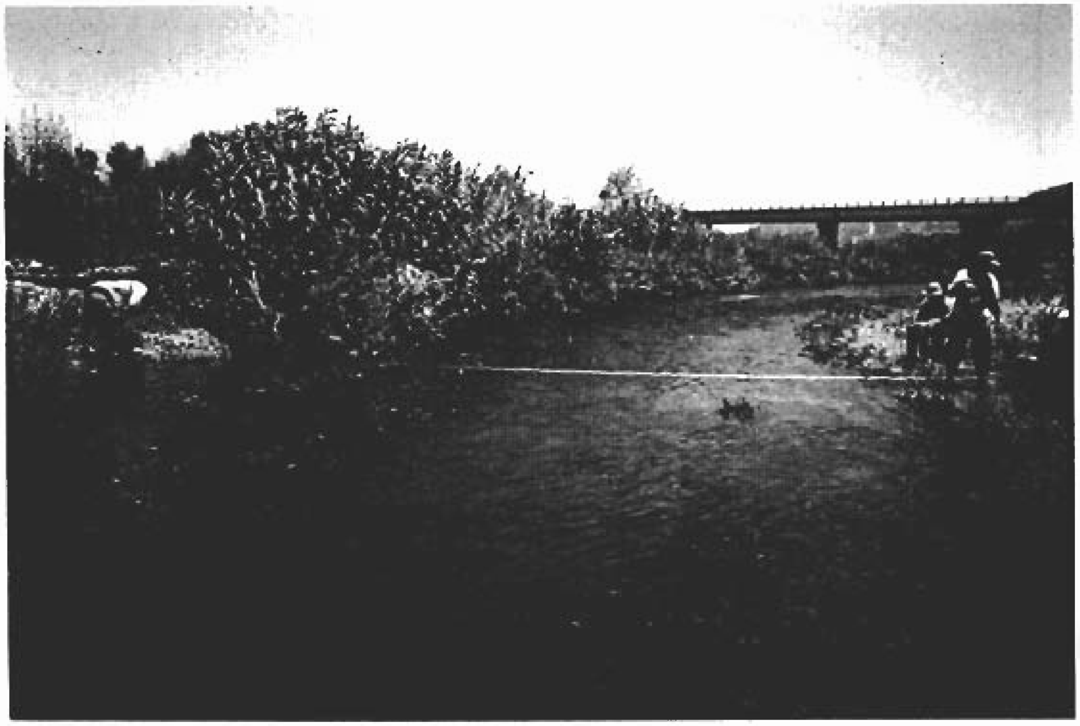


Photo 15. A photograph of the tagging location just downstream of Riverside Avenue

The length (mm SL) and weight (g) of each of the fish captured in the 100-meter sections is shown below in Tables 4-6.

Table 4. List of the length (SL mm) and weight (g) of the fish caught (N=60) in the 100-meter stream reach upstream of Mission Boulevard (Site 1) on 26 July 2003.

| LENGTH | WEIGHT | PIT TAG NUMBER |
|---|---|---|
| 139 | 44.3 | 426468390E |
| 141 | 47.4 | 4263324633 |
| 113 | 27.4 | 42655B0E12 |
| 121 | 31.4 | 42655C107B |
| 126 | 35.8 | 42654F0A68 |
| 110 | 24.5 | 4263295512 |
| 49 | 2.0 | |
| 51 | 2.9 | |
| 113 | 27.9 | 42631F532C |
| 160 | 60.5 | 426500133A |
| 117 | 27.3 | 4264531114 |
| 56 | 3.4 | |
| 53 | 2.9 | |
| 41 | 1.3 | |
| 35 | 0.7 | |
| 46 | 2.2 | |
| 42 | 1.5 | |

| | | |
|---|---|---|
| 32 | 0.6 | |
| 111 | 24.3 | 4263256A7F |
| 116 | 26.8 | 42657C0131 |
| 142 | 48.0 | 4267335431 |
| 120 | 31.8 | 4265055B1D |
| 136 | 42.4 | 4265783C3F |
| 125 | 37.2 | 42645C7F2E |
| 51 | 2.0 | |
| 42 | 1.3 | |
| 35 | 0.9 | |
| 36 | 1.0 | |
| 39 | 1.1 | |
| 51 | 2.4 | |
| 46 | 1.9 | |
| 50 | 2.2 | |
| 130 | 37.9 | 4265055C10 |
| 103 | 16.3 | 4264577356 |
| 113 | 25.5 | 42647F770C |
| 42 | 1.5 | |
| 51 | 2.3 | |
| 42 | 1.6 | |
| 49 | 2.1 | |
| 45 | 1.4 | |
| 50 | 2.1 | |
| 46 | 1.6 | |
| 128 | 36.9 | 42647C300B |
| 136 | 40.4 | 4266413A6F |
| 116 | 29.0 | 4265657E51 |
| 41 | 1.4 | |
| 37 | 0.9 | |
| 46 | 1.8 | |
| 121 | 32.8 | 4263257835 |
| 124 | 33.4 | 42656A6D10 |
| 117 | 29.0 | 42645D7D0E |
| 55 | 3.1 | |
| 56 | 2.9 | |
| 41 | 1.4 | |
| 123 | 26.8 | 42646B313B |
| 40 | 1.0 | |
| 57 | 2.8 | |
| 116 | 32.2 | 4264566E43 |
| 44 | 1.7 | |
| 42 | 1.4 | |

Table 5. List of the length (SL mm) and weight (g) of the fish caught (N=96) in the 100-meter stream reach upstream of Highway 60 (Site 2) on 27 July 2003.

| LENGTH | WEIGHT | PIT TAG NUMBER |
|---|---|---|
| 111 | 27.2 | 4263176A63 |
| 120 | 29.8 | 426508124E |
| 137 | 43.7 | 42657B5767 |
| 116 | 25.5 | 42654F097F |
| 112 | 27.9 | 42656E085F |
| 103 | 22.8 | 42657C2528 |
| 38 | 1.0 | |
| 45 | 1.6 | |
| 50 | 2.6 | |
| 40 | 1.2 | |
| 60 | 3.8 | |
| 54 | 3.3 | |
| 44 | 1.5 | |
| 49 | 2.4 | |
| 53 | 2.6 | |
| 55 | 3.2 | |
| 54 | 3.2 | |
| 40 | 1.5 | |
| 48 | 2.0 | |
| 50 | 2.5 | |
| 44 | 1.6 | |
| 55 | 2.8 | |
| 35 | 0.9 | |
| 51 | 2.5 | |
| 42 | 1.7 | |
| 47 | 2.4 | |
| 53 | 3.0 | |
| 40 | 1.6 | |
| 49 | 2.2 | |
| 35 | 0.7 | |
| 42 | 1.5 | |
| 43 | 1.7 | |
| 44 | 1.7 | |
| 49 | 2.4 | |
| 31 | 0.4 | |
| 34 | 0.8 | |
| 55 | 2.9 | |
| 55 | 3.1 | |
| 53 | 2.9 | |
| 54 | 2.8 | |

| | | |
|---|---|---|
| 55 | 3.0 | |
| 53 | 2.8 | |
| 35 | 0.8 | |
| 44 | 1.7 | |
| 50 | 2.5 | |
| 52 | 2.7 | |
| 55 | 2.9 | |
| 56 | 3.3 | |
| 56 | 3.3 | |
| 55 | 3.1 | |
| 58 | 3.7 | |
| 36 | 0.9 | |
| 34 | 0.7 | |
| 53 | 2.7 | |
| 54 | 3.0 | |
| 57 | 3.4 | |
| 56 | 3.3 | |
| 60 | 3.9 | |
| 55 | 3.0 | |
| 58 | 3.6 | |
| 56 | 3.3 | |
| 55 | 2.9 | |
| 56 | 3.1 | |
| 44 | 1.9 | |
| 48 | 2.2 | |
| 52 | 3.0 | |
| 58 | 3.6 | |
| 56 | 3.2 | |
| 55 | 3.0 | |
| 55 | 2.8 | |
| 42 | 1.8 | |
| 120 | 33.8 | 4265032946 |
| 118 | 31.8 | 4265572947 |
| 112 | 23.8 | 4266061342 |
| 118 | 28.1 | 42660A5360 |
| 59 | 3.3 | |
| 109 | 25.7 | 42657C0305 |
| 55 | 3.3 | |
| 56 | 3.6 | |
| 56 | 3.2 | |
| 52 | 2.8 | |
| 49 | 2.1 | |
| 34 | 0.8 | |
| 52 | 2.5 | |

| | | |
|---|---|---|
| 41 | 1.2 | |
| 59 | 3.3 | |
| 49 | 2.2 | |
| 47 | 2.2 | |
| 34 | 0.7 | |
| 34 | 0.8 | |
| 47 | 1.9 | |
| 55 | 3.4 | |
| 39 | 1.2 | |
| 55 | 2.9 | |
| 53 | 2.8 | |
| 52 | 2.1 | |

Table 6. List of the length (SL mm) and weight (g) of the fish caught (N=49) in the 100-meter stream reach downstream of Riverside Avenue (Site 3) on 28 July 2003.

| LENGTH | WEIGHT | PIT TAG NUMBER |
|---|---|---|
| 110 | 24.1 | 42634E7215 |
| 147 | 57.8 | 42650C4837 |
| 110 | 26.2 | 4265755B07 |
| 127 | 37.3 | 42655B141E |
| 114 | 27.4 | 4264670C62 |
| 129 | 35.1 | 4264731214 |
| 126 | 36.6 | 42645D5365 |
| 138 | 29.1 | 42650E1225 |
| 127 | 36.1 | 4265706033 |
| 53 | - | |
| 48 | 2.0 | |
| 58 | 3.4 | |
| 51 | 2.2 | |
| 137 | 37.0 | 4265782633 |
| 125 | 37.9 | 426556627B |
| 150 | 59.0 | 42650D4900 |
| 124 | 33.6 | 42657A0C25 |
| 115 | 29.0 | 4265622162 |
| 55 | 2.6 | |
| 56 | 3.9 | |
| 72 | 6.6 | |
| 51 | 2.7 | |
| 53 | 2.9 | |
| 68 | 5.4 | |
| 126 | 41.1 | 42645A0624 |
| 55 | 2.8 | |
| 55 | 3.3 | |

| | | |
|---|---|---|
| 56 | 3.1 | |
| 64 | 4.6 | |
| 113 | 28.3 | 4263342C50 |
| 120 | 28.9 | 4264727743 |
| 138 | 45.1 | 42647F7235 |
| 52 | 2.4 | |
| 58 | 3.4 | |
| 62 | 3.6 | |
| 167 | 71.6 | 4263126704 |
| 120 | 28.1 | 4265041336 |
| 116 | 30.1 | 42633F710C |
| 65 | 5.4 | |
| 60 | 3.8 | |
| 56 | 3.1 | |
| 125 | 38.3 | 4266040C10 |
| 110 | 22.9 | 42647A2858 |
| 56 | 4.0 | |
| 57 | 3.3 | |
| 61 | 4.3 | |
| 61 | 3.7 | |
| 55 | 2.9 | |
| 48 | 2.2 | |

In addition to the suckers tagged as part of the population estimate in 1991, additional suckers were tagged to increase the population of tagged suckers in the river. Fish were tagged at the following locations on the specified dates:

- 16 June 2001, Pool under Riverside Avenue bridge, N=34
- 18 June 2001, Pool under Riverside Avenue bridge, N=8
- 18 June 2001, About 100-150 m downstream of Highway 60, N=14
- 18 June 2001, Site 1 upstream of Mission Boulevard, N=3
- 22 June 2001, Sunnyslope Creek, N=19
- 27 July 2001, MWD Crossing, N=5

The length (mm SL), weight (g) and pit tag number of each of the fish captured and tagged in 2001 during the above tagging sessions is presented in Appendix 1. No comparable tagging sessions were conducted in 2002 or 2003. However, fish were tagged during 2003 as part of work on the Riverside Flood Control diversion and during a November field session, which was conducted to look for tagged fish. These data are presented in Tables 16, 19, 20 and 21.

**A. Population Estimates – Sequential Depletion.**

SMEA had originally hoped that it would be possible to use a mark-recapture technique to estimate the sucker population, and thus have yet another use for tagged fish as well as an alternative population estimate. However, because it is difficult to meet the assumptions of a mark-recapture in a riverine system, SMEA preferred the use of a depletion technique. However, a recapture attempt was made following the initial tagging.

In order to ascertain the feasibility of mark-recapture in this system, SMEA tagged fish from three localities on 16 June 2001. SMEA returned to these localities on 18 June to attempt to recapture the marked fish, and associated unmarked fish in order to make a population estimate. Too few fish were captured during the recapture phase of the technique to provide a reliable population estimate. As mentioned above, SMEA used a triple pass depletion to collect the fish on 16 June as a back-up to the mark-recapture procedure. It is the triple-pass depletion procedure that SMEA employed during 2002 (See Appendix 2 for a discussion of triple pass depletion procedure and calculations). The three sites used in this study were described above. The 2001 data from the triple pass depletion are presented in Tables 7 and 8; 2002 data from the triple pass depletion are presented in Tables 9 and 10; and 2003 data from the triple pass depletion are presented in Tables 11 and 12.

Table 7. The number of suckers captured in each of the three passes, at each of the three sampling sites on 15 and 16 June 2001.

| Pass # | Site 1 | Site 2 | Site 3 |
|---|---|---|---|
| 1 | 57 | 123 | 8 |
| 2 | 21 | 25 | 5 |
| 3 | 10 | 16 | 0 |

These data provide the following estimates for the population of Santa Ana suckers at each of the three 100-meter study reaches:

Site 1, upstream of Mission Boulevard = 89 fish
Site 2, upstream of Highway 60 = 164 fish
Site 3, downstream of Riverside Avenue = 13 fish

The standard error can be used to calculate the 95% confidence interval (confidence interval = $\pm$1.96(SE)). This means that there is only a 5% chance that the "true" population size is outside the confidence interval. The standard errors and confidence intervals for the population estimate from each of the three sites is shown in Table 8.

Table 8. Confidence intervals for the population estimates from the three sites.

| Locality | Population Estimate | Standard Error | Confidence Interval |
|---|---|---|---|
| Site 1 | 89 | 2.85 | 83-94 |
| Site 2 | 164 | 0 | 164 |
| Site 3 | 13 | 0.60 | 12-14 |

Based on the data presented above, one would estimate that there is an average of 86-91 fish per 100 meters. It is assumed that these habitats are representative of the habitat from 600 meter below Mission Boulevard upstream to Rialto Drain. This is a distance of approximately 7.65 kilometers. Therefore, based on the above data this stream reach would be expected to hold approximately 6,579-6,962 Santa Ana suckers.

Table 9. The number of suckers captured in each of the depletion passes, at each of the three sampling sites 26-28 July 2002.

| Pass # | Site 1 | Site 2 | Site 3 |
|---|---|---|---|
| 1 | 52 | 62 | 27 |
| 2 | 38 | 47 | 7 |
| 3 | 25 | 42 | 11 |
| 4 | 13 | | |

These data provide the following estimates for the population of Santa Ana suckers at each of the three 100-meter study reaches:

Site 1, upstream of Mission Boulevard = 146 fish
Site 2, upstream of Highway 60 = 170 fish
Site 3, downstream of Riverside Avenue = 47 fish

The standard error can be used to calculate the 95% confidence interval (confidence interval = $\pm$1.96(SE)). This means that there is only a 5% chance that the "true" population size is outside the confidence interval. The standard errors and confidence intervals for the population estimate from each of the three sites is shown in Table 10.

Table 10. Confidence intervals for the 2002 population estimates from the three sites.

| Locality | Population Estimate | Standard Error | Confidence Interval |
|---|---|---|---|
| Site 1 | 146 | 21.56 | 124-168 |
| Site 2 | 170 | 11.56 | 158-182 |
| Site 3 | 47 | 3.92 | 43-51 |

Based on the data presented above, one would estimate that there is an average of 108-134 fish per 100 meters. It is assumed that these habitats are representative of the habitat from 600 meter below Mission Boulevard upstream to Rialto Drain. This is a distance of approximately 7.65 kilometers. Therefore, based on the above data this stream reach would be expected to hold approximately 8,262-10,251 Santa Ana suckers.

Table 11. The number of suckers captured in each of the depletion passes, at each of the three sampling sites 26-28 July 2002.

| Pass # | Site 1 | Site 2 | Site 3 |
|---|---|---|---|
| 1 | 32 | 71 | 29 |
| 2 | 16 | 17 | 12 |
| 3 | 12 | 8 | 8 |

These data provide the following estimates for the population of Santa Ana suckers at each of the three 100-meter study reaches:

Site 1, upstream of Mission Boulevard = 63 fish
Site 2, upstream of Highway 60 = 96 fish
Site 3, downstream of Riverside Avenue = 50 fish

The standard error can be used to calculate the 95% confidence interval (confidence interval = ±1.96(SE)). This means that there is only a 5% chance that the "true" population size is outside the confidence interval. The standard errors and confidence intervals for the population estimate from each of the three sites is shown in Table 12.

Table 12. Confidence intervals for the 2002 population estimates from the three sites.

| Locality | Population Estimate | Standard Error | Confidence Interval |
|---|---|---|---|
| Site 1 | 63 | 4.11 | 59-67 |
| Site 2 | 96 | 0.00 | 96 |
| Site 3 | 50 | 2.20 | 48-52 |

Based on the data presented above, one would estimate that there is an average of 68-72 fish per 100 meters. It is assumed that these habitats are representative of the habitat from 600 meter below Mission Boulevard upstream to Rialto Drain. This is a distance of approximately 7.65 kilometers. Therefore, based on the above data this stream reach would be expected to hold approximately 5,202-5,508 Santa Ana suckers.

Table 13. Comparison of the 2001, 2002 and 2003 population estimates.

| | 2001 | 2002 | 2003 |
|---|---|---|---|
| Site 1 - upstream Mission bridge | 89 ± 2.85 | 146 ± 21.56 | 63±4.11 |
| Site 2 - upstream Hwy 60 bridge | 164 ± 0.0 | 170 ± 11.56 | 96±0.00 |
| Site 3 - downstream Riverside Dr bridge | 13 ± 0.60 | 47 ± 3.92 | 50±2.20 |
| Average per 100 meter reach | 86-91 | 108-134 | 68-72 |
| Estimated suckers in 7.65 km | 6,579-6,962 | 8,262-10,251 | 5,202-5,508 |

The data are displayed graphically below.

Figure 1. The graph illustrates the population variation at each of the three sites between 2001 and 2003.

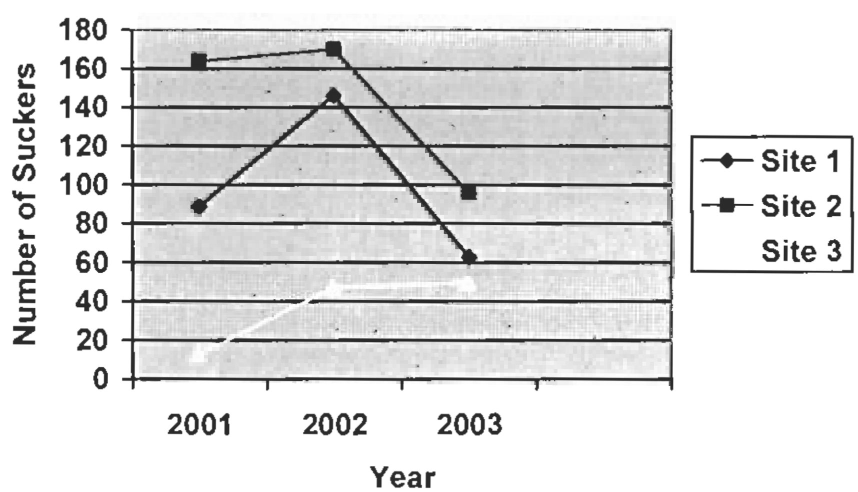
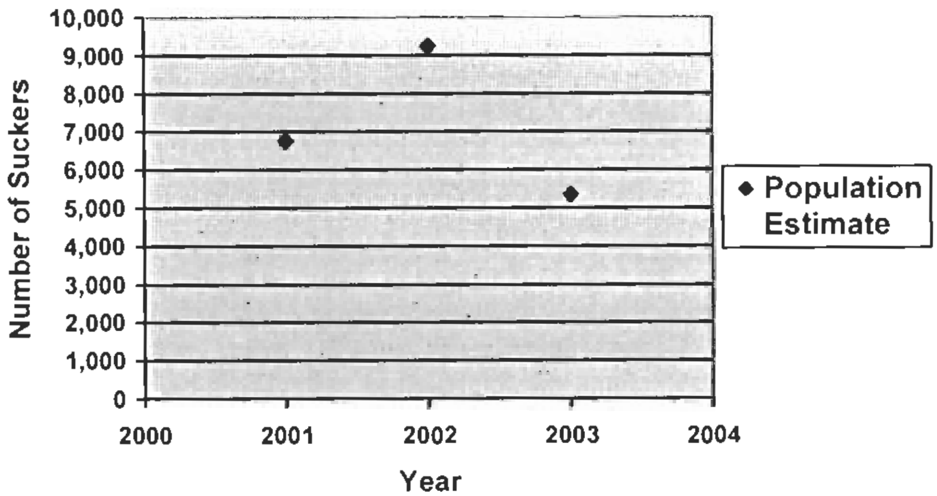


Figure 2. The graph shows the estimate for the total number of fish in 7.65 miles of the Santa Ana River.




Looked at simplistically, the data appear to suggest a decrease in the number of fish in the river, based on sampling at these three sites. However, two cautionary notes apply:

1. No population trend can be robustly defined by three data points.
2. If one looks at the number of fish per meter of stream, the values are 0.89, 1.21 and 0.70, at least 2001 and 2003 are about the same.
3. There were significant changes in the population structure (see discussion of population structure) between 2001 and 2002, which may reflect the exceptionally dry year of 2002. It is clear from the data, that there is considerable annual variation, as one would expect in a Southern California system.

It is essential to remember that robust determinations of population trends require many years of data. Furthermore, the Santa Ana sucker which evolved in the unpredictable hydrological regime of Southern California has evolved to become highly fecund. This allows the fish to exploit optimal conditions when they occur, and to recover rapidly after population drops resulting from years with poor recruitment (*e.g.* Greenfield *et al.* 1970).

**B. Population Estimates – Snorkeling Surveys.**

During 1999 and 2000, snorkeling surveys were conducted to estimate sucker density/abundance in the Santa Ana River. Because this dataset had been started in 1999, SMEA determined to continue to collect these data in 2001 and 2002. Appendix 3 contains a discussion of this technique as a method of population estimation. The data from 1999 through 2002 are presented in Table 14. This technique, although not as quantitatively reproducible, does provide a broader coverage of the river than can be accomplished using sequential depletion techniques without excessive cost and personnel effort.

Table 14. Results of snorkeling surveys 1999-2003.

| Year | Locality | Date | Length (m) | #YOY | #Adult | Total | Fish/Meter |
|---|---|---|---|---|---|---|---|
| 1999 | Below Riverside | 22 Dec | 645 | | | 707 | 1.096 |
| 2000 | Arr Tequesquite-Mission | 22 Jun | 2,100 | | | 46 | 0.022 |
| | Market to Riverside | 28 Jun | 2,600 | | | 422 | 0.162 |
| | Riverside to RIX outlet | 29 Jun | 2,300 | | | 125 | 0.054 |
| | Sunnyslope | 20 Jun | 430 | | | 156 | 0.363 |
| | Totals | | 7,430 | | | 749 | 0.101 |
| 2001 | Mission to Market | 14 Jun | 1,700 | | | 600 | 0.353 |
| | Market to Riverside | 03 Jul | 2,600 | 72 | 671 | 743 | 0.286 |
| | Riverside to RIX outlet | 03 Jul | 2,300 | 175 | 223 | 398 | 0.173 |
| | Sunnyslope | 22 Jun | 430 | | | 51 | 0.119 |
| | Totals | | 7,030 | 247 | 894 | 1,792 | 0.255 |
| 2002 | Mission to Market | 26 Jun | 1,700 | 614 | 1,264 | 1,868 | 1.099 |
| | Market to Riverside | 26,28 Jun | 2,600 | 46 | 414 | 460 | 0.177 |
| | Riverside to RIX outlet | 28 Jun | 2,300 | 31 | 87 | 118 | 0.051 |
| | Rialto Drain | 28 Jun | 350 | 29 | 1 | 30 | 0.086 |
| | Sunnyslope | 29 Jun | 430 | 0 | 0 | 0 | 0.000 |
| | Totals | | 7,380 | 720 | 1,766 | 2,476 | 0.336 |
| 2003 | Mission to Market | 30 Jun | 1,700 | 1,451 | 669 | 2,120 | 1.247 |
| | Market to Riverside | 30 Jun | 2,600 | 132 | 320 | 452 | 0.174 |
| | Riverside to RIX outlet | 02 Jul | 2,300 | 15 | 193 | 208 | 0.090 |
| | Rialto Drain | 02 Jul | 350 | 69 | 6 | 75 | 0.214 |
| | Sunnyslope | 02 Jul | 430 | 38 | 31 | 69 | 0.160 |
| | Totals | | 7,380 | 1,770 | 1,219 | 2,924 | 0.396 |

What is clear from these data is that there has been a decrease in the number of fish in Sunnyslope Creek over the period of 2000 to 2002. There is an increase in fish in Sunnyslope again in 2003 to approximately level found in 2001. These surveys show that from 2001-2003 the average number of fish/meter of stream stays relatively constant. For the accuracy of this method these numbers are probably all the same. In 2000, however, the population was lower. These data are impossible to compare directly to the sequential depletion data, however, they should be measuring the same pattern of population variation.

## C. Population Estimates – River Road 2002.

During the summer, workers around River Road found what was thought to be a very large number of small suckers. Because of this SMEA was asked to make a population estimate in the area of River Road. On 15 August 2002, a site just upstream of the bridge was selected. This river reach was in the main flow channel and thus somewhat resembled the other 100-meter sections being studied by SMEA. However, two passes with an electroshocker failed to produce any suckers. The area was then snorkeled and examined with a viewing tube. No suckers were found.

It was then decided to move upstream of the berm placed in the river by the sand mining operation. A 50 meter site along the berm was selected. Because the water is so wide at this area, a rectangle 50 meters long and 4 meters wide was cordoned off with blocking nets. One edge of the sampling area was the berm. A sequential depletion of this stream reach produced 304 juvenile suckers most between 40 and 60 mm SL. The estimated population was 304 fish per 50 meters with a standard error of ±0. To make the estimate comparable to the other reaches, this would be 608 fish per 100 meters. This is almost twice the number of suckers (YOY and adult combined) as were captured at all three other 100-meter sections. Young-of-the-year suckers were extraordinarily abundant at River Road in 2002. There is virtually no data from other years.

The large number of juvenile suckers that had been observed at River Road prompted SMEA to do a young-of–the-year survey on 13 July 2002. In order to obtain a gross idea of the distribution and abundance of YOY suckers. Seven (7) sites were selected and two 50-meter reaches were seined at each. The results are shown in Table 15.

Photo 16. A young-of-the-year (YOY) Santa Ana sucker.

Table 15. Summary of data collected on 13 July 2002 - Santa Ana sucker young-of-the-year survey.

| Locality | | # Seine Hauls | Sucker | | Other Fishes | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | YOY | Adult | Ga[2] | Bb[3] | Yb[4] | Fm[5] | Mc[6] | Lb[7] | Gf[8] | Ca[9] | Ac[10] |
| Market Street | Upstream | 16 | 1 | 0 | X | | | | | | | | X |
| | Downstream | 10 | 0 | 0 | X | | | | X | | | | X |
| Mission Boulevard | Upstream | 10.5 | 4[11] | 8 | X | | | | X | | | | X |
| | Downstream | 11 | 3 | 3 | X | | | | X | | | | X |
| Sunnyslope confluence | Section 1[1] | 10 | 8 | 0 | X | | | X | | | | | X |
| | Section 2 | 10 | 8 | 2 | X | | | X | | | | | X |
| MWD Crossing | Upstream | 11 | 0 | 0 | X | | | | | | | | |
| | Downstream | 13 | 0 | 0 | X | | | | | | | | |
| Van Buren Boulevard | Upstream | 11 | 0 | 0 | X | X | | | | | | | |
| | Downstream | 10 | 0 | 0 | X | | | | | | | | |
| Hamner Avenue | Upstream | 13 | 0 | 0 | X | | X | | | | | | |
| | Downstream | 15 | 0 | 0 | X | | | | | | | | |
| River Road | Upstream | 10.5 | 50 | 0 | X | | | X | | X | X | | X |
| | Downstream | 11 | 5 | 0 | X | | | X | | X | | X | |

1. Both 50 meter sections were upstream of the confluence of Sunnyslope Creek.
2. Mosquitofish
3. Black bullhead
4. Yellow bullhead
5. Fathead minnow
6. Mozambique cichlid
7. Largemouth bass
8. Goldfish
9. Carp
10. Arroyo chub
11. At this site several large schools were observed, in excess of 100 individuals total, captured 2 to verify that they were suckers.

The YOY survey demonstrated the presence of YOY suckers in the upstream areas and at River Road. However, none were found at intermediate sites. This raises the question of whether the large number of YOY suckers had been produced at River Road or whether they were the result of downstream drift of larval/YOY fish from the upstream reaches The currently available data do not provide an answer to this question.

**D. Riverside County Flood Control Diversion – 2003**

On 19 November 2003 Riverside County Flood Control (RCFC) found it necessary to divert the low flow channel of the Santa Ana River away from the south levee of the river at a point just upstream (east) of the Riverside Avenue Bridge in Riverside, CA. This flow was considered a threat to the levee in the event of a flood, therefore the diversion was declared to be an emergency. San Marino Environmental Associates (SMEA) was engaged by RCFC to implement protection and relocation for the Santa Ana sucker (*Catostomus santaanae*) during this diversion activity. This presented an opportunity to obtain data on the Santa Ana suckers occupying the reach that was diverted.

During this entire operation and for the following few hours SMEA fishery biologists were positioned along the original channel to rescue stranded fishes. Native fishes, suckers and chubs (*Gila orcutti*), were rescued, while exotic species (see species list, Table 14) were discarded. The data for size and weight of suckers is given on Table 15.

It should be noted that all of these fishes were taken immediately following the diversion, and some fishes were observed swimming downstream, out of the original channel as the water level dropped. Minor modifications to the channel were made both by hand and with mechanized equipment at the direction of SMEA to facilitate the downstream escape of these fishes. These fishes were not captured or counted, so all counts represent an under estimate of the number of fishes present in the original channel. Past experience indicates that fishes normally move downstream or take refuge in the deepest places in a channel when water levels drop. In this channel the deepest places, with the best cover and habitat for these fishes, especially adult suckers, were where the flow extended along the levee and several deep pools (up to about 1.5m deep) with good flow and vegetation cover were found. It is here that most fishes probably took refuge when the water dropped initially.

The most downstream area of the original channel consisted largely of shallow water (up to about 0.5m deep) with a sandy substrate (about 70%), 30% gravel/cobble, no boulders or deep spots and only one riffle. This area was the lowest quality sucker habitat in the original channel, and probably held the fewest suckers. The upstream portion of the original channel, in contrast, was made up almost entirely (90%) of an excellent gravel/cobble riffle with good algal growth on the substrate. Large numbers of small suckers, about 90, were found stranded among the rocks in this riffle during the initial drop of the water. Many suckers from this area probably took refuge in the deep pools just downstream. Loose soft sand made it impossible to remove fishes from the deep pools until the water level dropped substantially. SMEA biologists remained on site all day capturing fishes from deep spots. By the end of the day the entire downstream part of the original channel was dry, so all fishes remaining in the channel were isolated, unable to move downstream through this area. Consequently, it was necessary to return on the following day, November 20, to rescue additional fishes from the deeper pools as they became further dewatered and the fishes became accessible. Twenty suckers were taken that day, but not all pools were sufficiently accessible to remove all fishes. On November 22, these pools had dewatered sufficiently so that all stranded fishes could be removed with confidence (290 suckers, 794 chubs and numerous non-native fishes were removed).

The fishes captured on November 19 were returned to the stream downstream of the diversion channel. Those taken on November 20 and 22 were returned to the water in the diversion channel because they were stressed, and this was the closest habitat available.

The entire length of the original channel was 289 m, with an approximate average width of about 13m. About 95% of its bank was densely vegetated with riparian growth of willows, grasses, mule fat, Tamarisk and Arundo.

Table 16. Fish species found in original channel, totals for all days.

| Species | Species Status | Total Number Counted |
|---|---|---|
| Santa Ana sucker | Native, Federal Threatened Species | 456 |
| arroyo chub | Native, State Species of Special Concern | 1569 |
| black bullhead | Non-native | common |
| fathead minnow | Non-native | present |
| large mouth bass | Non-native | few |
| mosquito fish | Non-native | common |
| tilapia | Non-native | very numerous |

Table 17. Length and weight of a sample of the Santa Ana suckers captured November 19, 2003 in original channel.

| Standard Length (mm) | Weight (gms) |
|---|---|
| 50 | 2.6 |
| 54 | |
| 55 | 3.8 |
| 57 | 4.5 |
| 57 | 3.2 |
| 58 | 3.2 |
| 60 | 5.5 |
| 60 | 3.2 |
| 60 | 3.6 |
| 62 | |
| 62 | 5.1 |
| 63 | 5.5 |
| 64 | |
| 64 | 7.0 |

| | |
|---|---|
| 65 | 4.9 |
| 65 | 5.5 |
| 66 | 6.1 |
| 66 | 5.7 |
| 66 | 4.6 |
| 66 | 5.3 |
| 66 | 6.7 |
| 67 | |
| 67 | |
| 68 | |
| 68 | |
| 68 | 5.9 |
| 68 | 5.8 |
| 68 | 5.5 |
| 69 | 6.6 |
| 70 | 6.4 |
| 70 | 8.1 |
| 70 | 6.3 |
| 70 | 4.8 |
| 72 | 7.6 |
| 72 | 6.4 |
| 72 | 7.4 |
| 72 | 6.1 |
| 72 | 7.3 |
| 72 | 5.8 |
| 73 | |
| 74 | 7.7 |
| 74 | 6.1 |
| 75 | 10.0 |
| 75 | 6.3 |
| 75 | 6.8 |
| 75 | 7.1 |
| 75 | 6.4 |
| 76 | 8.7 |
| 76 | 8.6 |
| 77 | |
| 77 | 8.5 |
| 77 | 8.1 |
| 78 | |
| 78 | |
| 78 | 8.7 |
| 78 | 8.3 |
| 78 | 8.1 |
| 80 | |
| 80 | |

| | |
|---|---|
| 80 | 9.9 |
| 80 | 8.6 |
| 80 | 11.2 |
| 80 | 9.1 |
| 80 | 9.7 |
| 80 | 9.9 |
| 81 | 8.5 |
| 81 | 9.0 |
| 82 | 11.4 |
| 82 | 10.6 |
| 83 | |
| 83 | 10.7 |
| 83 | 11.3 |
| 83 | 12.4 |
| 83 | 10.8 |
| 84 | 11.0 |
| 84 | 11.0 |
| 85 | |
| 85 | 11.2 |
| 85 | 11.1 |
| 85 | 11.6 |
| 85 | 12.7 |
| 85 | 9.4 |
| 87 | |
| 87 | 13.0 |
| 87 | 7.4 |
| 88 | |
| 88 | 11.2 |
| 89 | 11.8 |
| 94 | |
| 95 | 19.0 |
| 99 | 14.4 |
| 104 | 17.4 |
| 105 | |
| 120 | 30.0 |
| 120 | 28.0 |
| 125 | |
| 125 | |
| 125 | 39.5 |
| 130 | 36.0 |
| 130 | 36.5 |
| 135 | 38.0 |
| 137 | 43.2 |
| 140 | 42.5 |
| 145 | |

| | |
|---|---|
| 145 | 52.0 |
| 152 | 58.3 |

As part of the mitigation for the channel diversion, RCFC placed two sets of boulders into the new channel. On 23 November, SMEA found 10 suckers in the newly created channel. Two individuals were large enough to tag. The length/weight data for these fishes are presented in Table 16. All ten suckers were captured at the boulders.

Table 18. Length and weight of a sample of the Santa Ana suckers captured 23 November 2003 in original channel.

| Standard Length (mm) | Weight (gms) | Tag Number |
|---|---|---|
| 116 | 30.4 | 4265550C1A |
| 118 | 29.9 | 42634F1F04 |
| 82 | 9.0 | |
| 85 | 11.0 | |
| 78 | 9.1 | |
| 69 | 7.3 | |
| 85 | 9.5 | |
| 88 | 12.0 | |
| 77 | 8.0 | |
| 74 | 7.2 | |

**E. Migration/Movement.**

Four fish were recaptured during 2001 during the attempted mark-recapture procedure. All four fish had been tagged at Site 2 upstream of Highway 60. One was captured where tagged, one was captured at Site 1, and two were captured 100-150 meters downstream of Highway 60. This information is summarized in Table 17.

Table 19. Data on locations of recaptured fish.

| Tag Number | Tagging Location | Date of Tagging | Recapture Location | Date of Recapture |
|---|---|---|---|---|
| 4264761B69 | Site 2 | 16 June | Site 2 | 18 June |
| 42645F1761 | Site 2 | 16 June | Site 1 | 18 June |
| 42647B200A | Site 2 | 16 June | Downstream of Highway 60 | 18 June |
| 4261660E7A | Site 2 | 16 June | Downstream of Highway 60 | 18 June |

During the 2002 sequential depletion work at the three 100-meter sites, four fish were recaptured that had been tagged in 2001. Four recaptures is a good return, remembering that recaptures of free-ranging animals typically have a very low return.

The following table provides information on the recaptured fish.

Table 20. Location of initial tagging and recapture for the four Santa Ana suckers recaptured in 2002.

| Recaptured Suckers Pit Tag Numbers | Tagged 2001 Tagging Location | Recaptured 2002 Recapture Location |
|---|---|---|
| 42655E0062 | Site 1 – Mission Blvd | Site 1 – Mission Blvd |
| 42645F4F20 | Site 1 – Mission Blvd | Site 1 – Mission Blvd |
| 4263245D1B | Site 1 – Mission Blvd | Site 1 – Mission Blvd |
| 4261600774 | Site 1 – Mission Blvd | Site 1 – Mission Blvd |

It is interesting that all four fish were tagged and recaptured at the same site. This raises two possibilities which will need to be addressed in future field work:

1. The fish are relatively sessile and show a degree of site fidelity.
2. The fish return to specific sites for reproduction or post-reproductive holding habitat.

Only future recapture data will allow these questions to be answered.

During November 2003 an attempt to locate previously tagged fish was made by collecting fish upstream and downstream of Highway 60 and upstream of Riverside Avenue. One fish captured downstream of Riverside was a recapture:

> Pit tag # 4263126704 was originally tagged on 28 July 2003 at sequential depletion site 3 just downstream from Riverside Avenue and was recaptured just downstream of Highway 60.

Additional fish were tagged during this field activity. The length/weight data and tag numbers (for the tagged fish) are presented in the tables below.

Table 21. Length and weight of a sample of the Santa Ana suckers captured 23 November 2003 downstream of Highway 60.

| Standard Length (mm) | Weight (gms) | Tag Number |
|---|---|---|
| 127 | 35.3 | 4265560C69 |
| 121 | 33.0 | 4264783962 |
| 111 | 23.9 | 42655A0828 |
| 67 | 4.4 | |
| 85 | 11.8 | |
| 73 | 6.6 | |
| 81 | 10.8 | |
| 87 | 13.0 | |
| 60 | 4.2 | |
| 64 | 4.1 | |
| 58 | 3.6 | |
| 74 | 6.5 | |
| 70 | 5.7 | |
| 119 | 29.0 | 4263480B1F |
| 114 | 24.2 | 4265710D22 |
| 123 | 34.3 | 426566350A |

| | | |
|---|---|---|
| 77 | 7.7 | |
| 70 | 5.2 | |
| 60 | 3.8 | |
| 62 | 4.4 | |
| 61 | 4.0 | |
| 60 | 4.4 | |
| 55 | 2.9 | |
| 66 | 4.6 | |
| 72 | 6.9 | |
| 70 | 5.8 | |
| 72 | 6.8 | |
| 70 | 5.6 | |
| 75 | 7.2 | |
| 63 | 4.1 | |
| 63 | 4.6 | |
| 44 | 1.5 | |
| 64 | 5.1 | |
| 72 | 6.9 | |
| 72 | 6.7 | |
| 84 | 11.6 | |
| 67 | 5.2 | |
| 58 | 3.0 | |
| 58 | 3.4 | |
| 62 | 4.0 | |
| 73 | 6.8 | |
| 59 | 4.0 | |
| 53 | 2.8 | |
| 63 | 4.9 | |
| 45 | 2.0 | |
| 53 | 3.8 | |
| 51 | 2.5 | |
| 59 | 3.3 | |
| 51 | 2.6 | |
| 55 | 3.3 | |
| 120 | 28.5 | 42650A3C42 |
| 112 | 20.5 | 4265721816 |
| 126 | 37.7 | 4263605873 |
| 130 | 38.1 | 4265514324 |
| 124 | 33.3 | 4265566D30 |
| 149 | 61.3 | 42634C5F0E |
| 58 | 3.1 | |
| 73 | 7.2 | |
| 51 | 2.4 | |
| 83 | 9.2 | |
| 78 | 7.8 | |

| | | |
|---|---|---|
| 63 | 4.9 | |
| 47 | 2.0 | |
| 65 | 5.2 | |
| 53 | 3.1 | |
| 54 | 3.0 | |
| 55 | 3.1 | |
| 62 | 3.8 | |
| 88 | 11.1 | |
| 57 | 3.4 | |
| 56 | 3.4 | |
| 48 | 2.6 | |
| 70 | 5.9 | |
| 68 | 5.4 | |
| 67 | 5.1 | |
| 170 | 69.1 | 4263126704 Recapture |
| 131 | 40.6 | 4263330D0F |
| 124 | 35.5 | 4266073161 |
| 127 | 32.9 | 4266012263 |
| 119 | 28.8 | 42655B7E16 |
| 134 | 43.1 | 42654F5E75 |
| 117 | 30.1 | 42657A4965 |
| 132 | 39.7 | 426347401F |
| 109 | 20.9 | 4264761735 |

Table 22. Length and weight of a sample of the Santa Ana suckers captured 23 November 2003 upstream of Highway 60.

| Standard Length (mm) | Weight (gms) | Tag Number |
|---|---|---|
| 118 | 29.2 | 4266033E26 |
| 61 | 4.1 | |
| 61 | 4.0 | |
| 69 | 5.5 | |
| 66 | 4.6 | |
| 66 | 4.7 | |

Table 23. Length and weight of a sample of the Santa Ana suckers captured 23 November 2003 upstream of Riverside Avenue (upstream of RCFC diversion). See Table 16 for the fishes captured in the diversion channel.

| Standard Length (mm) | Weight (gms) | Tag Number |
|---|---|---|
| 116 | 27.5 | 4265627039 |
| 132 | 44.6 | 42646F1017 |
| 126 | 31.0 | 4265682152 |
| 126 | 29.6 | 4263442D69 |

| | | |
|---|---|---|
| 100 | 16.2 | 4263133139 |
| 130 | 40.8 | 4263291C0E |
| 93 | 15.2 | 42654E5E61 |
| 80 | 10.3 | |
| 82 | 9.5 | |
| 92 | 13.4 | |
| 91 | 13.3 | |
| 82 | 9.2 | |
| 80 | 9.5 | |
| 79 | 8.5 | |
| 90 | 12.5 | |
| 78 | 8.7 | |
| 70 | 5.3 | |
| 80 | 9.1 | |
| 86 | 10.5 | |
| 70 | 5.5 | |
| 82 | 11.0 | |
| 88 | 12.3 | |
| 76 | 7.4 | |
| 60 | 4.7 | |
| 67 | 4.8 | |
| 64 | 5.3 | |
| 68 | 3.6 | |
| 128 | 37.1 | 4266010E3C |
| 120 | 31.9 | 42645B164E |
| 99 | 18.0 | 426465781B |

**F. Growth.**

The recapture data presented above also provided an opportunity to evaluate growth in the Santa Ana sucker. Table 16 below presents the length-weight data for the four recaptured suckers at the time of tagging and at their recapture one year later.

Table 24. Length/weight data from the four Santa Ana suckers recaptured in 2002. Length is standard length in millimeters and weight is in grams.

| Recaptured Suckers | 2001 | | 2002 | | Change | |
|---|---|---|---|---|---|---|
| Pit Tag Number | Length | Weight | Length | Weight | Length | Weight |
| 42655E0062 | 119 | 29.3 | 147 | 53.5 | 28 | 24.2 |
| 42645F4F20 | 116 | 27.9 | 155 | 62.6 | 39 | 34.7 |
| 4263245D1B | 132 | 39.2 | 161 | 65.5 | 29 | 26.3 |
| 4261600774 | 105 | 23.8 | 145 | 44.7 | 40 | 20.9 |

## G. Population Structure.

In order to evaluate the population structure of the Santa Ana sucker in the Santa Ana River it is necessary to know the sizes of the various year classes. These data are particularly important, because Saiki (2000) interpreted his data to suggest that in the Santa Ana River, the Santa Ana sucker lives only two years and therefore has only one reproductive year. This is important because in the San Gabriel River and the Santa Clara River the sucker appears to be longer lived.

Greenfield *et al.* (1970) and Sasaki and Drake (1987) provided date on the approximate size ranges of the various year classes in the Santa Clara River and the San Gabriel River respectively. Saiki's (2000) data can also be used to estimate size classes of suckers in the Santa Ana River. These data are presented in Table 17.

Table 25. Estimated lengths (SL mm) of the various age classes in the Santa Clara River, San Gabriel River and Santa Ana River.

| Age Class | Santa Clara River | San Gabriel River | Santa Ana River |
|---|---|---|---|
| 0+ | 0-51 | 0-70 | 0-80 |
| 1+ | 52-77 | 71-130 | 81-120 |
| 2+ | 77-140 | 131-160 | 121+ |
| 3+ | 140+ | 161-185 | |
| 4+ | | 186+ | |

SMEA examined five years of length data from the West Fork of the San Gabriel River. Based on these data the oldest year class ranged from 2+ to 4+ depending on the year, and the strength of the year classes varied considerably.

SMEA collected two large samples of suckers during 2001. These were collected on 16 June as part of the tagging activities. The size-frequency histograms for these two samples are shown below. Examination of the Site 2 graph (Figure 4) clearly shows at least three year classes, while the Site 1 histogram (Figure 3) may show one dominant year class with a few individuals from an older year class. A size-frequency histogram for a sample of Santa Ana suckers from the San Gabriel River (Figure 5) clearly shows more year classes. Samples over a period of years will be necessary to determine if Santa Ana sucker die after only one breeding season in the Santa Ana River. If this is the case, it must strongly influence the population dynamics.

Figure 3.

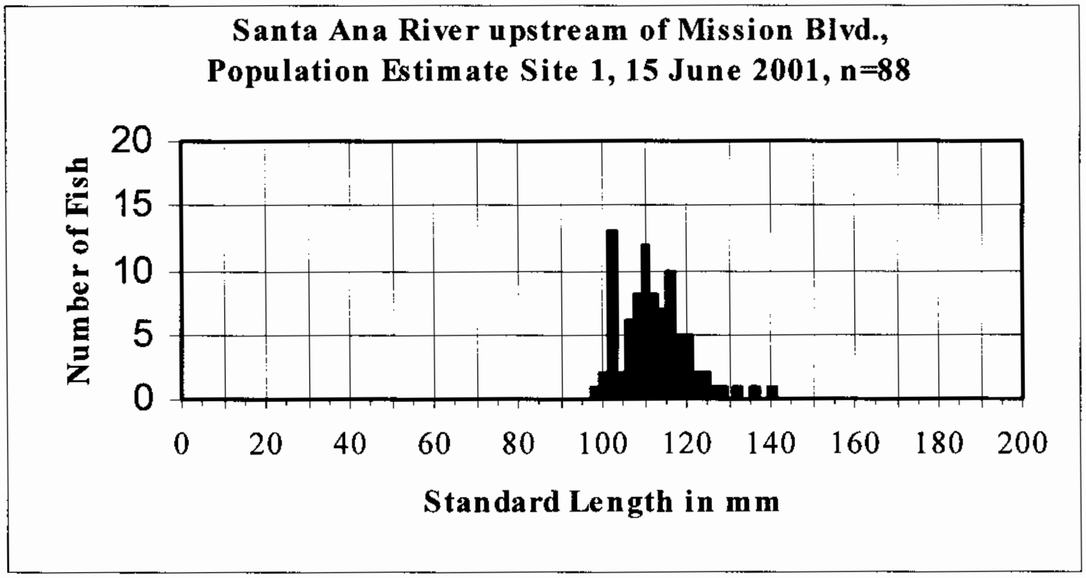



Figure 4.

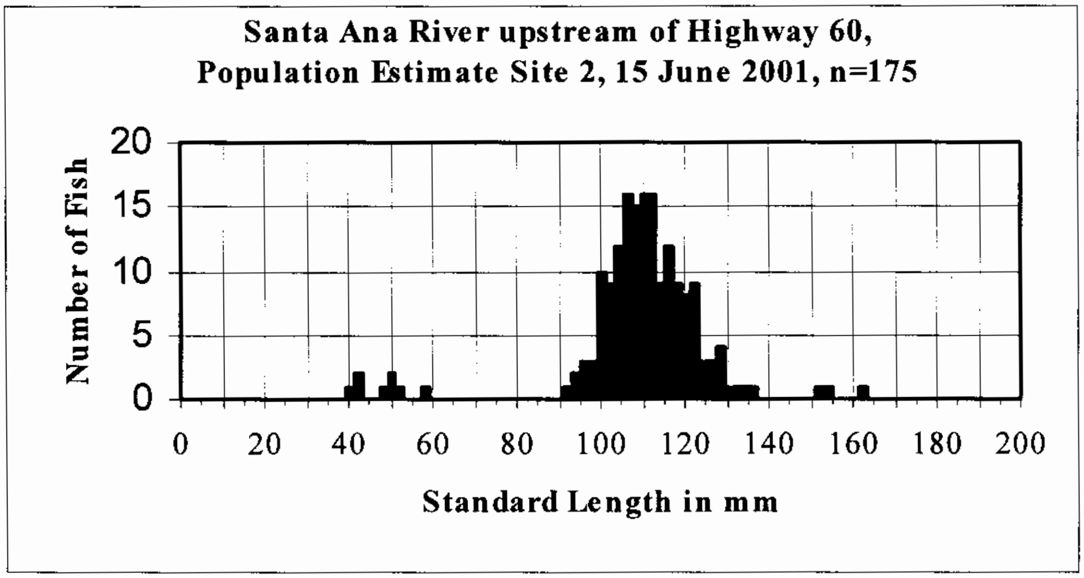
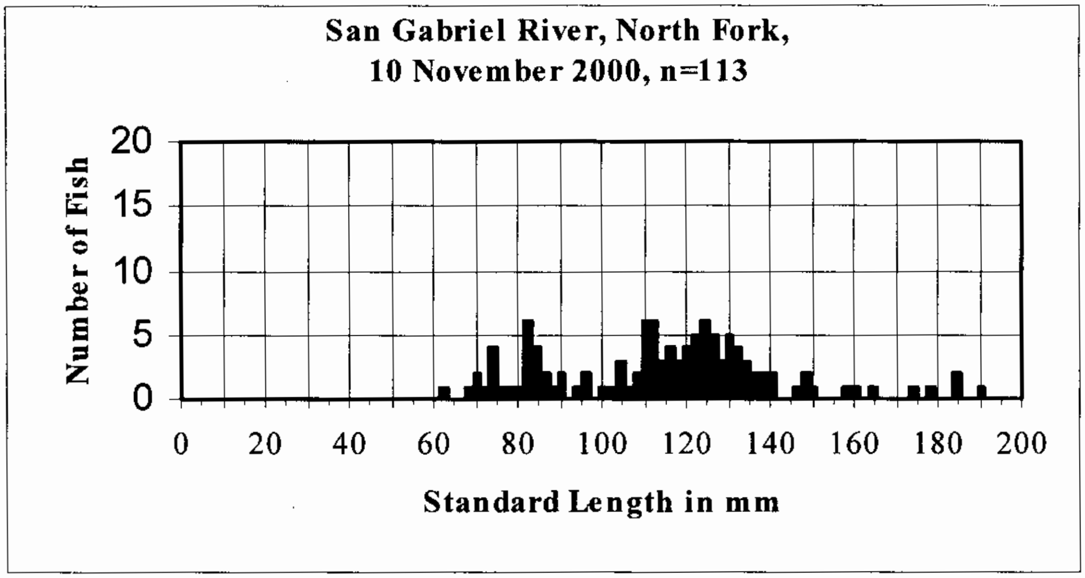


Figure 5.




An examination of the size (standard length) data presented in Tables 4-6 compared to the data presented in Appendix 1 demonstrates an obvious difference in the population structure. In 2001 the population was dominated by adults, fish greater than about 80mm SL, while in 2002 the population is dominated by younger, smaller fish less than 80 mm SL. Table 17 summarizes the differences which are displayed graphically following the table.

Table 26. Comparison of population structure data from 2001 and 2002. For simplicity, suckers less than 80 mm SL are designated as YOY and those greater than 80 mm SL are designated as adult.

| SUCKERS CAPTURED IN THE THREE 100-METER SECTIONS | | | | |
|---|---|---|---|---|
| **Location** | **2001** | | **2002** | |
| | **Adult** | **YOY** | **Adult** | **YOY** |
| Site 1 - Mission Bridge | 88 | 0 | 49 | 71 |
| Site 2 – Hwy 60 Bridge | 136 | 8 | 31 | 120 |
| Site 3 - Riverside Dr Bridge | 9 | 4 | 11 | 34 |
| Totals | 233 | 12 | 91 | 225 |
| Year Totals | 245 | | 316 | |
| **Percent of Population** | **95.10%** | **4.90%** | **28.80%** | **71.20%** |

Expressed a different way, this means that the population of adult reproductive suckers in 2001 was 6,257-6,621 individuals, while the adult sucker population in 2002 was 2,379-2,952 individuals. The following four figures show the differences graphically. The differences at so extreme that no statistical analysis is required to recognize that there is a significant difference

Figure 6. Histogram showing the standard length (SL) of all suckers captured during electroshocking in 2001.

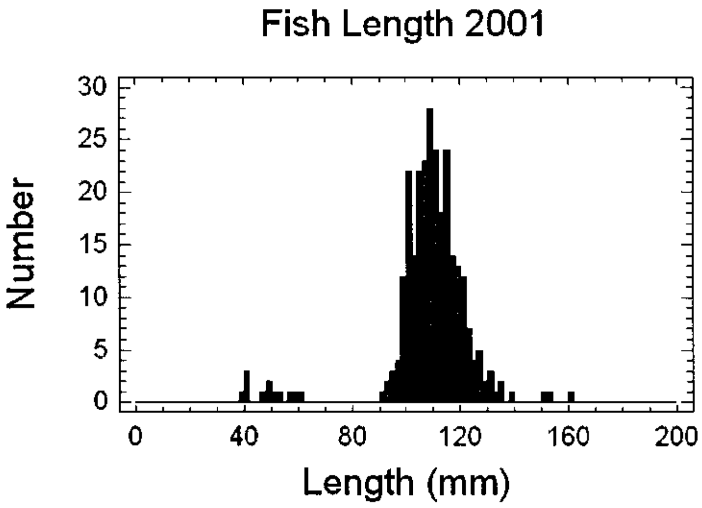



Figure 7. Histogram showing the standard length (SL) of all suckers captured during electroshocking in 2002.

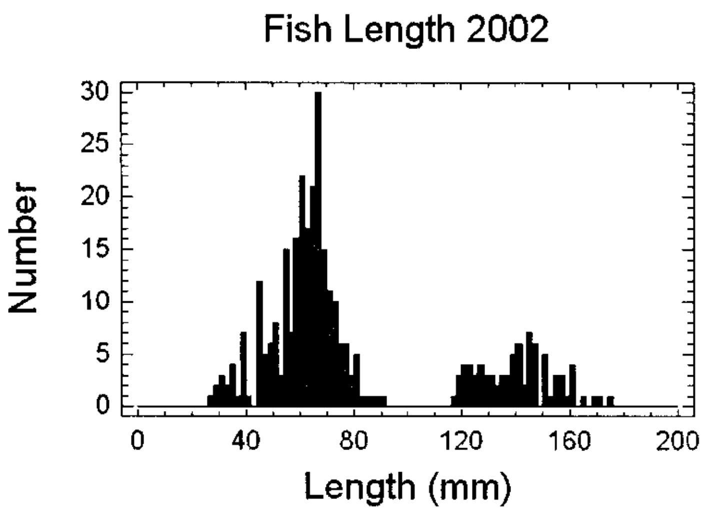


Figure 8. Box and whisker graph comparing the lengths of fish captured in 2001 and 2002.

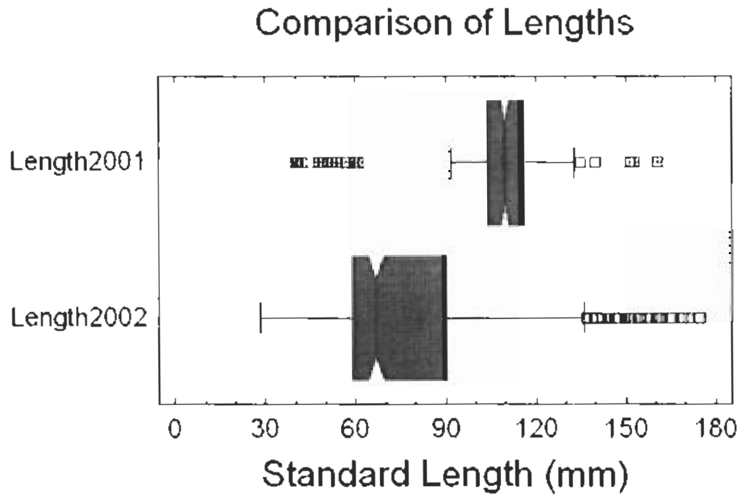



Figure 9. A comparison of the number of young-of-the-year (YOY) and adult Santa Ana suckers at each of the electroshocking sites in 2001, 2002 and 2003.

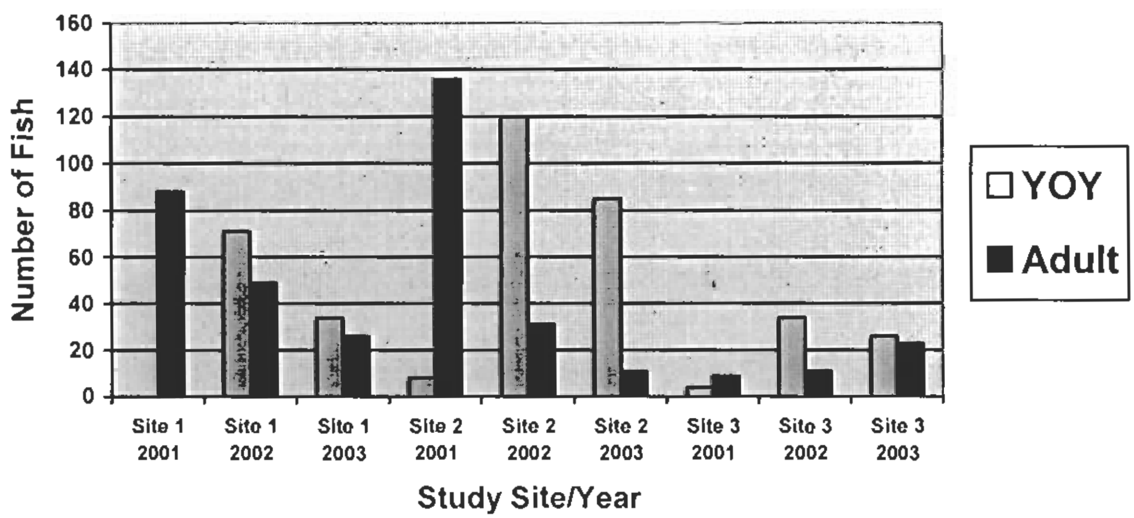
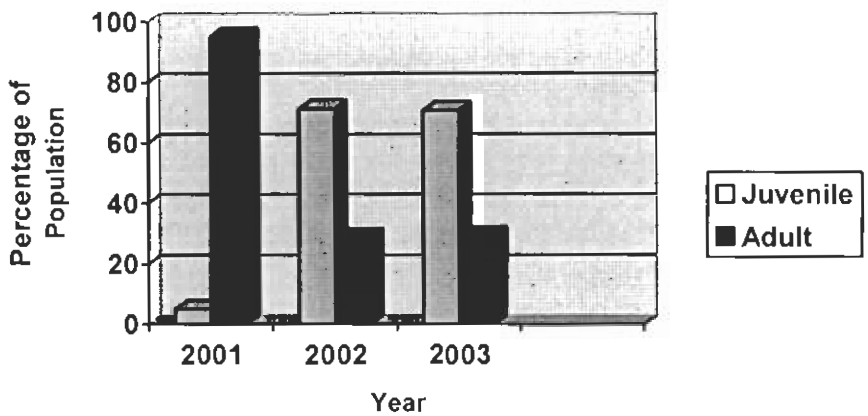



Figure 9 shows the dramatic shift in the population structure the sucker population. In 2001, the population was dominated by large fish, while in 2002 the population is dominated by small fish. While it is difficult to determine the meaning of this shift, several anecdotal observations apply. In 2001 SMEA observed relatively small numbers of fry, which is reflected in the low number of small fish captured during population sampling. In 2002 there were a large number of fry that were very widespread in the river, this observation is reflected in the strength of year class found when electroshocking. Presumeably, the small number of fry in 2001 partially accounts for the lower number of adults in 2002. If that is true and recruitment remains constant, then the large number of juveniles in 2002 should have produced a large adult population in 2003. This was not the case. In fact, the 2003 populations decreased in size. However the relative percentages of adults and juveniles are similar in 2002 and 2003 (Figure 10). Thus the population structure was similar in 2002 and 2003.

Figure 10. A comparison of the relative population percentages in 2001, 2002 and 2003.




## VI. REPRODUCTION.

### A. Introduction.

Reproductive surveillance and studies took place in three tributaries: Rialto Drain, Evans Lake Drain, and Sunnyslope Creek (see Photos 16-18). Surveillance was also conducted in the mainstem, but because of the clarity of water in the tributaries, most work focused in these areas.

SMEA determined the timing of appearance of the larvae, made observations on spawning, measured characteristics of the spawning habitat, made observations on larval habitat use, and noted the disappearance of the larval stage.

Photo 17. Sunnyslope Creek.

Photo 18. Rialto Drain

Photo 19. Evans Lake Drain

**B. Tuberculation Surveillance.**

As a mode of tracking reproductive readiness, SMEA periodically captured a sample of Santa Ana suckers and checked the frequency of tuberculate individuals and the degree of tuberculation. Photo 19 shows the tuberculate anal fin of a sucker captured in Rialto Drain.

Photo 20. Tuberculation is visible on the anal fin of this sucker.

Tables 27-33 show the data collected during the reproductive surveillance monitoring the degree and frequency of tuberculation in Santa Ana suckers. For simplicity only four degrees of tuberculation were recognized: (1) No tuberculation, (2) Incipient tuberculation when tubercles were beginning to develop, (3) Moderately well developed tuberculation when tubercles were obvious but not fully developed, and (4) Well develope tuberculation when the tubercles were fully developed. In addition to the data presented in the following tables a sample of 24 suckers was captured at Mission Boulevard on 17 December 2000. None of these fish showed any tuberculation.

Table 27. Length, weight and tuberculation data collected just downstream of Mission Boulevard on 7 January 2001. In the following table, SL = standard length; $W_T$ = total weight; and $W_F$ = fish weight.

| Length (mm SL) | Tare (g) | $W_T$ (g) | $W_F$ (g) | Tuberculation |
|---|---|---|---|---|
| 109 | 31 | 50 | 19 | Incipient tuberculation |
| 117 | 29 | 57 | 28 | None |
| 118 | 29 | 54.5 | 25.5 | None |
| 108 | 28 | 46.5 | 18.5 | None |
| 108 | 27 | 49 | 22 | None |
| 102 | 27 | 46 | 19 | Incipient tuberculation |
| 103 | 27.5 | 45.5 | 18 | None |
| 83 | 25 | 34.5 | 9.5 | None |
| 103 | 23.5 | 42.0 | 18.5 | None |
| 100 | 23.5 | 41.5 | 18 | None |
| 100 | 23 | 41.5 | 18.5 | None |
| 102 | 24 | 42.5 | 18.5 | None |
| 106 | 23.5 | 45.5 | 22 | None |
| 82 | 24.5 | 35 | 10.5 | None |
| 102 | 23.5 | 41 | 17.5 | None |
| 98 | 23 | 38 | 15 | None |
| 91 | 23.5 | 36 | 12.5 | None |
| 90 | 23 | 37.5 | 14.5 | None |
| 101 | 23.5 | 42.5 | 19 | None |
| 101 | 23.5 | 42 | 18.5 | None |
| 97 | 23 | 37.5 | 14.5 | None |
| 107 | 23 | 46 | 23 | Incipient tuberculation |
| 100 | 22 | 40.5 | 18.5 | None |
| 86 | 22 | 37 | 15 | None |
| 99 | 20 | 38 | 18 | None |

Table 28. Length, weight and tuberculation data collected at the Interstate-5 bridge over the Santa Clara River on 15 January 2001. In the following table, SL = standard length; $W_T$ = total weight; and $W_F$ = fish weight.

| Length (mm SL) | Tare | $Weight_T$ | $Weight_F$ | Tuberculation |
|---|---|---|---|---|
| 82 | 42 | 51.5 | 9.5 | None |
| 71 | 40 | 46 | 6 | None |
| 75 | 40 | 45.5 | 5.5 | None |
| 57 | 39 | 42 | 3 | None |
| 59 | 38 | 42 | 4 | None |
| 69 | 38 | 43 | 5 | None |
| 62 | 37 | 41 | 4 | None |
| 59 | 37 | 40.5 | 3.5 | None |

| | | | | |
|---|---|---|---|---|
| 89 | 36 | 47 | 11 | Incipient tuberculation |
| 82 | 35 | 43.5 | 8.5 | None |
| 77 | 34.5 | 43.5 | 11 | None |
| 75 | 33.5 | 40 | 6.5 | None |
| 65 | 33 | 38 | 5 | None |
| 65 | 32.5 | 37 | 4.5 | None |
| 55 | 31 | 34.5 | 3.5 | None |
| 62 | 30.5 | 35 | 4.5 | None |
| 63 | 30.5 | 34 | 3.5 | None |
| 63 | 30 | 34.5 | 4.5 | None |
| 69 | 29.5 | 35 | 5.5 | None |
| 52 | 29 | 32 | 3 | None |
| 52 | 28.5 | 31 | 2.5 | None |
| 72 | 28.5 | 35 | 6.5 | None |
| 56 | 28.5 | 31 | 2.5 | None |
| 58 | 27 | 30.5 | 3.5 | None |
| 61 | 24 | 28 | 4 | None |
| 47 | 24 | 25.5 | 1.5 | None |

Table 29. Length, weight and tuberculation data collected in Rialto Drain on 21 January 2001. In the following table, SL = standard length; $W_T$ = total weight; and $W_F$ = fish weight.

| Length (mm SL) | Tare (g) | $W_T$ (g) | $W_F$ (g) | Tuberculation |
|---|---|---|---|---|
| 110 | 60 | 79 | 19 | Incipient tubercles |
| 108 | 52 | 69 | 17 | Moderately well developed tubercles |
| 117 | 44.5 | 71 | 26.5 | None |
| 106 | 41.5 | 63.5 | 22 | Moderately well developed tubercles |
| 137 | 40 | 91.5 | 51.5 | None |
| 69 | 38 | 43.5 | 5.5 | None |
| 114 | 38 | 61.5 | 23.5 | Well developed tubercles |
| 110 | 36 | 58.5 | 22.5 | None |
| 92 | 34 | 45.5 | 11.5 | None |
| 121 | 33 | 63.5 | 30.5 | Well developed tubercles |
| 116 | 32.5 | 61.5 | 29 | Well developed tubercles |
| 95 | 31.5 | 47.5 | 16 | None |

Table 30. Length, weight and tuberculation data collected in Sunnyslope Creek on 17 February 2001. In the following table, SL = standard length and $W_F$ = fish weight.

| Length (mm SL) | $W_f$ (g) | Tuberculation |
|---|---|---|
| 110 | 23.5 | None |
| 86 | 11.1 | None |
| 88 | 12.2 | Moderately well developed tubercles |
| 104 | 20.6 | None |
| 105 | 19.6 | None |
| 90 | 14.5 | None |
| 117 | 22.4 | None |
| 87 | 10.6 | None |
| 98 | 18.5 | Moderately well developed tubercles |
| 95 | 15.7 | Incipient tubercles |
| 98 | 11.5 | None |
| 117 | 24.0 | None |

Table 31. Length, weight and tuberculation data collected at Mission Boulevard on 17 February 2001. In the following table, SL = standard length and $W_F$ = fish weight.

| Length (mm SL) | $W_f$ (g) | Tuberculation |
|---|---|---|
| 95 | 16.0 | Moderately well developed tubercles |
| 97 | 14.0 | Incipient tubercles |
| 100 | 14.7 | None |
| 108 | 18.4 | Well developed tubercles |
| 94 | 13.1 | Moderately well developed tubercles |
| 83 | 9.2 | Moderately well developed tubercles |
| 118 | 19.0 | Well developed tubercles |
| 85 | 9.2 | None |
| 76 | 6.9 | None |
| 92 | 12.6 | Incipient tubercles |
| 75 | 6.0 | None |
| 97 | 14.7 | None |
| 84 | 8.8 | None |
| 90 | 11.0 | None |
| 65 | 4.9 | None |
| 85 | 8.9 | None |
| 75 | 7.4 | None |
| 79 | 8.6 | None |

Table 32. Length, weight and tuberculation data collected at Rialto Drain on 17 February 2001. In the following table, SL = standard length and $W_F$ = fish weight.

| Length (mm SL) | $W_f$ (g) | Tuberculation |
|---|---|---|
| 108 | 18.3 | Moderately well developed tubercles |
| 116 | 20.5 | Well developed tubercles |
| 115 | 18.8 | Well developed tubercles |
| 111 | 22.7 | Well developed tubercles |
| 110 | 17.6 | Moderately well developed tubercles |

A definite trend of increasing tuberculation can be seen in these data, beginning in December 2000 when none of the fish captured showed any tuberculation through 17 February 2001 when tuberculation was significantly more common. This trend is summarized in Table 25 below.

Table 33. Frequency of tuberculate fish, at various localities, December 2000 – February 2001. None = No tubercles, Incip = Incipient tubercles, Moderate = Moderately well developed tubercles, Well = Well developed tubercles, and N = sample size

| Date | Locality | None | Incip | Moderate | Well | N |
|---|---|---|---|---|---|---|
| 17 Dec 00 | Mission Blvd | 24 | 0 | 0 | 0 | 24 |
| 7 Jan 01 | Mission Blvd | 22 | 3 | 0 | 0 | 25 |
| 21 Jan 01 | Rialto Drain | 6 | 1 | 2 | 3 | 12 |
| 17 Feb 01 | Sunnyslope Cr | 9 | 1 | 2 | 0 | 12 |
| 17 Feb 01 | Mission Blvd | 11 | 2 | 3 | 2 | 18 |
| 17 Feb 01 | Rialto Drain | 0 | 0 | 2 | 3 | 5 |

The data show a general increase in the degree of tuberculation of the suckers examined. However, between late January and mid February there is little change. Because the fish become tuberculate as they prepare for reproduction, the degree of tuberculation assisted us in tracking the general readiness for reproduction.

### C. Observations of Reproduction.

Considerable field time was spent trying to observe reproduction so that the actual characteristics of reproductive sites could be measured rather than relying on a general description of a stream reach where larvae were found.

On 31 March 2001, Haglund observed spawning in Rialto Drain in the pool at the very top of the drain where the water enters the "natural" channel (see Photo 21). The fish were spawning over a gravel bar that had developed near the pool tail. A large sucker (assumed to be a female) took up a position on the gravel bar, from the deeper water adjacent to the bar 1-3 smaller suckers (assumed males) would swim up to the female. All fish were facing upstream. The smaller fish would brush against the female (quiver), then all fish would swim away, however the larger individual returned almost immediately and resumed its (her) position on the gravel bar. This process was repeated three times while Haglund watched. The observations were made using a viewing tube and the water was clear over the gravel bar but there was no visibility into the adjacent deeper water.

Water over the gravel bar was 49-53 cm deep, and the deep adjacent water was in excess of one meter (no accurate measurement could be obtained). Substrate was a medium gravel. Flow over the spawning area was about 0.20 m/sec. Fry first appeared in Rialto Drain on 7 April.

Baskin and an SMEA field technician also observed spawning in Sunnyslope Creek (see Photo 20). The observations were made on 15 April 2001. The creek was 2.2 meters wide at the spawning site. The substrate was mixed fine/medium gravel with coarse sand. Spawning took place over the gravel at a depth of 51-60 cm. Flow over the gravel was 0.77 ft/sec (0.24 m/sec). One edge of the stream was deeper and had an undercut bank with exposed willow roots. The fish moved from the deeper area up onto the gravel then returned to the deeper water.

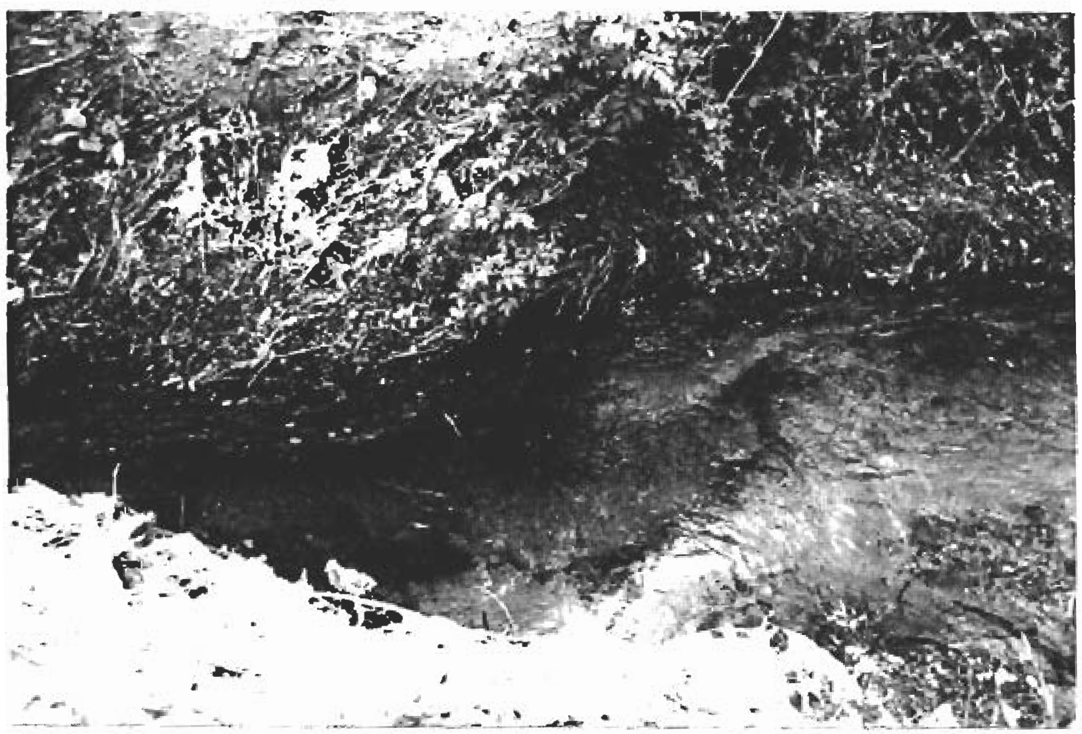


Photo 21. Sunnyslope Creek, where spawning was observed on 15 April 2001.

Photo 22 . Rialto Drain, where spawning was observed on 31 March 2001.

Based on these two observations it appears that the suckers prefer deeper water adjacent to spawning gravel. The spawning gravel in both cases was approximately 0.5 meter deep and the flows were similar (0.20 and 0.24 m/sec). The substrate in both cases was dominated by medium gravel, modal size 0.5 to 1.6 cm.

Typical spawning of suckers is illustrated by the longnose sucker, *Catostomus catostomus*, a widespread species found east of the Rocky Mountains. Stream spawning by longnose suckers was reported at depths of 15-30 cm. in a current of 30-45 cm/sec. over gravel substrate of 0.5 to 10 cm. diameter (Geen *et al.* 1966). Our observations of spawning of *C. santaanae* in the Santa Ana river study area are consistent with this data.

**D. Analysis of Spawning Gravels**

A sample of gravel was collected from each of the two spawning sites and analyzed for particle size. The histograms for particle size are shown below (Figures 10 and 11) along with their cumulative percent curves (Figure 12).

The graphs clearly show the dominance of the gravel sized particles and the presence of some sand. Sand ranges from 0.0625 mm to 1.00 mm in diameter, while gravel ranges from 1.00 mm to 64 mm in diameter. No significant amount of silt was present, nor were large particles present at either site.

These data will be used when "artificial" spawning areas are established

Figure 10. Histogram showing sediment size composition at an observed spawning site in Rialto drain.

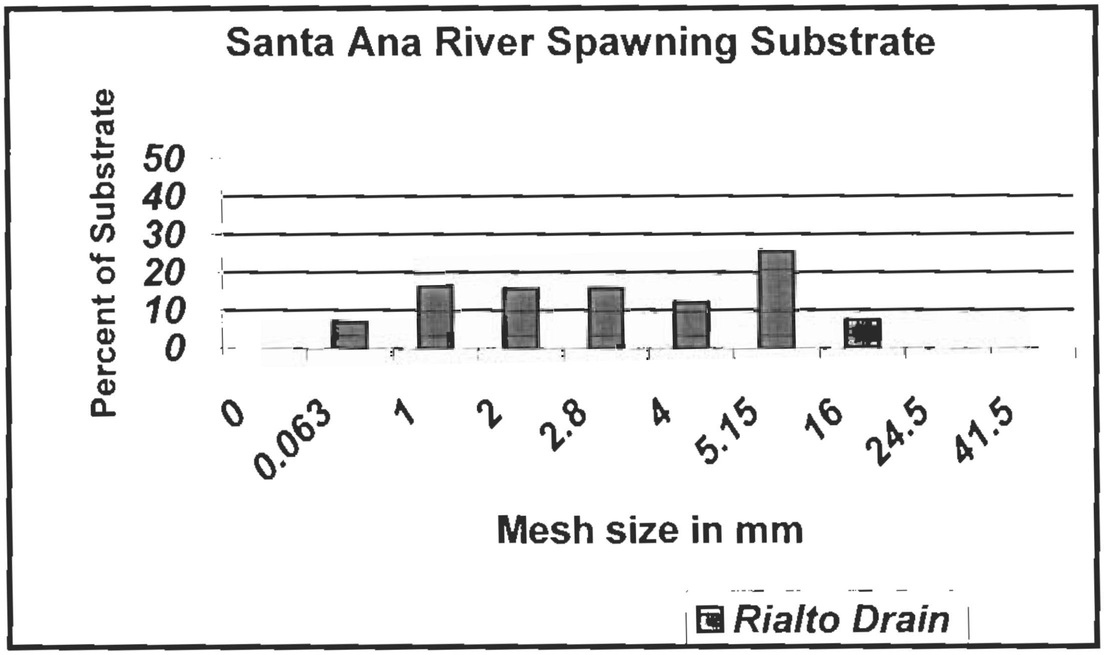



Figure 11. Histogram showing sediment size composition at an observed spawning site in Sunnyslope Creek.

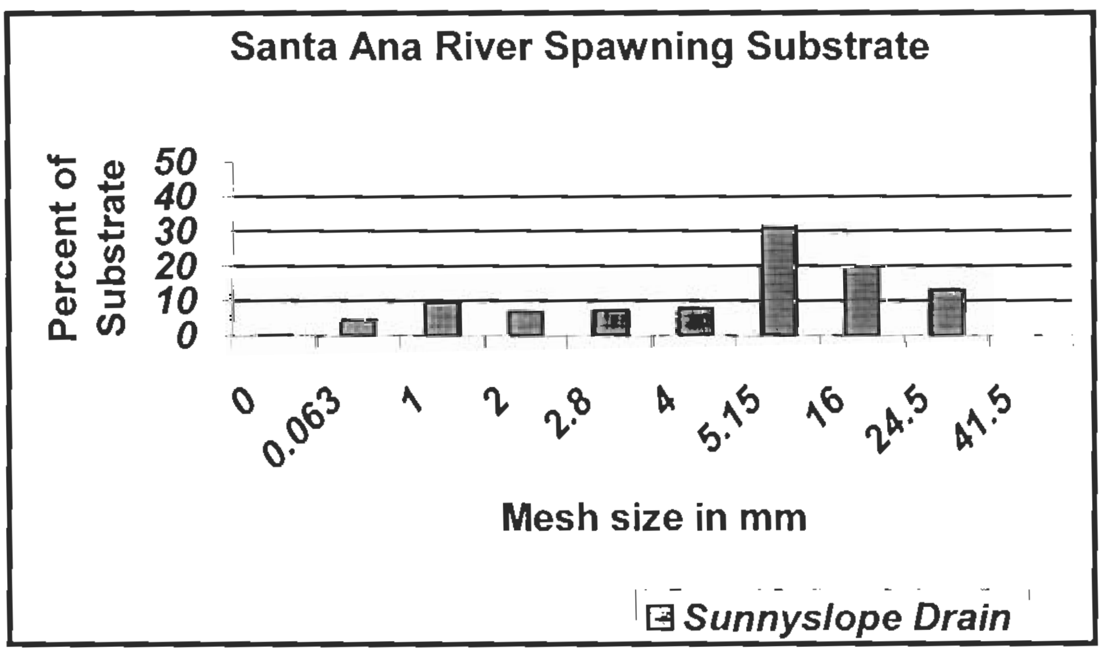
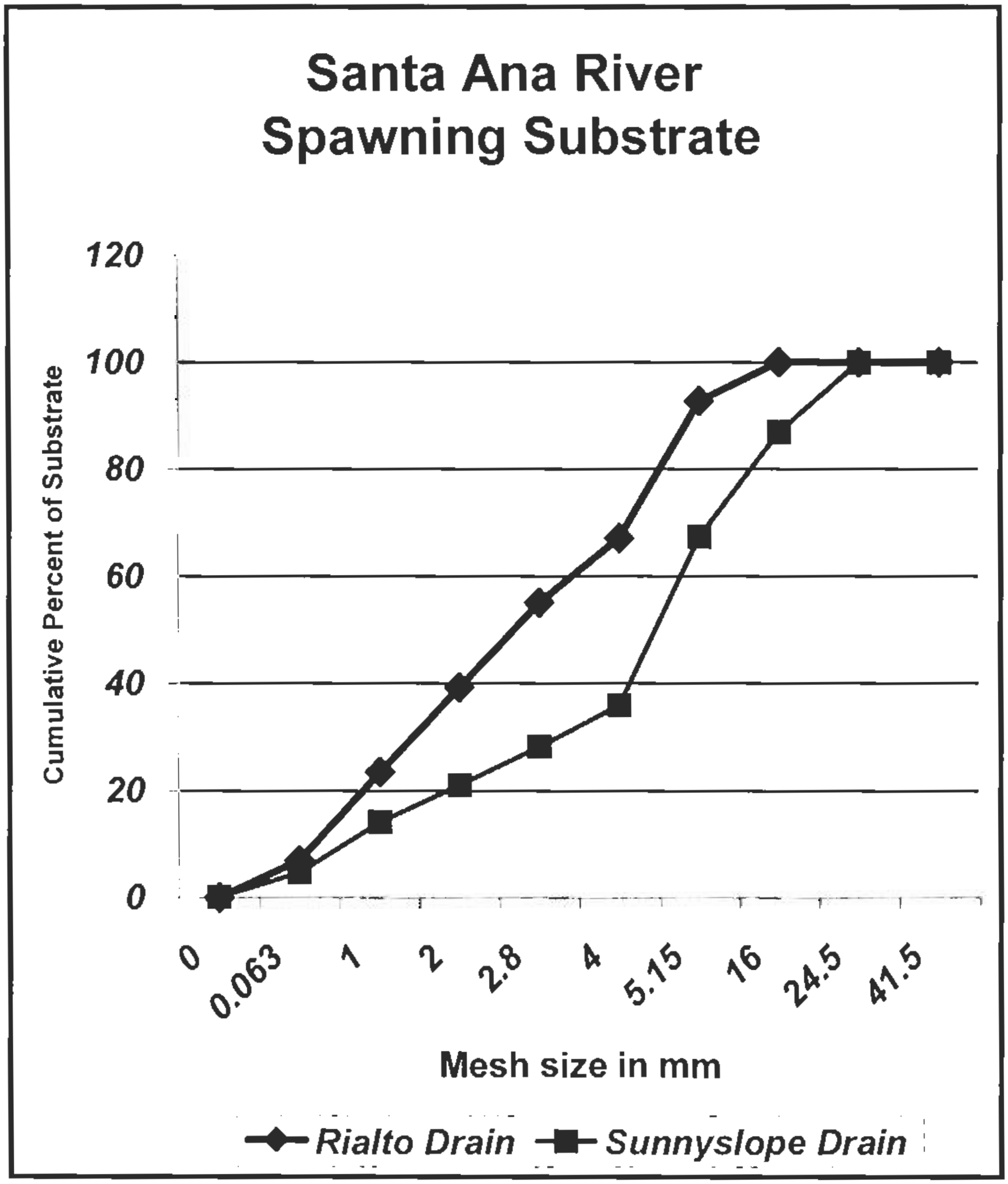


Figure 12. Cumulative percent curves for sediment composition at the two observed spawning sites.



## E. Observations on Larvae.

As described above, larvae appeared in Sunnyslope Creek on 31 March, Rialto Drain on 7 April. However, larvae were not detected in the mainstem at Mission Boulevard until 29 April, which raises the possibility that the larvae found in the mainstem had drifted out of the tributaries. Larval drift is a common feature of the life history of riverine suckers (Kennedy and Vinyard 1997).

Because of the abundance of the larvae, the access, and the ease of viewing, most observations of larvae were made in Sunnyslope Creek. Observations were made from the appearance of larvae on 31 March through mid-May when the larvae disappeared.
Larvae were almost always associated with specific habitat characteristics. Flow is low and consequently the bottom substrate is usually silt. Fry are most commonly found in shallow water 5-10 cm deep. They may or may not be associated with emergent vegetation or algae. However, in Rialto Drain they were frequently associated with small pockets of shallow water associated with an algal mat. These habitat characteristics apply to Sunnyslope Creek, Rialto Drain and the mainstem (see Photo 22).

Photo 23. Larval habitat in Sunnyslope Creek.

As part of the larval investigations SMEA devised a method of reliably recognizing larval suckers based on fin position, post anal distance and distribution of melanophores. This allows capture of larvae, and their identification in a petri dish without any larval mortality. All SMEA personnel were trained in larval identification. This technique will prove beneficial for more detailed larval studies next year.

The following three photographs show the development of larval Santa Ana suckers from just post-gravel emergence (6 mm total length (TL)) until they transform and settle to the substrate (15 mm TL).

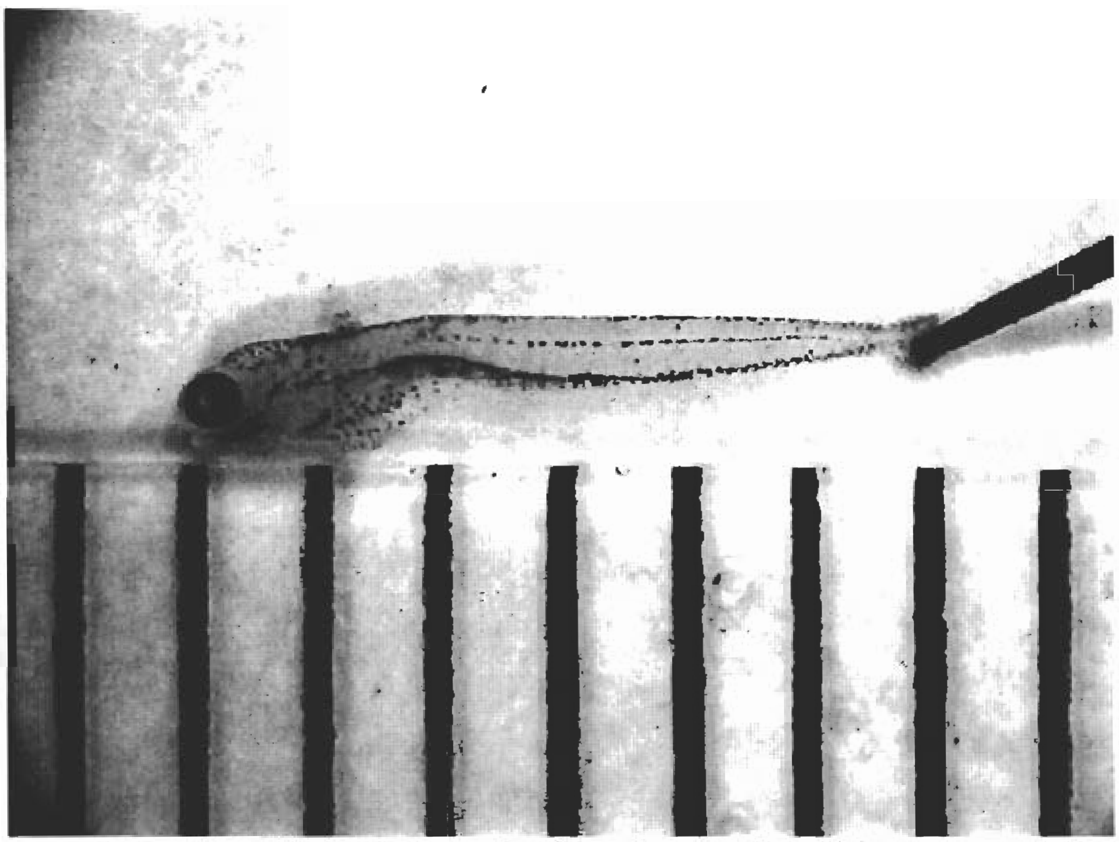


Photo 24. Santa Ana sucker fry at 6 mm TL from Rialto Drain.

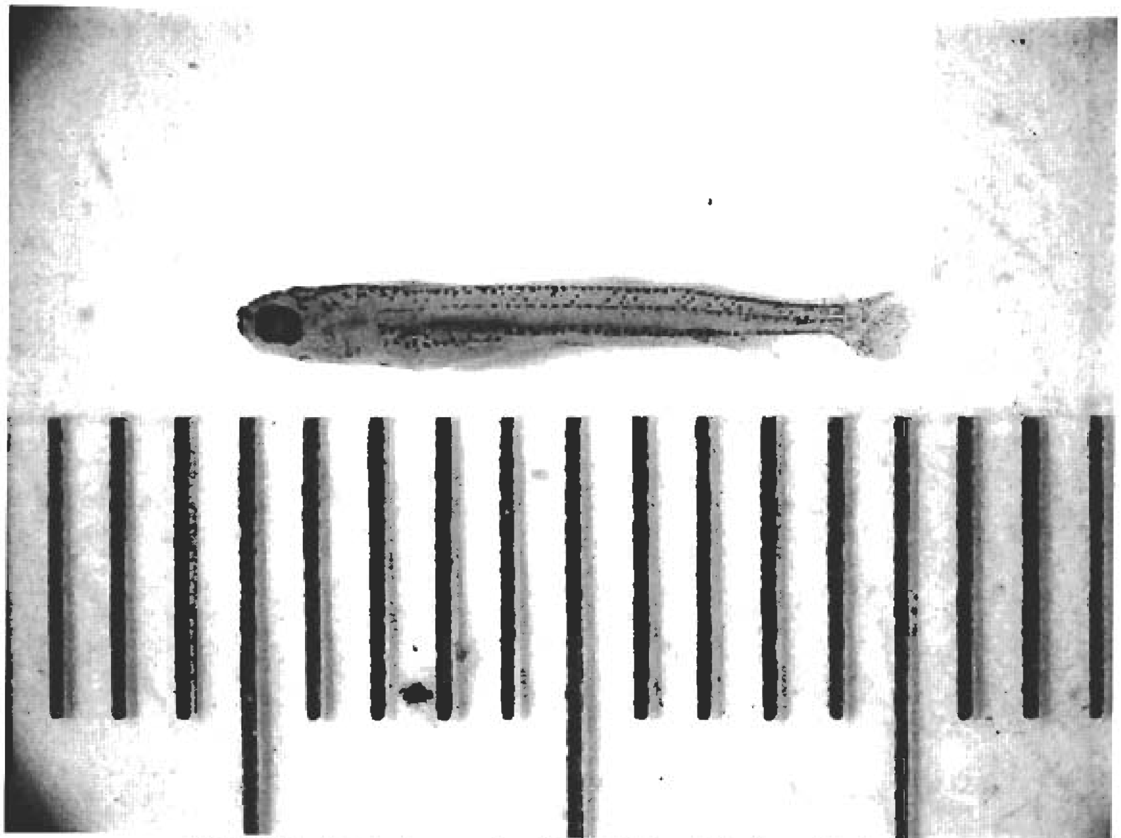


Photo 25. Santa Ana sucker fry at 10mm TL from Rialto Drain.

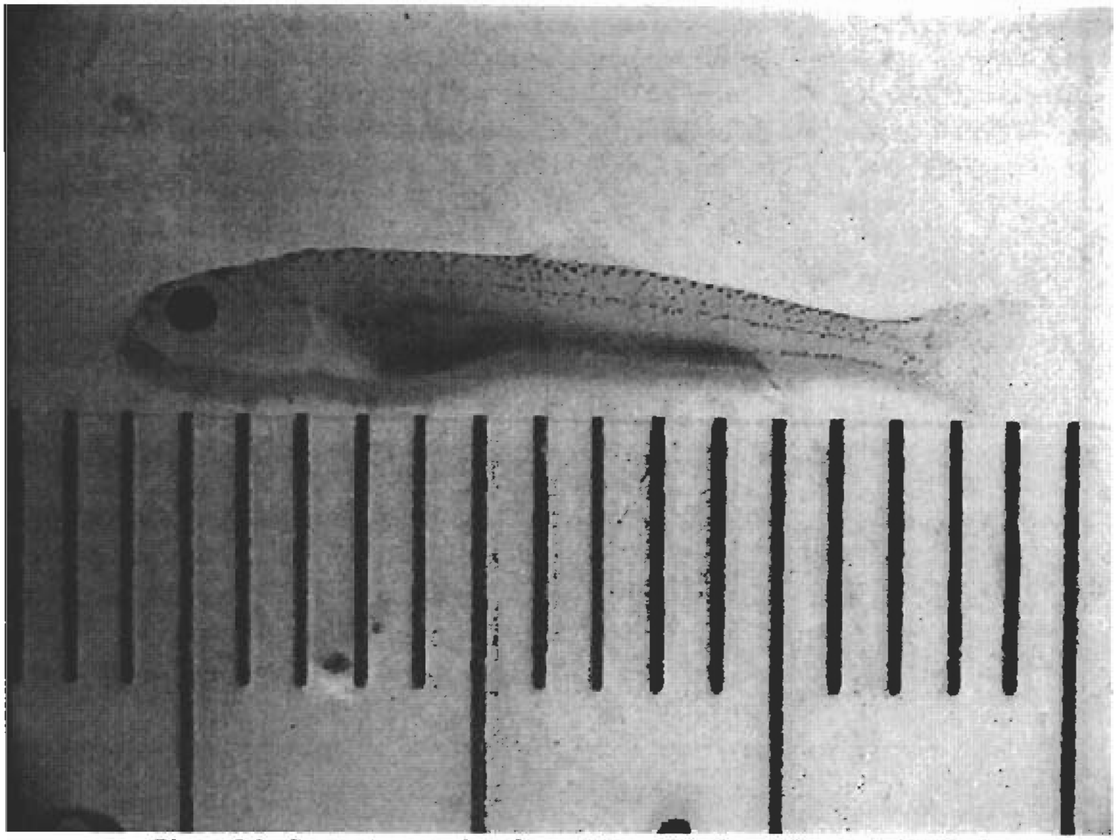


Photo 26. Santa Ana sucker fry at 15mm TL from Evans Lake Drain.

In order to study the fry it is important to be able to identify sucker fry. Three cyprinid fishes potentially reproduce at a similar time and are found sympatrically with the sucker in the Santa Ana River. The arroyo chub is native to the drainage, but the other two cyprinids, the fathead minnow and the carp, are exotics. Although other fishes such as mosquitofish, bullheads and cichlids are present; their larvae are easily distinguished from the sucker larvae. The following three composite photographs illustrate the key characteristics allowing the identification of sucker larvae.

Photo 27. (following page)

**Lateral View of Fry**

**Santa Ana Sucker**

Larvae are elongate, and later developed specimens show the presence of a sub-terminal mouth (white arrow). Larvae have a row of melanophores that extends forward from the caudal base about three quarters or more of the body along the lateral line (black arrow). Sucker larvae lack a distinct caudal spot at the caudal base but have melanophores extending to the end of the caudal rays. The dorsal fin base has a row of melanophores on each side.

**Arroyo Chub**

Larvae have a row of melanophores that extends forward from the caudal base about three quarters or more of the body along the lateral line (black arrow). Chubs have a large caudal spot with multiple rows of melanophores (white arrow). Larvae have a fairly dark dorsal fin base.

**Carp**

Carp larvae have a vertical bar (arrow) of melanophores at the base of the caudal fin bounded posteriorly by a depigmented area.

**Fathead Minnow**

Larvae lack the pigments and have a single lateral pigment line (arrow) on the posterior half of the body. Fathead larvae have a small caudal spot made of a few melanophores.

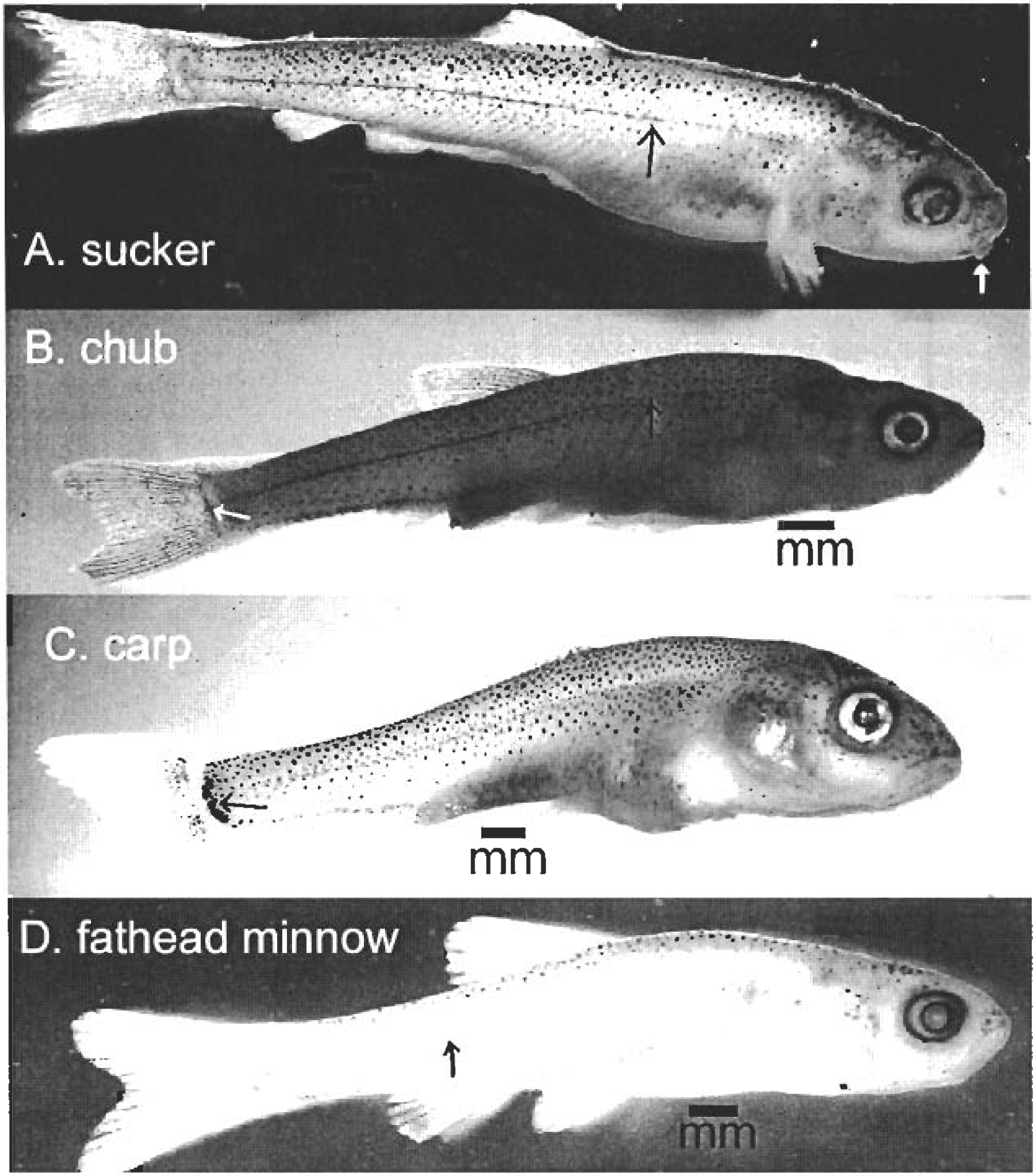

A. sucker
B. chub
mm
C. carp
mm
D. fathead minnow
mm

Photo 28. (following page)

**Lateral View of Fry – Anal Fin**

Sucker larvae can be distinguished by the position of the anal fin, where the distance from anal fin origin to tip of snout, is 66% of the total length or greater.

**A. Santa Ana Sucker**
Total Length = 11 mm Anal Distance = 8.5 mm
Anal Distance/ Total Length X 100% = 77.3%

**B. Arroyo Chub**
Total Length = 15 mm Anal distance = 9.25 mm
Anal distance/Total length X 100% = 61.7%

**C. Carp**
Total Length = 15.0 mm Anal distance = 8.5 mm
Anal distance = 56.7%

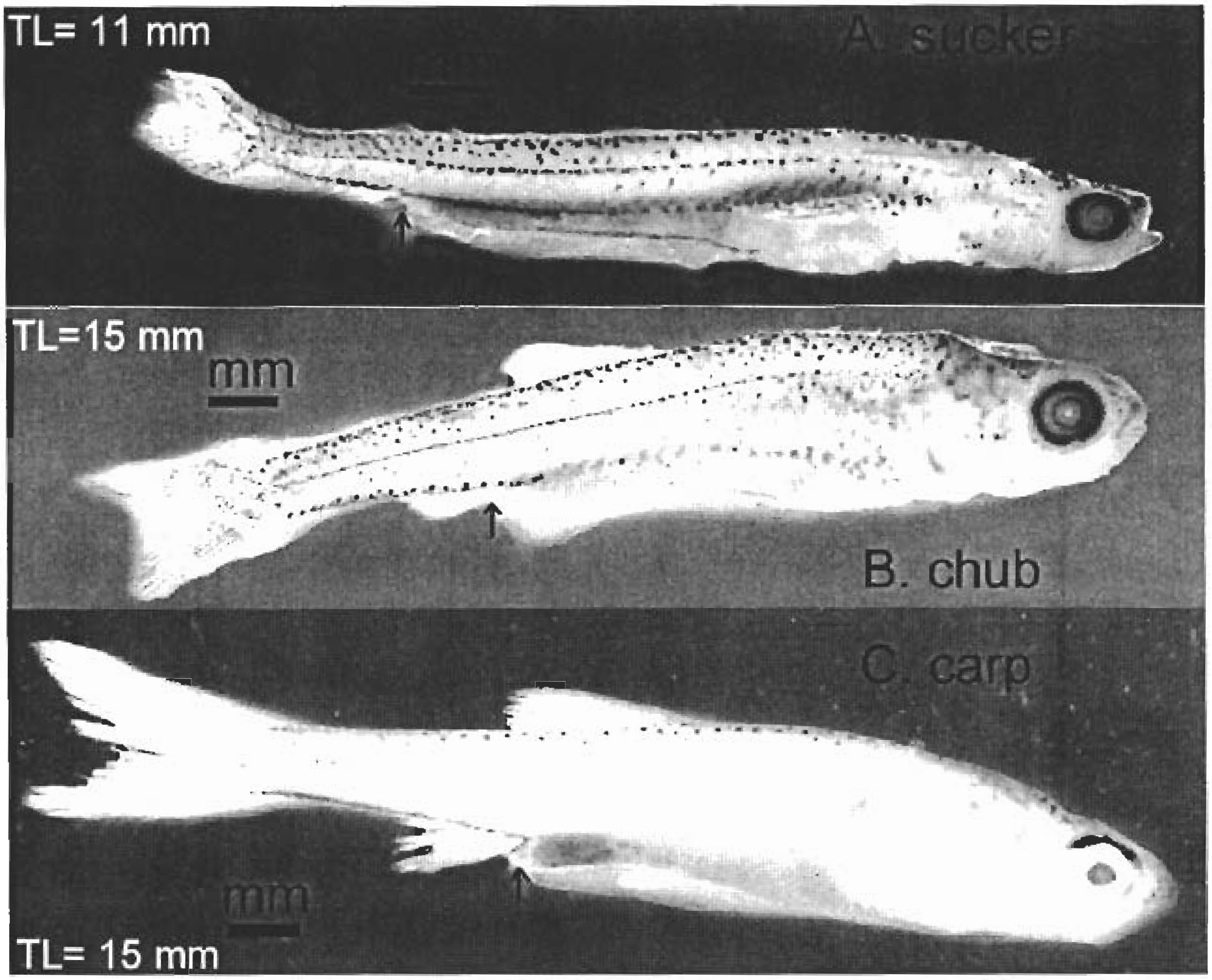

TL= 11 mm
A. sucker
TL=15 mm
mm
B. chub
C. carp
mm
TL= 15 mm

Photo 29. (following page)

**Dorsal View of Fry**

**Santa Ana Sucker**

Larvae are very dark with a large number of melanophores found dorsally and laterally. Larvae, up to 15 mm SL, have two separate distinct rows (black arrows) of melanophores on either side of the mid dorsal ridge.

**Arroyo Chub**

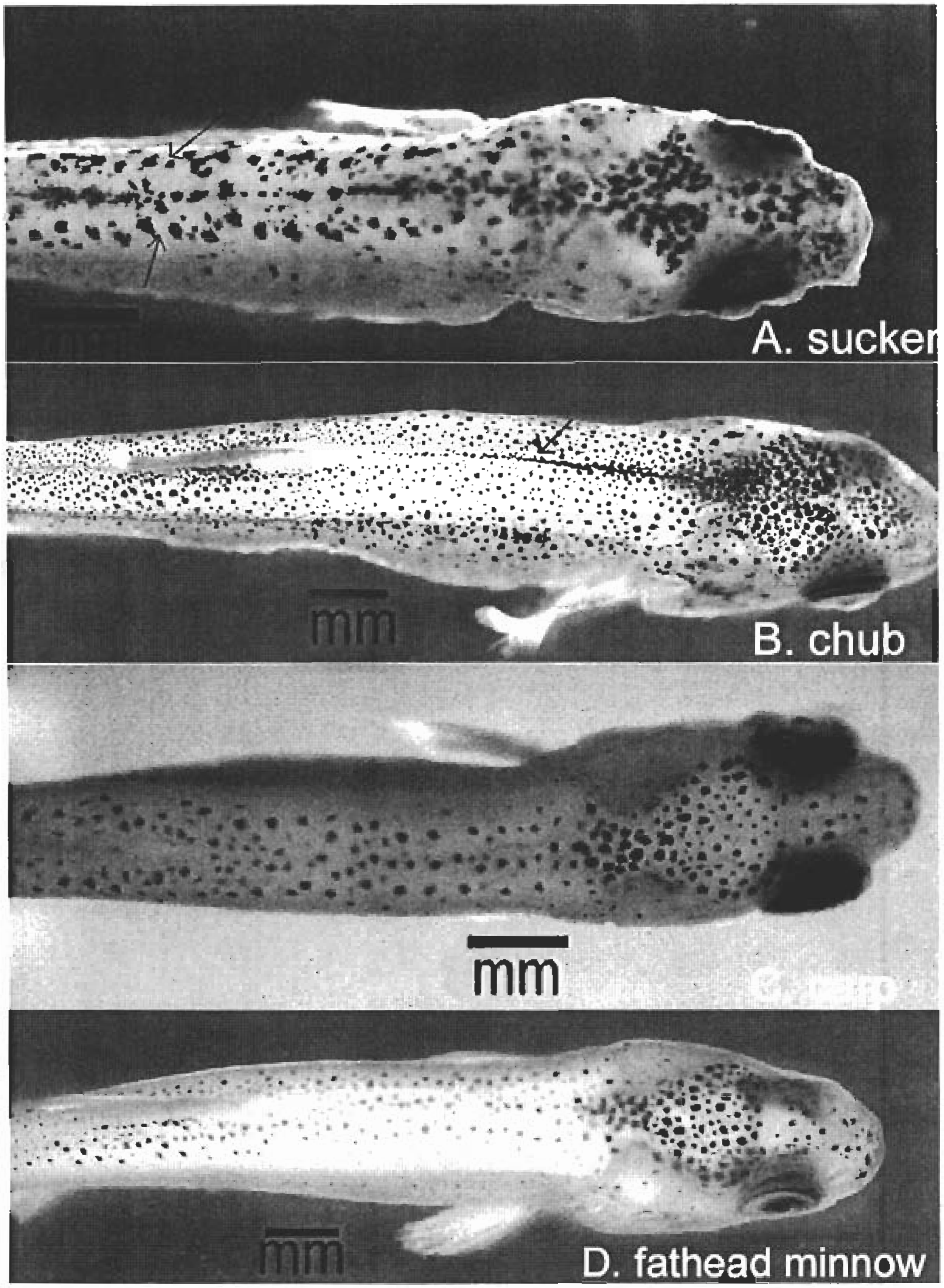
Larvae are dark with a large number of melanophores found dorsally and laterally. Larvae have a sharp dark single line of melanophores (arrow) extending from the occipital patch.

**Carp**

Larvae are robust with thickened bodies, paler, and have a uniform dusting of melanophores on the dorsal and lateral side.

**Fathead Minnow**

Larvae are slender and attenuated in body and have paler melanophores dorsally and laterally.


A. sucker
mm
B. chub
mm
mm
D. fathead minnow
mm

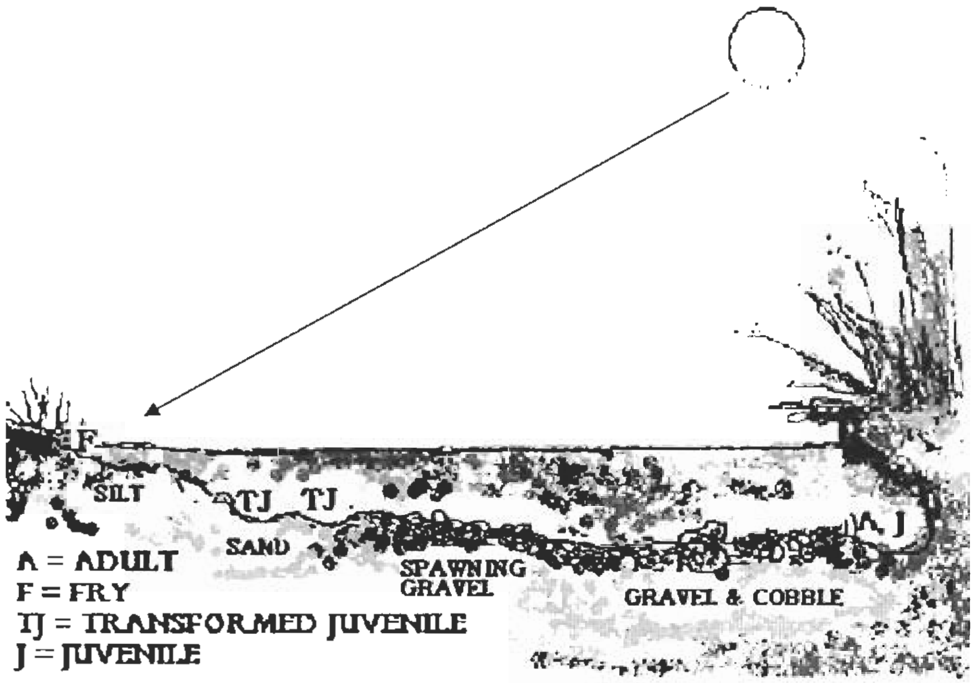



Figure 13. This is a diagrammatic representation of an idealized cross-section of the Santa Ana River showing habitat utilization by the Santa Ana sucker.

## VII. Habitat Preferences of Various Sucker Life Stages.

The following figures show examples of the typical microhabitats shown in the idealized cross-sectional diagram (Figure 13)

Photo 30 shows an undercut bank with vegetation adjacent to deep flowing water in Sunnyslope Creek. Within a few meters upstream there is a shallow area of typical spawning gravel. Several ripe adults were found in this spot in February of 2001.

Photo 31 shows the fry habitat along the left edge of the stream adjacent to the vegetation. Depths here where the fry were found were about 10cm. with undetectable flow. No fry were found on the right edge of the stream at the same time. This is consistent with our hypothesis that the fry tend to be found at places with maximum sun exposure in the afternoon when water temperatures tend to be higher.

Photo 30. Adult sucker habitat, Sunnyslope creek, February 2001. Arrows indicate deep area of undercut bank.

Photo 31. Sunnyslope Creek. White arrows indicate areas where fry were found.

Photo 32 shows the precise places where sucker fry where found on May 11, 2002. This was a year without significant flushing flows and fry appeared to be much more numerous throughout the season than in 2001, when more high flow events occurred. The sticks in the water in the foreground (black arrows) and background indicate the precise location of fry. Fry were found also in the shallow water in the right foreground (white lines) where a set of measurements was taken of depth and distance from the edge at regular intervals, noting the presence or absence of fry at each spot. The depths where fry were found here range from about 3 to 10 cm. None were found at shallower depths and very few deeper (maximum fry depth here was 12cm.).The range of depths in the area measured was 0 to 25cm.

Photo 32. Fry habitat, SAR mouth of Sunnyslope Creek, May 2002.

Note also the open sun exposure at this locality. Fry tend to be found on the downstream side of flow obstructions such as vegetation (see Photo 33) and sand bars such as this one where flow is reduced. Note dark silt material on the sandy substrate. This silt material tends to settle out of the water where the water flow rate is reduced, and the darkly pigmented fry match well with this background. We have not been able to test if the fry are picking out the shallow depth, the lack of flow, the dark silt on the substrate, or a combination of these factors.

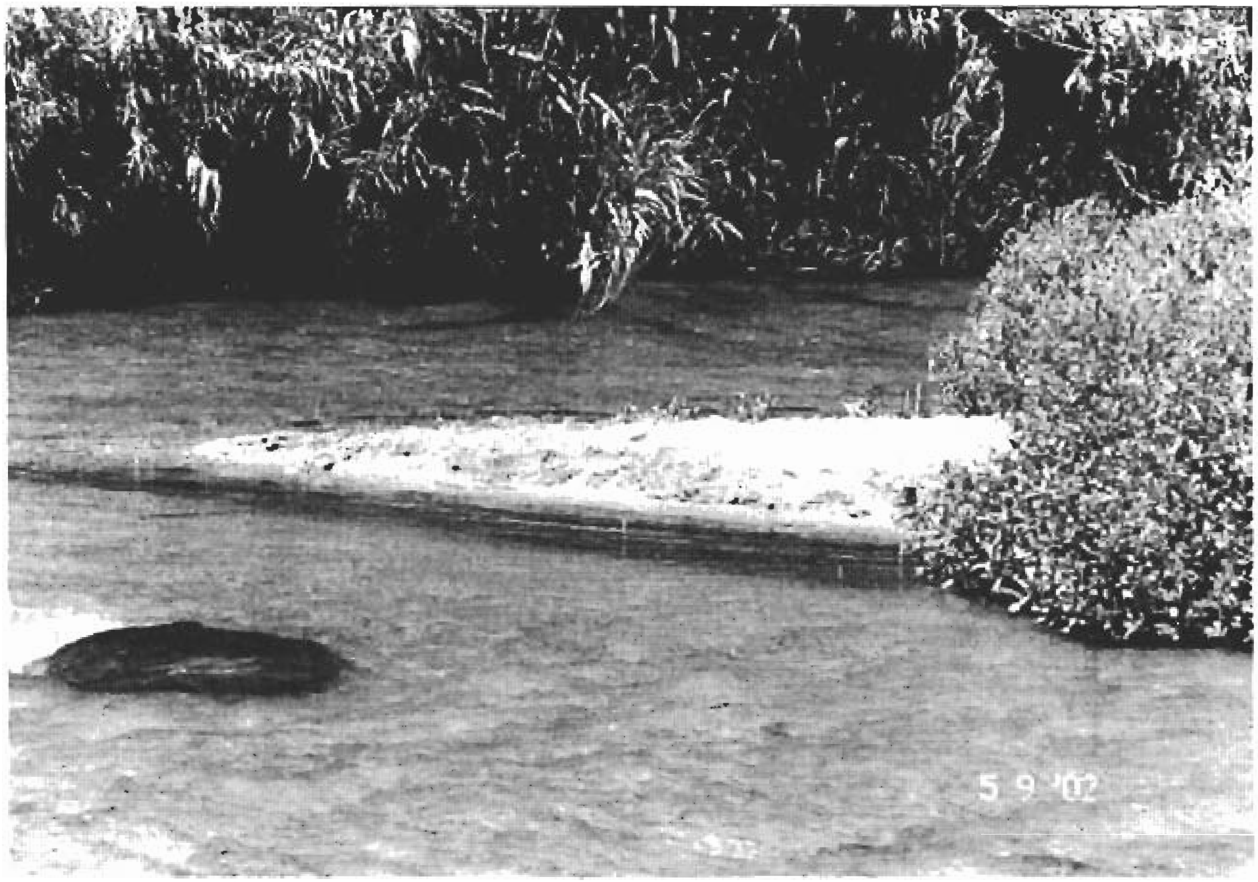



Photo 33. Fry habitat, SAR at mouth of Sunnyslope Creek, May 2002

All of the fry found here were over the dark silt material. Photo 34 shows a close up view of the fry in the foreground of Photo 33. The depth at these spots was about 5cm. Note the rippled appearance of the water surface and the strands of green algae, indicating that the position of fry is adjacent to slowly flowing water that could bring plankton food items within reach of the fry without subjecting them to the continuous impact of flowing water. Fry appeared to be usually above the bottom, about midway up the water column.

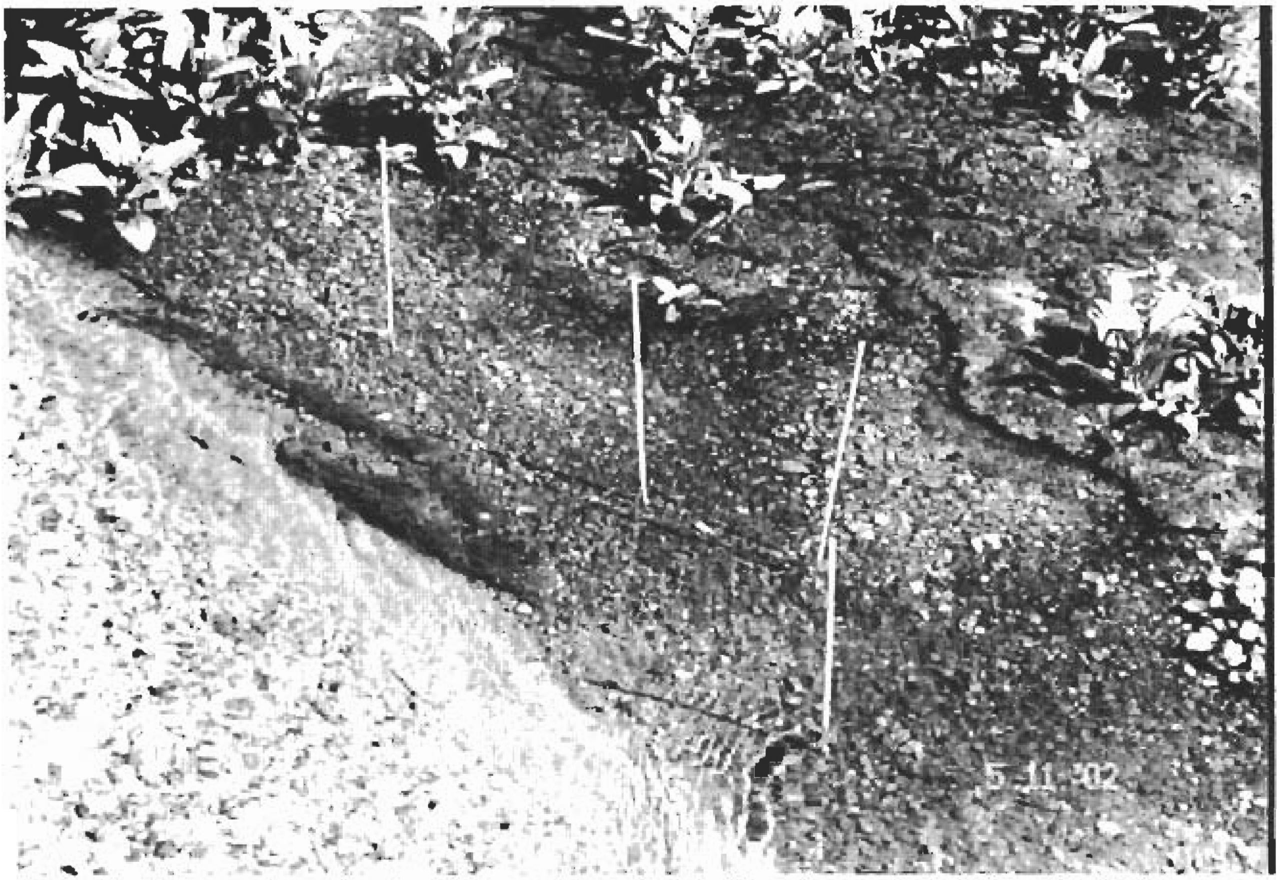
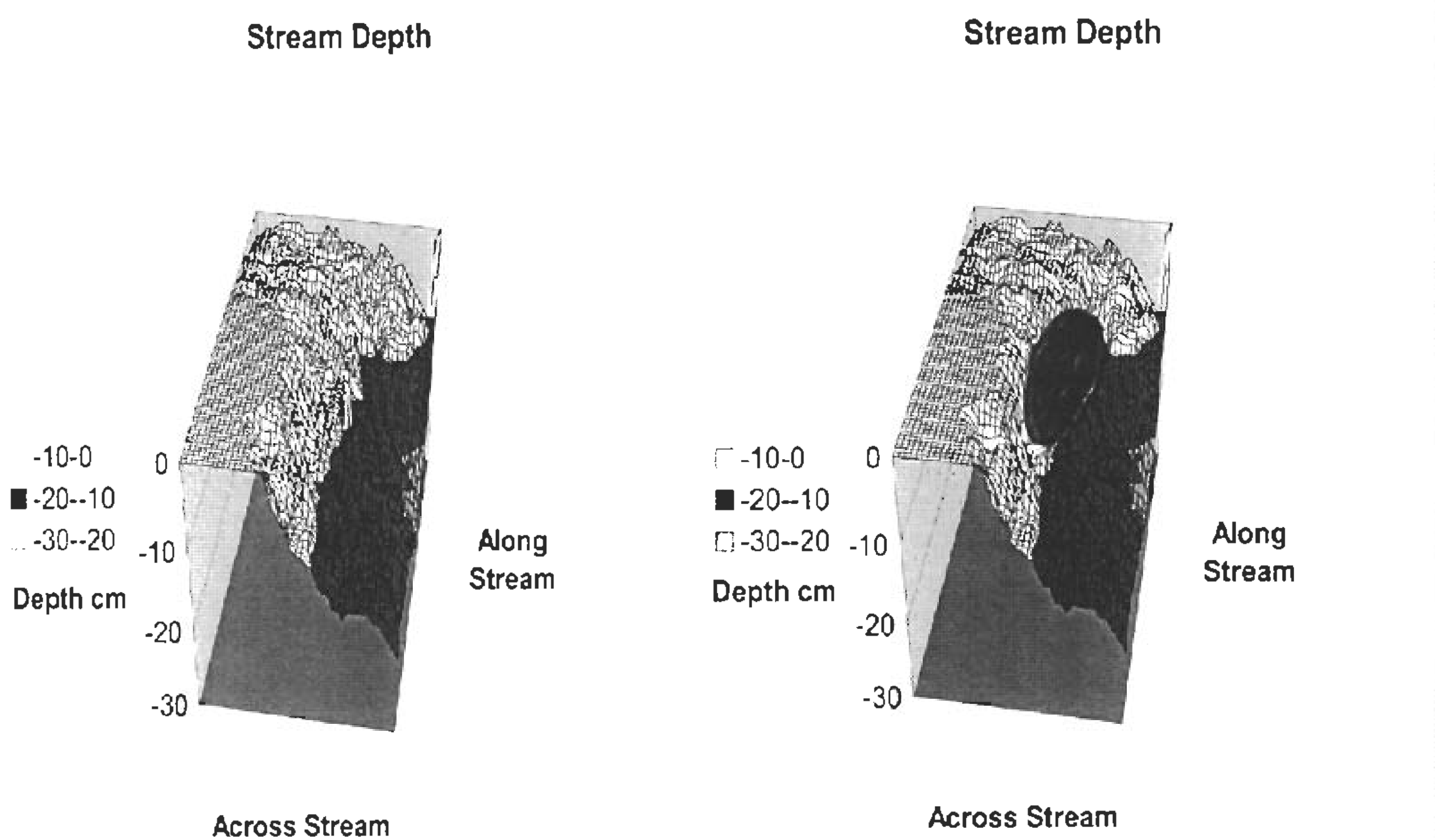


Photo 34. Close up view of sucker fry at position of sticks from foreground of Photo 35, SAR at mouth of Sunnyslope Creek, May 2002.

In this small patch of stream (205 cm wide by 365 cm along stream flow), sucker fry were found in depths of 5-10 cm primarily on a small shelf between the shore and the deeper water. This is shown graphically in Figure 14.

Figure 14. The left graph below is a map of the river depths; the graph on the right is the same except that the orange area represents the general area in which sucker fry were found. In this sample, it is clear that fry are not dispersed randomly, but are clustered in a specific area.



We also hypothesize that exposure to the sun in shallow water could also be a positive factor that the fry may be picking out. Photo 35 shows fry habitat at Mission Blvd Bridge in the afternoon. Note the sticks indicating the location of fry and the shadow of the bridge. Counts of fry in the shade and in the sun may suggest a greater concentration of fry in the sun than in the shade. There were 21 fry in 7.3meters of shaded stream edge (2.9 fry per meter) and 52 fry were found in 12.5 meters of sunny stream edge (4.2 fry/meter). The stream edge observed was judged to be approximately uniform with regard to other probable important factors for fry habitat and the amount fry habitat.


Photo 35. Sucker Fry habitat at Mission Blvd. Bridge, May 2002.

Figure 36. Juvenile sucker habitat, SAR at mouth of Sunnyslope Creek, May 2002. Pink streamer indicates position of fish at 13.5cm depth

**A. What We Know About Sucker Fry.**

The following is a summary of what we know or think we know about Santa Ana sucker fry in the Santa Ana River.

1. Breeding may begin as early as late January, perhaps in response to warm water periods.

2. Breeding may be mainly or even exclusively in side channels (e.g. Sunnyslope Creek) early in the season because water here warms faster and there may be less chance of eggs/fry being washed out by high flow because rain events may not impact all channels as much as the mainstem.

3. Fry and probably eggs in gravel are eliminated by high flow events.

4. Breeding is in specific sites with spawning gravel of specific characteristics adjacent to breeding adult holding habitat characterized by deep points in the

stream, at the edge of stream, or adjacent to some cover such as vegetation or undercut banks.

5. Eggs spend some number of days in gravel, hatch as yolk sack fry and stay in gravel until at least 12mm SL; so, fry found that are much smaller are probably not suckers.

6. Fry initially appear at this size or larger at the edge of the stream, usually in very shallow depth (3-10 cm), often over dark silt that matches their color where flow is negligible, and in the proximity of emergent vegetation.

7. Fry are often found along the edge of a sand bar or bank, just down stream from vegetation that protrudes into the flowing water, producing areas of negligible flow where silt settles out on the bottom.

8. The position of fry is in the approximate middle of the water column, adjacent to flowing water that may bring planktonic food items within reach. Actual feeding habits are not known.

9. Fry may take refuge in edge vegetation at night and/or during cloudy conditions and times of increased flow.

10. Fry emerge from vegetation during sunny conditions and "bask" in the sun. Their dark color may serve multiple functions: crypsis, heat absorption, and UV protection.

11. Fry may selectively occupy shallow edgewater habitat that is exposed most directly to the afternoon sun when water temperatures are highest. In our study area this is the north side of the stream or individual channel of the mainstem.

12. The deeper flowing water of any channel is probably a barrier for fry so they cannot get across to bask on both sides.

13. Fry may drift at night (or other times) but we have not yet tested this. Other species of suckers are known to drift.

14. SAS newly transformed into juveniles are about the same standard length as the largest fry, and are found in depths greater than 10cm. on the bottom over sandy substrate, often in small depressions in the bottom contours adjacent to the fry habitat.

## VIII. Habitat Utilization by Adult and Juvenile Santa Ana Suckers.

During the 2003 field season SMEA initiated the collection of data designed to determine habitat utilization/preferences of adult and juvenile Santa Ana Suckers in the Santa Ana River. It is anticipated that this dataset will be enhanced over the next 2 field seasons.

**A. Methods.**

The habitat utilization study addresses the question of whether the fish are using the habitat in proportion to the availability of the habitat or whether they are over-utilizing some habitat. If they are over-utilizing some habitats, it suggests there is preferential use of those habitats, and thus these data can provide guidelines for enhancing sucker habitat. The current analysis is based on observations of 137 juvenile and 85 adult Santa Ana suckers.

Habitat type availability was based on a visual examination of each stream reach. Substrate, depth and bottom velocity availability was gathered from cross-sectional data. Cross-sections were made every 10 meters in the study reaches, and data was collected every 0.5 meters across the stream. Consequently, total availability for depth, substrate and bottom velocity is based upon approximately 600 point measurements.

Habitat utilization observations were made by crawling upstream using a viewing tube (Photo 37). A single observer was used in all cases. When fish were spotted, a color-coded marker was placed to indicate the location of the fish (Photo 38). The marker was a lead sinker with attached flagging material. The color of the flagging material indicated the species and the shape of the sinker indicated whether the individual was an adult, juvenile or fry. The observer zigzagged upstream while making observations, in order to minimize the possibility of observing fish that had recently been disturbed by prior observations. Haglund and Baskin had previously determined that this technique could be used to view fish without disturbing them. Thus, the locations observed were locations selected by undisturbed fish.

Once the observer had finished the stream reach, a data collection crew collected habitat data at the location of each marker. Substrate, habitat type, depth and flow data were taken at each marker.

Photo 37. An observer crawling upstream to locate fish during the collection of habitat utilization data.

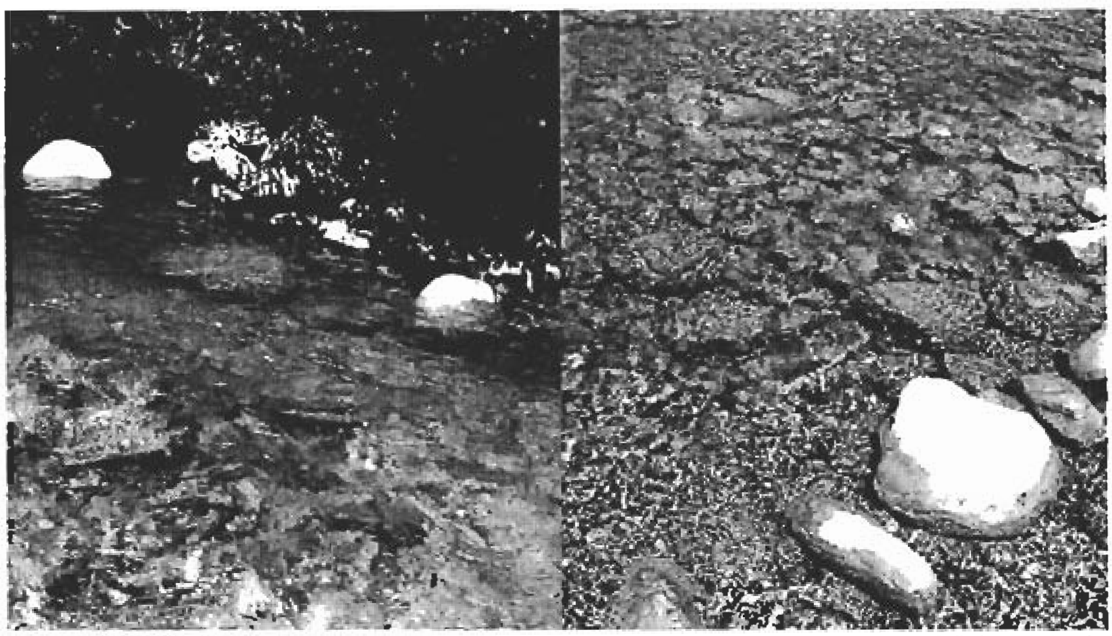


Photo 38. These two photographs show markers indicating the location of fish marked during observation. The left photo shows a blue flag indicating an adult sucker, while the right photo shows a pink tag indicating a juvenile sucker.

**B. Data Collected.**
The following table shows the dates and locations that observations were made, as well as, the number of fish observed (data points).

| DATE | LOCATION | NUMBER OF FISH OBSERVED | |
|---|---|---|---|
| | | Juveniles | Adults |
| 11 August 2003 | Upstream Mission Blvd. | 54 | 28 |
| 16 August 2003 | Upstream Highway 60 | 65 | 20 |
| 18 August 2003 | Downstream Riverside Dr. | 18 | 37 |
| TOTAL | | 137 | 85 |

**C. Habitat Availability.**
The following tables present the availability of habitat types, substrate, depth, and bottom velocity.

**Habitat Type Availability**

| Habitat Type | Individual Sites Surveyed Availability as Percent of Total | | | Total Availabilty All Sites Combined |
|---|---|---|---|---|
| | Mission Blvd | Highway 60 | Riverside Dr | |
| **Edgewater** | 10 | 15 | 10 | 11.7 |
| **Glide** | 4 | 12 | 3 | 6.3 |
| **Riffle** | 70 | 61 | 81 | 70.7 |
| **Run** | 15 | 10 | 5 | 10.0 |
| **Pool** | 1 | 2 | 1 | 1.3 |

**Substrate Availability**

| Substrate Type | Individual Sites Surveyed Availability as Percent of Total | | | Total Availabilty All Sites Combined |
|---|---|---|---|---|
| | Mission Blvd | Highway 60 | Riverside Dr | |
| **Silt** | 2.4 | 1.9 | 2.4 | 2.2 |
| **Silt/sand** | 7.2 | 4.5 | 15.9 | 7.7 |
| **Sand** | 68.3 | 76.0 | 22.2 | 62.6 |
| **Sand/gravel** | 19.2 | 13.6 | 48.4 | 22.5 |
| **Gravel** | 1.2 | 0.3 | 4.8 | 1.5 |
| **Sand/cobble** | 0.0 | 2.9 | 5.6 | 2.7 |
| **Gravel/cobble** | 0.0 | 0.6 | 0.8 | 0.5 |
| **Cobble** | 0.6 | 0.0 | 0.0 | 0.2 |
| **Boulder** | 1.2 | 0.0 | 0.0 | 0.3 |

### Depth Availability

| Depth (cm) | Individual Sites Surveyed Availability as Percent of Total | | | Total Availabilty All Sites Combined |
|---|---|---|---|---|
| | Mission Blvd | Highway 60 | Riverside Dr | |
| **0-5** | 1.8 | 5.6 | 7.1 | 4.8 |
| **6-10** | 4.2 | 18.0 | 6.3 | 11.7 |
| **11-15** | 10.2 | 25.9 | 10.3 | 18.2 |
| **16-20** | 16.2 | 16.4 | 14.3 | 15.9 |
| **21-25** | 15.0 | 14.8 | 11.1 | 14.0 |
| **26-30** | 19.8 | 8.2 | 9.5 | 11.7 |
| **31-35** | 12.0 | 6.9 | 10.3 | 9.0 |
| **36-40** | 15.0 | 1.3 | 11.1 | 7.2 |
| **41-45** | 1.8 | 1.0 | 10.3 | 3.2 |
| **46-50** | 1.2 | 0.7 | 1.6 | 1.0 |
| **51-55** | 1.8 | 0.7 | 2.4 | 1.3 |
| **56-60** | 0.6 | 0.0 | 2.4 | 0.7 |
| **61-65** | 0.6 | 0.3 | 1.6 | 0.7 |
| **66-70** | 0.0 | 0.3 | 1.6 | 0.5 |

### Bottom Velocity Availability

| Bottom Velocity (fps) | Individual Sites Surveyed Availability as Percent of Total | | | Total Availability All Sites Combined |
|---|---|---|---|---|
| | Mission Blvd | Highway 60 | Riverside Dr | |
| **0.00 – 0.50** | 15.1 | 17.2 | 26.6 | 18.6 |
| **0.51 – 1.00** | 16.9 | 20.8 | 16.9 | 18.9 |
| **1.01 – 1.50** | 18.7 | 27.9 | 27.4 | 25.3 |
| **1.51 – 2.00** | 24.1 | 19.2 | 20.2 | 20.7 |
| **2.01 – 2.50** | 18.7 | 14.0 | 6.5 | 13.7 |
| **2.51 – 3.00** | 6.6 | 1.0 | 2.4 | 2.8 |

**D. Habitat Utilization.**
The following tables present the data on the habitat utilization of juvenile and adult Santa Ana suckers with respect to habitat type, substrate type, depth and bottom velocity.

## Juvenile Sucker Habitat Type Utilization

| Habitat Type | Individual Sites Surveyed Utilization as Percent of Total Mission Blvd N=54 | Highway 60 N=65 | Riverside Dr N=18 | Total Utilization All Sites Combined N=137 |
|---|---|---|---|---|
| Edgewater | 42.6 | 0.0 | 0.0 | 16.8 |
| Glide | 22.2 | 0.0 | 0.0 | 8.8 |
| Riffle | 33.3 | 95.4 | 94.4 | 70.8 |
| Run | 1.9 | 4.6 | 5.6 | 3.6 |
| Pool | 0.0 | 0.0 | 0.0 | 0.0 |

## Adult Sucker Habitat Type Utilization

| Habitat Type | Individual Sites Surveyed Utilization as Percent of Total Mission Blvd N=28 | Highway 60 N=20 | Riverside Dr N=37 | Total Utilization All Sites Combined N=85 |
|---|---|---|---|---|
| Edgewater | 0.0 | 0.0 | 0.0 | 0.0 |
| Glide | 0.0 | 0.0 | 0.0 | 0.0 |
| Riffle | 10.7 | 55.0 | 32.4 | 30.6 |
| Run | 89.3 | 10.0 | 40.5 | 49.4 |
| Pool | 0.0 | 35.0 | 27.0 | 20.0 |

## Juvenile Sucker Substrate Type Utilization

| Substrate Type | Individual Sites Surveyed Utilization as Percent of Total Mission Blvd N=54 | Highway 60 N=65 | Riverside Dr N=18 | Total Utilization All Sites Combined N=137 |
|---|---|---|---|---|
| Silt | 0.0 | 0.0 | 0.0 | 0.0 |
| Silt/sand | 38.9 | 0.0 | 0.0 | 15.3 |
| Sand | 38.9 | 10.8 | 0.0 | 20.4 |
| Sand/gravel | 5.6 | 78.5 | 83.3 | 50.4 |
| Gravel | 0.0 | 0.0 | 16.7 | 2.2 |
| Sand/cobble | 0.0 | 0.0 | 0.0 | 0.0 |
| Gravel/cobble | 0.0 | 10.8 | 0.0 | 5.1 |
| Cobble | 0.0 | 0.0 | 0.0 | 0.0 |
| Boulder | 0.0 | 0.0 | 0.0 | 6.6 |

## Adult Sucker Substrate Type Utilization

| Substrate Type | Individual Sites Surveyed Utilization as Percent of Total | | | Total Utilization All Sites Combined N=85 |
|---|---|---|---|---|
| | Mission Blvd N=28 | Highway 60 N=20 | Riverside Dr N=37 | |
| **Silt** | 0.0 | 0.0 | 0.0 | 0.0 |
| **Silt/sand** | 0.0 | 0.0 | 0.0 | 0.0 |
| **Sand** | 35.7 | 40.0 | 0.0 | 21.2 |
| **Sand/gravel** | 35.7 | 25.0 | 54.1 | 41.2 |
| **Gravel** | 10.7 | 35.0 | 45.9 | 31.8 |
| **Sand/cobble** | 0.0 | 0.0 | 0.0 | 0.0 |
| **Gravel/cobble** | 0.0 | 0.0 | 0.0 | 0.0 |
| **Cobble** | 0.0 | 0.0 | 0.0 | 0.0 |
| **Boulder** | 17.9 | 0.0 | 0.0 | 5.9 |

## Juvenile Sucker Depth Utilization

| Depth (cm) | Individual Sites Surveyed Utilization as Percent of Total | | | Total Utilization All Sites Combined N=137 |
|---|---|---|---|---|
| | Mission Blvd N=54 | Highway 60 N=65 | Riverside Dr N=18 | |
| **0-5** | 0.0 | 0.0 | 0.0 | 0.0 |
| **6-10** | 0.0 | 0.0 | 0.0 | 0.0 |
| **11-15** | 0.0 | 0.0 | 22.2 | 2.9 |
| **16-20** | 9.3 | 9.2 | 33.3 | 12.4 |
| **21-25** | 5.6 | 10.8 | 16.7 | 9.5 |
| **26-30** | 11.1 | 16.9 | 27.8 | 16.1 |
| **31-35** | 66.7 | 12.3 | 0.0 | 32.1 |
| **36-40** | 0.0 | 4.6 | 0.0 | 2.2 |
| **41-45** | 0.0 | 41.5 | 0.0 | 19.7 |
| **46-50** | 7.4 | 0.0 | 0.0 | 2.9 |
| **51-55** | 0.0 | 0.0 | 0.0 | 0.0 |
| **56-60** | 0.0 | 4.6 | 0.0 | 2.2 |
| **61-65** | 0.0 | 0.0 | 0.0 | 0.0 |
| **66-70** | 0.0 | 0.0 | 0.0 | 0.0 |

## Adult Sucker Depth Utilization

| Depth (cm) | Individual Sites Surveyed Utilization as Percent of Total<br>Mission Blvd N=28 | Highway 60 N=20 | Riverside Dr N=37 | Total Utilization All Sites Combined N=85 |
|---|---|---|---|---|
| 0-5 | 0.0 | 0.0 | 0.0 | 0.0 |
| 6-10 | 0.0 | 0.0 | 0.0 | 0.0 |
| 11-15 | 0.0 | 0.0 | 0.0 | 0.0 |
| 16-20 | 3.6 | 0.0 | 0.0 | 1.2 |
| 21-25 | 0.0 | 0.0 | 0.0 | 0.0 |
| 26-30 | 0.0 | 0.0 | 0.0 | 0.0 |
| 31-35 | 0.0 | 5.0 | 5.4 | 3.5 |
| 36-40 | 7.1 | 0.0 | 2.7 | 3.5 |
| 41-45 | 10.7 | 10.0 | 10.8 | 10.6 |
| 46-50 | 0.0 | 10.0 | 18.9 | 10.6 |
| 51-55 | 28.6 | 30.0 | 0.0 | 16.5 |
| 56-60 | 0.0 | 10.0 | 21.6 | 11.8 |
| 61-65 | 0.0 | 0.0 | 0.0 | 0.0 |
| 66-70 | 0.0 | 0.0 | 10.8 | 4.7 |
| 71+ | 50.0 | 35.0 | 29.7 | 37.7 |

## Juvenile Sucker Bottom Velocity Utilization

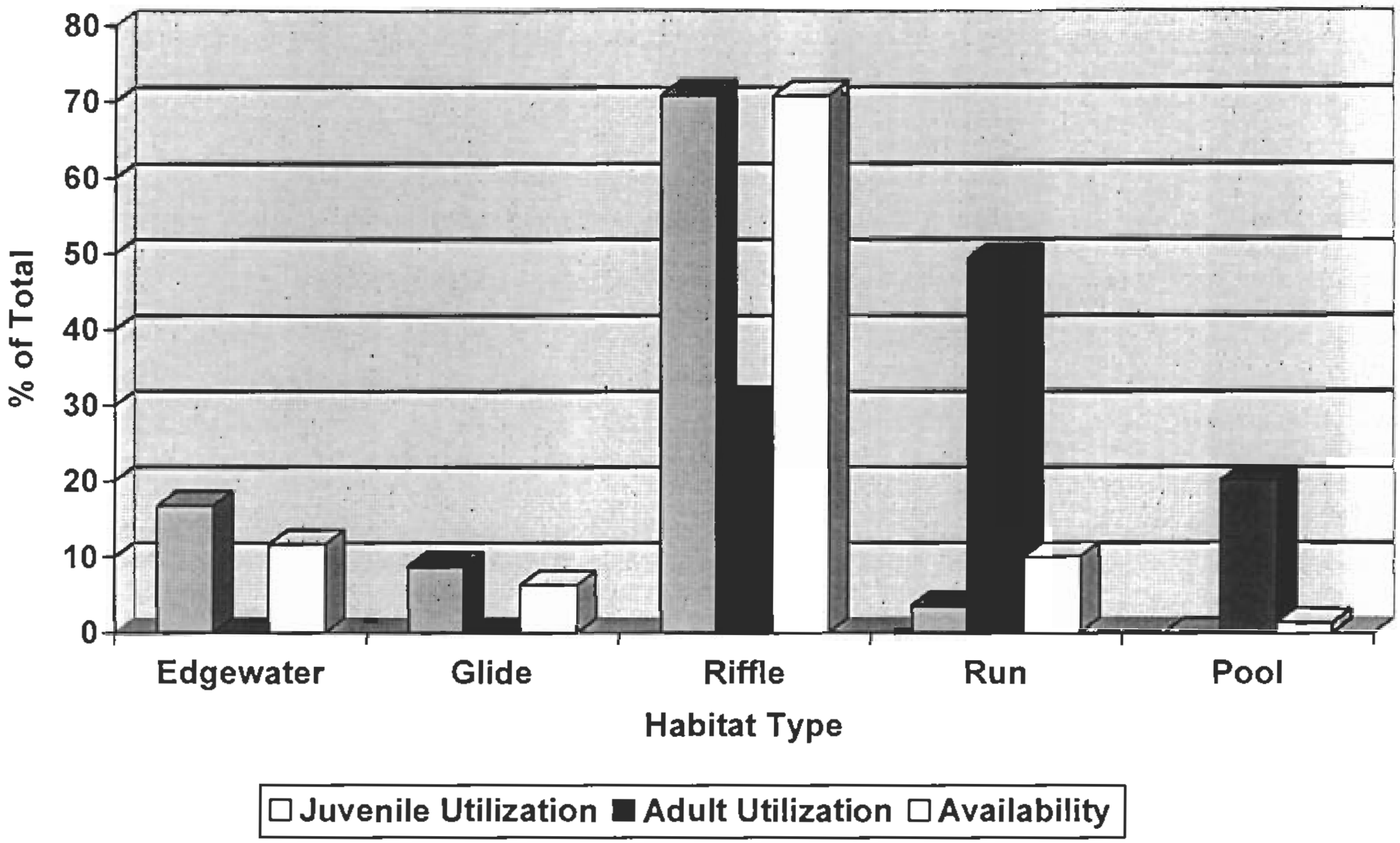
| Bottom Velocity (fps) | Individual Sites Surveyed Utilization as Percent of Total<br>Mission Blvd N=54 | Highway 60 N=65 | Riverside Dr N=18 | Total Utilization All Sites Combined N=137 |
|---|---|---|---|---|
| 0.00 – 0.50 | 66.7 | 38.7 | 0.0 | 44.8 |
| 0.51 – 1.00 | 13.0 | 17.7 | 27.8 | 17.2 |
| 1.01 – 1.50 | 1.9 | 29.0 | 50.0 | 20.9 |
| 1.51 – 2.00 | 14.8 | 11.3 | 22.2 | 14.2 |
| 2.01 – 2.50 | 3.7 | 3.2 | 0.0 | 3.0 |
| 2.51 – 3.00 | 0.0 | 0.0 | 0.0 | 0.0 |

## Adult Sucker Bottom Velocity Utilization

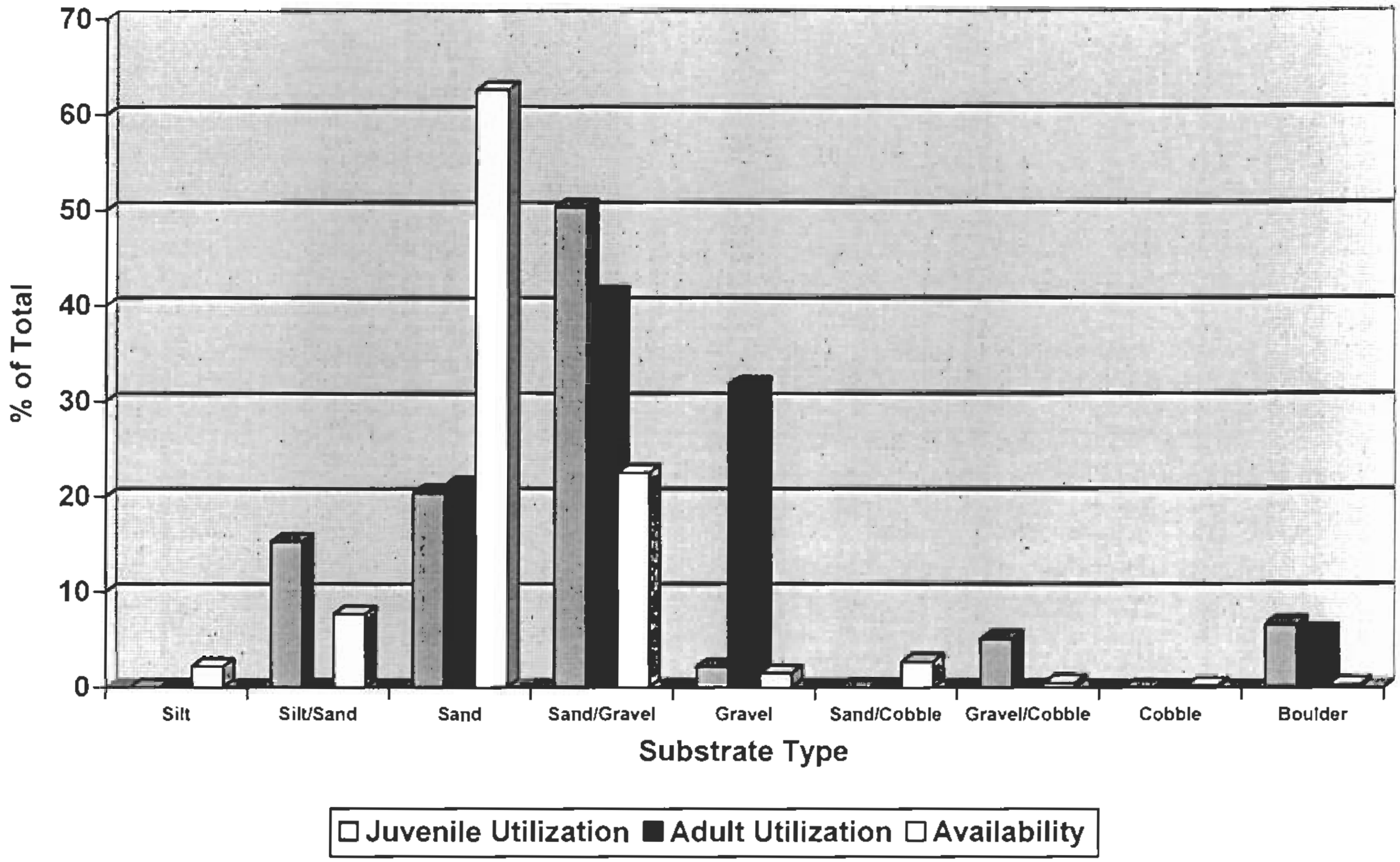
| Bottom Velocity (fps) | Individual Sites Surveyed Utilization as Percent of Total | | | Total Utilization All Sites Combined N=85 |
|---|---|---|---|---|
| | Mission Blvd N=28 | Highway 60 N=20 | Riverside Dr N=37 | |
| **0.00 – 0.50** | 25.0 | 0.0 | 40.5 | 28.2 |
| **0.51 – 1.00** | 21.4 | 61.5 | 54.1 | 43.6 |
| **1.01 – 1.50** | 50.0 | 23.1 | 5.4 | 24.4 |
| **1.51 – 2.00** | 0.0 | 15.4 | 0.0 | 2.6 |
| **2.01 – 2.50** | 3.6 | 0.0 | 0.0 | 1.3 |
| **2.51 – 3.00** | 0.0 | 0.0 | 0.0 | 0.0 |

On the following pages the habitat availability data are graphically compared to the habitat utilization of juvenile and adult Santa Ana suckers with respect to the four criteria shown above: habitat type, substrate, depth, and bottom velocity.

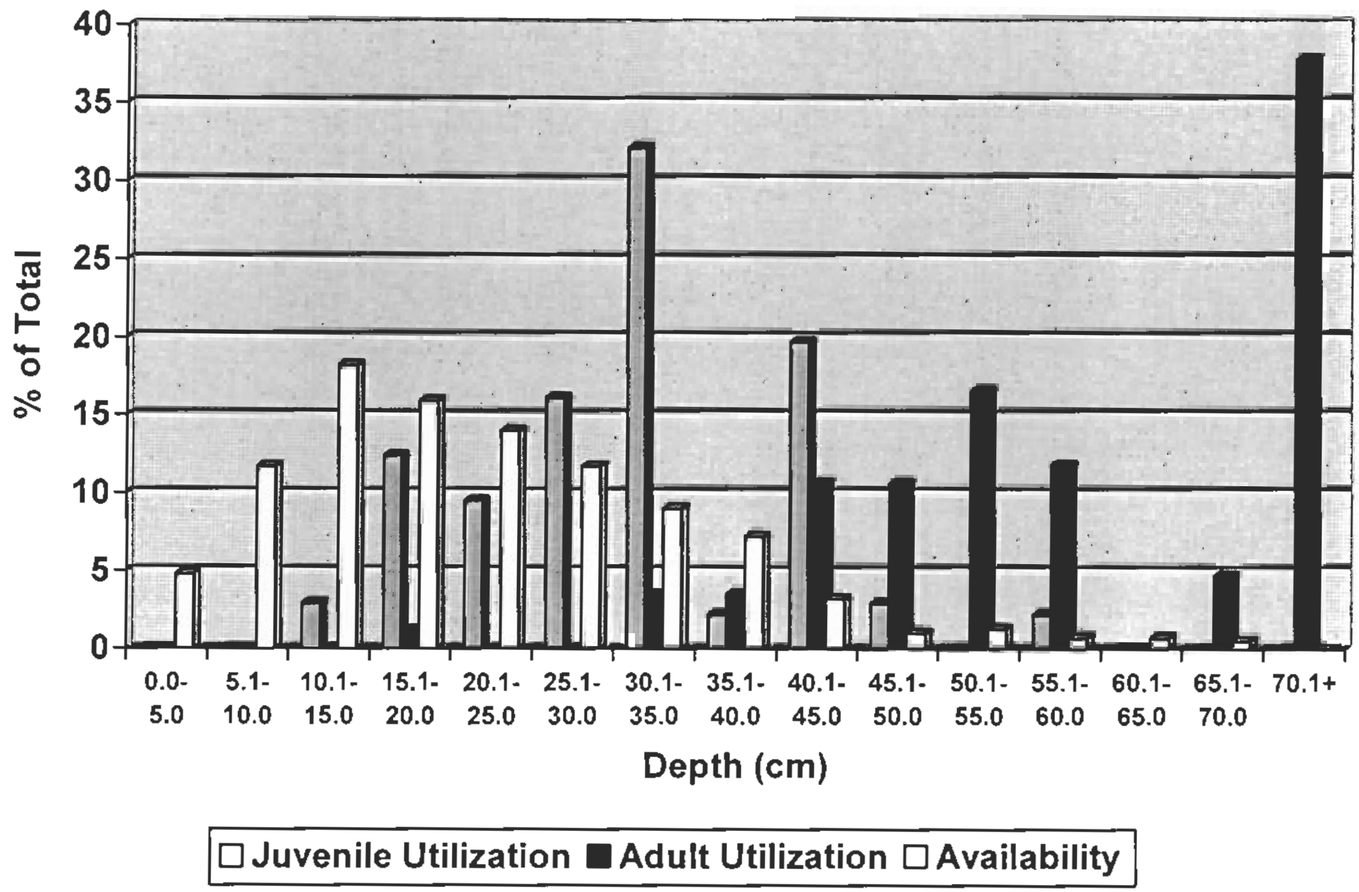
**Habitat Type Availability versus Utilization**



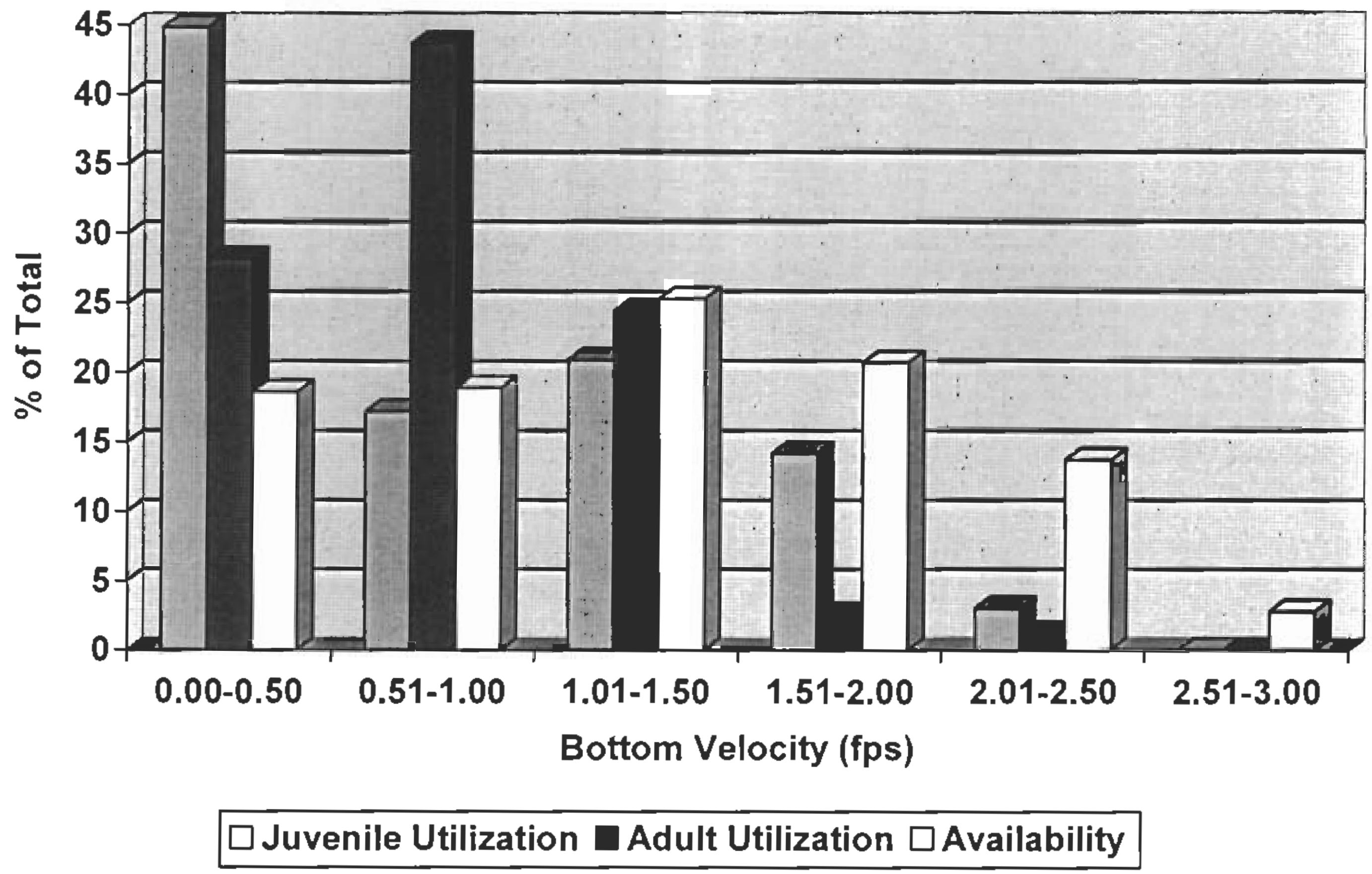
**Substrate Availability versus Utilization**



**Depth Availability versus Utilization**



Bottom Velocity Availability versus Utilization



## E. Conclusions

Although the data set will be enhanced over the next 2 field seasons, the data presented here show a statistically significant difference ($p<0.05$) between habitat availability and habitat utilization for both juvenile and adult suckers. All comparisons are statistically significant with the exception of the habitat type availability and the habitat utilization by juvenile suckers. Therefore, the current data suggest the following:

- Juvenile Santa Ana suckers utilize habitats types roughly in proportion to their availability. The juveniles heavily utilize riffle habitat which is the most common habitat available.
- Adult Santa Ana suckers show a significant over-utilization of run and pool habitat. Note that these are deeper water habitats, which correlates with the depth utilization data.
- Juvenile Santa Ana suckers show an over-utilization of coarser substrates and an under-utilization of sand, the most abundant substrate in the stream areas examined.
- Adult Santa Ana suckers also show an over-utilization of coarser substrates and an under-utilization of sand, the most abundant substrate in the stream areas examined. The adults have a strong relationship to gravel.
- The depth data show a striking pattern in which both juvenile and adult Santa Ana suckers over-utilize deeper water than the modal available depth.
- Adult Santa Ana suckers use deeper water than do the juveniles.
- Because Santa Ana suckers swim near the bottom of the stream, just above the substrate, bottom velocity may be an important habitat parameter.
- Both juvenile and adult Santa Ana suckers over-utilize slower bottom velocities than the modal available velocity.
- Adult Santa Ana suckers use somewhat more rapidly flowing water than do the juveniles.

## F. Comparison with Data Collected in the Upper San Gabriel River.

The following are the conclusions from two other multi-year habitat utilization studies performed by SMEA in the upper San Gabriel River drainage. One study was conducted on the West Fork of the San Gabriel River in the USFS OHV area and the other was conducted in the East Fork of the San Gabriel River at Heaton Flat.

The West Fork study area had less flow and less overall substrate heterogeneity than the East Fork study site. Despite these differences both studies found that:

- Adult Santa Ana suckers preferred depths greater than 40 cm
- Adult Santa Ana suckers preferred run habitat
- Juvenile Santa Ana suckers preferred riffles and runs
- Juvenile Santa Ana suckers preferred depths greater than 30 cm
- Both life stages preferred a low bottom velocity
- Both life stages preferred coarser substrates

These findings are consistent with the initial findings in the Santa Ana River.

## IX. Sunnyslope Creek Breeding Substrate Enhancement.

We have proposed over the past two years that sucker breeding habitat be enhanced by adding appropriate gravel substrate to Sunnyslope Creek, below the concrete lined channel in Louis Rubidoux Nature Center, in the Santa Ana River Wildlife Area, near the City of Riverside. This proposed enhancement activity is described in the attached memos to Juan Hernandez of the California Department of Fish and Game, Lucy Caskey of the U.S. Fish and Wildlife Service and Ron Baxter of Riverside County (see Appendix 4). Discussions have also been held with Robert Smith of the Army Corps of Engineers, and Barbara Ire of the Nature Center. All have informally expressed strong support. Mr. Smith has indicated that the amounts of gravel we will add are far below the amount necessary for a Corps permit. We plan to proceed with obtaining a state permit and to implement this project within the 2005 field season.

We have determined the appropriate characteristics of the breeding gravels for the sucker as described in this report (see pp. 56-58). Over the past 2 years we have noted many fewer very young suckers (fry) in the creek, and much less appropriate gravel substrate. Instead there is much more sand and silt substrate, and the gravel present is much more highly imbedded. This means that the gravel is at least partially buried in sand/silt, making it unsuitable for holding fish eggs and yolk-sac larvae. We believe this increase in sand/silt is due to a lack of flushing water flow events in Sunnyslope Creek in the past 2 years. We intend to add gravel of a similar nature to that found at the breeding site in Sunnyslope Creek, anticipating that this will increase the area available for sucker spawning. We will implement this in a manner and time to avoid impacts to the suckers already present in the stream.

Photos 39 and 40 show the present poor spawning substrate in Sunnyslope Creek as compared to Photo 21 in this report.

Photo 39. Sunnyslope Creek, January 17, 2004. Note gravel heavily imbedded with sand.

Photo 40. Sunnyslope Creek, January 17, 2004. Note sand/silt dominated substrate.

## X. Conclusions.

### Summary of SMEA's Approach

**The primary questions that SMEA has been attempting to answer relate to three major issues:**

- **What is the status of the Santa Ana Sucker in the Santa Ana River?**
  This is a fundamental question. We need to know the distribution of the sucker, its population size, population structure, and population trends. These data will ultimately be important in determining the current status of the sucker, but the data will also provide a baseline against which success and failure of enhancement and restoration efforts can be measured.

- **What habitat(s) is/are preferred by the various life stages of the Santa Ana sucker?**
  One of the critical goals of the conservation program is to be able to enhance and restore Santa Ana sucker habitat. This goal serves two functions: (1) it will allow the enhancement/restoration of stream reaches to aid in the recovery of the sucker, and (2) if projects necessitate work in the channel, we will be able to determine what channel characteristics are the most import to restore or maintain in order to support a healthy sucker population.

- **What are the critical life history attributes of the Santa Ana sucker?**
  It is important to understand critical life history attributes such as: (1) time of reproduction, (2) dispersal of fry or young-of-the-year, and (3) adult migration. Such data will provide insight into such diverse concerns as project timing and connectivity (patterns of gene flow) within the Santa Ana River.

### Current Status of Our Knowledge

**A. What is the Status of the Santa Ana sucker in the Santa Ana River?**

- ✓ The Santa Ana River from just downstream of Mission Boulevard upstream to Rialto Drain holds the largest most continuously distributed deme of Santa Ana suckers.
- ✓ Sunnyslope Creek and Rialto Drain were important reproductive sites for the Santa Ana sucker during 2001, but were not so important during 2002.
- ✓ Quality of the reproductive habitat in Sunnyslope Creek appears to be declining.
- ✓ There was considerable mainstem reproduction in 2002 and 2003.
- ✓ Santa Ana suckers can be successfully pit tagged, which will provide a useful tool in studying the Santa Ana sucker.
- ✓ SMEA's population estimate for Santa Ana sucker from about 600 meters downstream of Mission Boulevard upstream to Rialto Drain was 6,503-6,809 fish in 2001 and 8,262-10,251 in 2002.

- ✓ There were an estimated 6,288-6,584 adult fish in 2001, but only 2,379-2,952 adult fish in 2002.
- ✓ There was a major demographic shift between 2001 and 2002: In 2001 96.7% of the fish captured during the population estimate were adults and 3.3% were YOY, but in 2002 only 28.8% were adult and 71.2% were YOY. 2003 results were similar to 2002 with 30.7% adult and 69.3% YOY.
- ✓ Larval production was higher in 2002 than in 2001. In 2003 larval production was higher than 2001 but seemed to be lower than in 2002.
- ✓ An apparently abnormally large number of Santa Ana sucker YOY appeared at River Road during 2002, this was not repeated in 2003

**B. What habitats are preferred by the various life stages of the Santa Ana sucker?**

- ✓ Suckers spawn over medium gravel in water approximately 0.5 meters in depth, and with a flow of 0.20-0.24 m/sec.
- ✓ Sucker spawning habitat must contain a deeper, more protected area adjacent to the spawning area for fish to utilize when not spawning or between spawning bouts.
- ✓ Larval suckers utilize shallow (5-10 cm) water in low flow areas with a silt bottom. Emergent or aquatic vegetation does not appear to be a requirement but is commonly present.
- ✓ Recently transformed young are found in slightly deeper water than are the larvae, and they are associated with a particular habitat structure – the bottom sand is rippled and the young are found in the depression.
- ✓ Larval suckers may be selecting a position relative to the sun, basking?
- ✓ Juvenile suckers are often found over mid-channel gravel, but in areas such as River Road where the water is shallow, they are found in the deeper channels along the river margin. Juvenile suckers are also found in the deeper holes along with adults.
- ✓ Adult suckers are most frequently encountered in deeper holes along the margins of the river.
- ✓ Juvenile Santa Ana suckers utilize habitats types roughly in proportion to their availability. The juveniles heavily utilize riffle habitat which is the most common habitat available.
- ✓ Adult Santa Ana suckers show a significant over-utilization of run and pool habitat. Note that these are deeper water habitats, which correlates with the depth utilization data.
- ✓ Juvenile Santa Ana suckers show an over-utilization of coarser substrates and an under-utilization of sand, the most abundant substrate in the stream areas examined.
- ✓ Adult Santa Ana suckers also show an over-utilization of coarser substrates and an under-utilization of sand, the most abundant substrate in the stream areas examined. The adults have a strong relationship to gravel.
- ✓ The depth data show a striking pattern in which both juvenile and adult Santa Ana suckers over-utilize deeper water than the modal available depth.
- ✓ Adult Santa Ana suckers use deeper water than do the juveniles.

- ✓ Because Santa Ana suckers swim near the bottom of the stream, just above the substrate, bottom velocity may be an important habitat parameter.
- ✓ Both juvenile and adult Santa Ana suckers over-utilize slower bottom velocities than the modal available velocity.
- ✓ Adult Santa Ana suckers use somewhat more rapidly flowing water than do the juveniles.

**C. What are the critical life history attributes of the Santa Ana sucker?**

- ✓ The timing of larval appearance and observations of spawning indicate that suckers in the Santa Ana River, typically, breed from mid-March through late April.
- ✓ This is somewhat dependent on annual conditions. In early February of 2003 a larval sucker was found. Subsequent high flows removed any fry that were present and fry did not appear again until late March.
- ✓ Larval suckers are only present for approximately 1.5 months.
- ✓ Based on Saiki's (2000) data, and SMEA's 2001 data, most suckers may not survive past 1+, meaning that they have only a single reproductive season. Due to annual variability in year class composition in Santa Ana sucker from the San Gabriel River, more data are needed. 2002 data suggest an additional year class.
- ✓ In 2001 there was evidence of adult migration into Sunnyslope Creek
- ✓ Based on the recapture in 2002 of fish marked in 2001, the adults show, at least, seasonal site fidelity and migrate; or they are resident to a short stretch of stream.
- ✓ Based on the adult recapture data, the adults that were tagged in 2001 and recaptured in 2002 had grown an average of 34mm SL and increased in weight by 26.5 grams.

## XI. QUESTIONS.

- ➢ Is there significant sucker reproduction in the mainstem? Swift (2001) argued mainstem reproduction because of the broad larval distribution in the mainstem. In 2001, larvae appeared in the mainstem significantly later than they appeared in the tributaries. This raises the potential of larval drift accounting for larvae in the mainstem.

- ➢ Can we increase larval production? Now that SMEA has been able to characterize Santa Ana sucker spawning habitat in the tributaries, there is the potential to create more spawning habitat and increase larval production.

- ➢ Where were the juveniles (see Photo 22) in 2001? Swift (2001) reported large numbers of juveniles, but such large numbers were not observed in 2001 by SMEA.

- ➢ To what degree does the size of the sucker deme upstream of Mission Boulevard fluctuate from year to year, and is it stable? SMEA made three population estimates based on three 100-meter sections. As this is repeated year after year the question will be answered. The current data do not provide a robust answer.

- What are the specific characteristics of preferred adult habitat? Even upstream of Mission Boulevard where suckers are common, there is considerable variation in sucker density. What determines this mosaic of habitat occupation? SMEA has some data on this question but more is needed. Initial observations coupled with data collected in the San Gabriel River, and observations associated with Riverside County Flood Control's diversion of the Santa Ana River upstream of Riverside Avenue suggest the placement of boulders in the stream may be a beneficial habitat enhancement for suckers. However, more data are needed.

- Do suckers in the Santa Ana River normally survive only two years? Based on SMEA's experience in the West Fork of the San Gabriel River, several years of data will be necessary to answer this question without sacrificing fish to examine otoliths.

- Do the cichlids in the Santa Ana River compete for algal resources with the Santa Ana sucker? The potential for competition over food resources exists.

## XII. PROGRAM TASKS FOR 2004.

The following are the recommended focal tasks for the 2004 field season for the Santa Ana Sucker Conservation Program. As always SMEA will use its discretion (in coordination with SAWPA) in order to take advantage of any unique opportunities that arise during the field season.

**Task #1. Enhancement of breeding habitat in Sunnyslope Creek**

Subtask 1A. Evaluate adult sucker population status in Creek February/March 2004
Subtask 1B. Examine status of fry in creek in 2004 breeding season as a basis for evaluation of restoration project
Subtask 1C. Implementation of restoration in creek (incl. permitting, develop measures of success, obtain and prepare gravel, install gravel)

**Task #2. Studies of young-of-the-year and adult suckers**

Subtask 2A. Habitat utilization/preference

**Task #3. Population estimates/tagging**

Subtask 3A. Sequential depletion at three standard sites (Summer)
Subtask 3B. Sampling for tagging and detection of tagged fish to determine movement patterns (Fall)

**Task #4. Detect predation by exotic fishes on young suckers**

Collection and preservation of exotics will be done in conjunction w/other activities, and no funds are allocated for the analysis of gut contents this year. Exotics will have to be collected when fry and juveniles are present. Analysis is postponed until additional funds are available.

**Task #5. Project Management and Administration**

Subtask 5A. Coordination with SAWPA
Subtask 5B. Agency coordination/response
Subtask 5C. Project management
Subtask 5D. Data management
Subtask 5E. Meeting attendance
Subtask 5F. Preparation of materials for meetings
Subtask 5G. Preparation of draft and final annual report
Subtask 5H. Miscellaneous administration such as, assistance to SAWPA consultant (Jim Van Haun), other project or project development review.

This year SMEA has also provided SAWPA with two optional tasks should additional funding become available. SAWPA indicated an interest in having these tasks performed.

OPTIONAL TASKS
**Task #6**. Restoration planning for following year.

**Task #7. Population estimation by snorkeling.**
This will provide data comparable to previous years, and give us a means to validate the depletion method of population estimation.

It is not expected that all goals or definitive answers to the questions proposed for investigation in the above Tasks will be fully achieved this year. All of the Tasks will be pursued to the extent that time, access to sites, environmental conditions, permit restrictions and budgetary constraints allow.

## XIII. POTENTIAL ACTIVITIES FOR YEAR 8 OF THE CONSERVATION PROGRAM.

The year 8 implementation activities as currently envisioned are the year 5 activities outlined in the Conservation Plan (Baskin and Haglund 1999). Funding restrictions during years 1-3 have resulted in a delay in completing the tasks as originally conceived. The primary focus in year 8 should be the evaluation of the success of created habitat and the refinement of habitat design. This should be coupled with annual monitoring.

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## XV. ACKNOWLEDGEMENTS.

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- City of Riverside (Regional Water Quality Control Plant)
- City of San Bernardino Municipal Water Department (Rapid Infiltration & Extraction Facility)
- Orange County Flood Control District
- Orange County Water District, County of Orange Public Facilities & Resources Department
- Riverside County
- Riverside County Flood Control and Water Conservation District
- San Bernardino County Flood Control District

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# Appendix 1

Length-weight data and pit tag numbers from the fish captured in 2001

List of the length (SL mm) and weight (g) of the fish caught (N=88) in the 100-meter stream reach upstream of Mission Boulevard (Site 1) on 15 June 2001.

| LENGTH | WEIGHT | PIT TAG NUMBER |
|---|---|---|
| 102 | 18.8 | 4264610758 |
| 113 | 25.9 | 426502050D |
| 140 | 40.4 | 4263187801 |
| 107 | 27.4 | 425F623D68 |
| 113 | 29.8 | 42616B2D21 |
| 109 | 21.0 | 4264603D43 |
| 98 | 19.5 | 42656F2620 |
| 110 | 27.1 | 42631A7519 |
| 102 | 22.5 | 42645F0977 |
| 119 | 33.9 | 42645B1060 |
| 116 | 20.6 | 4261784118 |
| 116 | 33.7 | 4264743268 |
| 115 | 28.0 | 4262014F3A |
| 113 | 27.6 | 4264525A28 |
| 107 | 24.8 | 4265707F06 |
| 118 | 25.7 | 42645E2D7A |
| 102 | 21.4 | 4264533E5C |
| 111 | 27.5 | 4264666E38 |
| 109 | 23.1 | 4261627E72 |
| 114 | 28.0 | 426204114D |
| 113 | 27.0 | 426200201F |
| 118 | 29.5 | 4262104704 |
| 118 | 32.9 | 4262006820 |
| 102 | 19.1 | 426210684C |
| 115 | 22.9 | 4261561F5C |
| 116 | 29.0 | 42620E2865 |
| 109 | 22.8 | 4264712F71 |
| 112 | 28.5 | 4265041E49 |
| 107 | 25.5 | 42615B5215 |
| 132 | 39.2 | 4263245D1B |
| 119 | 29.3 | 42655E0062 |
| 112 | 26.9 | 426600274E |
| 126 | 36.3 | 4262032A1E |
| 99 | 21.4 | 4261680723 |
| 115 | 30.6 | 426578585F |
| 111 | 28.2 | 42632A2F17 |
| 105 | 23.2 | 42616F102F |
| 103 | 23.5 | 426204190B |
| 110 | 27.7 | 4264595B2F |
| 101 | 21.8 | 426205324D |
| 105 | 21.4 | 4262076B48 |

| | | |
|---|---|---|
| 135 | 42.5 | 426169220D |
| 121 | 30.4 | 4264584A66 |
| 107 | 25.3 | 42615E4164 |
| 110 | 24.2 | 42617B2111 |
| 113 | 27.7 | 42621D077D |
| 108 | 23.8 | 4262003B30 |
| 116 | 27.9 | 42645F4F20 |
| 120 | 32.4 | 42657F3F57 |
| 107 | 20.1 | 42615C705D |
| 101 | 22.0 | 4264634D34 |
| 102 | 17.6 | 42633C717F |
| 102 | 20.7 | 4259292F4C |
| 117 | 29.8 | 426557543C |
| 102 | 22.4 | 426501387C |
| 110 | 27.3 | 42633F6172 |
| 103 | 20.8 | 4264680850 |
| 119 | 29.9 | 4264646037 |
| 105 | 23.8 | 4261600774 |
| 112 | 26.7 | 42620C611E |
| 122 | 35.6 | 4265771571 |
| 109 | 24.0 | |
| 106 | 19.2 | 42617C0C12 |
| 116 | 31.3 | 426209526C |
| 112 | 26.3 | 42657B1013 |
| 107 | 24.1 | 4261672708 |
| 110 | 24.4 | 42615D6952 |
| 107 | 24.2 | 426560B6C |
| 110 | 28.4 | 4264511935 |
| 116 | 28.1 | 42616A7A3F |
| 115 | 28.5 | 42616F1722 |
| 117 | 29.4 | 4265781377 |
| 123 | 36.7 | 425F6F1C07 |
| 105 | 20.9 | 4262087B1E |
| 111 | 26.9 | 42645D2076 |
| 114 | 29.7 | 426500267E |
| 102 | 20.1 | 4262026847 |
| 120 | 32.5 | 4265523270 |
| 102 | 21.9 | 42645A3360 |
| 101 | 19.0 | 42633D5746 |
| 102 | 21.0 | 426209360C |
| 127 | 35.9 | 4265057B1E |
| 112 | 26.2 | 42646C155D |
| 110 | 22.3 | 4265621208 |
| 106 | 21.0 | 42620A294A |

| | | |
|---|---|---|
| 123 | 33.4 | 4266012D28 |
| 110 | 28.2 | 4264655C02 |
| 100 | 19.8 | 4261665970 |

List of the length (SL mm) and weight (g) of the fish caught (N=144) in the 100-meter stream reach upstream of Highway 60 (Site 2) on 15 June 2001.

| LENGTH | WEIGHT | PIT TAG NUMBER |
|---|---|---|
| 104 | 18.9 | 426505004B |
| 152 | 65.8 | 4265610D4E |
| 108 | 25.5 | 42617A4268 |
| 103 | 20.1 | 42650A4139 |
| 110 | 25.7 | 42615A635F |
| 110 | 29.3 | 4261641E63 |
| 112 | 25.3 | 4262001907 |
| 98 | 15.7 | 42617E3343 |
| 125 | 35.7 | 42620E1B0F |
| 101 | 18.1 | 4261663641 |
| 110 | 22.3 | 4264775F1E |
| 108 | 26.3 | 4264517604 |
| 111 | 22.3 | 4265083A0B |
| 94 | 16.5 | 4262110064 |
| 111 | 24.3 | 4262131467 |
| 99 | 19.1 | 4261775D12 |
| 102 | 18.3 | 4261614B45 |
| 114 | 25.2 | 4265092A61 |
| 107 | 19.5 | 4261796949 |
| 120 | 28.0 | 42645D1128 |
| 108 | 21.2 | 42620A7A5A |
| 98 | 18.1 | 4262002859 |
| 133 | 40.7 | 426207776A |
| 109 | 20.9 | 426604580D |
| 111 | 22.4 | 4267106F79 |
| 161 | 69.9 | 42634F4571 |
| 125 | 37.4 | 42645F1761 |
| 99 | 16.4 | 4264726F7B |
| 122 | 32.2 | 42617D517E |
| 120 | 29.3 | 426472792B |
| 120 | 33.5 | 42645C064F |
| 96 | 16.6 | 4262127D6C |
| 110 | 28.6 | 42617B542C |
| 108 | 18.8 | 426179075B |
| 116 | 32.0 | 4262027F34 |

| | | |
|---|---|---|
| 118 | 31.1 | 4264571615 |
| 116 | 29.8 | 426460066F |
| 111 | 25.7 | 42645E391E |
| 105 | 17.8 | 42616B151A |
| 122 | 29.5 | 426466644A |
| 106 | 19.9 | 4262007C44 |
| 112 | 28.7 | 42600A5939 |
| 105 | 24.0 | 42615B6E34 |
| 112 | 26.8 | 4261582175 |
| 103 | 21.1 | 42616D2F7E |
| 119 | 32.7 | 4263220F43 |
| 114 | 28.7 | 42647B712E |
| 120 | 29.9 | 4264761B69 |
| 104 | 18.9 | 4264765E29 |
| 103 | 20.3 | 425F6B356D |
| 104 | 22.2 | 4261616017 |
| 116 | 28.0 | 426508436A |
| 117 | 28.4 | 42620E7107 |
| 109 | 23.8 | 426608125D |
| 113 | 28.9 | 426162230A |
| 101 | 17.8 | 4264725B1C |
| 104 | 17.8 | 4262021A77 |
| 106 | 19.3 | 42620A594E |
| 126 | 33.7 | 42645B3B32 |
| 110 | 23.9 | 4262112A15 |
| 111 | 26.2 | 42615A7321 |
| 107 | 24.1 | 42620A1052 |
| 110 | 21.7 | 42617C4D48 |
| 103 | 19.4 | 426164184D |
| 107 | 24.7 | 4265734459 |
| 110 | 23.8 | 426461486A |
| 122 | 33.7 | 4264625D5E |
| 105 | 24.0 | 42563D6B0A |
| 100 | 16.8 | 42645B0713 |
| 121 | 30.8 | 42546A1179 |
| 120 | 31.0 | 42620B7D43 |
| 105 | 21.7 | 4264622D5A |
| 116 | 27.2 | 426458452D |
| 116 | 31.8 | 426502604E |
| 122 | 36.2 | 42615A7115 |
| 103 | 20.2 | 426479237A |
| 110 | 27.0 | 4261777474 |
| 111 | 25.2 | 42620C6613 |
| 108 | 19.8 | 4263355D63 |

| | | |
|---|---|---|
| 123 | 34.4 | 42647D6018 |
| 109 | 21.3 | 425F686945 |
| 105 | 20.5 | 42647B200A |
| 115 | 28.2 | 42617A126F |
| 101 | 20.2 | 425F7F5F05 |
| 107 | 22.9 | 4262087742 |
| 117 | 26.4 | 4264585B3B |
| 100 | 19.1 | 4265794150 |
| 102 | 20.1 | 42616D6D33 |
| 112 | 25.2 | 4262011658 |
| 98 | 20.8 | 4264745860 |
| 106 | 24.7 | 4264687977 |
| 96 | 19.4 | 42617A772C |
| 108 | 26.7 | 4262033B43 |
| 99 | 18.0 | 4265661A42 |
| 109 | 20.3 | 42650A622D |
| 118 | 36.8 | 425F627D11 |
| 120 | 39.4 | 4261731715 |
| 115 | 26.8 | 42617C4320 |
| 111 | 24.6 | 4262003558 |
| 41 | 1.2 | |
| 48 | 2.1 | |
| 110 | 23.9 | 426453342E |
| 112 | 24.1 | 42620A467B |
| 109 | 28.9 | 4261660E7A |
| 96 | 20.4 | 4264667868 |
| 112 | 20.3 | 426165330B |
| 100 | 17.4 | 42633C2756 |
| 107 | 18.0 | 4264766D43 |
| 100 | 17.6 | 42616F1D50 |
| 116 | 25.6 | 42645D7507 |
| 107 | 23.4 | 42645C5A14 |
| 127 | 33.0 | 4262055C5F |
| 105 | 20.3 | 42616D0D49 |
| 109 | 19.4 | 4264550C7E |
| 116 | 29.4 | 426213241A |
| 113 | 26.5 | 4264563721 |
| 107 | 20.6 | 42646D7D75 |
| 123 | 34.3 | 4265581360 |
| 117 | 28.7 | 4262112253 |
| 117 | 30.8 | 425F7A2B03 |
| 113 | 23.6 | 4264596F48 |
| 104 | 21.4 | 4266015449 |
| 106 | 28.4 | 4265633431 |

| | | |
|---|---|---|
| 107 | 26.5 | 42654E3247 |
| 105 | 21.5 | 4262007402 |
| 127 | 39.0 | 426501632A |
| 135 | 44.0 | 4262092672 |
| 115 | 31.3 | 4264694158 |
| 119 | 31.4 | 4265584C2C |
| 117 | 33.4 | 42617B5A44 |
| 101 | 20.7 | 4265031C02 |
| 57 | 4.0 | |
| 40 | 1.1 | |
| 122 | 32.7 | 4261684C0B |
| 121 | 36.4 | 42620B3920 |
| 122 | 34.9 | 42616C7026 |
| 117 | 25.0 | 4262091E49 |
| 132 | 37.6 | 42615B2106 |
| 121 | 35.0 | 42633C6A50 |
| 102 | 20.2 | 42646C0E72 |
| 118 | 30.0 | 4264574612 |
| 106 | 22.7 | 4264711D38 |
| 127 | 36.0 | 4261790D29 |
| 49 | 2.4 | |
| 49 | 1.9 | |
| 52 | 2.2 | |
| 105 | 20.4 | 4265777111 |
| 41 | 1.4 | |
| 113 | 24.6 | 4262113714 |
| 113 | 25.3 | 42616B6B76 |
| 114 | 23.5 | 4265035D58 |
| 94 | 15.5 | 4265660808 |
| 116 | 27.0 | 42647A4B35 |
| 112 | 26.2 | 42617B0031 |
| 102 | 18.6 | 42655C0A77 |
| 102 | 18.4 | 42617D1F6F |
| 105 | 17.6 | 42620C2B15 |
| 100 | 17.1 | 42646E4E6C |
| 103 | 24.0 | 426460266C |
| 99 | 19.2 | 42647A5A68 |
| 113 | 30.1 | 4266093C22 |
| 108 | 26.1 | 4264542A47 |
| 109 | 24.2 | 42650B2E1C |
| 112 | 26.9 | 42660A7074 |
| 105 | 21.5 | 4265656922 |
| 130 | 40.2 | 4261634A01 |
| 112 | 28.6 | 4265541B7D |

| | | |
|---|---|---|
| 116 | 31.0 | 4262104C55 |
| 105 | 20.9 | 426001170C |
| 103 | 18.7 | 4264666935 |
| 124 | 36.9 | 4265504609 |
| 127 | 34.7 | 42616F2345 |
| 99 | 20.9 | 4265006056 |
| 92 | 19.7 | |
| 153 | 60.8 | |

List of the length (SL mm) and weight (g) of the fish caught (N=9) in the 100-meter stream reach downstream of Riverside Avenue (Site 3) on 16 June 2001.

| LENGTH | WEIGHT | PIT TAG NUMBER |
|---|---|---|
| 124 | 37.5 | 4261646702 |
| 115 | 32.6 | 4261710538 |
| 113 | 31.8 | 4261566C4F |
| 124 | 45.1 | 4265060501 |
| 121 | 33.8 | 4264757877 |
| 113 | 33.8 | 42650D6903 |
| 116 | 33.3 | 4261597748 |
| 131 | 42.5 | 4265591479 |
| 129 | 39.5 | 4262075D18 |
| 54 | 2.8 | |
| 42 | 1.4 | |
| 60 | 4.4 | |
| 61 | 3.8 | |

# Appendix 2

Length-weight data and pit tag numbers from the fish captured in 2002

List of the length (SL mm) and weight (g) of the fish caught (N=120) in the 100-meter stream reach upstream of Mission Boulevard (Site 1) on 19 July 2002.

| LENGTH | WEIGHT | PIT TAG NUMBER |
|---|---|---|
| 66 | 5.6 | |
| 142 | 59.4 | 42645C697E |
| 119 | 32.8 | 4264791C4C |
| 39 | 1.1 | |
| 39 | 1.1 | |
| 37 | 0.9 | |
| 47 | 1.7 | |
| 60 | 4.1 | |
| 36 | 0.8 | |
| 45 | 1.7 | |
| 34 | 0.6 | |
| 151 | 53.4 | 4266074800 |
| 148 | 51.7 | 4264636A3A |
| 147 | 52.3 | 4264772172 |
| 125 | 35.0 | 4265070602 |
| 125 | 36.8 | 42620D5D2B |
| 130 | 39.8 | 4261657B34 |
| 141 | 70.3 | 4263343B23 |
| 78 | 9.1 | |
| 66 | 6.1 | |
| 52 | 2.7 | |
| 58 | 3.9 | |
| 47 | 2.0 | |
| 132 | 6.2 | 42617F6047 |
| 146 | 50.1 | 4261605464 |
| 64 | 4.2 | |
| 62 | 4.2 | |
| 72 | 8.7 | |
| 62 | 4.9 | |
| 65 | 4.7 | |
| 61 | 4.3 | |
| 36 | 0.9 | |
| 77 | 8.2 | |
| 66 | 5.9 | |
| 59 | 4.2 | |
| 76 | 8.0 | |
| 76 | 8.4 | |
| 55 | 3.0 | |
| 67 | 4.2 | |
| 137 | 49.3 | 42616C560B |
| 131 | 40.1 | 4265510573 |

| | | |
|---|---|---|
| 30 | 0.5 | |
| 40 | 1.6 | |
| 67 | 5.4 | |
| 36 | 0.8 | |
| 46 | 1.7 | |
| 59 | 3.7 | |
| 60 | 4.2 | |
| 56 | 2.9 | |
| 49 | 2.3 | |
| 46 | 2.2 | |
| 91 | 14.2 | 42617F6A35 |
| 119 | 31.1 | 426210431E |
| 147 | 39.7 | 4265521922 |
| 147 | 53.5 | 42655E0062 |
| 76 | 9.7 | |
| 31 | 0.5 | |
| 51 | 2.0 | |
| 87 | 12.4 | 426179775F |
| 151 | 55.6 | 4261792342 |
| 147 | 50.4 | 42620D567A |
| 155 | 62.6 | 42645F4F20 |
| 39 | 0.9 | |
| 49 | 1.8 | |
| 31 | 0.5 | |
| 42 | 1.2 | |
| 31 | 0.6 | |
| 30 | 0.6 | |
| 40 | 1.8 | |
| 28 | 0.2 | |
| 49 | 2.0 | |
| 55 | 3.2 | |
| 146 | 54.5 | 4260163132 |
| 169 | 79.8 | 4262087C13 |
| 135 | 41.8 | 4264733865 |
| 123 | 32.4 | 4265592E76 |
| 81 | 11.9 | 4262061627 |
| 117 | 29.7 | 4264733100 |
| 68 | 5.2 | |
| 64 | 5.1 | |
| 74 | 7.6 | |
| 68 | 5.6 | |
| 158 | 73.3 | 4264614436 |
| 51 | 2.5 | |
| 161 | 61.8 | 42615F0109 |

| | | |
|---|---|---|
| 122 | 30.7 | 42620C7043 |
| 67 | 5.4 | |
| 49 | 2.0 | |
| 47 | 1.9 | |
| 137 | 40.8 | 425F687349 |
| 82 | 9.2 | 42655A1F5B |
| 130 | 35.4 | 4262005A69 |
| 72 | 7.5 | |
| 70 | 5.6 | |
| 62 | 4.6 | |
| 62 | 3.8 | |
| 145 | 50.5 | 42672E2622 |
| 139 | 51.3 | 42615D3113 |
| 151 | 64.4 | 425F5B4B7A |
| 158 | 65.4 | 4263357E77 |
| 140 | 48.3 | 4261653228 |
| 80 | 10.2 | 42647E3D13 |
| 135 | 41.6 | 426018110D |
| 76 | 7.8 | |
| 61 | 4.4 | |
| 51 | 2.0 | |
| 129 | 30.0 | 42620E272E |
| 144 | 54.8 | 4261701E03 |
| 125 | 33.5 | 426567151D |
| 79 | 9.3 | |
| 67 | 5.7 | |
| 65 | 4.9 | |
| 74 | 7.4 | |
| 70 | 5.8 | |
| 55 | 2.8 | |
| 161 | 65.5 | 4263245D1B |
| 73 | 8.3 | |
| 36 | 0.8 | |
| 63 | 4.5 | |
| 82 | 9.2 | 425F724E17 |
| 121 | 30.6 | 4264766C60 |
| 46 | 1.5 | |
| 40 | 1.3 | |
| 55 | 2.8 | |
| 145 | 44.7 | 4261600774 |
| 66 | 5.7 | |
| 82 | 9.7 | 42631F0E54 |
| 157 | 62.8 | 4261745A6C |

List of the length (SL mm) and weight (g) of the fish caught (N=151) in the 100-meter stream reach upstream of Highway 60 (Site 2) on 21 July 2002.

| LENGTH | WEIGHT | PIT TAG NUMBER |
|---|---|---|
| 128 | 37.1 | 4265025324 |
| 138 | 42.5 | 42645F325B |
| 63 | 4.2 | |
| 66 | 5.3 | |
| 59 | 4.4 | |
| 69 | 6.0 | |
| 67 | 5.7 | |
| 64 | 5.5 | |
| 55 | 3.3 | |
| 59 | 4.2 | |
| 165 | 72.5 | 42615F4344 |
| 171 | 77.4 | 4265006F62 |
| 122 | 34.2 | 4261634916 |
| 122 | 29.7 | 4261653979 |
| 133 | 41.8 | 426475561C |
| 143 | 49.6 | 4261594B69 |
| 141 | 46.5 | 4261641706 |
| 139 | 45.3 | 426505704F |
| 140 | 51.5 | 42620A4F16 |
| 141 | 49.8 | 42617F3274 |
| 145 | 58.5 | 42615F4A21 |
| 69 | 5.6 | |
| 74 | 7.5 | |
| 67 | 6.1 | |
| 68 | 5.2 | |
| 59 | 3.9 | |
| 65 | 4.7 | |
| 65 | 4.6 | |
| 49 | 2.1 | |
| 69 | 5.9 | |
| 62 | 3.7 | |
| 68 | 5.5 | |
| 67 | 5.1 | |
| 141 | 43.9 | 4265025F78 |
| 155 | 62.0 | 4261767F31 |
| 146 | 51.2 | 426509071D |
| 127 | 33.3 | 4255717B5D |
| 65 | 5.4 | |
| 40 | 1.0 | |
| 62 | 4.2 | |

| | | |
|---|---|---|
| 68 | 6.2 | |
| 54 | 2.9 | |
| 58 | 4.0 | |
| 63 | 4.9 | |
| 60 | 4.5 | |
| 63 | 4.7 | |
| 74 | 7.7 | |
| 63 | 4.6 | |
| 48 | 2.1 | |
| 68 | 6.2 | |
| 65 | 4.7 | |
| 59 | 3.8 | |
| 69 | 6.1 | |
| 55 | 3.1 | |
| 61 | 5.0 | |
| 55 | 3.3 | |
| 54 | 3.0 | |
| 52 | 3.1 | |
| 62 | 4.8 | |
| 55 | 3.3 | |
| 55 | 3.3 | |
| 63 | 5.0 | |
| 151 | 62.6 | 4261644B5D |
| 124 | 34.3 | 4261717A77 |
| 128 | 35.5 | 4261612379 |
| 67 | 5.2 | |
| 63 | 4.6 | |
| 67 | 6.3 | |
| 65 | 5.1 | |
| 86 | 11.7 | 4264793D6C |
| 140 | 44.7 | 425F630A0C |
| 128 | 35.7 | 42633F3E3E |
| 76 | 7.5 | |
| 73 | 7.7 | |
| 62 | 4.1 | |
| 56 | 3.3 | |
| 67 | 5.2 | |
| 61 | 4.4 | |
| 56 | 3.1 | |
| 45 | 1.6 | |
| 132 | 37.2 | 42620D3C72 |
| 63 | 4.8 | |
| 68 | 5.5 | |
| 56 | 3.4 | |

| | | |
|---|---|---|
| 64 | 4.5 | |
| 71 | 6.1 | |
| 61 | 3.8 | |
| 46 | 1.6 | |
| 62 | 5.3 | |
| 58 | 4.0 | |
| 61 | 4.7 | |
| 59 | 3.5 | |
| 55 | 3.0 | |
| 66 | 4.8 | |
| 69 | 5.3 | |
| 45 | 1.6 | |
| 52 | 2.8 | |
| 34 | 0.8 | |
| 45 | 1.9 | |
| 46 | 2.0 | |
| 52 | 2.6 | |
| 55 | 3.5 | |
| 63 | 4.9 | |
| 58 | 3.3 | |
| 59 | 3.8 | |
| 45 | 1.7 | |
| 52 | 2.7 | |
| 62 | 4.4 | |
| 64 | 5.0 | |
| 84 | 10.2 | 4265026F05 |
| 58 | 3.8 | |
| 57 | 3.7 | |
| 66 | 5.1 | |
| 70 | 5.9 | |
| 72 | 6.2 | |
| 45 | 1.5 | |
| 124 | 35.8 | 42633C151F |
| 78 | 8.9 | |
| 59 | 3.3 | |
| 50 | 2.6 | |
| 60 | 4.0 | |
| 68 | 5.6 | |
| 66 | 6.0 | |
| 68 | 5.1 | |
| 68 | 5.4 | |
| 59 | 3.4 | |
| 60 | 4.2 | |
| 62 | 4.6 | |

| | | |
|---|---|---|
| 54 | 2.7 | |
| 45 | 1.9 | |
| 65 | 5.4 | |
| 63 | 5.0 | |
| 61 | 4.5 | |
| 66 | 4.8 | |
| 82 | 10.0 | 4261594A4A |
| 161 | 66.9 | 42616F7A27 |
| 147 | 55.3 | 4265036440 |
| 124 | 33.2 | 4261704909 |
| 65 | 4.6 | |
| 75 | 7.2 | |
| 71 | 6.0 | |
| 65 | 4.9 | |
| 65 | 4.9 | |
| 79 | 8.7 | |
| 63 | 4.0 | |
| 48 | 1.8 | |
| 155 | 63.0 | 4264704E3C |
| 74 | 6.9 | |
| 61 | 4.0 | |
| 67 | 5.1 | |
| 62 | 4.4 | |

List of the length (SL mm) and weight (g) of the fish caught (N=45) in the 100-meter stream reach downstream of Riverside Avenue (Site 3) on 21 July 2002.

| LENGTH | WEIGHT | PIT TAG NUMBER |
|---|---|---|
| 175 | 89.1 | 4261782B10 |
| 63 | 4.9 | |
| 145 | 56.3 | 4264717427 |
| 160 | 79.0 | 4264671A32 |
| 142 | 51.0 | 4261704555 |
| 62 | 4.6 | |
| 162 | 76.5 | 4264524D5B |
| 78 | 9.2 | |
| 153 | 66.3 | 426168533E |
| 133 | 44.7 | 426156082F |
| 136 | 40.6 | 4264706D67 |
| 66 | 5.3 | |
| 61 | 3.7 | |
| 69 | 5.6 | |
| 72 | 6.9 | |
| 70 | 6.0 | |

| | | |
|---|---|---|
| 70 | 7.1 | |
| 68 | 6.0 | |
| 70 | 6.6 | |
| 71 | 5.2 | |
| 71 | 7.4 | |
| 73 | 7.0 | |
| 68 | 5.8 | |
| 77 | 7.0 | |
| 89 | 12.5 | 42616A5808 |
| 68 | 5.4 | |
| 68 | 5.8 | |
| 67 | 6.1 | |
| 71 | 5.7 | |
| 120 | 31.7 | |
| 74 | 7.5 | |
| 70 | 5.8 | |
| 67 | 5.3 | |
| 57 | 3.2 | |
| 152 | 58.5 | 4264570D3A |
| 73 | 6.5 | |
| 72 | 6.3 | |
| 68 | 5.2 | |
| 72 | 7.3 | |
| 77 | 7.3 | |
| 68 | 5.2 | |
| 69 | 5.4 | |
| 68 | 5.1 | |
| 60 | 4.1 | |
| 70 | 6.5 | |

# Appendix 3

Discussion of the triple pass sequential depletion method of population estimation

The following discussion was presented to a group of agency personnel and concerned scientists that wanted to standardize Santa Ana sucker monitoring techniques throughout its range.

Discussion of Proposed Santa Ana Sucker Monitoring Protocol
**By**
**Thomas R. Haglund, Ph.D.**
**Jonathan N. Baskin, Ph.D.**

**Introduction.**
The following is a discussion of the potential alternatives considered in establishing a Santa Ana sucker monitoring protocol and a recommendation for establishing a protocol.

**Population Estimation Methods To Be Considered.**

1. Electrofishing
2. Snorkeling
3. Mark-Recapture
4. Seining
5. Underwater Camera

**General Considerations.**
Estimation of population sizes in streams presents significant sampling problems when the entire stream must be censused. Since it is seldom feasible to survey the entire stream, two-stage sampling designs are necessary. A random or systematic selection of sampling units is selected during the first stage, and the population of fish within each of these is estimated during the second stage. Hankin (1984) concluded that errors in the estimation of fish numbers within selected units (second stage errors) are likely to be small compared with errors that arise due to variation in fish numbers between these units (first stage errors).

The necessity of stratification by habitat type and location could be evaluated following one or more sampling rounds. Observations by Haglund and Baskin (unpubl. data) clearly indicate stratification by habitat type is necessary, and surveys conducted by Haglund and Baskin in 1991 throughout the upper San Gabriel River drainage suggest that location may be relevant because fish abundance appears to decrease with gradient.

In concept, all methods of population estimation are simple, but their application to natural populations has stimulated the development of a large body of statistical and mathematical models (e.g. Seber, 1973; Ricker, 1975).

**Electrofishing – Sequential Removal**
Electrofishing is an efficient capture method that is widely used to obtain reliable population estimates of salmonid fishes. Although it has been used less frequently on smaller nonsalmonid fishes, it can be an effective technique for the study of small nonsalmonids if properly used. The technique tends to collect larger fishes more readily than smaller ones but the controls on the newer electrofishers allow adjustments that reduce size selectivity and enhance the efficacy of this technique for use on smaller riverine fish species. Stream

conditions such as conductivity of the water, temperature, and depth can affect the efficiency of electroshocking. However, it still remains a technique of choice for salmonids, and is becoming so for other fishes occupying similar habitats because it is less affected by boulder-rubble substrates, aquatic vegetation and undercut banks - all conditions likely to be encountered in a productive trout stream (where Santa Ana suckers occur).

Standard censusing with an electrofisher involves the use of successive removal-depletion techniques. The removal-depletion method of population analysis (Zippin, 1958) assumes that:

1. No animal can move in or out of the sampling area.
2. Each animal has an equal chance of being captured.
3. The probability of capture is constant over all removal passes.

These assumptions are readily reached if (1) size selectivity is reduced through proper adjustment of the electrofisher, (2) the sample area is blocked to prevent fish from leaving the area, (3) a consistent proportion of the population is captured during each pass, and (4) timing devices are used on the electrofishers to insure that capture effort is the same on all removals (Platts et al, 1983). During electrofishing it is imperative that a downstream blocking net be in place, as well as an upstream blocking net to insure that fish did not leave the sampling area; in our experience fish will attempt to leave the area.

Although a two-step removal method (Seber and LeCren, 1967) is frequently used to reduce effort, and because of the simplicity of population estimate calculations, it is less reliable than methods using additional removals. Multiple-removal methods provide more accurate estimates of the population size (Zippin, 1958). A three-step removal procedure is a good compromise between reliability of the population estimate and effort.

The Zippin method is based on a maximum likelihood model (Moran, 1951) which has the probabilities reduced to easily read graphs or to computer programs. In order to calculate a population estimate the following quantities must be calculated:

$$T = \sum_{i=1}^{k} U_i \qquad (T = U_1 + U_2 + \ldots + U_k)$$

where:

$T$ = total number of fish collected
$U_i$ = number of fish collected in the ith removal
$k$ = the number of removals

Next the ratio (R) must be determined from the following formula:

$$R = \frac{\sum_{i=1}^{k} (i-1)\, U_i}{T}.$$

The population estimate is then determined by :

$$eN = \frac{T}{Q}$$

where:
$Q$ = the proportion of the fish captured during all removals. Q can be determined from a graph (Platts et al, 1983) or it is calculated by the computer program.

This method allows the measurement of length-weight data which can be used to determine fish condition (Saiki 2000) and age class distribution. In the case of the Santa Ana sucker, the sizes of Santa Ana sucker age classes were determined by Drake and Sasaki (1987) for the West Fork of the San Gabriel River.

| Age class | Santa Ana sucker Length (mm) |
|---|---|
| YOY | 0 - 70 |
| 1+ | 71 - 130 |
| 2+ | 131 - 160 |
| 3+ | 161 - 185 |
| 4+ | 186 - |

These data are relatively similar to the data presented in Greenfield *et al.* (197) for the lowland Santa Clara River population. Thus age class structure of the population can be determined if length data are collected.

This technique has been criticized due to potential injury related mortality of electroshocked fish. However, in our experience mortality is minimal if electrofishers are carefully adjusted and the fish are properly held during the removal period. In fact, Santa Ana suckers are less subject to injury than are rainbow trout.

**Snorkeling Counts.**
Hankin and Reeves' (1988) snorkeling surveys of salmonids in Cummins Creek, Oregon is a frequently used example of a snorkeling study design. Habitat units must be classified (*e.g.* riffle, pool, glide), and the stream may be further stratified based on location (*e.g.* lower,

middle or upper). The second order of stratification is only necessary if sampling occurs over significant changes in stream orders or physical changes (*i.e.* gradient or channel conformation).

Habitat units must be classified over the stream length to be studied, and their areas estimated/calculated. Next, units to be sampled must be determined. Multiple units of each habitat type must be sampled within each stream unit.

Independent counts of fish should be made by a team of two observers in each unit to be sampled. Observers enter downstream of the unit to be counted and proceed upstream, identifying species and age class (rough estimate) and counting individual fish. Observers should position themselves along the stream midline and coordinate their upstream movements. Counts must be made at a time of day when visibility is good. In the Hankin and Reeves' (1988) study the technique was variably effective dependent on species and age class.

Observer counts must be standardized for each species/age class and habitat type. Standardization is accomplished by selecting a subsample of each habitat type (using about one of every three or four of each habitat type as the subsample). Standardization is accomplished by electrofishing using a Moran-Zippin successive removal method (Seber 1973), which provides a population estimate independent of the diver counts. This is considered the optimal standardization method because many authors consider sequential removal by electroshocking a more accurate method of population size estimation (*e.g.* Gunderson 1993).

The number of fish in habitat unit $i$ can be estimated by:

$$P_i = d_i R$$

Where $P_i$ = estimated population size in habitat unit $i$

$d_i$ = mean observer count in habitat unit $i$

$R = \sum_i P_{ei} / \sum_i d$ where $P_{ei}$ is the population estimate obtained in selected units by electrofishing

An analysis of the data in the Hankin and Reeves (1988) study demonstrated that the number of fish present was poorly correlated with the area of each habitat unit, so the total number of fish within a habitat type/location stratum ($P_h$) was estimated using the formula below:

$$P_h = \frac{N}{n} \sum_{i=1}^{n} P$$

Where $P$ = estimated population size for the $i^{th}$ sampling unit in habitat type $h$

$N$ = total number of habitat units of type $h$ present in the survey area

$n$ = number of habitat units of type $h$ in the systematic sample

The variance of this estimate is a function of the variance of *R*, between-observer variance, and the variance in population size between habitat units. Hankin and Reeves (1988) an estimator for *Var(P)*, which takes all these sources of variance into account.

A more complex estimator, incorporating a measure of the size of each primary unit selected, may be preferable to the one presented above if the population size in the habitat units is highly correlated with area (Hankin 1984).

The potential advantage of snorkeling is that the total number of habitat units for which fish numbers can be estimated is increased by the use of the technique. This increased first stage sampling fraction can result in a reduction of total errors of estimation because the variance contributions associated with second stage sampling (within habitat units) are expected to be relatively small.

The potential drawbacks with snorkeling surveys are that the suckers are highly substrate associated so they are more difficult to locate, and experienced observers will be required. In the Hankin and Reeves (1988) study steelhead trout in pools were more closely associated with the substrate, this was interpreted as making them more difficult to observe; the result was that observer counts were not highly correlated with removal estimates. Additionally, snorkeling surveys do not allow collection of length-weight data, which may be used to evaluate fish condition. The length data can also be used to examine age class composition, and such data may be valuable in evaluating the status of the population, particularly over time.

**Mark-Recapture Estimates.**
Mark/recapture is one of the most common, easily performed and reliable methods of estimating fish population size. Mark/recapture is based on a simple principle. A sample of fish, $n_1$, is taken from the population at time 1, each fish is given a recognizable, nondeliterious mark that will distinguish it from uncaptured individuals, and then the sample is returned to the population. At time 2, another sample, $n_2$, is taken. The separation between time 1 and time 2 samples must be sufficient for the marked individuals to redistribute themselves among the population in the sampling area. We have found collection of the two samples 24 hours apart is appropriate. In the second sample *m* individuals are found which were previously marked. It is then assumed that the proportion of marked fish in the second sample is the same as the proportion of marked fish in the total population, *N*. Therefore:

$$n_1/N = m/n_2$$

and an estimate of *N*, *eN*, can be calculated as:

$$eN = n_1 n_2/m$$

This is the Petersen estimate of population size. It is the simplest form of mark/recapture, requiring only two samples and one type of mark. This method avoids the stress, and potential mortality, associated with the multiple captures that are necessary for other mark/recapture methods. The method makes the following assumptions (Seber, 1973; Bejon, 1979):

1. The marks are not lost in the period between the two samples and are correctly recognized in recaptured specimens.
2. Being caught, handled and marked has no effect on the probability that the individual will be recaptured.
3. Capture, handling and marking have no effect on the probability that the individual will die or emigrate.
4. All fish, marked and unmarked, have the same probability of dying or emigrating.
5. The population is sampled at random.

These assumptions may be difficult to meet in a riverine system if emigration is high. The fish can be marked with Sudan Brown Y, a vital dye that is taken up by all tissues but rapidly metabolized from muscle while remaining for several days in the bony elements. This dye persists sufficiently to allow recognition of individuals of these species for several days following staining (Baskin and Haglund, Unpubl. data). In laboratory tests the dye did not induce mortality in stained fishes over a seven day examination period (Baskin, Unpubl. data). Using this method, the fish are stained by placing them in a container and allowing them to swim in water containing the dye (2ml saturated aqueous solution/liter water) for approximately one hour. This methodology reduces the handling of the fish to an absolute minimum.

It is difficult to determine if the probability of capture is affected by previous encounter, but either seining or electroshocking can provide a random sample of fishes from the area being studied. Previous experience with this technique has shown that 24 hours allows a sufficient time interval for the fish to redistribute themselves within the capture area (the fish are manually released throughout the capture area following marking). Furthermore, mortality and emigration are minimized by using a 24 hour recapture period.

This technique allows the collection of length-weight data, however seining would be a difficult capture technique, so electroshocking would be necessary. As a result, this technique doesn't offer an advantage over depletion with an electroshocker.

**Seining Estimates.**
Seining will not be discussed in any detail here. Seining as a technique in the frequently swift, deep cobble substrate areas occupied by Santa Ana suckers is not an efficient capture technique, and reproducibility of effort is difficult. Techniques requiring seining are not recommended.

**Population Estimates Using Underwater Cameras.**
Although this sounds like a nice high tech solution to the sampling problem, it will likely be expensive, and there are many unknowns. Camera sleds have been successfully used in deepwater marine environments. Success is based on the assumption that there is neither avoidance of or attraction to the camera sled. Therefore reports of successful surveys usually involve sedentary species. Because this technique was largely developed as a marine

technique, transects were used. In a small stream two cameras (equivalent to two underwater observers) would have to be moved upstream. The cameras could either be mounted to provide two slightly different views as with the underwater observers or the two cameras could be forward facing and mounted in stereo configuration. Unless the cameras used are video cameras, there is the problem of photo interval and area calculation. Additionally because of the stratification recommended in the introduction, there would have to be surveys of different habitat boundaries, and we are not sure that habitat type boundaries would be readily discernable, particularly in still photos. Additionally, as previously mentioned, a technique that can produce length-weight data instead of just population size will be more useful in studying and understanding short and long term population trends.

**Conclusion.**
Based on the preceding discussion we recommend the use of a sequential removal technique using a backpack electroshocker to monitor Santa Ana sucker populations. If accord can be reached on this point, we will provide a more detailed protocol based on the recommended methodology.

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# Appendix 4

Communications Regarding the Enhancement of Santa Ana Sucker Breeding Substrate in Sunnyslope Creek

# San Marino Environmental Associates

## MEMO

March 14, 2002

To: Mr. Juan Hernandez, Fishery Biologist
California Department of Fish and Game

From: Jonathan Baskin, Ph.D.
Thomas Haglund, Ph.D.
Principal Senior Scientists

Re: Sunnyslope Creek – Santa Ana sucker habitat enhancement

This is to follow through on our phone conversation last week in which I requested a Streambed Alteration Agreement to do habitat enhancement for the Santa Ana sucker (*Catostomus santaanae*) in Sunnyslope Creek, at the Louis Rubidoux Nature Center, in the Santa Ana River Wildlife Area, near the City of Riverside. The specific proposed activity is to add additional substrate gravel to the stream bottom in the creek to increase the amount of appropriate spawning habitat for the sucker. This species, along with most to the species in the family Catostomidae, is known to spawn in a gravel substrate.

In 2001, as part of a study of the biology of this species in the Santa Ana River, sponsored by Santa Ana Water Project Authority, we observed spawning at two sites. One of these was in Sunnyslope Creek and the other in Rialto Drain, which were also sites where we observed sucker fry. At both of these sites, samples of the gravel substrate were taken at the exact spot where the spawning was observed, and analyzed for particle size distribution. The results of this analysis are attached here. We intend to add gravel of a similar nature to Sunnyslope Creek, anticipating that this will increase the area available for sucker spawning. We will implement this in a manner and time to avoid impacts to the suckers already present in the stream. This project is also sponsored by SAWPA.

We have gotten verbal approval for this from the people at the Nature Center, which is of course contingent upon the approval of your department.

**560 South Greenwood Avenue San Marino, California 91108-1270 (626) 792-2382**

**SMEA**
**San Marino Environmental Associates**

560 South Greenwood Avenue
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# Memo

**To:** Lucy Caskey, U.S. Fish and Wildlife Service

**From:** Jonathan N. Baskin and Thomas R. Haglund

**Cc:** Santa Ana Sucker Discussion Group

**Date:** June 10, 2002

**Re:** Sucker Breeding Habitat Enhancement Proposal - Revised

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We propose to enhance and increase breeding habitat for Santa Ana suckers in Sunnyslope Creek of the Santa Ana River by adding appropriate gravel substrate.

Suckers are known to be gravel spawners, as described in our 1999 Conservation Program. We directly observed sucker spawning and fry in Sunnyslope and Rialto creeks last year, and sampled the gravel where this spawning was observed. Analysis of this gravel (see attached graph) provides us with a good estimate of the characteristics of the substrate used by the suckers for spawning. We plan to place up to 15 cubic meters of river gravel of a similar size composition into specific spots in the lower approximately 300 meters of Sunnyslope Creek presently dominated by silt and sand, which is not used for spawning.

These areas are downstream from the sites where we observed spawning and fry in the past two years. During this period we have always found fry in proximity to spawning gravels, which are not presently found in this lower part of the creek where we propose putting the gravel. The appearance of fry in this lower area during the breeding season following the addition of gravel here would be an indication that the suckers could have used the new gravel for spawning, and that our activities could be enhancing sucker breeding.

We plan to implement this proposal after breeding has ended this year, but before flushing flows have begun in the fall.

The site is located on the grounds of the Louis Rubidoux Nature Center, in the Santa Ana River Wildlife Area, near the City of Riverside. We have discussed this proposal with the authorities at the Nature Center and received their verbal approval. A written proposal has also been submitted to the Department of Fish and Game requesting Streambed Alteration Agreement, if it is necessary.

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# Memo

**To:** Lucy Caskey, U.S. Fish and Wildlife Service

**From:** Jonathan N. Baskin and Thomas R. Haglund

**Cc:** Santa Ana Sucker Discussion Group

**Date:** September 16, 2002

**Re:** Sucker Breeding Habitat Enhancement Proposal - Revised

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We propose to enhance and increase breeding habitat for Santa Ana suckers in Sunnyslope Creek of the Santa Ana River by adding appropriate gravel substrate.
Suckers are known to be gravel spawners, as described in our 1999 Conservation Program. We directly observed sucker spawning and fry in Sunnyslope and Rialto creeks last year, and sampled the gravel where this spawning was observed. Analysis of this gravel (see attached graph) provides us with a good estimate of the characteristics of the substrate used by the suckers for spawning. We plan to place up to 5 cubic meters of river gravel of a similar size composition into specific spots in the lower approximately 300 meters of Sunnyslope Creek presently dominated by silt and sand, which is not presently used for spawning.
The two specific spots we have tentatively selected have a maximum depth of about 0.5 meters, a with of 1.5 m and a length of about 5m. We plan to place the gravel into the stream by hand, and at time just after initial flushing flows in the upcoming wet season. We anticipate that the high flow will remove a large part of the sediment now present. The exact amount of gravel placed in to the stream will be determined by the depth of the water, flow and stream conditions at the time. The following questions remain to be resolved, based mainly on the funding resources available for this activity and anticipated environmental conditions:

1. Exact timing of gravel placement.

2. Source of the gravel to be used.

These areas are downstream from the sites where we observed spawning and fry in the past two years. During this period we have always found fry in proximity to spawning gravels, which are not presently found in this lower part of the creek where we propose putting the gravel. The appearance of fry in this lower area during the breeding season following the

addition of gravel here would be an indication that the suckers could have used the new gravel for spawning, and that our activities could be enhancing sucker breeding.
The site is located on the grounds of the Louis Rubidoux Nature Center, in the Santa Ana River Wildlife Area, near the City of Riverside. We have discussed this proposal with the authorities at the Nature Center and received their verbal approval. A written proposal has also been submitted to the Department of Fish and Game requesting Streambed Alteration Agreement, if it is necessary.
Preliminary discussions with Robert Smith of the Army Corps of Engineers indicate that no Corps permits will be necessary because the amount of gravel to be placed in the stream is small.

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# Memo

**To:** Mr. Ron Baxter
Natural Resources Manager
Riverside County Regional Parks and Open-space District

**From:** Jonathan Baskin, Ph.D.
Thomas R. Haglund, Ph.D.
Principal Senior Scientists

**Date:** January 18, 2004

**Re:** Sunnyslope Creek – Santa Ana sucker breeding habitat enhancement

This is to follow through on our meeting last week in which we discussed our plan to do habitat enhancement for the Santa Ana sucker (*Catostomus santaanae*) in Sunnyslope Creek, at the Louis Rubidoux Nature Center, in the Santa Ana River Wildlife Area, near the City of Riverside. The specific proposed activity is to add additional substrate gravel to the stream bottom in the creek to increase the amount of appropriate spawning habitat for the sucker. This species, along with most to the species in the family Catostomidae, is known to spawn in a gravel substrate. We are requesting the approval of your department to implement this plan.

In 2001, as part of an ongoing study of the biology of this species in the Santa Ana River, sponsored by Santa Ana Water Project Authority (SAWPA), Santa Ana Sucker Conservation Team, we observed spawning at two sites. One of these was in Sunnyslope Creek and the other in Rialto Drain, which were also sites where we observed very young suckers (fry). At both of these sites, samples of the gravel substrate were taken at the exact spot where the spawning was observed, and analyzed for particle size distribution. The results of this analysis are in our 2002 report (enclosed, pp. 54-58).

Over the past 2 years we have noted many fewer sucker fry in the creek, and much less appropriate gravel substrate. Instead there is much more sand and silt substrate, and the gravel present is much more highly imbedded. This means that the gravel is at least partially buried in sand/silt, making it unsuitable for holding fish eggs and yolk-sac larvae. We believe this increase in sand/silt is due to a lack of flushing water flow events in Sunnyslope creek in the past 2 years. We intend to add gravel of a similar nature to that found at the breeding site in Sunnyslope Creek, anticipating that this will increase the area available for sucker spawning. We will implement this in a manner and time to avoid impacts to the suckers already present in the stream.

Barbara Ire, of the Rubidoux Nature Center is aware of our activities and plans. We have been in communication with the Department of Fish and Game (Raul Rodriquez and Juan Hernandez), U. S. Fish and Wildlife Service (Lucy Caskey) and the Army Corps of Engineers (Robert Smith) about this, and they have informally indicated support for this project. Mr. Smith has indicated that the amounts of gravel we intend to use are below the amount necessary for an Army Corps permit. The exact amounts and point of placement of the gravel in the creek, below the concrete lined channel will be determined by conditions at the time of implementation.

# Exhibit 4

## SPECIES NAME AND GROUP DESIGNATION

**Common Name and Scientific Name:** arroyo chub (*Gila orcutti*) (Eigenmann and Eigenmann 1890)

**Status:** **State:** Species of Special Concern
**Federal:** None

## GROUP DESIGNATION AND RATIONALE

### Group 2

The arroyo chub is distributed within two watersheds, the Santa Ana and Santa Margarita watersheds. It occurs in several locations within these watersheds. Although the preferred habitat, open water and emergent vegetation in lower gradient streams with sand or mud substrate, is located in numerous areas within the Plan Area, only six drainages currently support populations of the arroyo chub. These locations comprise the Core Areas for the species and include the Santa Margarita River, De Luz Creek upstream of the De Luz Post Office, lower Sandia Creek, Murrieta Creek near its mouth at the Santa Margarita River, Cole Creek between the confluence of Murrieta Creek and the edge of the Conservancy property, and Temecula Creek upstream of Vail Lake. Within the Santa Ana River, the species Core Area occurs from the Riverside and San Bernardino county line downstream to the Prado Dam (Swift 2001). Because it requires specific well known habitat conditions and occurs in few Core Areas within a larger habitat category, the arroyo chub will require conservation on a landscape level as well as on site specific considerations for the known Core Areas as a Group 2 species.

## SPECIES CONSERVATION OBJECTIVES

The species-specific conservation objectives developed for this species are based upon the best available scientific information at the time of MSHCP preparation. Pursuant to *Section 5.0* which includes Management, Monitoring and the Adaptive Management Program, the MSHCP's mitigation requirements will be monitored and analyzed to determine if they are producing the desired result. Based upon this information, the following species-specific conservation objectives will be adjusted if appropriate, as new information is gathered during Plan implementation. The Adaptive Management Program will be used to identify alternative strategies for meeting the MSHCP's general biological goals and objectives and, if necessary, adjusting future conservation strategies according to the information received.

### Objective 1

Include within the MSHCP Conservation Area, 4,580 acres of habitat that provides potential spawning and foraging opportunities for the arroyo chub in the Santa Ana and Santa Margarita watersheds.

### Objective 2

Include within the MSHCP Conservation Area, the suitable Core Areas for the arroyo chub in the Santa Ana watershed. Conserve the natural river bottom and banks, including the adjacent upland habitat where available to provide shade and suitable microclimate conditions (*e.g.*, alluvial terraces, riparian vegetation) of the Santa Ana River from the Orange County and Riverside County line to the upstream boundary of the Plan Area.

### Objective 3

Include within the MSHCP Conservation Area, the suitable Core Areas and available adjacent habitat for the arroyo chub in the Santa Margarita watershed. Conserve the natural river and or creek bottom and banks up to an elevation of 400 meters in the reach of the Santa Margarita River in the Plan Area, and in De Luz Creek and its tributary downstream to the County line, in upper Sandia Creek downstream to the County line, in Murrieta Creek from Winchester Road to near its confluence with the Santa Margarita River, in Cole Creek between its confluence with Murrieta Creek and the boundary of Conservancy property and in Temecula Creek from Long (Smith) Canyon just below the falls near the County line downstream to a concrete drop structure at Highway 79 (upstream of Vail Lake).

### Objective 4

Within the MSHCP Conservation Area, the Reserve Managers responsible for the areas identified in the Santa Margarita watershed will assess the range of chub movement in the watershed and the need for connectivity and identify measures to restore connectivity to be implemented as feasible.

### Objective 5

Within the MSHP Conservation Area, the Reserve Managers responsible for the areas identified in Objectives 2 and 3 will assess threats to the chub from degraded habitat (*e.g.*, reduced water quality, loss of habitat, presence of non-native predators and vegetation); identify areas of the watershed that are necessary to successful spawning of the chub, identify areas for creation of stream meanders, pool riffle complexes and reestablishment of native riparian vegetation as appropriate and feasible and identify and implement management measures to address threats and protect critical areas.

## SPECIES CONSERVATION ANALYSIS

### Conservation Levels

For the purpose of the conservation analysis, potential habitat for the arroyo chub within western Riverside County was identified as open water channels and emergent vegetation areas or lower gradient stream sections within the Santa Ana watershed and Santa Margarita watershed and specific tributaries to the main drainage. Additional vegetation types adjacent to the streams were included as buffer habitats essential to maintaining the ecological integrity of the freshwater systems. Additional habitats included riparian forest/woodland/scrub habitats, oak woodland and forest, Riversidean alluvial fan sage scrub, grassland, coastal sage scrub and agricultural lands. These habitats were included in the analysis for a width of approximately 1,300 feet centered on the channel of the Santa Ana River. Also included in the area of the Santa Ana watershed conserved for the arroyo chub are the main tributaries for a distance of at least 0.5 miles upstream from the confluence of the tributary with the Santa Ana River. These tributaries include Sunnyslope Creek, Mount Rubidoux Creek, Arroyo Tequesquite, Anza Park Drain, Evans Lake Drain, Temescal Creek and Aliso Creek. The elevation included in the analysis extended to 400 meters above median sea level (AMSL); elevations above this point were considered to be typical of higher gradient steam sections unlikely to support any life stage of the arroyo chub. For the Santa Margarita watershed, these habitats were included in the analysis for a width of approximately 600 feet centered on the main channel of the Santa Margarita River and the tributaries including De Luz Creek and its tributary downstream to the County line, upper Sandia Creek downstream to the County line, Murrieta Creek from Winchester Road to near its confluence with the Santa Margarita River, Cole Creek between its confluence with Murrieta Creek and the boundary of Conservancy property, and Temecula Creek from Long (Smith) Canyon just below the falls near the County line downstream to a concrete drop structure at Highway 79 (upstream of Vail Lake). These drainages within the Santa Margarita watershed are included within the Proposed Constrained Linkages 11, 12 and 13 with average widths of 380, 700, and 980 feet respectively. The Santa Margarita River is located within Existing Core G and the eastern reach of the Temecula Creek is located within Proposed Core 7.

Based on these habitats, the Plan Area supports approximately 5,100 acres of potential habitat for the arroyo chub. *Table 1* shows the conservation and loss of potential habitat for the arroyo chub. Overall, approximately 4,580 acres (90 percent) of potential habitat in the Plan Area will be conserved in Criteria Area or existing Public/Quasi-Public Lands. This includes a total of 100 percent of the open water and freshwater marsh within the Santa Margarita watershed and 97 percent of the open water and freshwater marsh habitat within the Santa Ana watershed. The open water areas not included within the Santa Ana watershed included small ponds or water bodies that are isolated from the main channel of the river but that are located within the area analyzed for conservation for the species.

In addition, the wetland habitats policy described in *Section 6.1.2* of the *MSHCP, Volume I* provides for conservation of wetlands which provide habitat for this species through avoidance and minimization. Mitigation for impacts to wetlands shall be incorporated in accordance with the "No Net Loss" policy of federal and state wetland regulations. The proposed mitigation shall be directly related to the functions and values of the wetland as related to this species and result in equivalent replacement.

The conservation of core populations includes the Santa Ana River, including the Sunnyslope Creek, Lake Evans Drain, Arroyo Tequesquite, Anza Park Drain, Temescal Creek, Aliso Creek, and Mount Rubidoux Creek tributaries, from the county line downstream of Prado Dam to the upstream boundary of the County line. Definable core population locations are also located within the Santa Margarita watershed including the mainstem of the Santa Margarita River, in De Luz Creek and its tributary downstream to the County line, in upper Sandia Creek downstream to the County line Murrieta Creek from its mouth upstream to Winchester Road, Cole Creek between its confluence with Murrieta Creek and the boundary of Conservancy property and Temecula Creek from Vail Lake upstream to Long Canyon. All of these conserved core populations include the stream channel itself with its associated open water and emergent vegetation, as well as riparian and other habitats analyzed for a 1,300-foot area centered on the main channel of the river for the Santa Ana River and a 600-foot area centered on the main channel of the river for the Santa Margarita River.

Additional conservation measures for the arroyo chub include an assessment of the barriers to fish movement and identification of measures to restore connectivity if feasible. Conservation measures also will include an assessment of threats to the arroyo chub, identification of areas that are necessary for spawning, identification of areas for the creation of stream meanders, creation of pool riffle complexes, and establishment of native vegetation.

# TABLE 1
# SUMMARY OF HABITAT CONSERVATION
# ARROYO CHUB

| | Within MSHCP Conservation Area | | | | Outside MSHCP Conservation Area | | |
|---|---|---|---|---|---|---|---|
| Vegetation Type | MSHCP Plan Area (Acres) | Criteria Area[1] (Acres) | Public/ Quasi-Public (Acres) | Total Within MSHCP Conservation Area (Acres) | Rural/ Mountainous (Acres) | Outside MSHCP Conservation Area (Acres) | Total Outside MSHCP Conservation Area (Acres) |
| **Santa Ana River Watershed** | | | | | | | |
| Water | 200 | 20 | 170 | 190 | 0 | 10 | 10 |
| Freshwater marsh | 100 | 30 | 70 | 100 | 0 | 0 | 0 |
| Riparian habitat, Riversidean alluvial fan sage scrub, and coastal sage scrub adjacent to the channel | 3,570 | 360 | 2,830 | 3,190 | 0 | 380 | 380 |
| **Subtotal Santa Ana River Watershed** | **3,870** | **410 (11%)** | **3070 (79%)** | **3480 (90%)** | **0 (0%)** | **390 (10%)** | **390 (10%)** |
| **Santa Margarita Watershed** | | | | | | | |
| Water | 50 | 50 | 0 | 50 | 0 | 0 | 0 |
| Freshwater marsh | 30 | 30 | 0 | 30 | 0 | 0 | 0 |
| Riparian habitat, Riversidean alluvial fan sage scrub, and coastal sage scrub adjacent to the channel | 1,150 | 690 | 330 | 1,020 | 90 | 40 | 130 |
| **Subtotal Santa Margarita River Watershed** | **1,230** | **770 (63%)** | **330 (27%)** | **1,100 (90%)** | **90 (7%)** | **40 (3%)** | **130 (10%)** |
| TOTAL | 5,100 | 1,180 (23%) | 3,400 (67%) | 4,580 (90%) | 90 (2%) | 430 (8%) | 520 (10%) |

[1] Acres refer to Additional Reserve Lands to be assembled from within the Criteria Area.

The Reserve Managers responsible for the areas identified in Objectives 2 and 3 will assess the threats to the sucker due to degraded habitat and implement management measures to address the threats and protect critical areas. Restoration of potential habitat areas through enhancement of existing habitats, removal of non-native vegetation, instream habitat modifications in tributaries that provide potential spawning and nursery habitat, and planting of stream side native riparian trees and shrubs may improve and restore the habitat for the Santa Ana sucker.

### MSHCP Conservation Area Configuration Issues

Conserved tributaries (*e.g.*, Sunnyslope Creek or Murrieta Creek) are contiguous with the conserved portions of the main river channels (*i.e.*, both the Santa Ana and the Santa Margarita River). The arroyo chub requires lower flow tributaries of high quality water and as such, the MSHCP Conservation Area will provide adequate habitat linkages between the main Santa Ana River channel and tributaries and between Temecula Creek and the Santa Margarita River. Based on this information, the MSHCP Conservation Area will contain the major known Core Areas for the species within western Riverside County. Within the Santa Margarita River, this includes the mainstem of the river from the junction with Rainbow Creek upstream to junction with Murietta Creek, Cole Creek between its confluence with Murrieta Creek and the boundary of Conservancy property, Temecula Creek from its mouth (Vail Lake) upstream to Long Canyon (locally known as Smith Canyon) just below the falls near county line (including the Wilson Miller Creek tributary), and Murietta Creek downstream of the Winchester Road crossing in Temecula to its junction with the Santa Margarita River. Within the Santa Ana River, the MSHCP Conservation Area will include the mainstem of and tributaries to the river from Riverside and San Bernardino County line downstream to the Riverside and Orange County line below Prado Dam.

### Conservation Summary

In summary, conservation for this species will be achieved by inclusion of at least 4,580 acres of suitable Conserved Habitat including the occupied habitat (water and freshwater marsh) and adjacent buffer and streambank (includes a variety of habitats) within the MSHCP Conservation Area. All of the known and potential locations, refugia, and spawning areas are included within the MSHCP Conservation Area. In addition, Objectives 4 and 5 will provide assessment of barriers and threats to the arroyo chub by the Reserve Managers and will identify measures to be implemented if feasible.

## INCIDENTAL TAKE

About 520 acres (10 percent) of potential habitat for the arroyo chub will be outside the Criteria Area and Public/Quasi-Public designations and individuals within these areas will be subject to consistent with the Plan. A total of 10 acres (3 percent) of the open water habitat within the Santa Ana River will be outside the Criteria Area and Public/Quasi-Public designations. These open water areas are currently unsuitable areas of isolated ponds that are not connected to the Santa Ana River but are located within the area analyzed for conservation of this species. Other upland and adjacent areas within the Santa Ana River watershed that are not conserved include adjacent habitat within the Green River Golf Club, an upland area within the Silver Lakes areas and and upland area between Mission Boulevard and Rancho Jurupa Park where the adjacent habitat area narrows. None of the stream channel reaches of the Santa Ana River are outside of the MSHCP Conservation Area. None of the open water or emergent vegetation within the Santa Margarita River and its arroyo chub occupied tributaries is located outside the Criteria Area and Public/Quasi-Public designations. Other upland and adjacent areas within the Santa Margarita River watershed that are not conserved include adjacent habitat within De Luz Creek which averages narrower than the 600-foot area analyzed for conservation. This drainage averages approximately 380 feet in width within the MSHCP Conservation Area. De Luz Creek drainage is conserved, however the buffer of upland habitat is narrower than most of the other drainages within which the arroyo chub occurs. None of the Core Areas, spawning areas, dispersal, or refugia areas are outside of the MSHCP Conservation Area for either watershed. It should be noted that wetland habitats located outside the MSHCP Conservation Area would be subject to the wetland policy presented in *Section 6.1.2* of the *MSHCP, Volume I.*

The of the chub is difficult to quantify because larva and adults are quite small in body sizes, finding a dead or impaired specimen is unlikely, the species occurs in habitat that make detection difficult and losses may be masked by fluctuations in abundance and distribution during the life of the permit.

## Data Characterization

Data reviewed includes the California Natural Diversity Database (CNDDB) and the University of California, Riverside, GIS database, and available literature.

There are eight records for the arroyo chub in the UCR location database ranging in date from 1974 to 1999. All of the records are for the Santa Ana River. However, other investigators report locations within the Santa Margarita River Watershed as well as the Santa Ana River Watershed.

The quantity and scope of the available literature for the species is moderately high, including descriptions of general biology for the species, recent locational information within several historically occupied watersheds, edaphic factors limiting the species distribution within portions of the watersheds, current habitat conditions, as well as general and specific management recommendations.

## Habitat and Habitat Associations

The arroyo chub is adapted to surviving in the warm fluctuating streams of the Los Angeles Plain. They prefer slow moving or backwater sections of warm to cool streams with substrates of sand or mud (Moyle 1976a). The depth of the stream is typically greater than 40 centimeters (Moyle 1976a).

## Biogeography

The native range of the arroyo chub includes the Los Angeles, San Gabriel, San Luis Rey, Santa Ana, and Santa Margarita rivers and also Malibu and San Juan creeks (Wells and Diana 1975). This species is common at three localities within its native range, namely the upper Santa Margarita River and its tributary, De Luz Creek; Trabuco Creek below O'Neill Park and San Juan Creek drainage; and Malibu Creek. It is present, but scarce in Big Tujunga Canyon (Pacoima Creek above Pacoima Reservoir), and in the Sepulveda Flood Control Basin, Los Angeles River drainage; upper San Gabriel River drainage; and middle Santa Ana River tributaries between Riverside and the Orange County line (Swift *et al.* 1993).

Introduced populations occur at Santa Maria-St. Inez, Mojave, Santa Clara, and Cuyama river drainages, and a portion of San Felipe Creek (Miller 1968; Moyle 1976b; Bell 1978; Sigler and Sigler 1987; Page and Burr 1991). Within the literature, there is some disagreement regarding the extent of this species' native distribution. Miller (1968) and Bell (1978) conclude that the Santa Clara population is probably introduced while Moyle (1976b), and Page and Burr (1991) indicated that this population is native. Fish fossils at Rancho La Brea, including arroyo chub (Swift 1989) indicate local, permanent stream conditions, and not stream transport from distant mountainous areas.

## Known Populations Within Western Riverside County

The arroyo chub is known to occur in the Santa Ana River from the County line (approximately Riverside Avenue) downstream to approximately Van Buren Boulevard, primarily within the willow forest area two to three kilometers upstream of Prado Dam (Swift 2001). Temescal Creek reportedly contained a large population of arroyo chubs; however, sampling conducted from 1997 onward within the creek yielded only a few fish (Swift 2001). Therefore, the stream may no longer support a population large enough to be considered a Core Area. It is abundant at only a few widely scattered locations within the Santa Margarita River watershed where both permanent water and low numbers of exotic predators occur (Fisher and Swift 1998). These locations include the Santa Margarita River mainstem from Murietta Creek downstream to Rainbow Creek, in Murrieta Creek downstream of the Winchester Road crossing in Temecula downstream to the junction with the Santa

Margarita River, in Cole Creek upstream of its confluence with Murrieta Creek and the boundary of Conservancy property (Robert Fisher 2002, pers. comm.), in Temecula Creek from Long (Smith) Canyon just below the falls near the County line downstream to a concrete drop structure at Highway 79 (upstream of Vail Lake), in upper Sandia Creek downstream to the County line, and in De Luz Creek and its tributary downstream to the County line (Swift et. al. 2000). The arroyo chub has been documented in the past in lower Temescal Creek (Robert Fisher 2001, pers. comm., Swift 2001), and may still occur in San Jacinto River (Fisher and Swift 1998); however, it has not been documented in either drainage recently.

## Biology

***Genetics:*** The increase in fragmentation of the remaining population causes a loss of genetic variability and results in higher vulnerability to random events, environmental factors, and inbreeding which may allow increased expression of deleterious genes. Small populations cannot respond successfully to environmental stressors when genetic variability is reduced (Moyle 1976a). Several documented barriers to annual upstream migration of the arroyo chub exist within both the Santa Ana and Santa Margarita Rivers, potentially reducing gene flow between refugia populations within the watersheds. Swift (2001) notes that the Prado Dam in the Santa Ana River may present a genetic barrier if reproduction of native fish species does not occur below the dam, since several impassable upstream barriers prevent any fish below the dam from returning to reproducing populations upstream. Although the arroyo chub may have several refugia populations within portions of a creek in perennial water areas, there may be annual gene flow between these populations, making the maintenance of the intermediate creek stretches important for long-term persistence of the species (Fisher and Swift 1998).

***Diet and Foraging:*** The arroyo chub is omnivorous, feeding primarily on algae (Greenfield and Deckert 1973), but also ingesting other plants, aquatic insects and their larvae, small crustaceans, and feeding extensively on roots of a floating water fern (*Azolla*) infested with nematodes (Moyle 1976a).

***Reproduction:*** Arroyo chubs are fractional spawners that breed more or less continuously from February through August, although most spawning takes place in June and July (Tres 1992). Most spawning occurs in pools or in quiet edge water, at temperatures of 14 to 22 degrees Celsius during March and April (Moyle *et al.* 1995). Larger fins distinguish males from females, and when breeding, males develop a prominent patch of tubercles on the upper surface of the pectoral fins (Tres 1992). Egg release is initiated by the male rubbing his snout against the area below the female's pelvic fins. Once released, eggs may be fertilized by more than one male. Chubs attach their eggs to trailing vegetation in flowing water, at least in captive situations (Tres 1992). After four days (at 24 degrees Celsius) embryos hatch, with larvae about 4 to 6 millimeters long when they emerge (Swift 2001). After hatching, the fry spend the first three to four months in quiet water, in the water column and usually among vegetation or other flooded cover. They begin to reproduce at the age of one year. Age and growth in arroyo chubs remains to be thoroughly investigated, but Moyle (1976a) reports that they seldom exceed 75 mm. Tres (1992) found that arroyo chubs live three to four years.

***Survival:*** Castleberry and Cech (1986) demonstrated in laboratory studies that this species is physiologically adapted to survive hypoxic conditions and the wide fluctuations in temperature common in south coastal streams. They are adapted for surviving the warm fluctuating streams of the Los Angeles Plain which historically shifted naturally between muddy torrents in the winter and clear intermittent brooks in the summer (Moyle 1976a).

***Dispersal:*** Natural dispersal is typically up- or downstream as conditions and suitable habitat permit, and is typically facilitated by flooding events (Moyle 1976a). Fisher and Swift (1998) noted that arroyo chub dispersal within the mainstem of the Santa Margarita River appeared to increase dramatically after El Nino rains produce flood waters that heavily scour the vegetation within the drainage, widening channels and reducing channel depths, creating habitat conditions that favor the chub and reduce exotic fish presence. The larvae and juveniles of the species tend to invade standing backwaters and/or disperse downstream from upstream spawning areas within the Santa Ana River (Swift 2001). Dispersal within both watersheds is currently limited by several large dams that serve as migration barriers. In addition, many tributaries within each watershed are limited to chub occupation by artificial or natural upstream migration barriers (Swift 2001, Fisher and Swift 1998).

***Socio-Spatial Behavior:*** No information is available or was reviewed.

***Community Relationships:*** Arroyo chub prefer low gradient portions of streams with sand and mud substrates, and often spawn in warmer water relative to the Santa Ana sucker. These species tend to complement each other's distributions within the watersheds they occupy, with suckers found in higher elevation, higher gradient portions of the stream and chubs found in lower elevation, lower gradient stream sections (Swift 2001). Mass hybridization between the arroyo chub and the Mojave tui chub have depleted most, if not all, pure stock of tui chub in the Mojave River drainage (Hubbs and Miller 1943; Moyle 1976b, 1976b; Miller *et al.* 1991; Swift *et al.* 1993). Castleberry and Cech (1986) studied the response of arroyo chubs and Mojave tui chubs to abiotic factors. They found that arroyo chubs are more tolerant and respond more appropriately to laboratory conditions simulating stressors of desert rivers than the tui chubs. This presumably is because they are better suited to habitats such as these, evolving in environments similar to the Mojave River (Eigenmann and Eigenmann 1890; Miller 1942). In contrast, tui chubs, until the late Cenozoic, have evolved in lake environments and are less suited for inhabiting rivers. Arroyo chub were found to be more tolerant of higher temperatures which would occur under low water conditions. They exhibited a large metabolic rate increase following temperature increases which could aid in remaining active and escaping stressful conditions. Moreover, arroyo chub experienced difficulty acclimating to cooler temperatures, while tui chubs showed a greater tolerance for colder temperatures, which is typical of lake dwelling fishes. In the Mojave River environment, in which low water temperatures are transient, this would give the tui chubs a selective disadvantage in relation to arroyo chubs. Castleberry and Cech (1986) suggest that tui chubs persisted in the Mojave River in the absence of a similar fish.

Within the Cuyama River, California roach-arroyo chub hybrids are abundant (Moyle 1976a). High stream flows segregate the two species, the chubs preferring large pools and reservoirs while the roach utilizes riffles and smaller pools. Low flow events force the species together, resulting in hybridization.

## Threats to Species

The arroyo chub is currently scarce within their native range because the low-gradient streams in which they do best have largely disappeared. Their native range is largely coincident with the Los Angeles metropolitan area where most streams are degraded and populations are reduced and fragmented (Moyle *et al.* 1995). The potential effects of introduced species, combined with the continued degradation of the urbanized streams that constitute much of its habitat, mean that this species is not secure despite its relatively wide range. The high degree of fragmentation of the remaining populations make the arroyo chub especially vulnerable to random events, environmental factors, and loss of genetic variability. Random events such as floods, fires, variations of annual weather patterns, predation and associated demographic uncertainty, may lead to the demise of the remnant populations in the Santa Ana River and Santa Margarita River watersheds. Threats to the arroyo chub within the Santa Ana River and the Santa Margarita River may be generalized into three categories; habitat based threats (*e.g.*, degradation, fragmentation, destruction), biological threats (*e.g.*, predation, competition), and water quality threats (*e.g.*, temperature, salinity, pollution). Many of the threats are unique to each watershed, whereas others are the result of changes affecting the entire range of the species. Specific threats to the species are discussed below by watershed.

## Santa Ana River

Threats to the continued persistence of the arroyo chub within the Santa Ana River are wide-spread and diverse. Habitat-based threats include extensive existing and proposed channelization, hardbank stabilization, flood control projects that directly remove habitat for the chub, modify it to such a degree that the species can no longer utilize it, or fragment the existing areas of occupied habitat within the watershed. The Santa Ana River and tributaries within western Riverside County currently contain miles of rip-rap bank stabilization between Riverside Avenue and the Prado Dam. Swift (2001) documented a portion of Sunnyslope Creek that has been progressively migrating northward due to a capped landfill and associated rip-rap bank stabilization upstream at the present mouth of Arroyo Tequesquite. The river has been diverted to the north by this streambank armoring and is progressively eroding away an existing stream meander in lower Sunnyslope Creek, removing habitat occupied by native fish. Swift (2001) estimates that three to four miles of stream habitat have been removed in the last fifteen years due to intensive flood control projects within the Sunnyslope and Arroyo Tequesquite drainages alone. Bridges and diversions and their associated regular maintenance also negatively affect the species.

The River Road bridge does not span the floodplain of the Santa Ana River and requires regular removal of sand to prevent drifting sand from overwhelming the bridge. Swift (2001) documented sand mining at River Road that restricted the downstream movement of native fish. In addition, the diversion downstream of River Road reduces the amount of water in the river by one-half (Swift 2001), reducing instream habitat quantity within the river for native fish and creating a one-way flow of fish through culverts. Abundant predatory fish species moving from ponds are also a significant threat in this area of the Santa Ana River. Extensive cement channelization, rip-rap bank stabilization, construction and maintenance of diversions and drop-structures has been implicated as a key factor responsible for the decline of freshwater fishes native to the Los Angeles basin (USFWS 2000).

Instream migration barriers in the form of culverts, drop-structures, and dams pose a serious threat to the Santa Ana River population of arroyo chubs. Dams and other barriers isolate and fragment fish populations, and likely have resulted in some populations being excluded from suitable spawning and rearing tributaries (USFWS 1999). Swift (2001) documents two major instream migration barriers within the Santa Ana River; the Prado Dam outlet, which contains rapid flow over a laminar concrete surface and the diversion dam just downstream of River Road, which allows water to pass downstream through culverts with 40 to 70 centimeter falls at their downstream ends. In addition, all tributaries to the Santa Ana River between Riverside Avenue and the Prado Dam (excepting the seep under Market Street Bridge and Mt. Rubidoux Creek) are limited upstream by artificial barriers, consisting primarily of unpassable culverts or concrete-lined channels (Swift 2001).

An additional habitat-based threat to the species within the Santa Ana River includes the spread of invasive giant reed (*Arundo donax*) and tamarisk (*Tamarix* sp.) throughout the watershed. These plants tend to create large monocultures of emergent vegetation and habitat areas suitable to exotic predatory fish by gradually increasing water depth, lowering flow gradients, covering spawning gravels or cobbles, and out-competing emergent vegetation beneficial to the arroyo chub and other native fishes.

The primary water quality threat to the arroyo chub in the Santa Ana River in western Riverside County is the long-term security of base flows within the river downstream of the Rapid Infiltration and Extraction Plant (RIX) outlet. The flow within the river is subject to frequent drops downstream of the Rialto Drain and the RIX plant, which are the origination sources of flow for the river below the Seven Oaks Dam in San Bernardino County. Swift (2001) indicates that every few weeks the flow drops by more than 50 percent for a few hours or more during maintenance and Clean Water Act (CWA) requirements, dramatically reducing the shallow water habitats favored by native fishes downstream to Riverside Avenue and potentially limiting the number of fish that may inhabit the upstream areas of the river. A portion of these flows may be subject to sale in the future, potentially reducing the flow volume available to the arroyo chub in the river. In addition, water pollution from non-point sources including heavy metals, high-levels of bacteria, and low levels of protozoa and viruses has been identified as a potential threat (Egan *et. al.* 1992).

Biological threats to the species in the Santa Ana River include high levels of predation by exotic and introduced fish, as well as competition with non-native fish species. Swift (2001) notes that arroyo chub were absent from lower gradient habitats with softer substrates downstream of Van Buren Boulevard that would otherwise have been appropriate for them. This absence of chubs is correlated with an abundance of predatory fish species including green sunfish, largemouth bass, back bullhead, and mosquitofish (Swift 2001). The greatest predatory effect of these species is in the lower two-thirds of the river where habitat conditions are most favorable for arroyo chub, as well as the exotics. In addition, arroyo chub were observed in standing backwaters within the watershed, where habitat conditions strongly favor exotic predators (Swift 2001). Competition may also be a significant issue for chubs, especially with fathead minnows, and tilapia, all of which have ecological requirements similar to those of the arroyo chub (Swift *et. al.* 2000).

## Santa Margarita River

Habitat-based threats to the species within the Santa Margarita River differ markedly from those in the Santa Ana River, primarily because the majority of the watershed below Vail Lake is intact, with minimal physical disturbance of the floodplain and tributaries (Fisher and Swift 1998). However, significant threats to arroyo chub habitat within Western Riverside County include hardbank stabilization, the channelization of a portion of Temecula Creek within the city of Temecula, and the proposed channelization of approximately eleven miles of Murietta Creek. These flood control measures have removed or threaten to remove existing arroyo chub habitat. Although the chub is relatively widespread throughout the watershed, it is abundant in only a few locations that contain both perennial water and few predators. Thus, removal of those habitats that contain these conditions may negatively affect the species abundance and distribution throughout the watershed. In addition, several barriers to upstream fish migration occur within the watershed, including a concrete drop structure at Highway 79 upstream of Vail Lake on Temecula Creek, and the gauging station at the top of the gorge in Temecula (at the mouth of Murietta Creek) (Fisher and Swift 1998). These structures, in addition to many tributaries that contain seasonally dry conditions limit the distribution of the species within the watershed.

Additional habitat-based threats to the chub include invasive giant reed (*Arundo donax*) and Tamarisk (*Tamarix* sp.), which are encroaching on streambanks throughout the Santa Margarita River watershed and channelizing flows in low gradient drainages to the benefit of exotic predators, reducing the amount of shallow water habitats available for the arroyo chub (Swift *et. al.* 2000). Also, as urbanization increases within the upper portions of the watershed, threats such as reduction of the riparian zone and aggressive water use threaten to diminish available habitat areas for the chub (Swift *et. al.* 2000).

Water quality threats within the Santa Margarita River watershed include increased amounts of nitrates from sewage effluents and agricultural runoff (Swift *et. al.* 2000). Biological threats to the chub in the watershed are significant due to the presence of several predatory exotic species including redeye bass, largemouth bass, black bullheads, green sunfish, and mosquitofish. Redeye bass appear to be excluding arroyo chub from portions of the river mainstem that are optimal for the bass, but the species does not appear to have invaded any of the tributaries. The remaining species prey on the chub in deeper, warmer waters throughout the watershed, often excluding smaller size classes of chub through predation. In contrast to the Santa Ana River, the chub may benefit from the apparent absence of two competitor cyprinid species including red shiners and fathead minnows within the Santa Margarita River (Swift *et. al.* 2000). Chubs generally decline when red shiners become abundant (Moyle *et al.* 1995). However, an additional threat unique to the Santa Margarita watershed is the presence of beavers, which are creating ponded conditions within the drainage that may be adversely affecting the chub by promoting warm, deep water habitats that favor exotic predatory fish.

## Special Biological Considerations

Arroyo chub are now considered scarce within their native range, because they prefer lower gradient streams that have largely disappeared. The majority of the arroyo chub population occurs within areas of large human populations associated with the Los Angeles metropolitan area, and consequently should be monitored closely (Moyle 1976a).

Dams and reservoirs greatly reduce the natural variability in environmental conditions, resulting in the domination of non-native fish faunas (Moyle 1976a; Herbold and Moyle 1986; Moyle and Light 1996). High disturbance systems support groups of species that would probably not coexist under natural conditions. For example, 3-4 species of predatory bass commonly live within reservoirs on California rivers, while rarely are more than two species found together in natural systems (Moyle and Light 1996). Cornell and Lawton (1992) argue that ecological communities are rarely saturated with species, thus, even complex systems may be invaded relatively easily. Successful invasions are most likely to occur when native assemblages have been temporarily disrupted or depleted (Moyle and Light 1996). The match between an invader and the hydrologic regime seems to be the most important factor in determining the success of an invasion, rather than the biotic resistance (Moyle and Light 1996; Case 1991). However, most invasions do not result in direct extirpation, except in the case of piscivores, or when invaders can hybridize with native species (Moyle and Light 1996). In relatively unmodified streams, such as Deer Creek (Tehama County), the natural hydrologic regime prevents repeated invasions of nonnative fish (Moyle and Light 1996).

Management considerations for the arroyo chub should include careful consideration of several factors that appear to be influencing the population demographics of the species within both the Santa Ana and Santa Margarita watersheds. Preservation of existing connected habitat areas for the species within the mainstem of the rivers and their associated tributaries, as well as restoration of additional habitat areas within the mainstem of the rivers and any appropriate tributaries to promote the maximum genetic flow and widest distribution possible for the species is paramount.

To support preservation and restoration activities, accurate characterization and mapping of seasonally restricted habitat areas and migration barriers within each watershed should be conducted, as should identification of tributaries and mainstem areas that provide the most appropriate spawning, rearing, and adult foraging habitats for arroyo chub. The various ownerships and management regimes of the lands that surround and contribute to the ecological integrity of the arroyo chub instream habitat also need to be taken into consideration. Management activities should target reduction or removal of exotic predatory fish species, especially within areas of potential habitat for the arroyo chub, and consider the effects that other non-native species such as beaver, crayfish, and African clawed-frogs may be having on the species. Management considerations within the Santa Ana River must also account for the presence of the Santa Ana sucker. The Santa Ana sucker generally prefers habitats with steeper gradients and faster flows than the arroyo chub, so they complement each other's distributions in the watershed. Saiki (2000) states that a stepwise multiple regression analysis of the biological variables from his study of the Santa Ana Sucker within the San Gabriel and Santa Ana Rivers indicates that the relative abundance of arroyo chub is directly correlated to and is a predictor of Santa Ana sucker abundance.

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# Exhibit 5

**Habitat Conservation Planning Branch**
1416 Ninth St., Sacramento, CA 95814
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http://www.dfg.ca.gov/hcpb/cgi-bin/read_one.asp?specy=fish&idNum=28

**Santa Ana Speckled Dace**
***Rhinichthys osculus ssp.***

**State Status:** Species of Special Concern
**Federal Status:** None

**Fish Species of Special Concern in California, Santa Ana Speckled Dace. California Department of Fish and Game, 1995.**

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Nonindigenous Fish Distribution Information, Species List, Rhinichthys osculus. U.S. Geological Survey, Nonindigenous Aquatic Species, 1999.

http://nas.er.usgs.gov/fishes/accounts/cyprinid/rh_oscul.html

SANTA ANA SPECKLED DACE

Description: This is a small (<80 mm SL) cyprinid, with basic characteristics similar to those of Amargosa Canyon speckled dace. Cornelius (1969) presented evidence that the Santa Ana dace differs from other speckled dace in some of its meristic and morphometric characteristics. Santa Ana speckled dace have finer scales (69-82 scales in lateral line), a better developed frenum on the upper lip, a longer head, and smaller eggs than other California dace.

Taxonomic Relationships: The Santa Ana speckled dace has not been formally described as a subspecies, but the data of Cornelius (1969) suggest that it warrants this status. Hubbs et al. (1979) listed it as an undescribed subspecies. Preliminary electrophoretic data seem to confirm that Santa Ana speckled dace are distinctive and deserve taxonomic recognition (T. R. Haglund, pers. comm.). The data also support the contention of Cornelius (1969) that this dace appears to be more closely related to dace of the Colorado River drainage than to populations to the north.

Life History: No specific information is available on the life history of this subspecies, although length data in Deinstadt et al. (1990) indicate that it probably lives for three years. Other aspects of its life history are presumably similar to those described for other stream dwelling speckled dace, summarized by Minckley (1973) and Moyle (1976).

Habitat Requirements: The Santa Ana speckled dace requires permanent flowing streams with summer water temperatures of 17-20 C. Typically, these streams are maintained by outflows of cool springs. The dace inhabits shallow cobble and gravel riffles (Wells and Diana 1975). The best description of its habitat is provided by Deinstadt et al. (1990) for the West Fork of the San Gabriel River. The West Fork is a small (typical summer flow of 4 cfs, 5-8 m wide, depths mostly 15-30 cm), permanent stream that flows through a steep, rocky canyon with chaparral-covered walls. Overhanging riparian plants, mainly alders and sedges, provide cover for fish. Even though Deinstadt et al. (1990) found dace throughout the 14 km of stream they sampled, the dace were common only in the lower reaches of the stream where the dominant habitat types were runs and riffles with gravel and cobble substrates. In the West Fork, Santa Ana speckled dace are most common where other native fishes (rainbow trout and Santa Ana sucker) are common as well. Introduced species (largemouth bass, green sunfish) may be present, but only in low numbers so far. Brown trout are more piscivorous and are believed to prey on native cyprinids such as the dace. Brown trout are very rare or absent from the San Gabriel system, but flourish in the Santa Ana River and its major tributary, Bear Creek, where speckled dace have been absent for a long time.

Distribution: The Santa Ana speckled dace was once distributed throughout the upland portions of the Santa Ana, San Gabriel, and Los Angeles river systems of southern California (Los Angeles and Orange counties), but was rare in the lowlands. In all three drainages, the species occurred in the mountains and was scattered in the foothills. It was not noted among other freshwater fishes that occurred farther down on the Los Angeles Plain (Culver and Hubbs 1917). Later, a few widely scattered local populations were documented, but they all disappeared by about 1950 (Swift et al. 1993). Today the dace has a very limited distribution in the headwaters of only the Santa Ana and San Gabriel rivers. It seems to have been recently extirpated from the Los Angeles River drainage (T. R. Haglund, pers. comm.).

Santa Ana speckled dace also have been reported from the South Fork of the San Jacinto River, Riverside County, and they were introduced into the Santa Clara and Cuyama rivers and River Springs on the east side of Adobe Valley, Mono County (Miller 1968, Swift et al. 1993). The status of the introduced populations is not known, although the Santa Clara introduction apparently failed. This subspecies has been reported from Pismo and Arroyo Grande creeks south of San Luis Obispo Creek. Populations in San Luis Obispo Creek probably are more closely related to those farther north rather than to the southern California form (Cornelius 1969; Swift et al. 1993), based on electrophoretic data (T. R. Haglund, pers. comm.).

Abundance: Numbers of dace have been reduced in all cases because of reductions in range. It is now so diminished in numbers that it is in danger of extinction. The Lytle Creek situation is documented in the section that follows. The situation is repeated for Big Tujunga Canyon and the San Gabriel River as shown by comparing collections from the 1960s at California State University, Fullerton (now in the Natural History Museum of Los Angeles County [LACM]), from the 1970s (at LACM), and the 1980s (at LACM, University of California, Los Angeles, and the U.S. Forest Service).

Nature and Degree of Threat: The Santa Ana speckled dace occupies only remnants of its native range because of water diversions, urbanization of watersheds, introduction of nonnative species, and a myriad other factors associated with expanding human populations in the Los Angeles region. It is considered to be one of the rarest native fishes in coastal southern California. Its possible remaining populations, and the threats to them, are (from Swift et al. 1993):

- Big Tujunga Creek. Fish inhabited the stream for 10-20 km below Big Tujunga Dam. Stream flows and temperatures vary so much that a trout population cannot maintain itself. During drought years, these unstable conditions, in combination with the establishment of red shiners (Cyprinella lutrensis), apparently led to the extinction of the dace. The shiners became established around 1985 and may have competed with dace for food and space and preyed on dace eggs. In any case, surveys of the creek in 1991-92 failed to find any dace (T. R. Haglund, pers. comm.)

- Fish Canyon (lower tributary of the San Gabriel River). The population is this tiny stream was very small on February 15, 1988; only 6-7 fish were seen, despite a thorough search, and it may now (1994) be gone. The best habitat in the lower canyon is being actively encroached upon by a rock quarry operation. The population is isolated from other San Gabriel River fish by Morris Dam.

- The contiguous West, North and East Forks San Gabriel River. These streams together are the best remaining habitat for the dace. They consist of about 40 km of stream below Cogswell Reservoir and 1-2 km each in Devil's Canyon and the West Fork, all tributaries to the reservoir. The population estimates of Deinstadt et al. (1990) indicate that probably less than 2,000 dace exist in the West Fork. The West Fork is constantly threatened by accidental high releases of water and sediment from Cogswell Reservoir that have devastated this stream section several times in the past. There were major releases of sediments from Cogswell Dam in 1981 and again in 1991, from which the stream is now recovering. These sediments smothered most of the dace's habitat and were not flushed out until 1988 through a combination of high rainfall and releases from the dam. Cogswell Dam was constructed for flood control, so the water stored in it is normally released after storms have passed. Often there is little water in the reservoir during the summer, and the stream is maintained only by seepage from below the dam and from springs. This water is reliable enough, however, for the CDFG to manage much of the stream below the dam as a wild trout fishery (Deinstadt et al. 1990). Dace were present in "fair numbers" in 1993; in a 68 m section of stream 29 dace were captured with three passes of an electrofisher (J. Deinstadt, pers. comm.). Sampling by CDFG in 1993 also indicated that the dace was abundant in the 1 km of stream immediately above the reservoir. Mining has increased on the Cattle Canyon tributary of the East Fork, and at times the population has been much smaller or nonexistent in Cattle Canyon.

- Cajon Creek has a large population, but much of the watershed has not burned in a long time; thus, a large fire (and subsequent catastrophic flood scouring) could eliminate the population (S. Loe, pers. comm.). Recently most of the fish have been within 2 km above and below the crossing of Interstate 15.

- North Fork of Lytle Creek. A CDFG survey crew noted one fish on June 30, 1977, the only recent record from the Lytle Creek drainage. This population has been very small since 1975 and may no longer exist. Fish were abundant in 1967 (Cornelius' collection, LACM), but none were found in 1992 (T. R. Haglund, pers. comm.).

- The West Fork of City Creek had dace in 1982; a small but stable population apparently still exists, but it has not be examined recently.

- Strawberry Creek (tributary of the Santa Ana River. A small population was discovered in the fall of 1992 by R. Robinson (U.S. Forest Service; C. Swift, pers. comm.). The viability of this population is undetermined.

- Siverado Canyon at Shrewsberry Springs. A small population maintained itself here through 1987. During the fall of 1990 none were found in the few areas in which they had been seen previously.

- Mill Creek (tributary to the Santa Ana River) held speckled dace into the late 1980s, but they could not be found after 1990. The dace probably no longer occur in this creek.

- The San Jacinto River has about 15-30 km of stream where fish had been recorded in the 1970s. However, Dr. Thomas Haglund had difficulties finding any native fishes in the middle 1980s. He is completing a survey of the area. This should be the second largest and best locality for the speckled dace after the San Gabriel River. In particular, the North Fork, South Fork, Herkey Creek, and Strawberry Creek are desirable Rhinichthys and trout habitat. Dr. Haglund and the U.S. Forest Service note that large portions of the main river and lower creeks become dry in the summer, and the minimum habitat in the fall has not been documented.

The populations of Cajon Creek, North Fork of Lytle Creek, West Fork of City Creek, Silverado Canyon, and the San Jacinto River represent isolated headwater stocks separated by vast areas of dry washes most of the year, so that repopulation among them is not possible. The Lytle Creek population already has apparently become extirpated. The localities suffer variously from (1) severe reduction in size of habitat, (2) inability of populations to intermix, even during the (wetter) winter, because of dams, (3) erratic water flows from upstream control devices, (4) introductions of nonnative species, (5) heavy human recreational use of areas that can alter stream habitats and disturb spawning and feeding behavior, (6) degradation of water quality, and (7) historically record-breaking low water levels during the 1986-1992 drought.

Overall, it appears that the remaining populations of Santa Ana speckled dace in the Los Angeles River were extirpated during the past ten years and that dace in the Santa Ana River system are in imminent danger of extinction. Populations in the San Gabriel River are less threatened, but their very limited range means that they could be eliminated from either or both forks by major floods, debris torrents, or landslides. Such events can occur if heavy rains follow a season of heavy fires that eliminate stabilizing vegetation on the slopes of the drainages. The problems with Cogswell Dam in the past indicate that its presence is no guarantee for the safety of the fish that live in the stream below it.

Management: Immediate steps should then be taken to protect the remaining habitats in all the San Gabriel and Santa Ana drainages, including measures to secure enough water for the fish to live in. Studies of their life history should be undertaken to establish the parameters needed for survival.

As an immediate conservation measure, the East and West Forks of the San Gabriel River should be given the status of Aquatic Diversity Management Areas (Moyle and Ellison 1991, Moyle and Yoshiyama 1992) or refuges to protect the dace as well as other native fishes. Jonathan Baskin and Thomas Haglund completed a thorough survey of the San Gabriel River system in the summer of 1991, so there is adequate information to establish a refuge.

For the Los Angeles River system, thorough surveys should be made of all habitats where the dace have been recorded as existing. If any populations are rediscovered then immediate conservation actions should be taken. If the dace is found to be extirpated from the drainage, rehabilitation of potential habitats should begin and dace reintroduced as soon as possible.

# FINAL
# 2003 AQMP APPENDIX II

## CURRENT AIR QUALITY

AUGUST 2003

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# Exhibit 6

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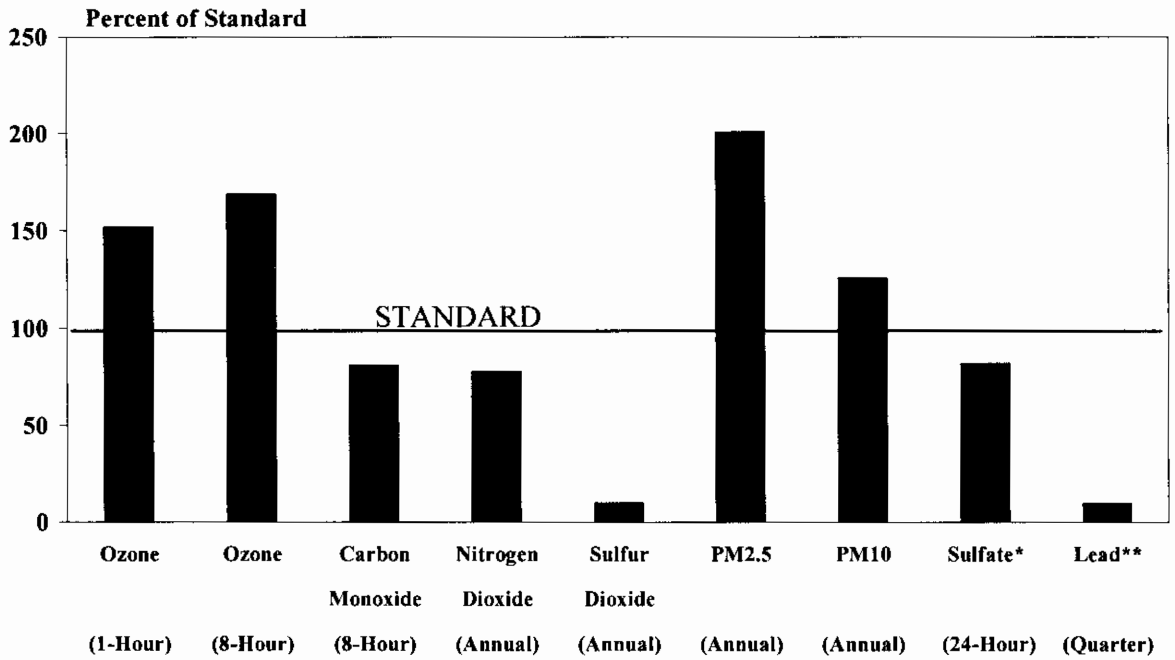
# CHAPTER 1

# INTRODUCTION

# INTRODUCTION

## Air Quality Overview

In 2001, the South Coast Air Quality Management District (District) monitored ambient air quality for criteria pollutants (ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, particulate matters, lead and sulfate) at 32 locations in Southern California's South Coast Air Basin (Basin) and in the neighboring areas of the Salton Sea Air Basin (SSAB) that are within the District's jurisdiction. Pollutant concentrations exceeded federal and/or state standard(s) for ozone and particulate matters (PM10 and PM2.5). Figure 1-1 shows the maximum pollutant concentrations for 2001 as a percentage of the federal standards.




* There is no federal standard for sulfate.
** Higher measurements were recorded at special monitoring sites immediately adjacent to sources.

**FIGURE 1-1**
2001 Maximum Pollutant Concentrations as Percent of Standards

Maximum 1-hour average and 8-hour average ozone concentrations in 2001 (0.190 ppm and 0.144 ppm) were 152% and 169% of the federal 1-hour and 8-hour standards, respectively. Maximum 24-hour average and annual average PM10 concentrations (219 μg/m$^3$ and 63.1 μg/m$^3$) were 146% and 125% of the federal 24-

hour and annual standards, respectively. Maximum 24-hour average and annual average PM2.5 concentrations (98.0 $\mu g/m^3$ and 31.1 $\mu g/m^3$) were, respectively, 150% and 201% of the federal 24-hour and annual standards. Carbon monoxide concentration did not exceed the standards in 2001. The highest 8-hour average carbon monoxide concentration of the year (7.71 ppm) was 81% of the federal standard.

In 2001, the federal nitrogen dioxide standard was not exceeded, with a maximum concentration (0.0419 ppm) which was 78% of the federal standard. The maximum 1-hour average nitrogen dioxide concentration (0.25 ppm) was 96% of the state standard. The maximum 24-hour sulfate concentration (20.6 $\mu g/m^3$) was 82% of the state standard. (There is no federal sulfate standard.) Sulfur dioxide and lead concentrations continued to remain well below the federal and state standards in 2001.

## Air Quality Standards and Episode Levels

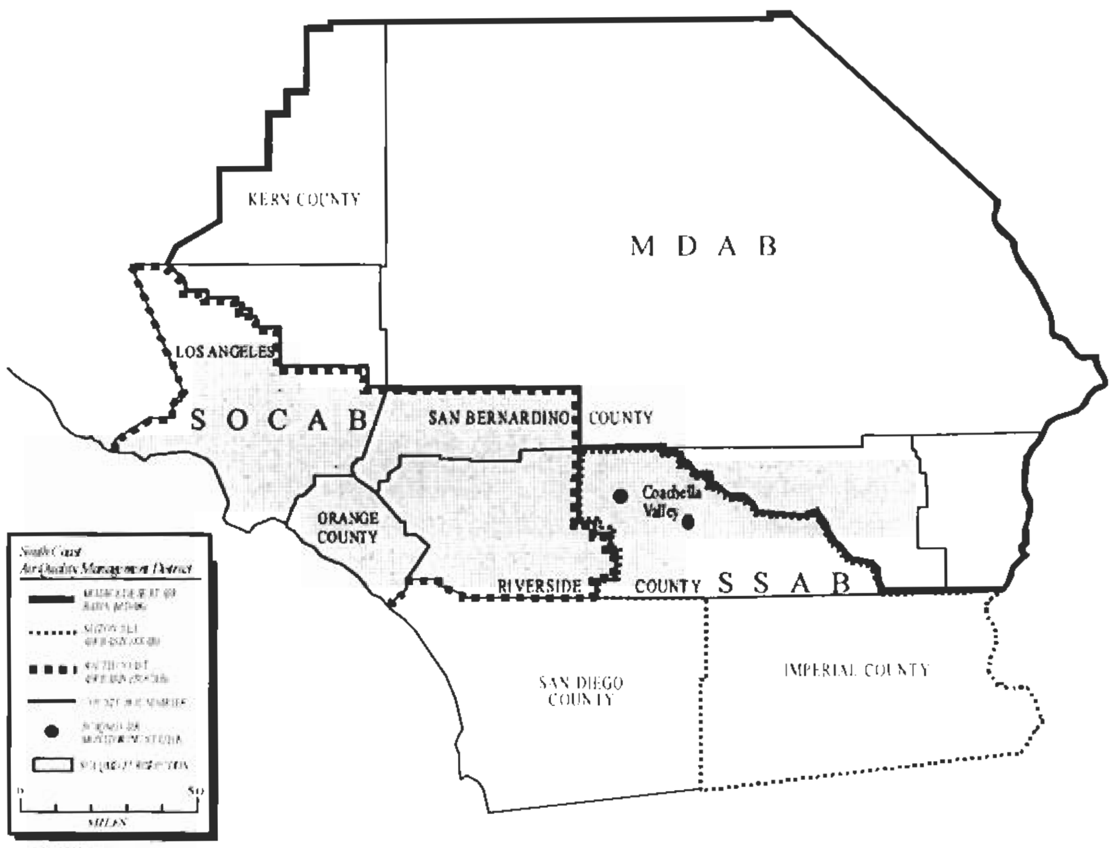
Both the federal and state governments have adopted ambient air quality standards, which define the concentration below which long-term exposure to a pollutant is not expected to cause adverse effects to public health and welfare. Episode levels have also been established, below which short-term exposures are not expected to be injurious to health. The standards and episode levels are summarized in Tables A-1 and A-2 in the Attachment.

Both standards and episode levels are periodically reviewed to incorporate the findings from the most current research available on effects of pollutants. In 1997, the U.S. EPA adopted new federal air quality standards for particulate matter and ozone. The 8-hour average ozone standard (0.08 ppm) would protect the public health against the effects of prolonged exposure and represents a tightening of the 1-hour ozone standard. For particulate matter, annual and 24-hour standards for the finest fraction of particulate, PM2.5 (particles less than 2.5 micrometer), was established to complement the PM10 federal and state standards that target a full range of inhalable particulate matter. PM2.5 is estimated to be the most injurious to health and causes the greatest visibility reduction. The form of the 24-hour PM10 standard was also revised. The 1-hour average ozone standard and the annual PM10 standard are retained.

## South Coast Air Quality Management District

California's first local air pollution control agency, the Los Angeles County Air Pollution Control District (LAAPCD), was formed in 1947 and APCDs were formed in Orange, Riverside, and San Bernardino counties not long afterward. These four agencies combined in 1976 to form the Southern California APCD, which was later replaced by the South Coast Air Quality Management District and the Mojave Desert APCD.

The South Coast Air Quality Management District was established by state legislation effective February 1, 1977, and was assigned jurisdiction over air quality in the South Coast Air Basin. The District is also responsible for air quality in the Riverside county area of the Salton Sea Air Basin (SSAB), by contract with the county. The South Coast Air Quality Management District is the name applied both to the agency and to the geographic jurisdiction which region it serves. The region encompassed by the District is shown in Figure 1-2. In 2001, the District maintained a network of 30 air monitoring stations in the Basin and an additional two in the District portions of SSAB (shown in Figure A-1 and Table A-3 in the




Attachment).

**FIGURE 1-2**
South Coast Air Quality Management District

## South Coast, Salton Sea and Mojave Desert Air Basins

The South Coast Air Basin (Basin) has an area of 6800 square miles and the population was 15 million in 2001. It includes all of Orange county and the non-desert areas of Los Angeles, Riverside and San Bernardino counties. The Los Angeles urban area (the nation's second largest) and the Anaheim-Fullerton and Riverside-San Bernardino urban areas lie within the Basin's boundaries. About two-thirds of the Basin's population lives within Los Angeles county.

The Salton Sea Air Basin and the Mojave Desert Air Basin (MDAB) have a combined area of approximately 32,200 square miles. The two Basins include the desert portions of Los Angeles, Riverside and San Bernardino counties as well as Imperial county and part of Kern county.

The SSAB and MDAB were previously included in a single large Basin called the Southeast Desert Air Basin (SEDAB). The SEDAB also included the San Gorgonio Pass area. On May 30, 1996, the California Air Resources Board replaced the SEDAB with the SSAB and MDAB, and transferred the San Gorgonio Pass area to the Basin. In July 1997, the Antelope Valley area of MDAB was separated from the District and incorporated into a new air district under the jurisdiction of the newly formed Antelope Valley Air Pollution Control District (AVAPCD).

The South Coast Air Quality Management District has the jurisdiction over the Coachella Valley portion of Riverside county in SSAB. The population in the SSAB portion under the jurisdiction of the District is about 300,000. The District also has the jurisdiction over a small portion of the MDAB in eastern Riverside county. The area is sparcely populated desert.

## Weather

The South Coast Air Basin is arid, with virtually no rainfall and abundant sunshine during the summer months. It has light winds and poor vertical mixing compared to the other large urban areas in the U.S. The combination of poor dispersion and abundant sunshine provide conditions especially favorable to the formation of photochemical smog. The Basin is also bounded to the north and east by mountains with maximum elevations exceeding 10,000 feet. The unfavorable combination of meteorology, topography, and emissions from the nation's second largest urban area result in the Basin having the worst air quality in the U.S. More detailed information on Basin climatology appeared in a previous District publication.

## Emissions

The amount of each of the major pollutants emitted into the atmosphere of the Basin in 1997 is shown in Figure 1-3. In 1997, approximately 7800 tons of carbon monoxide (CO), 1400 tons of oxides of nitrogen ($NO_x$), 1200 tons of volatile organic compounds (VOC), 80 tons of oxides of sulfur ($SO_x$), 330 tons of directly emitted particulate (PM10), 120 tons of finer particlate (PM2.5), and 600 tons of total suspended particulate (TSP) were emitted into the Basin's atmosphere each day. (Additional PM10 forms by chemical reaction of the gaseous pollutants.) Emissions vary relatively little by season, but there are large seasonal differences in the atmospheric concentrations of pollutants due to seasonal variations in the weather. (Details of the 1997 emissions inventory are contained in Appendix III.)

Volatile organic compounds and oxides of nitrogen are precursors of ozone. Oxides of nitrogen and volatile organic compounds also react to form nitrates and solid organic compounds, which are a significant fraction of PM10. Sulfur dioxide reacts to form sulfates which are likewise significant contributors to the Basin's PM10 and PM2.5. In addition to the PM10 formed by reaction of gaseous precursors, there is directly emitted PM10, most of which is attributed to fugitive dust sources such as re-entrained road dust, construction activities, farming operations and wind-blown dust.

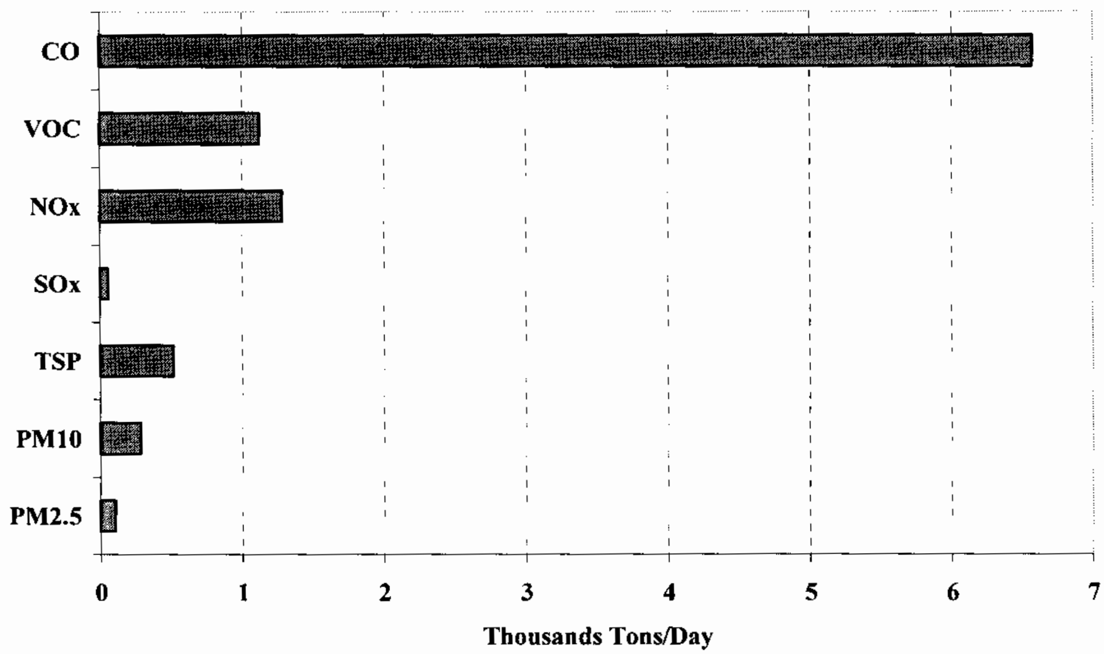



**FIGURE 1-3**
1997 Average Daily Emissions in the Basin

## Air Quality Trends

In 2001, the SCAB locations exceeded one or more of the federal standards on 37 days (excluding the recently adopted 8-hour ozone and PM2.5 standards exceedances).

Figure 1-4 shows the long-term annual trend of percent "basin-days" exceedances of the federal standards. (A "basin-day" is recorded if any location in the South Coast Air Basin exceeds the standard. Multiple locations exceeding on the same day count as a single basin-day.)

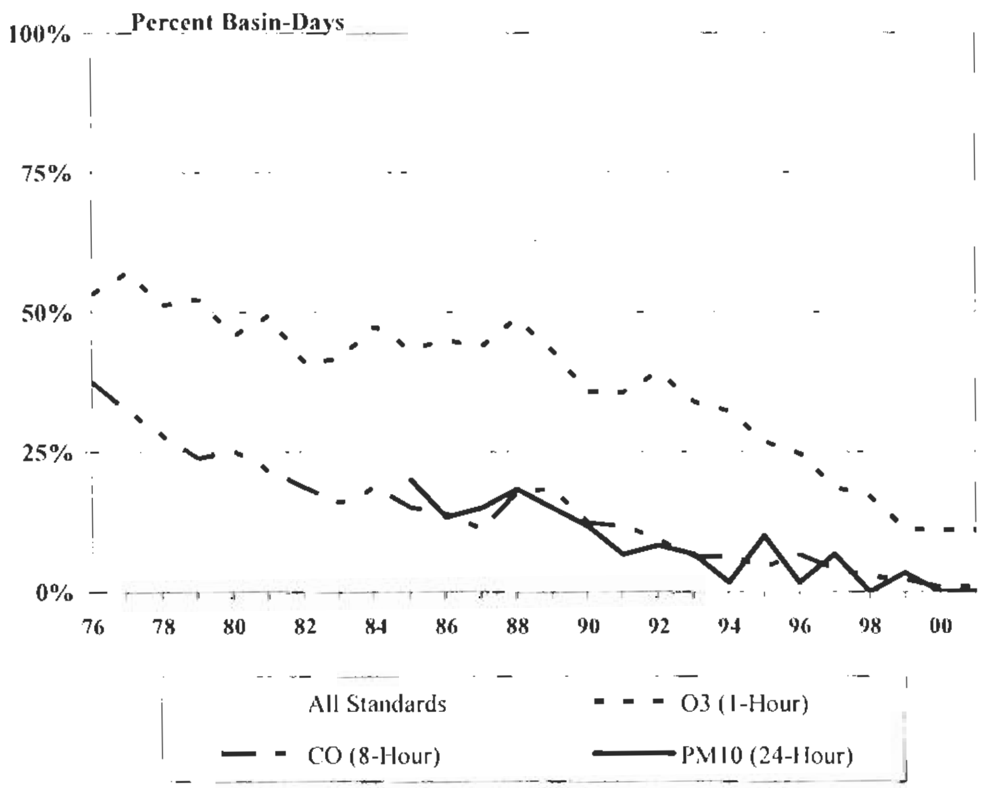



**FIGURE 1-4**

Percent Basin-Days Exceeding the Federal Standards, 1976-2001

## Air Quality in the District Compared to Other Areas of the U.S.

Despite the significant downtrend, the South Coast Air Basin still has some of the worst air quality in the nation in terms of the annual number of days exceeding the federal standards. In 2001, the highest U.S. location in terms of number of days over the federal ozone standard was located in the Basin (Central San Bernardino

Mountains, 26 days). Other area with the greatest number of exceedances outside California was located in the Houston Metropolitan Area, Texas (10 days). Figure 1-5 shows the average number of days on which the federal ozone standard was exceeded at U.S. locations for the years 1998-2000.

Over the past decade, reductions in vehicular emissions have reduced carbon monoxide levels throughout the U.S., and many areas have ceased violating the standards. In 2001, the Basin continued to rank among the areas of the U.S. with high 8-hour average carbon monoxide concentration, although it did not exceed the standards.

The Basin exceeded the federal 24-hour average and annual PM10 standards in a few areas in 2001. The highest 24-hour average PM10 concentration in the U.S. was recorded at a location in the Great Basin Valleys Air Basin in California. More detailed information on air quality in the U.S. is available in EPA's annual National Air Quality and Emissions Trend Report.

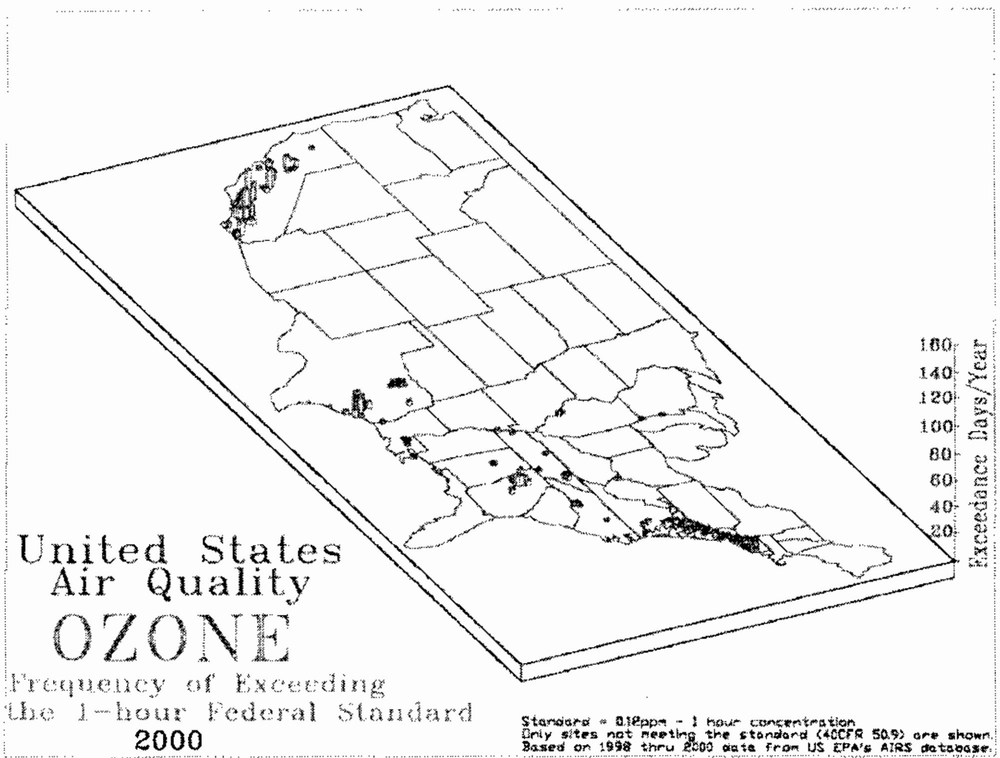



**FIGURE 1-5**
OZONE, 1998-2000
Average Number of Days Exceeding the Federal Standard

The following two chapters of this report summarize current air quality in the District. Analyses are presented for:

- Ozone ($O_3$)
- Carbon monoxide (CO)
- Nitrogen dioxide ($NO_2$)
- Sulfur dioxide ($SO_2$)
- Particulate matter (PM10)
- Particulate matter (PM2.5)
- Lead (Pb)
- Sulfate ($SO_4^{=}$)

Chapters 2 and 3 contain summaries of air quality in the South Coast Air Basin, and the Riverside county portion of Salton Sea Air Basin, respectively. Salton Sea Air Basin includes Coachella Valley. For those pollutants still designated as nonattainment, maps are presented which show how air quality varies in different areas in the Basin. Detailed air quality statistics for each of the District's monitoring locations in the Basin and SSAB are contained in the attachment to this report.

A brief update of air quality trends through 2001 are presented in this report. Detailed analyses of air quality trends in the Basin are available in Appendix II of the 1997 AQMP and the December editions of the Air Quality Standards Compliance Reports (AQSCR's).

# CHAPTER 2

# AIR QUALITY IN THE SOUTH COAST AIR BASIN

# AIR QUALITY IN THE SOUTH COAST AIR BASIN

The maximum pollutant concentrations recorded at District monitoring stations in 2001 (Figure 1-1 in Chapter 1) were all recorded in the densely populated South Coast Air Basin. However, air quality in the Basin varies widely by season and by area.

The prevailing daytime sea breeze tends to transport pollutants from coastal areas into the Basin's inland valleys, and from there, still further inland into neighboring areas of Salton Sea Air Basin of the District as well as the MDAB. Concentrations of primary pollutants (those emitted directly into the air) are typically highest close to the sources which emit them. However, secondary pollutants (those formed in the air by chemical reaction of precursors) reach maximum concentrations some distance downwind of the sources that emit the precursors, due to the fact that the polluted air mass is moved inland many miles by the prevailing winds before maximum concentrations are reached.

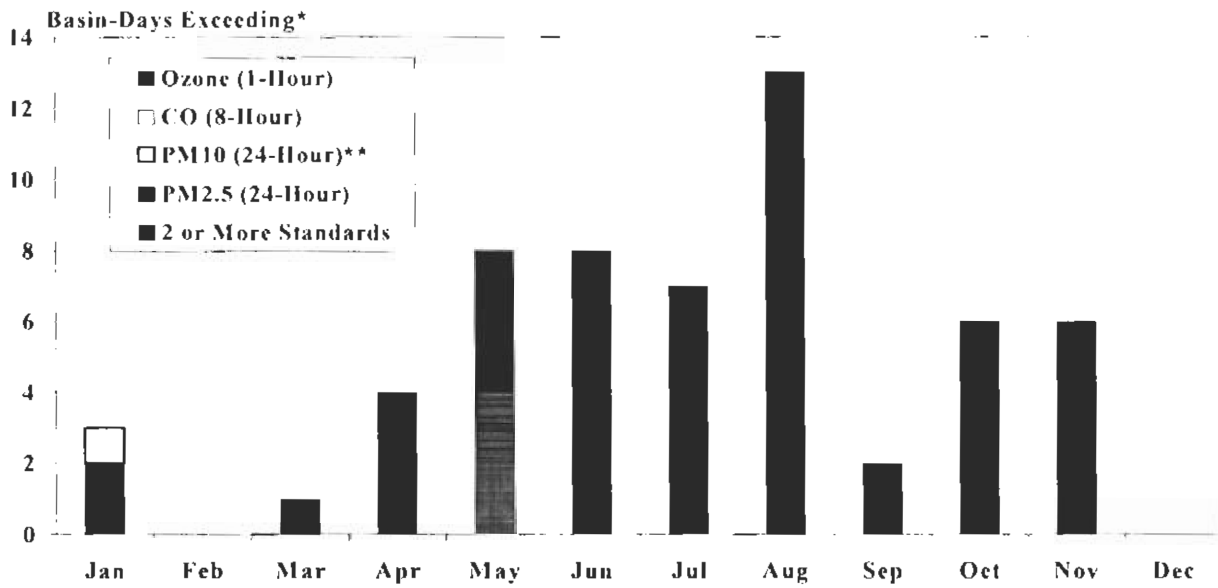
The Basin's air quality varies with season due to seasonal differences in the weather. In Figure 2-1, the number of days exceeding federal standards for each criteria pollutant is shown for each month of 2001. All of the ozone exceedances occurred during the May to October "smog season." Particulate matter ($PM_{10}$ and $PM_{2.5}$) standards are exceeded at times throughout the year and do not have a clear pattern like ozone and carbon monoxide. $PM_{2.5}$ exceedances, however, typically occur more frequently during late fall and early winter months. The standards were exceeded on a total of 54 days in 2001 (37 days excluding $PM_{2.5}$).

## Ozone ($O_3$)

### <u>Properties</u>

The Basin's unique air pollution problem first began to be recognized in the 1940's. Unlike the smog in many other urban areas, the Los Angeles smog was worse in summer. Early research showed that ozone was being formed in the Basin's atmosphere from hydrocarbons and oxides of nitrogen being emitted into the air in the presence of steady sunshine. Regular monitoring of total oxidants was begun by the Los Angeles Air Pollution Control District (LAAPCD) in the 1950's, and annual maximum 1-hour ozone concentrations in excess of 0.6 ppm were recorded at that time.

Ozone ($O_3$), a colorless gas with a sharp odor, is a highly reactive form of oxygen. High ozone concentrations exist naturally in the stratosphere. Some mixing of stratospheric ozone downward through the troposphere to the earth's surface does occur; however, the extent of ozone transport is limited. At the earth's surface in sites remote from urban areas ozone concentrations are normally very low (0.03-0.05 ppm).




* Basin-days represents the number of days a standard was exceeded anywhere in the Basin.
** Number of exceedances due to PM10 may have been higher, since PM10 samples are collected every 6 days (or every 3 days at a few sites).

**FIGURE 2-1**

Monthly Number of Days Exceeding Federal Standards in 2001

In urban areas, ozone is formed by a complicated series of chemical and photochemical reactions between reactive organic compounds, nitrogen oxides, and the oxygen in the air. A decrease in ozone precursors may or may not give a decrease in ozone. Ozone concentrations are dependent not only on overall precursor emissions, but on the ratio of hydrocarbon concentration to oxides of nitrogen concentration, the reactivity of the specific hydrocarbons present, the spatial and temporal distribution of emissions, and weather.

While ozone is beneficial in the stratosphere because it filters out skin-cancer-causing ultraviolet radiation, it is a highly reactive oxidant. It is this reactivity which accounts for its damaging effects on materials, plants, and human health at the earth's surface.

The propensity of ozone for reacting with organic materials causes it to be damaging to living cells, and ambient ozone concentrations in the Basin are frequently sufficient to cause health effects. Ozone enters the human body primarily through the respiratory tract and causes respiratory irritation and discomfort, makes breathing more difficult during exercise, and reduces the respiratory system's ability to remove inhaled particles and fight infection. People with respiratory diseases, children, the elderly, and people who exercise heavily are more susceptible to the effects of ozone.

Plants are sensitive to ozone at concentrations well below the health-based standards and ozone is responsible for significant crop damage. Ozone is also responsible for damage to forests and other ecosystems.

### Federal 8-Hour Ozone Standard

Studies have shown that even relatively low concentrations of ozone, if continued for several hours, can significantly reduce lung function in normal healthy people. In July 1997, the U.S. Environmental Protection Agency (U.S. EPA) adopted an 8-hour average federal ozone standard with a level of 0.08 ppm. The new standard was based on exposure studies reporting health effects associated with long-term (6 to 8 hours) exposures at levels below the level of the 1-hour standard. The 8-hour ozone standard is more stringent than the 1-hour standard and provides greater protection to public health than the 1-hour standard. It will help protect people who spend a significant amount of time working or playing outdoors -- a group that is particularly vulnerable to the effects of ozone. The federal 1-hour ozone standard continues to apply in non-attainment areas (including the District), where the standard is still violated.

The effect of the adopted 8-hour ozone standard on this region's attainment of federal ozone standards has been evaluated by comparing the number of exceedances of the 1-hour standard (0.12 ppm 1-hour average) with the number of exceedances of 8-hour average concentrations of 0.08 ppm. The number of exceedances in different areas in the Basin and SSAB vary; however, there are a greater number of days exceeding the federal 8-hour ozone standard level in most areas, especially in the inland valleys and adjacent mountains where high ozone concentrations normally occur.

### Current Ozone Air Quality

In 2001, the District measured ozone concentrations at 28 regular ambient monitoring locations. The maximum 1-hour average and 8-hour ozone concentrations in the Basin in 2001 (0.190 ppm and 0.144) were 152% and 169% of the federal 1-hour and 8-hour standards, respectively, and 190% of the state standard. The federal 1-hour ozone standard was exceeded at one or more Basin locations on a total of 36 days, the 8-hour standard was exceeded on 100 days. The California state standard was exceeded on 121 days, and the health advisory level on 15 days. The stage 1 episode level (1-hour average ≥ 0.20 ppm) was not exceeded anywhere in the Basin for the third consecutive year.

Figure 2-2 is a contour diagram of the number of days exceeding the 1-hour federal ozone standard in different areas of the Basin in 2001. The standard was exceeded most frequently in the Basin's Central San Bernardino Mountains and adjacent valleys. The coastal areas of Los Angeles and Orange counties and areas near the boundary between the Basin and San Diego county did not exceed the 1-hour federal ozone standard.

The more stringent state standard was exceeded almost everywhere in the Basin with the greatest number of exceedances occuring in the Central San Bernardino Mountains and adjacent valleys (not shown).

A decade ago, only the coastal areas of the Basin did not record exceedances of the stage 1 episode level (1-hour average $O_3$ greater than or equal to 0.20 ppm). In 2001, stage 1 episodes were not recorded anywhere in the Basin. In addition, there have been no exceedances of the stage 2 episode level (1-hour average $O_3$ greater than or equal to 0.35 ppm) since 1988 and the stage 3 episode level (1-hour average $O_3$ greater than or equal to 0.50 ppm) has not been exceeded since 1974.

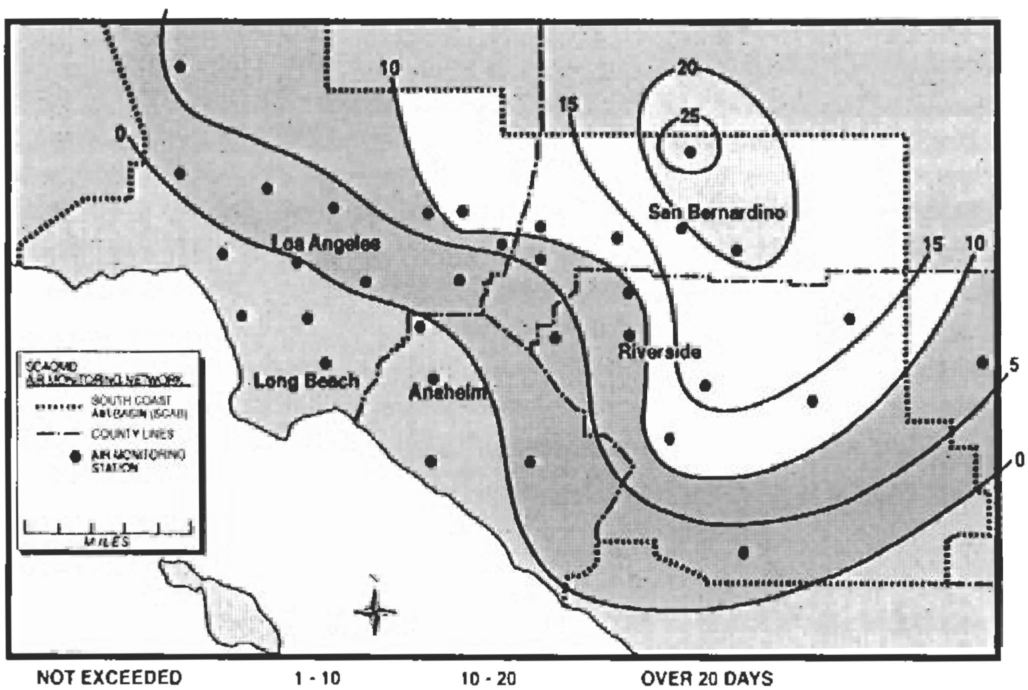



**FIGURE 2-2**
OZONE - 2001
Number of Days Exceeding 1-Hour Federal Standard
(1-hour average ozone > 0.12 ppm)

Figure 2-3 shows the number of days exceeding the 8-hour federal standard in the Basin in 2001. The 8-hour federal ozone standard was also exceeded most frequently in the Basin's Central San Bernardino Mountains and adjacent areas. The federal standards were not exceeded in the coastal areas.

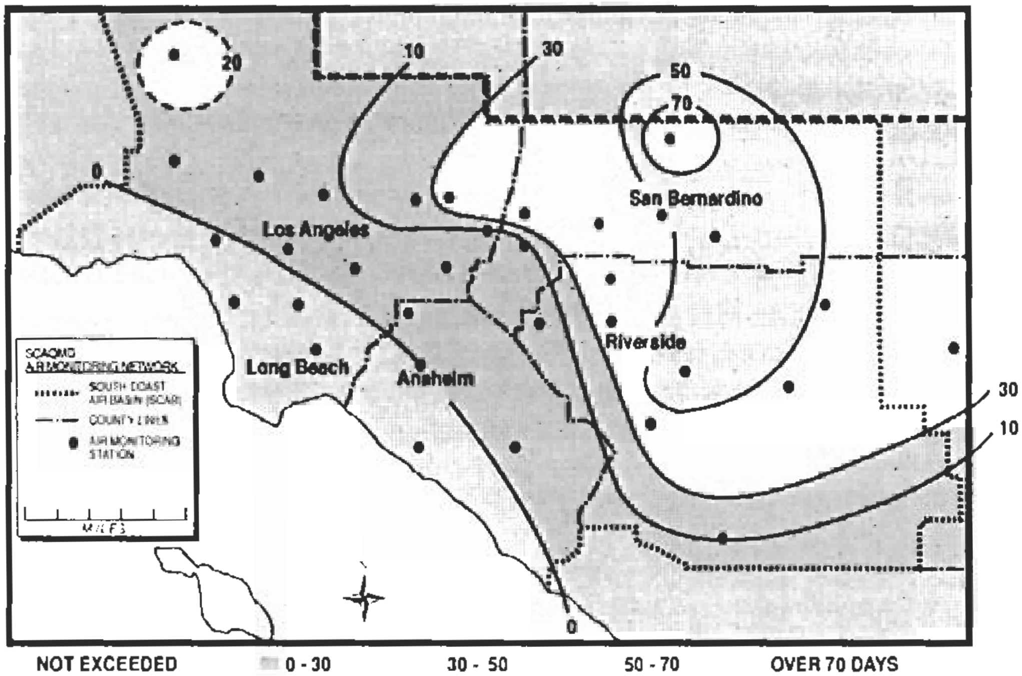



**FIGURE 2-3**
OZONE - 2001
Number of Days Exceeding 8-Hour Federal Standard
(8-hour average ozone > 0.08 ppm)

Table A-4 in the Attachment shows the number of exceedances of the 1-hour federal ozone standard at all District air monitoring sites, for all years for which data was available during the period 1976-2001. Tables A-5 and A-6 show the number of days exceeding stage 1 and stage 2 episode levels and the maximum1-hour ozone concentrations.

## Seasonal Variation

Because photochemical reactions require sunlight to proceed, ozone formation is favored by strong solar radiation. Solar radiation is more intense and of longer duration, and temperature inversions are stronger and more persistent, in summer than in winter. This causes ozone concentrations to be higher in summer than in winter. Peak ozone concentrations generally occur near the middle of the day during the period May through October.

Figure 2-4 shows the 5-year average of number of days per month exceeding the federal ozone standard for the period 1976-2000. Up until the late 1980's it was common to have days exceeding the federal ozone standard as early as February and as late as November and December. In late 1990's (since 1996) there have been no federal standard exceedances recorded in the months of January-March and November-December. Also, the frequency of exceedances in fall (September and October) has been reduced significantly in the recent years.

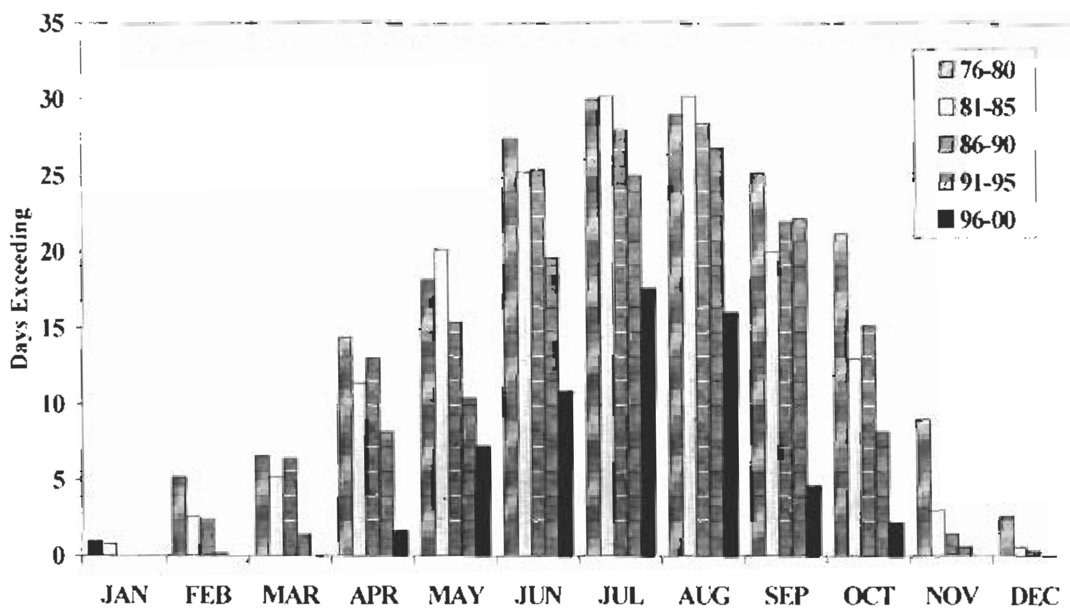



**FIGURE 2-4**
5-Year Average of Number of Days Per Month Exceeding Federal Ozone Standard in the Basin

## Diurnal Variation

Because time and sunlight are required for the precursor organic gases and nitrogen oxides to react to form ozone, peak ozone concentrations usually occur from afternoon to early evening. By this time, the prevailing sea breeze has moved the polluted air mass miles inland from the major sources of precursor emissions. Figure 2-5 illustrates the maximum ozone concentrations for each hour of the day for the smog season (May-October) of 2001 at three representative areas in the Basin. The diurnal pattern in these areas, coastal area of Los Angeles county, inland valley area and San Bernardino mountain area, depicts diurnal formation and impact of ozone transport.

Ozone concentrations in the Basin are typically low during early morning hours, increasing rapidly after sunrise and peaking in the afternoon. However, peak concentrations occur earlier in the day for coastal areas and later in the day for locations further downwind. Examining diurnal variation throughout the District, the time of the peak concentration was found to vary from noon - 1 p.m. PST in coastal-central Los Angeles county, to 4 - 7 p.m. in the farthest inland Basin and SSAB locations.

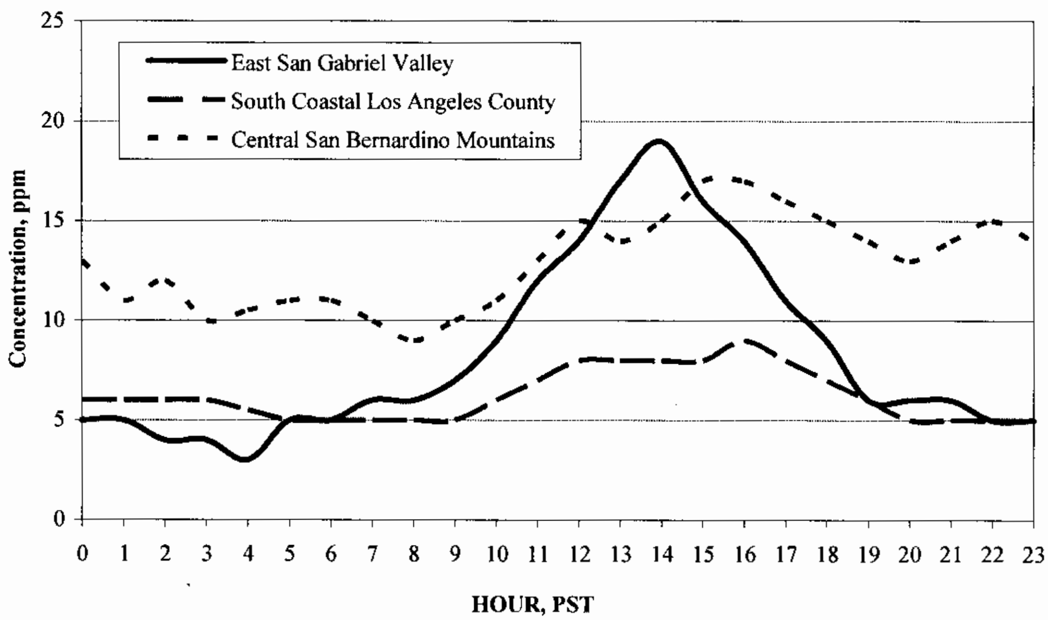



**FIGURE 2-5**
OZONE
Diurnal Variation, May-October 2001
Maximum Concentration for Each Hour

In East San Gabriel Valley, an area typical of the inland valley areas of the Basin where high ozone concentrations occur, concentrations are usually low at night and remain relatively low until mid-morning, reaching peak concentrations in the afternoon around 1 - 3 p.m. Diurnal variation in the South Coastal Los Angeles county area where ozone concentrations are typically low, show a similar pattern except that the peak concentrations are lower. In the mountain area where the Basin's highest concentrations have been recorded in recent years, concentrations are usually higher all the times and the peak is reached later in the afternoon around 4 - 5 p.m. and remains relatively high through out the evening hours during the smog season.

## Day-of-Week Variation

Since the mid-1970s, it has been documented that ozone concentrations in the Basin are higher on weekends than on weekdays, in spite of the fact that ozone pollutant precursors are lower on weekends than on weekdays. Similar effects have been observed in some other metropolitan areas in the nation such as San Francisco, Washington D.C., Philadelphia and New York.

Figure 2-6 shows the three-year average number of exceedances of the federal 1-hour ozone standard for each day of the week in the Basin for the period 1999-2001. The number of exceedances was higher on Sundays followed by Saturdays. Fridays

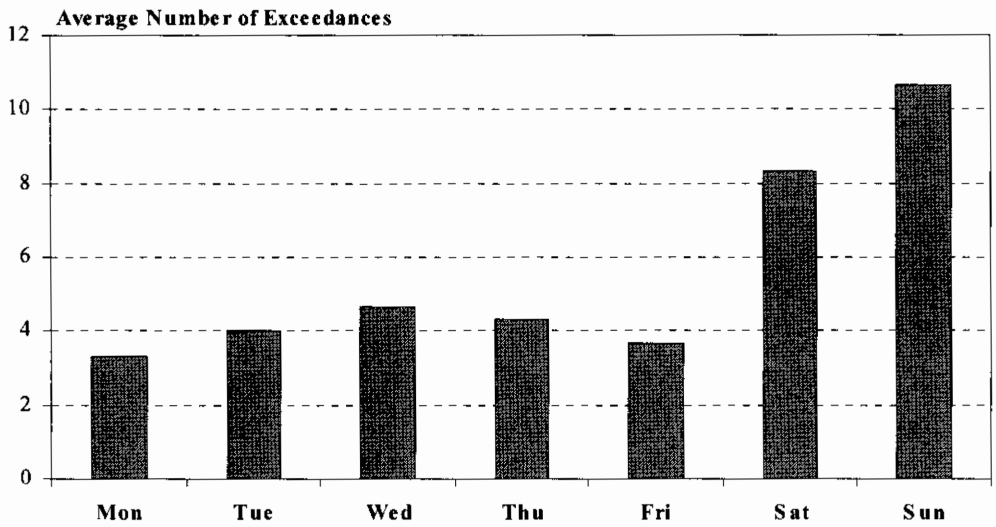



**FIGURE 2-6**
OZONE
Day-of-Week Variation, 1999-2001
Exceedances of the Federal Standard by Day of Week

exceeded least. Average ozone concentrations also show a pattern similar to the average number of exceedances, with weekends tending to be higher than weekdays. The California Air Resources Board (ARB) has sponsored several research projects to study the causes of elevated ozone levels on weekends in the Basin. Changes in daily patterns that impact the quantity and temporal loading of emissions have been suggested as strongly contributing to observations. Carryover of matured precursor from weekdays to weekends is also suggested as contributing factor.

## Carbon Monoxide (CO)

### Properties

Carbon monoxide (CO) is a colorless, odorless, relatively inert gas. It is a trace constituent in the unpolluted troposphere, and is produced by both natural processes and human activities. In remote areas far from human habitation, carbon monoxide occurs in air at an average background concentration of 0.04 ppm, primarily as a result of natural processes such as forest fires and the oxidation of methane. Global atmospheric mixing of CO from urban and industrial sources creates higher background concentrations (up to 0.20 ppm) near urban areas. The major source of CO in urban areas is incomplete combustion of carbon-containing fuels, mainly gasoline. In 1997, 97% of the CO emitted into the Basin's atmosphere was from mobile sources. Consequently, CO concentrations are generally highest in the vicinity of major concentrations of vehicular traffic.

Carbon monoxide is a primary pollutant, meaning that it is directly emitted into the air, not formed in the atmosphere by chemical reaction of precursors, as is the case with ozone and other secondary pollutants. Ambient concentrations of CO in the Basin exhibit large spatial and temporal variations, due to variations in the rate at which CO is emitted, and in the meteorological conditions that govern transport and dilution. Unlike ozone, CO tends to reach high concentrations in the fall and winter months. The highest concentrations frequently occur on weekdays at times consistent with rush hour traffic and late night during the coolest, most stable portion of the day.

When carbon monoxide is inhaled in sufficient concentration, it can displace oxygen and bind with the hemoglobin in the blood, reducing the capacity of the blood to carry oxygen. Individuals most at risk from the effects of CO include heart patients, fetuses (unborn babies), smokers, and people who exercise heavily. Normal healthy individuals are affected at higher concentrations, which may cause impairment of manual dexterity, vision, learning ability, and performance of work. The results of studies concerning the combined effects of CO and other pollutants in animals have shown a synergistic effect after exposure to CO and ozone.

## Current Carbon Monoxide Air Quality

The District currently monitors carbon monoxide air quality at 23 of its 32 air monitoring stations. The highest CO concentrations are found in coastal and central Los Angeles county. The highest 8-hour average CO concentration in 2001 (7.71 ppm) was recorded in South Central Los Angeles county and was 81% of the federal standard and 85% of the state standard. This was the lowest concentration recorded in the Basin since carbon monoxide monitoring began in this region. The highest 1-hour average concentration in 2001 (12.0 ppm) was 33% of the federal and 57% of the state 1-hour standards. Concentrations in the less urbanized areas of the Basin and in the SSAB were well below the standards.

In 2001, for the first time since montoring began, carbon monoxide standards were not exceeded anywhere in the Basin. The Basin, however, continued to rank in the nation among the locations with the highest carbon monoxide concentrations. Figure 2-7 shows the distribution of maximum 8-hour average carbon monoxide concentrations in the Basin in 2001. Highest concentrations were recorded in Los Angeles county areas, in the areas of South Central Los Angeles county and West San Fernando Valley. There have been no exceedances of the stage 1 episode (federal alert) level (8-hour average CO greater than or equal to 15 ppm) since 1994.

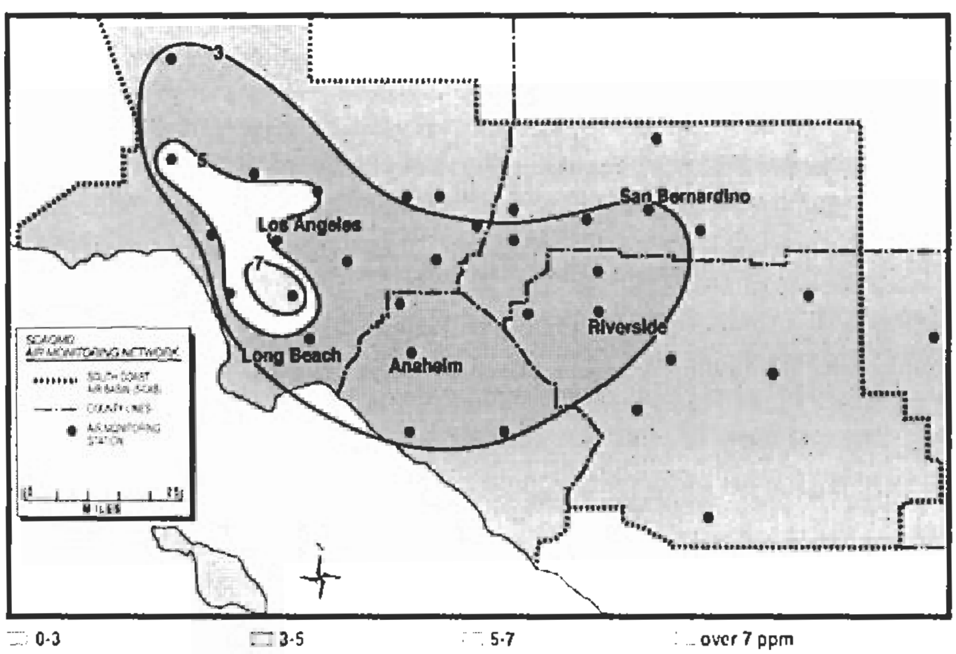



**FIGURE 2-7**
CARBON MONOXIDE - 2001
Maximum 8-Hour Average Concentration, ppm

The annual number of days exceeding the federal carbon monoxide standard at all monitoring sites during the period 1976-2001 is given in Table A-7 in Attachment. Tables A-8 and A-9 show the annual number of federal alerts and maximum CO concentrations for all sites for the years 1976-2001.

**Seasonal Variation**

Carbon monoxide concentrations in the Basin tend to be highest in the late fall and winter months. This is due mainly to meteorological conditions which occur more frequently in late fall and winter; specifically, light winds and late night and early morning radiation inversions, which inhibit the vertical dispersion of pollutants. Also, mobile sources produce more CO emissions in colder temperatures. Figure 2-8 shows the three-year average monthly number of exceedances of the federal CO standard for the years 1999-2001 in the Basin. In the late fall and winter months, the actual number of exceedances for each of the three years 1999-2001 ranged from one day to four days per month in January and December. No exceedances of the CO standards were recorded during February through November of the years 1999-2001.

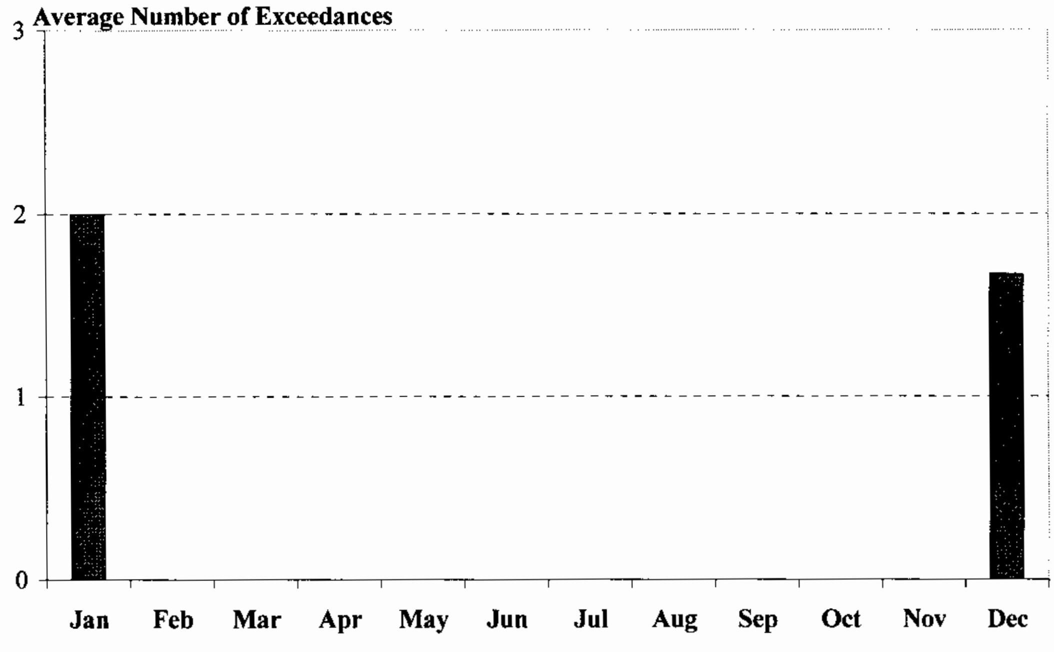



**FIGURE 2-8**
CARBON MONOXIDE
Seasonal Variation, 1999-2001
Average Monthly Exceedances of Federal Standard

**Diurnal Variation**

Figure 2-9 shows the maximum concentration of carbon monoxide for each hour of the day for the winter months (January, February, November and December) of 2001 in the Basin areas where typically higher CO concentrations are recorded, all located in Los Angeles county. On average, the CO concentration exhibits two peaks: first at around 7 - 8 a.m., the time of morning rush traffic congestion. A second peak is typically observed at 10 - 11 p.m. after the evening commute. Hourly concentrations during the summer months were relatively low at all hours, with the peak concentration for winter averaging more than two times higher than the average peak concentration for summer. The seasonal and diurnal patterns in these Los Angeles county areas are typical of those found at most locations in the District.

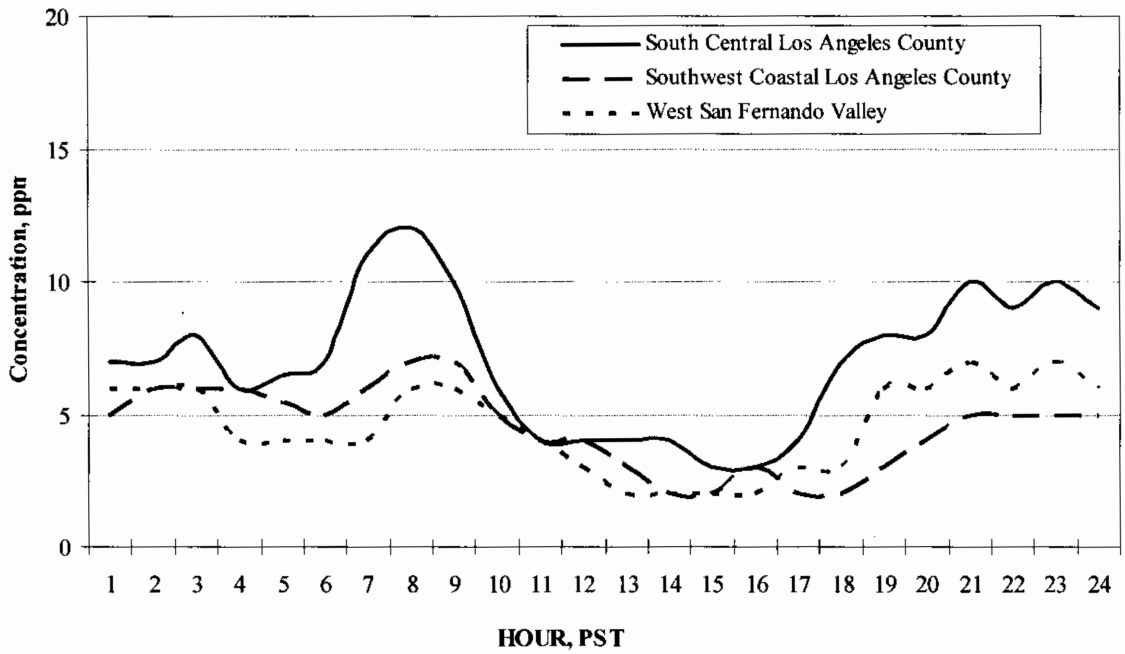



**FIGURE 2-9**
CARBON MONOXIDE
Diurnal Variation, 2001
Maximum Concentration for Each Hour

## Day-of-Week Variation

Concentrations of carbon monoxide and exceedances of the carbon monoxide standards have been found to vary significantly with day of week. This is due to variation in vehicular traffic and CO emissions by day of week. Figure 2-10 shows the three-year average maximum hourly concentrations for each day of the week in the South Central Los Angeles county area during the period 1999-2001. The average concentration for weekends (due primarily to Sunday) was lower than the average concentration for weekdays (Monday to Friday). A similar pattern has been observed for day-of-week variation at most locations in the District.

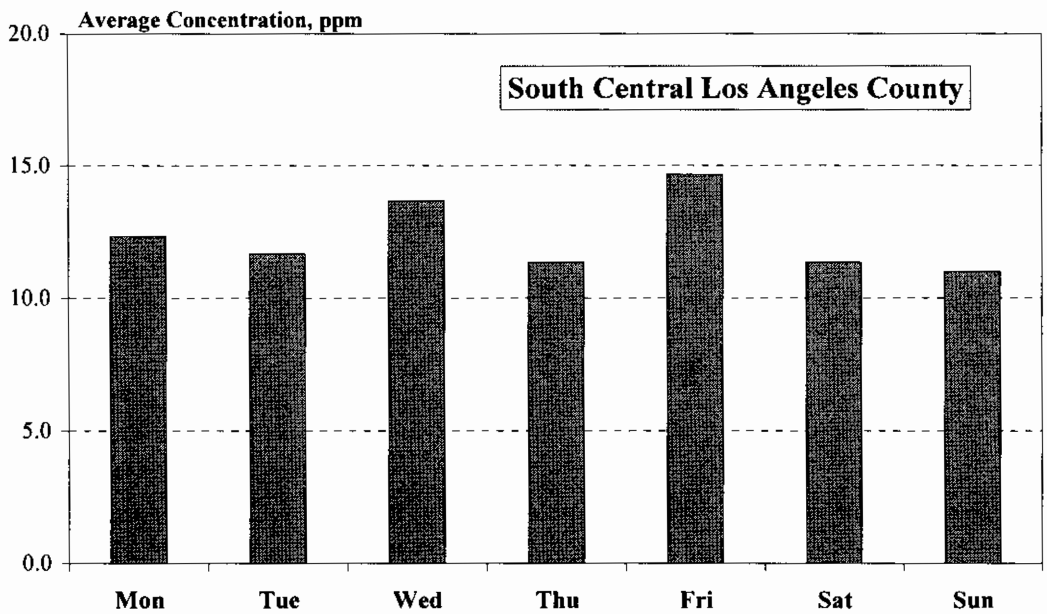



**FIGURE 2-10**
CARBON MONOXIDE
Day-of-Week Variation, 1999-2001
Average Concentrations by Day of Week

## Suspended Particulate Matter

Total suspended particulate (TSP) is the name applied to the complex mixture of solid material suspended in the atmosphere. TSP is collected on a glass fiber filter by means of a high volume sampler. Samples are collected for a 24-hour period every sixth day, and then returned to the District laboratory for chemical analysis to determine the relative concentrations of sulfate, nitrate and lead. The federal and state standards for lead and sulfate are based on analyses of TSP samples. In 2001, TSP samples were collected by the District at 13 sites. These samples were analyzed for sulfate and nitrate and were found to contain an average of from 5 to 19 percent sulfate and 5 to 21 percent nitrate, depending on location. Lead concentrations were determined for 9 of the sites, and the average lead concentration ranged from 0.03 to 0.06 percent of the TSP.

The fine fraction of TSP has greater effects on health and visibility than the coarse fraction. In 1987 EPA adopted $PM_{10}$ standards, which replaced the earlier TSP standards. $PM_{10}$ samples are collected on quartz filters with a size selective inlet high volume sampler. The District began $PM_{10}$ monitoring in late 1984.

In 1997, the U.S. EPA adopted new federal air quality standards for finer particulate matter, $PM_{2.5}$, to complement existing $PM_{10}$ standards that target the full range of inhalable particulate matter. In compliance with the adopted standard, the District monitored $PM_{2.5}$ concentrations at 18 sites in 2001.

## Suspended Particulate Matter ($PM_{10}$)

### Properties

Of greatest concern to public health are the particles small enough to be inhaled into the deepest parts of the lung. Respirable particles (particulate matter less than about 10 micrometers in diameter) can accumulate in the respiratory system and aggravate health problems such as asthma, bronchitis and other lung diseases. Children, the elderly, exercising adults, and those suffering from asthma are especially vulnerable to $PM_{10}$'s adverse health effects.

$PM_{10}$ particles are both directly emitted or formed from diverse emission sources. Major sources of directly emitted (primary) $PM_{10}$ include re-suspended road dust or soil entrained into the atmosphere by wind or activities such as construction and agriculture. Other components of $PM_{10}$ form in the atmosphere (secondary $PM_{10}$) from precursor emissions of the gaseous pollutants.

In 2001, the District measured $PM_{10}$ concentrations at 18 locations. At the 7 locations where both $PM_{10}$ and TSP were monitored, $PM_{10}$ averaged 50 to 76% of TSP. $PM_{10}$

samples are routinely analyzed for sulfate and nitrate, and in 2001 sulfates constituted an average of 7 to 18% of $PM_{10}$, and nitrates constituted 4 to 18% of $PM_{10}$.

An intensive study of $PM_{10}$ was conducted at six locations in 1995, using special samplers designed to allow detailed chemical analyses of $PM_{10}$. The study sites included five Basin locations in Central Orange county (CEOC), Central Los Angeles county (CELA), Pomona/Walnut Valley (PWV), Central San Bernardino Valley (CSBV), and Metropolitan Riverside county (MRIV) areas and one remote area in San Nicolas Island (SANI).

Figure 2-11 shows the average amounts of sulfate ($SO_4$ ), nitrate ($NO_3^-$), ammonium ($NH_4^+$), organic carbon (OC), elemental carbon (EC), sodium ($Na^+$), chloride ($Cl^-$), and other materials such as soil components in the $PM_{10}$ samples which were collected during 1995. Sulfates, nitrates, and organic carbon are typically formed in the air by reaction of gaseous precursors such as oxides of nitrogen, oxides of sulfur, volatile organic compounds (hydrocarbons and related compounds) and ammonia, which are emitted by a variety of sources. Soil-related materials tend to be larger particles which are suspended in the air by human activity or by wind.

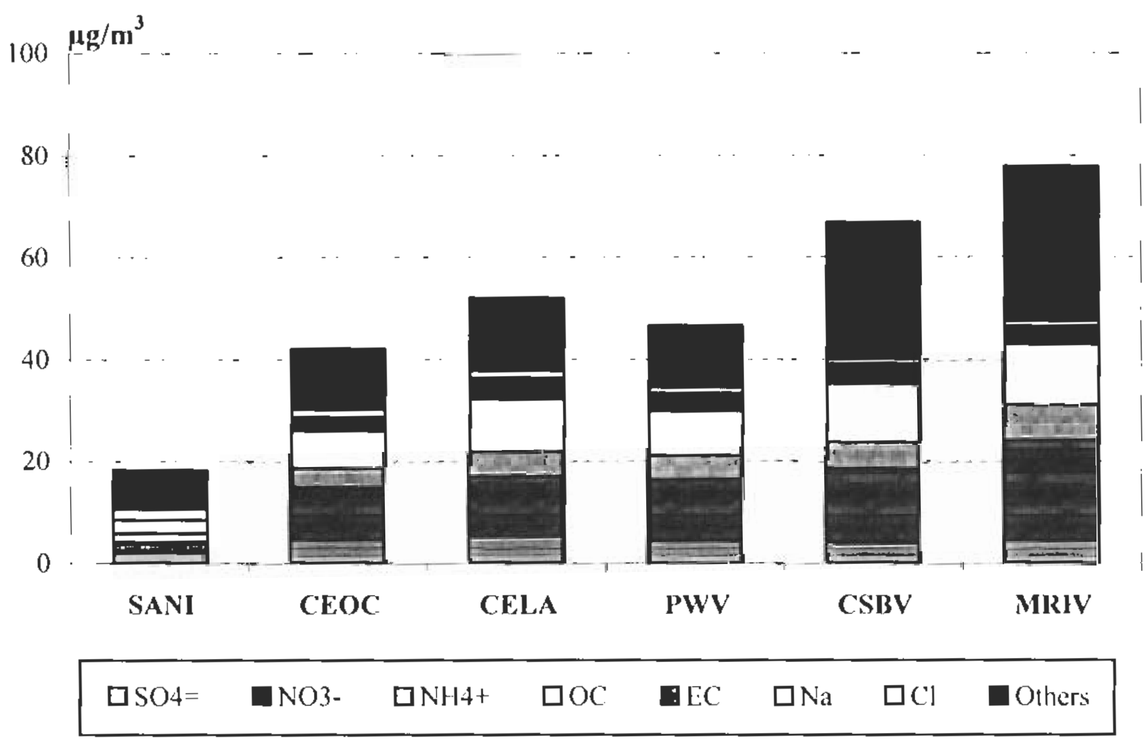



**FIGURE 2-11**
Chemical Composition of $PM_{10}$, 1995

San Nicolas Island, 80 miles offshore and remote from the Basin's urban areas, recorded a very low average $PM_{10}$ (18 $\mu g/m^3$), which contained a relatively large fraction of Na and Cl (25% of the $PM_{10}$). The relatively high Na and Cl is due to the influx of sea salt from the surrounding ocean. The concentrations of, and in most cases percentages of, the other components ($NH_4^+$, $NO_3^-$, $SO_4^=$, OC, EC, crustal material) were low compared to mainland Basin sites.

$PM_{10}$ annual concentrations measured at the five Basin locations recorded $PM_{10}$ concentrations from 42 $\mu g/m^3$ to 78 $\mu g/m^3$. These Basin sites contain relatively high proportions of sulfates (6-11%), nitrates (22-26%), organic carbon(15-20%), and elemental carbon (5-8%). These materials derive from stationary or mobile sources of pollution in the Basin. The amount of soil-related material in the air is also greater (17% to 31%), due to suspension of soil in the air by human activities such as re-entrainment of road dust and construction.

### Current $PM_{10}$ Air Quality

In 2001, the District measured $PM_{10}$ concentrations at 18 locations throughout the South Coast and Salton Sea Air Basins. Figure 2-12 shows for 2001 the annual average (arithmetic mean) $PM_{10}$ concentrations in the Basin. The area which exceeded the federal standard (inside the dashed line) is limited to the areas of Riverside and San Bernardino counties close to Metropolitan Riverside county. The maximum annual average recorded (63.1 $\mu g/m^3$ in the Metropolitan Riverside county area) was 125% of the federal standard.

The federal 24-hour standard was exceeded at two Basin locations in the inland valley areas 2001 (not shown). The maximum 24-hour average concentration (219 $\mu g/m^3$ recorded in Metropolitan Riverside county) was 146% of the federal 24-hour standard.

The more stringent state annual standard was exceeded in a much larger area than the federal annual standard, with most of the Basin and part of the Riverside county SSAB recording annual average concentrations above the standard. The maximum annual average (annual geometric mean $PM_{10}$ 54.3 $\mu g/m^3$, recorded at Metropolitan Riverside county) was 180% of the state annual standard.

The state 24-hour $PM_{10}$ standard was exceeded at all locations monitored in the District. The standard was exceeded most frequently in the Basin's inland valleys, centering in Metropolitan Riverside county. The maximum 24-hour average was 429% of the state 24-hour standard.

The annual arithmetic and geometric mean, the percent of days exceeding state and federal standards, and the maximum 24-hour average concentration for the years 1985 - 2001 are given in Tables A-10 to A-13 in Attachment.

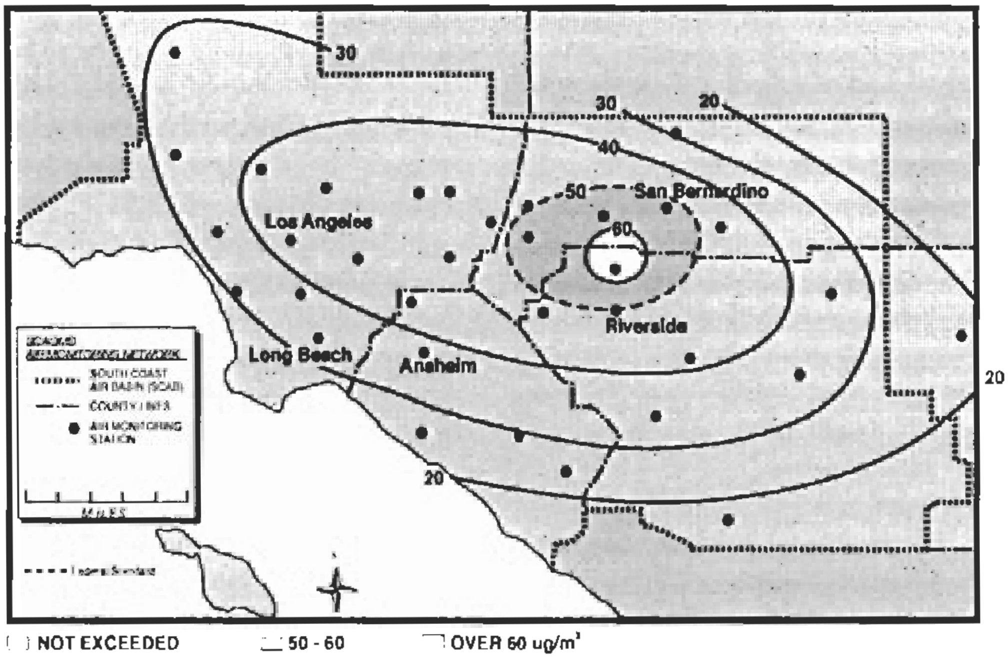



**FIGURE 2-12**
Suspended Particulate Matter ($PM_{10}$) - 2001
Annual Arithmetic Mean, $\mu g/m^3$

## Seasonal and Day-of-Week Variation in $PM_{10}$

$PM_{10}$ samples are only collected every sixth day (or third day at sites where an intensive monitoring schedule has been adopted) and exceedances of the federal standard are relatively infrequent in recent years. As a consequence, seasonal and day-of-week variations in exceedances of the federal standard for the last few years cannot be determined accurately. However, if exceedances of the state standard are considered, seasonal and day-of-week patterns do emerge.

Previous analyses of seasonal variations in $PM_{10}$ show that the monthly average $PM_{10}$ concentration and the monthly average number of days exceeding the state standard tend to peak in summer and fall in the inland valley area of the Basin where $PM_{10}$ concentrations are highest. However, in the South Coastal Los Angeles county area, monthly average $PM_{10}$ concentrations and the average number of days exceeding the state standard are highest in late fall and winter months.

Figure 2-13 shows the average number of days in each month exceeding the state standard at one or more Basin locations over the period 1999-2001. The greatest number of state standard exceedances occurred in the summer and fall months. Due to higher number of exceedances in the inland valleys, the pattern for the Basin is more similar to those for individual sites in the inland valley areas. Figure 2-14 shows the monthly average $PM_{10}$ concentrations for the two sites, Metropolitan Riverside county in inland valleys and South Coastal Los Angeles county. In the inland valley areas, $PM_{10}$ concentrations are higher in the summer and fall months while in the coastal areas higher concentrations are recorded in the late fall and winter months.

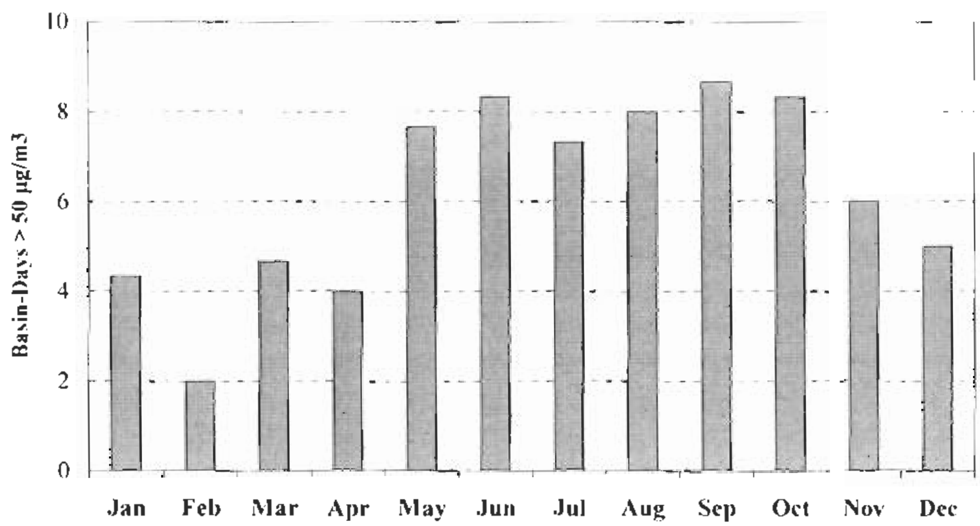



**FIGURE 2-13**
Basin-Days Exceeding State $PM_{10}$ Standard by Month, 1999-2001

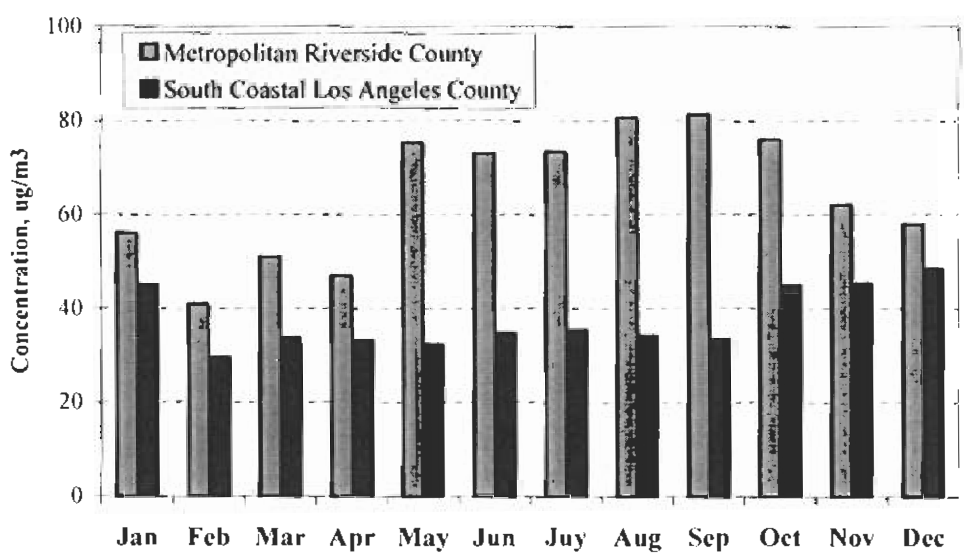



**FIGURE 2-14**
Monthly Average $PM_{10}$ Concentration, 1999-2001

Day-of-week variations have also been examined, and it was found that the average weekend concentrations were lower than the weekday average at all sites monitored in the Basin and SSAB locations. Figure 2-15 shows the average $PM_{10}$ concentrations by day of week at three representative monitoring sites in the Basin for the period 1999-2001, based on the Beta Attenuation Monitor (BAM) and Tapered Element Oscillating Microbalance (TEOM) data.

Diurnal variations proved to be complex and location dependent.

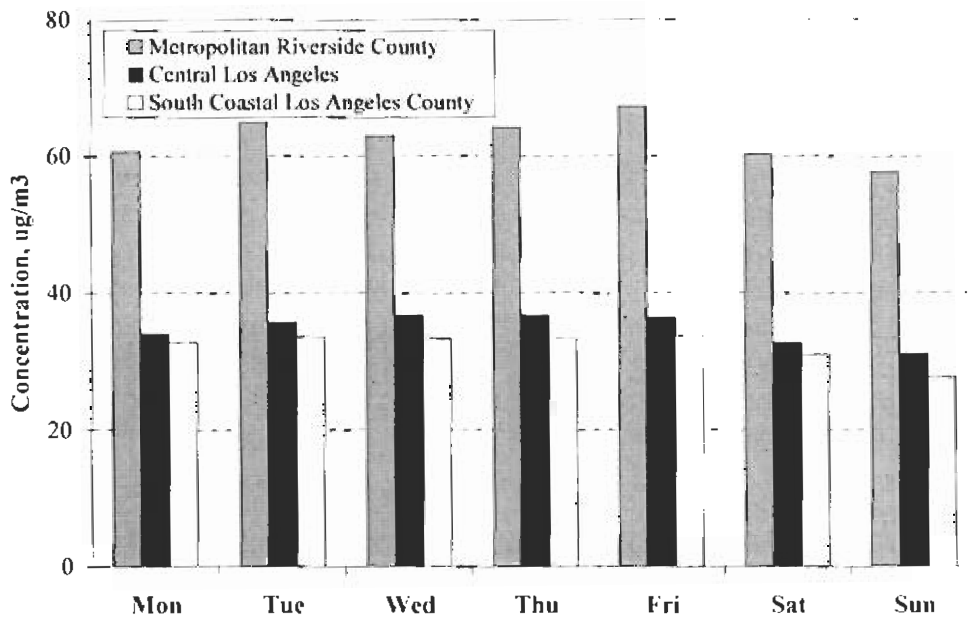



**FIGURE 2-15**
Day-of-Week Variation, 1999-2001
Average $PM_{10}$ Concentration by Day of Week

## Suspended Particulate Matter ($PM_{2.5}$)

### Properties

$PM_{2.5}$, the fine sized particles less than 2.5 micrometers in diameter, are small enough to penetrate the defenses of the human respiratory system and lodge in the deepest recesses of the lung, causing adverse health impacts. The health effects include increased respiratory symptoms and diseases such as ashma, bronchitis, acute and chronic respiratory problems like shortness of breath and painful breathing (in children, the elderly and sensitive people), and premature deaths (mainly in the elderly due to a weaker immune system). The sources of $PM_{2.5}$ include diesel-powered vehicles such as buses and trucks, fuel combustion from automobiles, power plants, industrial processes, and wood burning.

In the South Coast Air Basin, much of the $PM_{10}$ fraction is actually finer in size than $_{2.5}$ micrometers, a condition which has major implications for both health and atmospheric visibility. Reducing $PM_{2.5}$ concentrations will therefore not only reduce the threat to the health of the Basin's population, but will also improve visual air quality in this region.

The District began monitoring $PM_{2.5}$ regularly in 1999. In 2001, the District measured $PM_{2.5}$ concentrations at 18 locations. Samples are collected for a 24-hour period every 3 days at most locations except for a few sites with high $PM_{2.5}$ levels where samples are taken every day.

**Current $PM_{2.5}$ Air Quality**

Figure 2-16 shows 2001 the annual average arithmetic mean $PM_{2.5}$ concentrations in different areas of the Basin. Like $PM_{10}$, $PM_{2.5}$ concentrations were higher in the inland valley areas of San Bernardino county and Metropolitan Riverside county. However, $PM_{2.5}$ concentrations were also high in the metropolitan areas of Los Angeles and Orange counties. The high $PM_{2.5}$ concentrations in these areas are mainly due to the

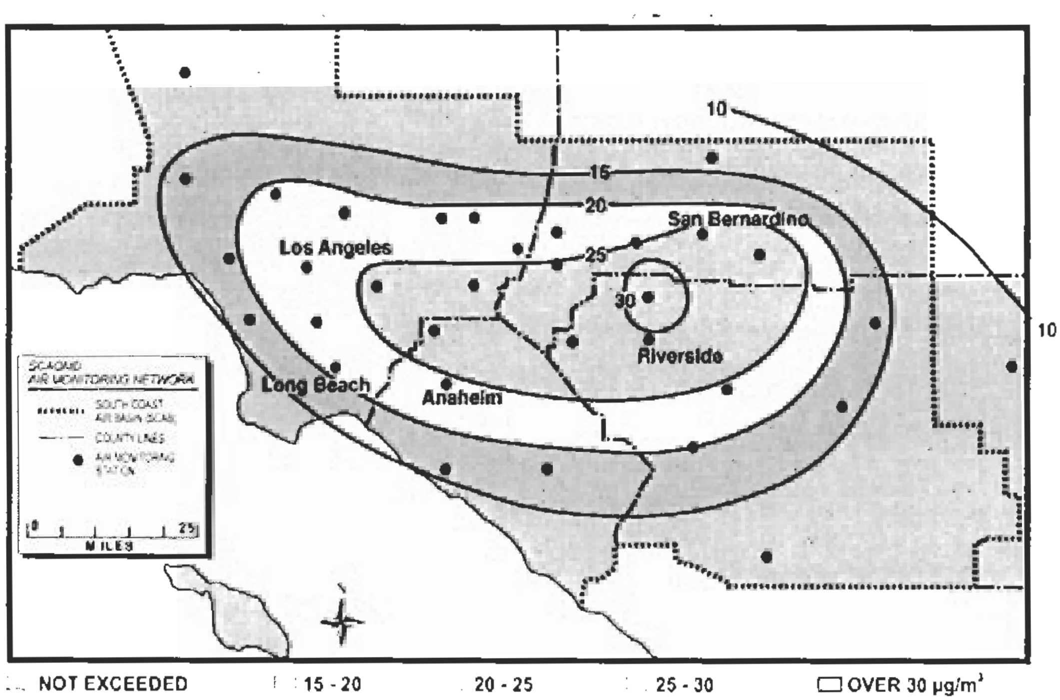



**FIGURE 2-16**
Suspended Particulate Matter ($PM_{2.5}$) - 2001
Annual Arithmetic Mean, $\mu g/m^3$

secondary formation of smaller-sized particulate resulting from mobile and stationary source activities. The maximum annual average recorded (31.1 $\mu g/m^3$ in the Metropolitan Riverside county area) was 201% of the federal standard. In 2001, the federal annual $PM_{2.5}$ standard was exceeded everywhere in the District except for the San Bernardino Mountain area in the Basin and Coachella Valley area in SSAB.

The federal 24-hour $PM_{2.5}$ standard was exceeded likewise almost everywhere in the Basin in 2001. The standard was exceeded most frequently in the metropolitan areas of Los Angeles and Riverside counties. Maximum 24-hour average concentration (98.0 $\mu g/m^3$ in Metropolitan Riverside county) was 150% of the federal 24-hour standard.

**Seasonal and Day of Week Variation in $PM_{2.5}$**

Evaluation of the available data for the past two years that $PM_{2.5}$ has been monitored shows that the $PM_{2.5}$ concentrations tend to peak during the late fall-winter months. Figure 2-17 shows the average number of days in each month exceeding the federal standard at one or more Basin locations over the years 1999-2001. The greatest number of exceedances occurred in January and October-December.

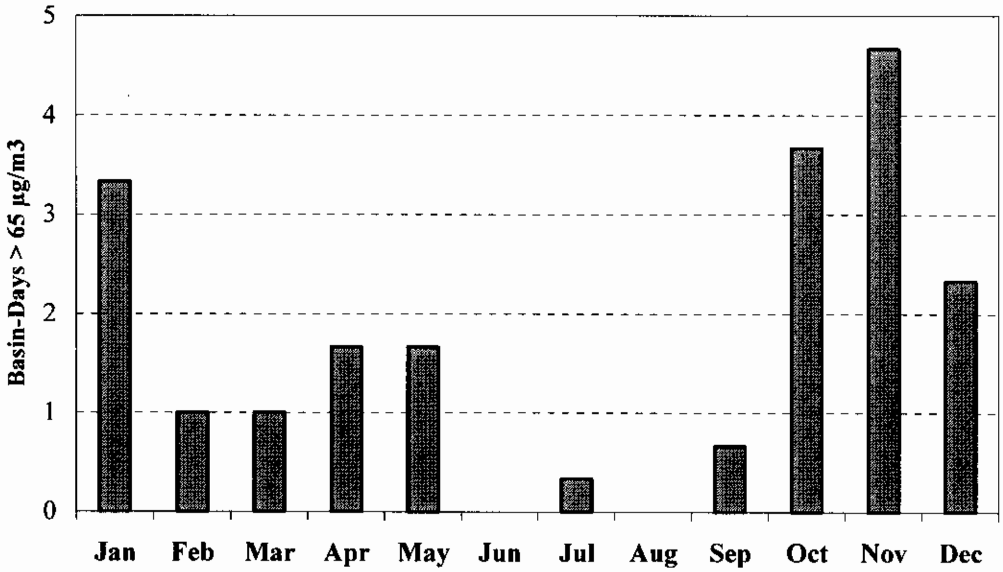



**FIGURE 2-17**
$PM_{2.5}$ Seasonal Variation, 1999-2001
Average Number of Basin-Days Exceeding Federal Standard by Month

Because $PM_{2.5}$ standards and monitoring requirements are of recent adaption, there is insufficient data accumulated thus far to accurately determine day-of-week trends in $PM_{2.5}$ concentrations in the Basin. Preliminary analysis of available data shows slightly higher frequency of number of days exceeding the federal standard on Sundays and Mondays. No specific day-of-week pattern was found in the in $PM_{2.5}$ concentrations in the Basin. Figure 2-18 the total number of days exceeding the federal standard in the Basin by day of week for the three-year period 1999-2001.

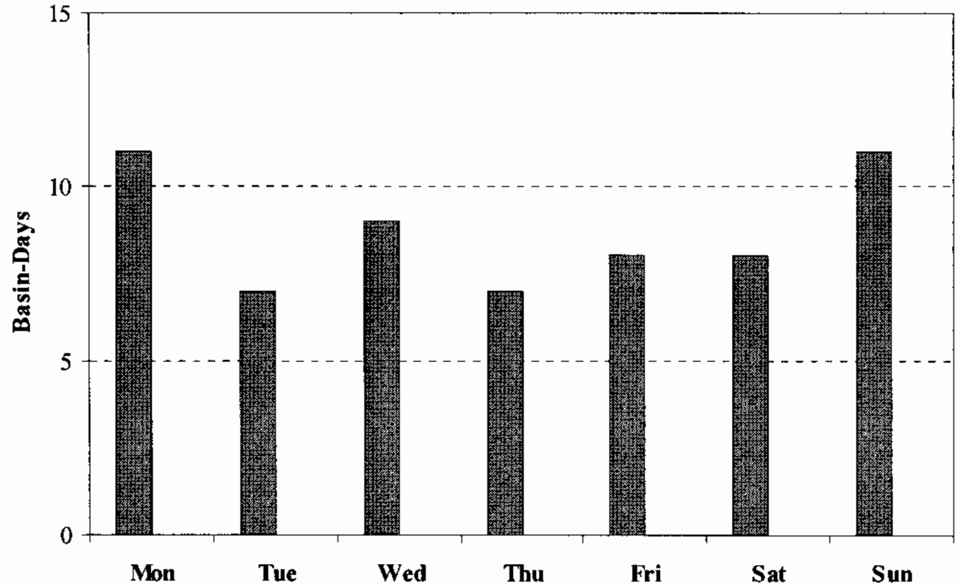



**FIGURE 2-18**
$PM_{2.5}$ Day-of-Week Variation, 1999-2001
Basin-Days Exceeding the Federal Standard by Day of Week

## Nitrogen Dioxide ($NO_2$)

### Properties

Nitrogen dioxide ($NO_2$) is a reddish-brown gas with a bleach-like odor. Nitric oxide (NO) is a colorless gas, formed from the nitrogen ($N_2$) and oxygen ($O_2$) in air under conditions of high temperature and pressure which are generally present during combustion of fuels; NO reacts rapidly with the oxygen in air to give nitrogen dioxide ($NO_2$). $NO_2$ is responsible for the brownish tinge of polluted air. The two gases, nitric oxide and nitrogen dioxide, are referred to collectively as oxides of nitrogen ($NO_x$). In the presence of sunlight, nitrogen dioxide reacts to give nitric oxide and an oxygen atom. The oxygen atom can react further to give ozone, via a complex series of chemical reactions involving hydrocarbons. Nitrogen dioxide may also react to give nitric acid ($HNO_3$) which reacts further to give nitrates, which are a component of $PM_{10}$.

Nitrogen dioxide is a respiratory irritant and reduces resistance to respiratory infection. Children and people with respiratory disease are most susceptible to its effects.

### Current Nitrogen Dioxide Air Quality

In 2001, the District monitored nitrogen dioxide concentrations at 23 locations. Federal and state standards for nitrogen dioxide were not exceeded at any location. The federal standard has not been exceeded in the Basin since 1991.

Table 1 below shows the 2001 maximum annual average nitrogen dioxide concentrations by Basin and county. The maximum annual average nitrogen dioxide concentration (0.0419 ppm recorded in the East San Fernando Valley area of Los Angeles county) was 78% of the federal standard. Concentrations in the downwind SSAB areas were much lower. The maximum 1-hour average concentration in the Basin (0.25 ppm in East San Fernando Valley) was 96% of the state standard.

The annual averages, number of days exceeding the state standard, and maximum 1-hour average concentrations for each individual area of the District for the years 1976-2001 are given in Tables A-14 to A-16 in Attachment.

**TABLE 1**

2001 Maximum Annual Average Nitrogen Dioxide Concentrations*

| Basin/County | Maximum Annual Avg. ppm | Percent Federal Standard | Area |
|---|---|---|---|
| South Coast Air Basin | | | |
| Los Angeles | 0.0419 | 78% | East San Fernando Valley |
| Orange | 0.0293 | 55% | Central Orange County |
| Riverside | 0.0247 | 46% | Metropolitan Riverside County |
| San Bernardino | 0.0384 | 72% | Northwest San Bernardino Valley |
| Salton Sea Air Basin | | | |
| Riverside | 0.0175 | 33% | Coachella Valley |

* Federal standard = 0.0535 ppm

Though the state and federal standards were not exceeded in 2001, nitrogen dioxide is still a concern since it is a precursor to both ozone and particulate matter. Further control of oxides of nitrogen will be required to attain the ozone and particulate standards.

## Sulfur Dioxide ($SO_2$)

### Properties

Sulfur dioxide ($SO_2$) is a colorless gas with a sharp odor. It reacts in the air to form sulfuric acid ($H_2SO_4$), which contributes to acid precipitation, and sulfates, which are a component of $PM_{10}$ and $PM_{2.5}$. Most of the $SO_2$ emitted into the atmosphere is produced by the burning of sulfur-containing fuels.

At sufficiently high concentrations, sulfur dioxide affects breathing and the lungs' defenses, and can aggravate respiratory and cardiovascular diseases. Asthmatics and people with chronic lung disease or cardiovascular disease are most sensitive to its effects. Sulfur dioxide also causes plant damage, damage to materials, and acidification of lakes and streams.

### Current Sulfur Dioxide Air Quality

In 2001, sulfur dioxide was measured at seven Basin locations. No violations of federal or state standards occurred. The federal standards were last exceeded in the 1960's and the state standard was last exceeded in 1990.

The maximum 24-hour average $SO_2$ concentrations recorded in the District in 2001 are shown in Table 2. The highest 24-hour average $SO_2$ concentration (0.012 ppm in South and Southwest Coastal Los Angeles county areas) was 8% of the federal 24-hour standard. The highest 1-hour average (0.05 ppm in South Coastal Los Angeles county) was 19% of the state standard. The maximum annual average concentration (0.0041 ppm in the Southwest Coastal Los Angeles county area) was 13% of the federal standard.

Detailed statistics including annual average and maximum 1-hour average $SO_2$ concentrations for each location monitored for the years 1976-2001 are given in in Attachments A-17 and A-18.

While sulfur dioxide concentrations in the Basin no longer exceed standards, $SO_2$ is a precursor of $PM_{10}$ and sulfate.

**TABLE 2**
2001 Maximum 24-Hour Average Sulfur Dioxide Concentrations*

| Basin/County | Maximum 24-hr Avg. ppm | Percent Federal Standard | Area |
|---|---|---|---|
| South Coast Air Basin | | | |
| Los Angeles | 0.012 | 8% | Southwest Coastal LA County |
| Orange | 0.007 | 5% | North Coastal Orange County |
| Riverside | 0.011 | 8% | Metropolitan Riverside County |
| San Bernardino | 0.010 | 7% | Central San Bernardino Valley |
| Salton Sea Air Basin | | | |
| Riverside | N.D. | | |

N.D. = No Data. Historical measurements indicate concentrations are below standard.
* Federal standard = 0.14 ppm

## Sulfate ($SO_4^=$)

### Properties

Sulfates are chemical compounds which contain the sulfate ion ($SO_4^=$), and are part of the mixture of solid materials which make up $PM_{10}$ and TSP. Most of the sulfates in the atmosphere are produced by oxidation of sulfur dioxide. Oxidation of sulfur dioxide yields sulfur trioxide ($SO_3$) which reacts with water to give sulfuric acid ($H_2SO_4$), which contributes to acid precipitation. The reaction of sulfuric acid with basic substances such as ammonia yields sulfates, a component of $PM_{10}$.

### Current Sulfate Air Quality

In 2001 sulfate concentrations were measured at 13 Basin locations. Table 3 shows the 2001 maximum 24-hour average concentrations in the District by Basin and county. The maximum sulfate concentration (20.6 $\mu g/m^3$) recorded in the District was 82% of the state standard.

The percent of days exceeding the standard and the maximum 24-hour average concentration at each monitoring location for the years 1976-2001 are given in Tables A-19 to A-20 in Attachment.

**TABLE 3**
2001 Maximum 24-Hour Average Sulfate Concentrations

| **Basin/County** | **Maximum 24-hr. Avg. μg/m³** | **Percent State Standard** | **Area** |
|---|---|---|---|
| South Coast Air Basin | | | |
| Los Angeles | 20.6 | 82% | Southwest Coastal LA County |
| Orange | N.D. | | |
| Riverside | 10.7 | 43% | Metropolitan Riverside County |
| San Bernardino | 11.5 | 46% | Central San Bernardino Valley |
| Salton Sea Air Basin | | | |
| Riverside | N.D. | | |

N.D. = No Data. Historical measurements indicated concentrations were below standard.
* State standard = 25 μg/m3

## Lead (Pb)

### Properties

Lead in the atmosphere is present as a mixture of a number of lead compounds. Leaded gasoline and lead smelters have been the main sources of lead emitted into the air. Due to the phasing out of leaded gasoline, there was a dramatic reduction in atmospheric lead in the Basin over the past two decades. However, lead concentrations in excess of the standards have been recorded since 1990 in very localized areas near stationary sources of lead.

### Current Lead Air Quality

In 2001 lead concentrations were measured at nine Basin air monitoring stations, none of which exceeded the state or federal standards. Table 4 shows the maximum quarterly average lead concentrations in the District by Basin and county in 2001. The maximum quarterly average lead concentration (0.12 $\mu g/m^3$) was 8% of the federal standard. The maximum monthly average lead concentration (0.23 $\mu g/m^3$) was 15% of the state standard.

**TABLE 4**
2001 Maximum Quarterly Average Lead Concentrations

| Basin/County | Maximum Qtr. Avg.* μg/m³ | Percent Federal Standard | Area |
|---|---|---|---|
| South Coast Air Basin | | | |
| Los Angeles | 0.12 | 8% | South Central LA County |
| Orange | N.D. | | |
| Riverside | 0.03 | 2% | Metropolitan Riverside County |
| San Bernardino | 0.04 | 3% | Multiple Sites |
| Salton Sea Air Basin | | | |
| Riverside | N.D. | | |

N.D. = No Data. Historical measurements indicated concentrations were below standard.
* Higher concentrations (0.49 μg/m3) were measured in localized areas near sources.

In addition to lead measurements at District air monitoring stations, special monitoring was done in the immediate vicinity of several stationary sources of lead. Data from the special monitoring sites showed that higher concentrations were reached in very localized areas near sources, with a maximum quarterly average (0.49 $\mu g/m^3$) 32% of the federal standard, and a maximum monthly average (0.57 $\mu g/m^3$) 38% of the state standard.

Maximum quarterly average and monthly average lead concentrations at each of the regular monitoring sites for the years 1976-2001 are given in the Attachment, Tables A-21 and A-22 in Attachment.

# CHAPTER 3

# AIR QUALITY IN THE RIVERSIDE COUNTY SSAB

## AIR QUALITY IN THE RIVERSIDE COUNTY SSAB

In 2001, the District monitored air quality at two locations in the Riverside county portion of the Salton Sea Desert Air Basin (SSAB), both in the Coachella Valley. One monitoring station was located immediately downwind of the densely populated Basin, and the other was located further downwind in the Coachella Valley. The maximum concentrations recorded at these locations in 2001 are shown in Figure 3-1.

In 2001, pollutant concentrations in the Riverside county SSAB exceeded standards for ozone and PM10. The maximum 1-hour average ozone concentration (0.137ppm) was 137% and 110% of the state and federal standards, respectively. The maximum 8-hour average ozone concentration (0.114 ppm) was 134% of the 8-hour federal ozone standard. The maximum annual average PM10 concentration (50.2 $\mu g/m^3$) was 99% of the federal annual PM10 standard. (The annual average PM10 does not include the data for the samples collected on high-wind days in accordance with EPA's Natural Event Policy.) The maximum annual average PM2.5 concentration (12.2 $\mu g/m^3$) was 79% of the standard.

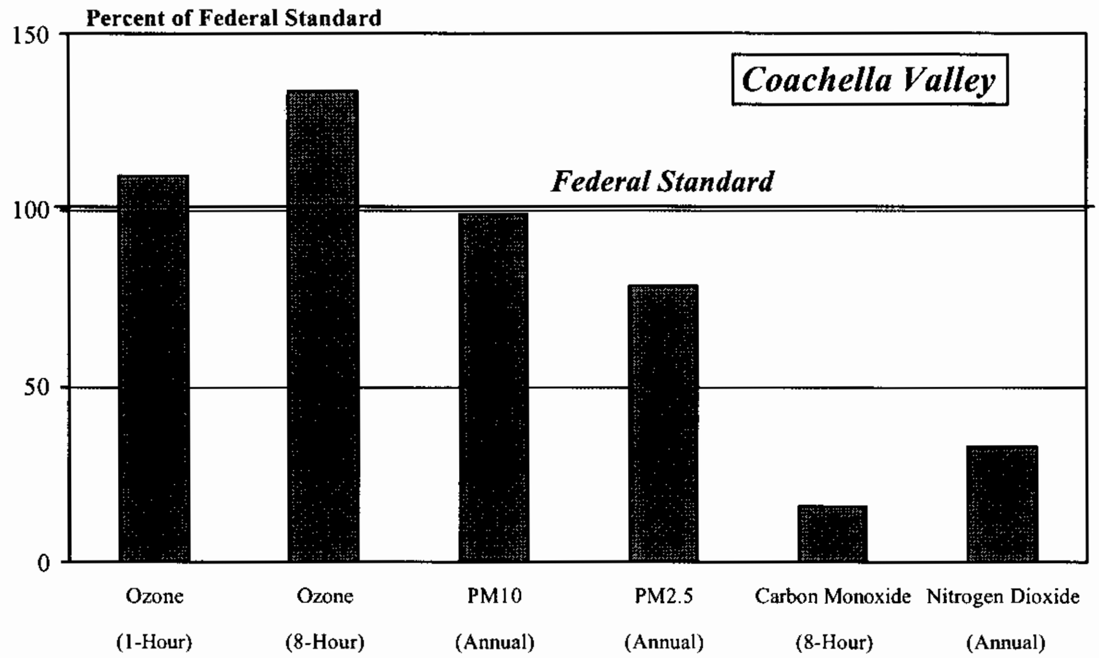



**FIGURE 3-1**
2001 Maximum Pollutant Concentrations as Percent of Standards
Riverside County SSAB

Federal and state standards for carbon monoxide and nitrogen dioxide were not exceeded. The highest 8-hour average carbon monoxide concentration (1.75 ppm) was 16% of the federal standard. The maximum annual average nitrogen dioxide concentration recorded (0.0175 ppm) was 33% of the federal $NO_2$ standard. No measurements of sulfur dioxide, sulfate or lead were made in the Riverside county SSAB area of the District in 2001. Historical measurements in this area showed concentrations of these pollutants to be well below the state and federal standards and monitoring was discontinued. Detailed information on historical air quality and trends in air quality in this area was presented in a previous report.

## Ozone ($O_3$)

Ozone in the atmosphere of the Riverside county portion of SSAB is both directly transported from the Basin and formed principally from precursors emitted upwind. These precursors are emitted in greatest quantity in the coastal and central Los Angeles county areas of the Basin. The Basin's prevailing sea breeze causes polluted air to be transported inland. As the air is being transported inland, ozone is formed, with peak concentrations occurring in the inland valleys of the Basin in an area extending from eastern San Fernando Valley through the San Gabriel Valley into the Riverside-San Bernardino area and the adjacent mountains. As the air is transported still further inland into the desert areas, ozone concentrations decrease.

The 1-hour federal ozone standard level was exceeded on a maximum of six days in Coachella Valley in 2001. The more stringent 8-hour federal standard was exceeded on 42 days. Ozone concentrations and the number of days exceeding the federal ozone standard are greatest in summer. There are typically no exceedances during the winter months.

The 1-hour state ozone standard was exceeded on a maximum of 53 days in Coachella Valley in 2001. The health advisory level has not been exceeded in the Coachella Valley area since 1999. No stage 1 episode level has been recorded in the Riverside county SSAB areas since 1989.

Number of days exceeding the 1-hour federal ozone standard and episode levels and the maximum 1-hour ozone concentrations for the years 1976-2001 are given in the Attachment, in Tables A-4 through A-6.

## Particulate Matter (PM10)

Although exceedances of the ozone standard in the Coachella Valley area are due to the transport of ozone from the densely populated areas of the Basin upwind, the same cannot be said for PM10 exceedances. PM10 exceedances in the Coachella Valley are primarily due to locally generated sources of fugitive dust (e.g. construction activities, re-entrained dust from paved road travel, and natural wind-blown sources) and not as a result of secondary PM10 generated from precursor gaseous emissions. In addition, the Riverside county SSAB is subject to frequent high winds which generate wind-blown sand and dust that can cause high levels of PM10. PM10 is the only pollutant which has sometimes reached higher concentrations in SSAB than in the densely populated Basin.

In 2001, the federal 24-hour PM10 standard was exceeded in Coachella Valley on a maximum of five days (4% of sampling days). All samples which exceeded the standard were collected on high-wind days which resulted in windblown dust. The data for these samples are excluded from the data base in accordance with the EPA's Natural Event Policy. The federal annual PM10 standard level was not exceeded in the Riverside county part of SSAB in 2001. The maximum annual average PM10 concentration (50.2 $\mu g/m^3$) was 99% of the standard.

The maximum annual average PM10 concentrations in the western portion of the Coachella Valley area, as well as the San Gorgonio Pass area at the eastern edge of the Basin, remained well below the federal PM10 standards in 2001.

In 2001, the state 24-hour PM10 standard was exceeded on a maximum of 50 days (45% of sampling days) in Coachella Valley. The state annual standard was also exceeded. The maximum annual average (44.3 $\mu g/m^3$, annual geometric mean) was 147% of the state standard.

Analyses of the seasonal distribution of exceedances of the PM10 standards showed a pattern similar to the inland valleys with a peak in summer and falling to a minimum in winter.

Variation in average concentration by day-of-week in Coachella Valley also shows the same pattern as other areas in the Basin, with concentrations lower on weekends than on week days.

Annual average, percent number of days exceeding standards and maximum 24-hour average concentrations for the years 1985-2001 for the Riverside county SSAB and other District air monitoring stations are presented in the Attachment, in Tables A-10 to A-13.

## Particulate Matter (PM2.5)

PM2.5 has been measured in Coachella Valley since 1999 when the District began PM2.5 monitoring. In 2001, federal PM2.5 standards were not exceeded at either of the two Riverside county SSAB air monitoring sites. The maximum 24-hour average and annual average concentrations recorded in 2001 (44.7 $\mu g/m^3$ and 12.2 $\mu g/m^3$) were, respectively, 68% and 79% of the federal 24-hour and annual standards.

## Carbon Monoxide (CO)

Carbon monoxide was measured at one of the Riverside county SSAB air monitoring stations in 2001. Neither the federal nor state standards were exceeded. The maximum 8-hour average CO recorded in 2001 (1.75 ppm) was 16% of the federal and 19% of the state standards. Historical carbon monoxide air quality and trends in the Riverside county SSAB area shows that the area has not exceeded the federal standard over the last two decades.

Summary statistics for carbon monoxide in the Riverside county SSAB as well as other District areas are given in the Attachment, in Tables A-7 to A-9.

## Nitrogen Dioxide ($NO_2$)

Nitrogen dioxide was measured at one of the stations in the Riverside county SSAB in 2001. The maximum annual average nitrogen dioxide concentration (0.0175 ppm) was 33% of the federal standard and the maximum 1-hour average (0.08 ppm) was 31% of the state 1-hour standard.

Table 1 (Chapter 2) and Tables A-15 to A-17 in the Attachment contain nitrogen dioxide summary statistics for the Riverside county SSAB and other District monitoring stations for the year 2001 and earlier years.

## Sulfur Dioxide ($SO_2$)

Sulfur dioxide concentrations were not measured in the Riverside county SSAB in 2001. Measurements made in past years have shown concentrations to be well below the standard.

Tables A-17 and A-18 in the Atthachment contain annual average and maximum 1-hour averages for available years for the period 1976-2001 at Riverside county SSAB and other District monitoring stations.

## Sulfate ($SO_4^=$)

No measurements of sulfate concentrations were made in 2001 at the two monitoring stations in the Riverside county SSAB. Historical monitoring has shown concentrations to be less than the state standard.

The percent of days exceeding the standard, and the maximum 24-hour average and annual average sulfate concentrations at each monitoring location for past years are presented in the Attachment, in Tables A-20 to A-22.

## Lead (Pb)

Lead concentrations were not measured at the two Riverside county SSAB stations in 2001. Measurements made in past years have shown concentrations to be less than the state and federa standards.

Maximum quarterly average and monthly average concentrations for past years are given in Tables A-23 and A-24 in the Attachment.

# SUMMARY

# SUMMARY

This report contains a summary of the year 2001 air quality in the South Coast Air Basin and the portion of Salton Sea Air Basin monitored by the South Coast Air Quality Management District. For those pollutants for which the Basin is in nonattainment of the federal standards, an updated air quality trends through the year 2001 are presented.[1]

In 2001 the South Coast Air Quality Management District monitored concentrations of air pollutants at 32 locations in Southern California's Los Angeles, Orange, Riverside and San Bernardino counties. Pollutant concentrations exceeded the federal and state standards for ozone and particulate matter (PM10, PM2.5). Standards for carbon monoxide, nitrogen dioxide, sulfur dioxide, sulfate and lead were not exceeded.

In the year 2001, the U.S. location with the highest number of days exceeding the federal ozone standard was located in the South Coast Air Basin (Orange county and the non-desert portions of Los Angeles, Riverside and San Bernardino counties). The Basin also continued to rank among the areas of the U.S. with high carbon monoxide and PM10 concentrations in 2001.

## South Coast Air Basin (SCAB)

In 2001, there were a total of 37 days on which the federal standards for 1-hour ozone and 24-hour PM10 were exceeded at one or more SCAB (Basin) locations. The recently adopted federal 24-hour PM2.5 standard was exceeded on 23 days in the Basin.

The number of days exceeding the federal ozone standard varied widely by area, from zero to 26 exceedances, depending on location. Exceedances were fewest at the coast, increasing to a maximum in the Basin's Central San Bernardino Mountains and inland valleys, and then decreasing further downwind in the Basin's far inland areas. The Central San Bernardino Mountains area exceeded the federal ozone standard most frequently (26 days). The more stringent state standard was exceeded on 88 days in the same area. The highest 1-hour average and 8-hour average ozone concentration recorded in 2001 (0.190 ppm and 0.144 ppm) were 152% and 169% of the federal 1-hour and 8-hour standards, respectively.

In 2001, carbon monoxide concentrations did not exceed the standards anywhere in the Basin. The highest carbon monoxide concentrations were recorded in coastal and central Los Angeles county areas. The maximum 8-hour average concentration of 7.71 ppm, recorded in South Central Los Angeles County, was 81% of the federal standard.

[1] The current air quality analysis presented in this report is based on the data through the year 2001. Complete particulate data for the year 2002 is not available at this time.

Exceedances of the federal annual PM10 standard were confined to Riverside and San Bernardino counties, primarily in and around the Metropolitan Riverside county area. The more stringent state annual PM10 standard was exceeded in a much larger area, covering most of the Basin. The federal 24-hour PM10 standard was also exceeded at a few locations in the inland valley areas in 2001. The state 24-hour standard, however, was exceeded at all locations monitored, with the Metropolitan Riverside county area exceeding most frequently (67% of sampling days). The maximum 24-hour average and annual PM10 concentrations (219 $\mu g/m^3$ and 63.1 $\mu g/m^3$) were 146% and 125% of the federal 24-hour and annual standards, respectively.

PM2.5 concentrations were monitored in the District in 2001 in accordance with the adopted federal PM2.5 standards. Maximum 24-hour average and annual average PM2.5 concentrations (98.0 $\mu g/m^3$ and 31.1 $\mu g/m^3$) were 150% and 201% of the federal 24-hour and annual standards, respectively, both recorded in the Metropolitan Riverside county area.

## Riverside County Salton Sea Air Basin (SSAB)

Pollutant concentrations in the Riverside county portion of SSAB were monitored at two locations in the Coachella Valley in 2001, and exceeded the federal and state standards for ozone. No other standards were exceeded.

The highest 1-hour and 8-hour ozone concentrations recorded in the Coachella Valley in 2001 (0.137 ppm and 0.114 ppm) were 110% and 134% of the federal 1-hour and 8-hour standards, respectively. The federal 1-hour ozone standard exceeded on a maximum of six days in SSAB in 2001. The more stringent state standard was exceeded on 42 days.

Both the state and federal 24-hour PM10 standards and the state and federal annual PM10 standards were exceeded in the Coachella Valley. However, the deletion of high-wind day samples from consideration results in there being no exceedances of the federal standards in 2001. PM2.5 concentrations were below the federal 24-hour and annual PM2.5 standards.

## Seasonal, Day-of-Week and Diurnal Variations

Concentrations of pollutants have been found to vary by season, day of week, and time of day, and these variations were examined for 1999-2001 for ozone, carbon monoxide and PM10. Ozone standard exceedances generally peak in summer, while carbon monoxide exceedances peak in late fall and winter, and federal 24-hour PM10 exceedances peak in fall and winter. Ozone tended to be higher on weekends than on weekdays, while the opposite was true for carbon monoxide and PM10. The time of the day which averaged highest in ozone concentration was early afternoon in the peak ozone area, while carbon monoxide averaged highest at the time of morning rush-hour traffic.

# ATTACHMENT

# TABLE A-1

## AMBIENT AIR QUALITY STANDARDS

| | CALIFORNIA | FEDERAL | | | |
|---|---|---|---|---|---|
| **AIR POLLUTANT** | **CONCENTRATION** | **DISTRICT METHOD** | **PRIMARY (>)** | **SECONDARY (>)** | **METHOD** [a] |
| **Ozone** [b] | 0.09 ppm, 1-hour average > | U.V. Photometry | 0.12 ppm, 1-hour average<br>0.08 ppm, 8-hour average[b] | Same as Primary Standrd | Chemiluminescence |
| **Carbon Monoxide** | 9.0 ppm, 8-hour average > [c]<br>20 ppm, 1-hour average > | Gas Correlation | 9 ppm, 8-hour average [d]<br>35 ppm, 1-hour average | None | Non-dispersive Infra-Red Spectrophotometry |
| **Nitrogen Dioxide** | 0.25 ppm, 1-hour average > [e] | Gas Phase Chemiluminescence | 0.053 ppm, annual average [f] | Same as Primary Standrd | Gas Phase Chemiluminescence |
| **Sulfur Dioxide** | 0.04 ppm, 24-hour average > [g]<br>0.25 ppm, 1-hour average > [h] | Ultraviolet PulseFluorescence | 0.03 ppm, annual average<br>0.14 ppm, 24-hour average | 0.50 ppm, 3-hour average | Para-rosaniline |
| **Suspended Particulate Matter (PM10)**** | 30 $\mu g/m^3$, annual geometric mean ><br>50 $\mu g/m^3$, 24-hour average > [i], **<br>20 $\mu g/m^3$, annual arithmetic mean > ** | Size Segregation Inlet High Volume Sampling | 50 $\mu g/m^3$, annual arithmetic mean<br>150 $\mu g/m^3$, 24-hour average [j] | Same as Primary Standrd | Inertial Separation and Gravimetric Analysis |
| **Suspended Particulate Matter (PM2.5)** [k], ** | 12 $\mu g/m^3$, annual arithmetic mean ** | Inertial Separation and Gravimetric Analysis | 15 $\mu g/m^3$, annual arithmetic mean [k]<br>65 $\mu g/m^3$, 24-hour average [k] | Same as Primary Standrd | Inertial Separation and Gravimetric Analysis |
| **Lead** | 1.5 $\mu g/m^3$, 30-day average >= | High Vol. Sampling Atomic Absorption | 1.5 $\mu g/m^3$, calendar quarter | Same as Primary Standrd | High Vol. Sampling Atomic Absorption |
| **Sulfates** | 25 $\mu g/m^3$, 24-hour average >= | High Vol. Sampling Ion Chouromatography | **NO FEDERAL STANDARDS** | | |
| **Hydrogen Sulfide** | 0.03 ppm, 1-hour average > | Cadmium Hydroxide Stractan | | | |
| **Vinyl Chloride** | 0.010 ppm, 24-hour average >= | Gas Chouromatography | | | |
| **Visibility Reducing Particles** | In sufficient amount to give an extinction coefficient > 0.23 inverse kilometers (visual range less than 10 miles), with relative humidity <70%, 8-hour average (10am-6pm, PST) [f]. | Nephelometry and AISI Tape Sampler (COH) | | | |

a) Reference method as described by the federal government. An equivalent method of measurement may be used as approved by the federal government.

b) Effective September 16, 1997, new federal 8-hour average standard was established.

c) Effective December 15, 1982. The previous standards were 10 ppm, 12-hour average and 40 ppm, 1-hour average.

d) Effective September 13, 1985, standard changed from >10 $\mu g/m^3$ (>=9.3 ppm) to > 9 ppm (>=9.5 ppm).

e) Effective March 9, 1987, standard changed from >=0.25 ppm to > 0.25 ppm.

f) Effective July 1, 1985, standard changed from > 100 $\mu g/m^3$ (>0.0532 ppm) to > 0.053 ppm (>= 0.0535 ppm).

g) Effective July 29, 1992. The previous standard was >= 0.05 ppm, 24-hour average with ozone > 0.1 ppm, 1-hour average or TSP >=100 $\mu g/m^3$, 24-hour average.

h) Effective October 5, 1984. The previous standard was 0.5 ppm, 1-hour average.

i) Effective August 19, 1983**. The previous standards were annual geometric mean TSP > 60 $\mu g/m^3$, and 24 hour average TSP > 100 $\mu g/m^3$.

j) Effective July 1, 1987. The previous standards were annual geometric mean TSP > 75 $\mu g/m^3$, and 24 hour average TSP > 260 $\mu g/m^3$.

k) Effective September 16, 1997, new federal standards were established. There were no previous standards for PM2.5.

** The new PM2.5 annual average state standard of 12 µg/m$^3$ and revised PM10 annual average state standard of 20 µg/m3 (to replace AGM 30 µg/m3) recommended by the California Air Resources Board was approved by the state Office of Administrative Law effective July 5, 2003.

l) Effective October 18, 1989. The previous standard was "In sufficient amount to reduce the prevailing visibility to less than 10 miles at relative humidity less than 70%, 1 observation", and was based on human observation rather than instrumental measurement.

***Revised***
July ***2003***

**TABLE A-2**

Episode Criteria

| | SCAQMD AND CALIFORNIA | | | | FEDERAL | | |
|---|---|---|---|---|---|---|---|
| AIR POLLUTANT | HEALTH ADVISORY (≥) | STAGE I (≥) | STAGE II (≥) | STAGE III (≥) | STAGE I (≥) (ALERT) | STAGE II (≥) (WARNING) | STAGE III (≥) (EMERGENCY) |
| Ozone | 0.15 ppm, 1-hr. avg. | 0.20 ppm, 1-hr. avg. | 0.35 ppm, 1-hr. avg. | 0.50 ppm, 1-hr. avg. | 0.2 ppm, 1-hr. avg. | 0.4 ppm, 1-hr. avg. | 0.5 ppm, 1-hr. avg. |
| Carbon Monoxide | | 40 ppm, 1-hr. avg.<br>20 ppm, 12-hr. avg. | 75 ppm, 1-hr. avg.<br>35 ppm, 12-hr. avg. | 100 ppm, 1-hr. avg.<br>50 ppm, 12-hr. avg. | 15 ppm, 8-hr. avg. | 30 ppm, 8-hr. avg. | 40 ppm, 8-hr. avg. |
| Nitrogen Dioxide | | | | | 0.6 ppm, 1-hr. avg.<br>0.15 ppm, 24-hr. avg | 1.2 ppm, 1-hr. avg.<br>0.30 ppm, 24-hr. avg. | 1.6 ppm, 1-hr. avg.<br>0.40 ppm, 24-hr. avg. |
| Sulfur Dioxide | | 0.50 ppm, 1-hr. avg.<br>0.20 ppm, 24-hr. avg. | 1.00 ppm, 1-hr. avg.<br>0.70 ppm, 24-hr. avg. | 2.00 ppm, 1-hr. avg.<br>0.90 ppm, 24-hr. avg. | 0.3 ppm, 24-hr. avg. | 0.6 ppm, 24-hr. avg. | 0.8 ppm, 24-hr. avg. |
| Suspended Particulate ($PM_{10}$) | | | | | 350 $\mu g/m^3$, 24-hr. avg. | 420 $\mu g/m^3$, 24-hr. avg. | 500 $\mu g/m^3$, 24-hr. avg. |
| Suspended Particulate ($PM_{2.5}$) | | | | | | | |
| Sulfates* | 25 $\mu g/m^3$, 24-hr. avg. combined with ozone > 0.20 ppm, 1-hr. avg. | | | | | | |
| Actions to be Taken** | Health Advisory to a) Persons with respiratory and coronary disease, b) School officials in order to curtail students' participation in strenuous activities. | First steps in abatement plans. Health Advisory to a) Persons with respiratory and coronary disease, b) School officials in order to curtail students' participation in strenuous activities. | Intermediate Steps. Abatement actions taken to reduce concentration of pollutant at issue. | Mandatory abatement measures. Extensive actions taken to prevent exposure at indicated levels. State can take action if local efforts failed. | Open burning prohibited. Reduction in vehicle operation requested. Industrial curtailment. | Incinerator use prohibited. Reduction in vehicle operation required. Further industrial curtailment. | Vehicle use prohibited. Industry shut down or curtailment. Public activities ceased. |

* Episodes based upon these criteria are not classified according to stages.

** For ozone, actions a) and b) are taken at Health Advisory level. For all other pollutants, these actions are taken at Stage I Episode level.

# TABLE A-3

## Air Monitoring Stations and Source/Receptor Areas

| AREA # | SOURCE/RECEPTOR AREA* | AIR MON STN # |
|---|---|---|
| **LOS ANGELES COUNTY** | | |
| 1 | Central LA | 087 |
| 2 | Northwest Coastal LA County | 091 |
| 3 | Southwest Coastal LA County | 094 |
| 4 | South Coastal LA County | 072 |
| 6 | West San Fernando Valley | 074 |
| 7 | East San Fernando Valley | 069 |
| 8 | West San Gabriel Valley | 088 |
| 9 | East San Gabriel Valley 1 | 060 |
| 9 | East San Gabriel Valley 2 | 591 |
| 10 | Pomona/Walnut Valley | 075 |
| 11 | South San Gabriel Valley | 085 |
| 12 | South Central LA County 1 | 084 |
| 12 | South Central LA County 2 | 801 |
| 13 | Santa Clarita Valley | 090 |
| **ORANGE COUNTY** | | |
| 16 | North Orange County | 3177 |
| 17 | Central Orange County | 3176 |
| 18 | North Coastal Orange County | 3195 |
| 19 | Saddleback Valley 1 | 3186 |
| 19 | Saddleback Valley 2 | 3812 |
| **RIVERSIDE COUNTY** | | |
| 22 | Norco/Corona | 4155 |
| 23 | Metropolitan Riverside County 1 | 4144 |
| 23 | Metropolitan Riverside County 2 | 4146 |
| 24 | Perris Valley | 4149 |
| 25 | Lake Elsinore Area | 4158 |
| 29 | Banning Airport | 4164 |
| 30 | Coachella Valley 1** | 4137 |
| 30 | Coachella Valley 2** | 4157 |
| **SAN BERNARDINO COUNTY** | | |
| 32 | Northwest San Bernardino Valley | 5175 |
| 33 | Southwest San Bernardino Valley | 5817 |
| 34 | Central San Bernardino Valley 1 | 5197 |
| 34 | Central San Bernardino Valley 2 | 5203 |
| 35 | East San Bernardino Valley | 5204 |
| 37 | Central San Bernardino Mountains | 5181 |
| 38 | East San Bernardino Mountains | 5818 |

* Source/Receptor areas and numbers are shown in detail on the map "South Coast Air Quality Management District and Air Monitoring Areas" which is available from SCAQMD Public Information.

**Salton Sea Air Basin.

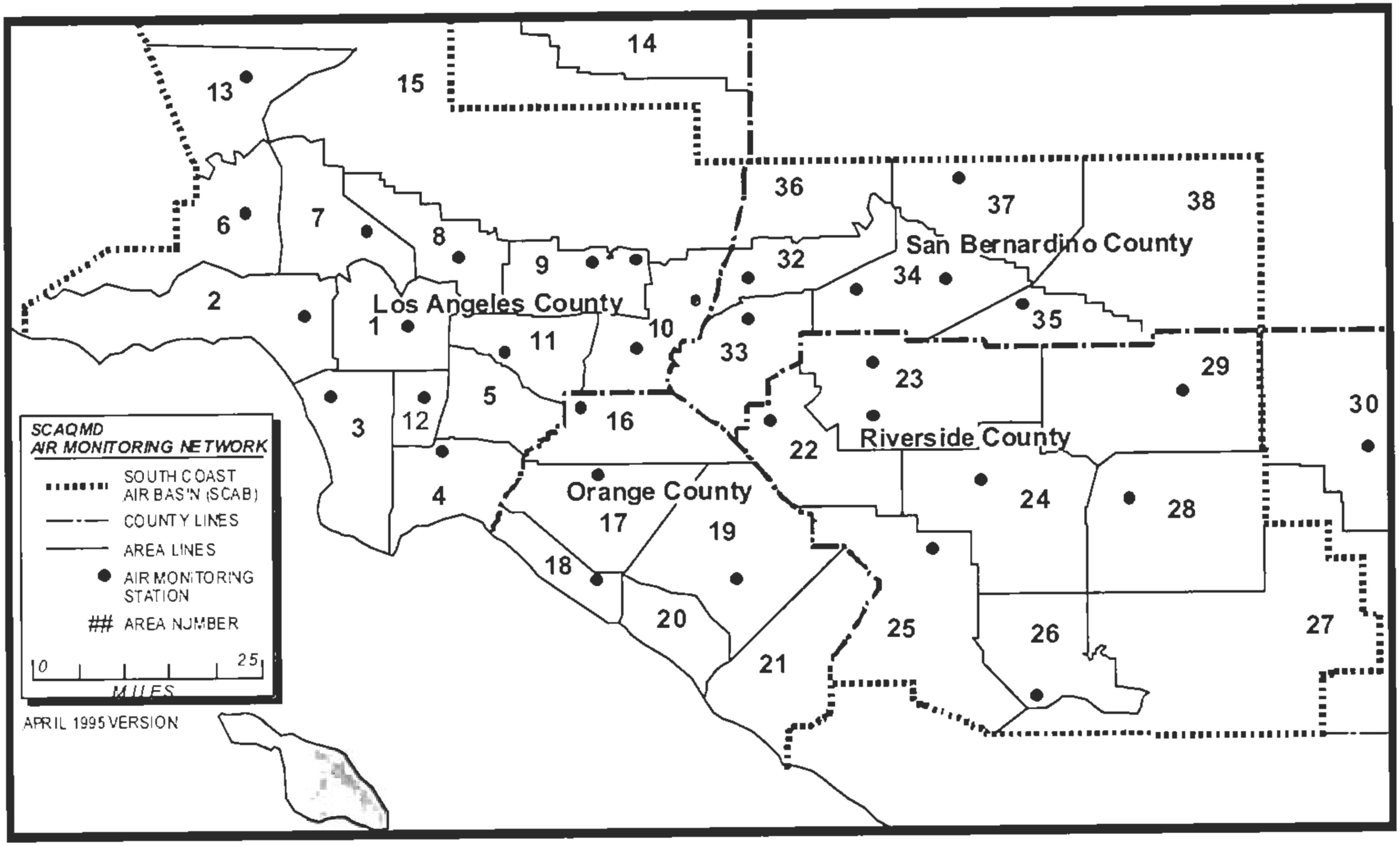



**FIGURE A-1**
South Coast Air Basin and Adjoining Areas of Salton Sea Air Basin

# TABLE A-4

## Ozone - Number of Days Exceeding the Federal Standard (12 pphm, 1-Hour Average)

| STN# | LOCATION | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOS ANGELES COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 060 | East San Gabriel Valley 1 | 129 | 137 | 155 | 146 | 129 | 137 | 104 | 123 | 129 | 117 | 126 | 111 | 125 | 112 | 84 | 73 | 91 | 79 | 72 | 63 | 26 | 11 | 19 | 2* | 11 | 9 |
| 069 | East San Fernando Valley | 138 | 75 | 102 | 92 | 99 | 91 | 63 | 95 | 73 | 87 | 93 | 76 | 64 | 40 | 40 | 55 | 47 | 16 | 18 | 20 | 6 | 2 | 7 | 0 | 3 | 2 |
| 072 | South Coastal Los Angeles County | 3 | 4 | 8 | 12 | 6 | 13 | 6 | 16 | 13 | 11 | 10 | 4 | 7 | 3 | 0 | 0 | 6 | 1 | 1 | 0 | 0 | 0* | 0 | 1 | 0 | 0 |
| 074 | West San Fernando Valley | 122 | 126 | 68 | 103 | 98 | 96 | 66 | 67 | 78 | 75 | 72 | 60 | 71 | 54 | 41 | 53 | 25 | 32 | 7 | 8 | 11 | 0 | 7 | 0 | 0 | 2 |
| 075 | Pomona/Walnut Valley 1 | 108 | 120 | 136 | 126 | 99 | 97 | 66 | 102 | 98 | 98 | 89 | 72 | 91 | 61 | 60 | 60 | 56 | 45 | 47 | 47 | 16 | 7 | 18 | 2 | 3 | 1 |
| 076 | Southwest Coastal Los Angeles County | 9 | 4 | 13 | 7 | 0 | 4 | 2 | 9 | 8 | 4* | a) | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 080 | Southeast Los Angeles County | 70 | 53 | 65* | 47 | 40 | 56 | 44 | 67 | 60 | 58 | 39 | 40 | 29 | 37 | 21 | 23 | 32 | 12 | -- | -- | -- | -- | -- | -- | -- | -- |
| 084 | South Central Los Angeles County 1 | 18* | 3* | 16 | 26 | 14* | 15 | 13 | 27 | 22 | 16 | 16 | 11 | 12 | 7 | 3 | 1 | 4 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 085 | South San Gabriel Valley | 69* | 130 | 120 | 110 | 107 | 94 | 66 | 98 | 92 | 79 | 79 | 63 | 67 | 61 | 43 | 48 | 45 | 33 | 21 | 20 | 32 | 6 | 10 | 0 | 2 | 1 |
| 087 | Central Los Angeles | 71 | 58 | 55 | 50* | 59 | 74 | 48 | 69 | 53 | 56 | 48 | 36 | 24 | 34 | 32 | 23 | 23 | 8 | 14 | 5 | 24 | 0 | 5 | 1 | 1 | 0 |
| 088 | West San Gabriel Valley | 129 | 134 | 152 | 151 | 118 | 116 | 89 | 122 | 125 | 116 | 110 | 95 | 119 | 80 | 69 | 70 | 71 | 53 | 61 | 44 | 54 | 5 | 14 | 0 | 7 | 1 |
| 090 | Santa Clarita Valley | 120 | 132 | 121 | 140 | 96 | 123 | 94 | 85 | 86 | 93 | 87 | 67 | 107 | 71 | 62 | 65 | 71 | 44 | 66 | 26 | 68 | 13 | 16 | 0 | 1 | 9 |
| 091 | Northwest Coastal Los Angeles County | 32 | 14 | 34* | 44 | 35 | 40 | 20 | 37 | 35 | 37 | 30 | 16 | 16 | 15 | 8 | 9 | 12 | 7 | 2 | 1 | 13 | 0 | 1 | 0 | 0 | 0 |
| 094 | Southwest Coastal Los Angeles County | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 8 | 3 | 5 | 3 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 108 | Pomona/Walnut Valley 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 44* | 26 | 23 | 2* | -- | -- | -- | -- | -- |
| 591 | East San Gabriel Valley 2 | -- | -- | -- | -- | -- | 135 | 126 | 134 | 130* | 141 | 148 | 135 | 148 | 121 | 103 | 91 | 118 | 96 | 88 | 73 | 49 | 18 | 28 | 3 | 11 | 13 |
| 801 | South Central Los Angeles County 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 1* | 1* | 0* | -- |
| ORANGE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3176 | Central Orange County 1 | 26* | 14* | 51 | 27 | 39 | 32 | 28 | 40 | 37 | 35 | 28 | 25 | 19 | 13 | 11 | 11 | 22 | 3 | 5 | 2 | 1 | 0 | 2 | 0* | 1 | 0* |
| 3177 | North Orange County | 32 | 37 | 69 | 62 | 63 | 60 | 39 | 64 | 59 | 57 | 49 | 41 | 33 | 36 | 35 | 28 | 31 | 13 | 9 | 4 | 5 | 1 | 5 | 0 | 1 | 0 |
| 3186 | Saddleback Valley 1 | 26 | 17* | 33 | 24 | 25 | 18 | 18 | 24 | 26 | 30 | 12 | 16 | 18 | 7 | 11 | 10 | 9 | 7 | 5 | 1 | 2 | 2 | 2 | 0 | 1* | -- |
| 3190 | Central Orange County 2 | 20 | 18* | 39 | 17 | 13 | 13 | 10 | 16 | 12 | 11 | 5 | 4 | 17 | 11 | 7 | 10 | 9 | 4 | -- | -- | -- | -- | -- | -- | -- | -- |
| 3195 | North Coastal Orange County | 3 | 6* | 25 | 16 | 5 | 6 | 6 | 15 | 7 | 17 | 10 | 2 | 1* | -- | 3 | 5 | 3 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| 3812 | Saddleback Valley 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 2* | 1 |
| RIVERSIDE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4137 | Coachella Valley 1** | 33* | 51 | 57 | 49* | 49 | 57 | 37 | 40 | 36 | 25 | 31 | 33 | 35 | 37 | 27 | 22 | 21* | 20 | 13 | 9 | 12 | 4* | 8 | 1 | 0 | 6 |
| 4141 | Hemet/San Jacinty Valley | 17 | 31 | 20* | -- | -- | -- | -- | -- | -- | 13 | 9 | 27 | 28 | 21 | 20 | 23 | 5 | 8 | 13 | 2 | 0* | -- | -- | -- | -- | -- |
| 4144 | Metropolitan Riverside County | 141 | 152 | 139 | 151 | 132 | 127 | 96 | 121 | 127 | 125 | 106 | 113 | 123 | 112 | 90 | 79 | 75 | 71 | 77 | 52 | 36 | 13* | 32 | 3 | 3 | 7 |
| 4149 | Perris Valley | 109 | 132 | 109 | 118 | 103 | 118 | 90 | 88 | 75 | 96 | 79 | 82 | 82 | 78 | 62 | 71 | 83 | 73 | 59 | 36 | 31 | 6 | 8 | 0 | 15 | 19 |
| 4150 | Banning/San Gorgonio Pass | 37* | 62 | 79 | 84 | 76 | 50 | 58 | 67 | 48 | 55 | 45 | 53 | 64 | 60 | 43 | 31 | 19 | 8 | 25 | 15 | 11 | 2 | 0* | b) | -- | -- |
| 4155 | Norco/Corona | 102 | 116 | 113 | 114 | 99 | 101 | 67 | 97 | 85* | 92 | 77 | 73 | 61 | 56 | 13 | 54 | 16 | 17 | 14 | 23 | 2* | -- | -- | -- | -- | -- |
| 4157 | Coachella Valley 2** | -- | 35 | 37 | 16 | -- | 30 | 18 | 33 | 19 | 16 | -- | -- | -- | 16 | 10 | 13 | 8 | 3 | 0 | 3 | 0 | 0 | 2 | 1 | 0 | 0 |
| 4158 | Lake Elsinore | 55 | 74 | 45* | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 62 | 36 | 45 | 24 | 27 | 27 | 23 | 17 | 4 | 22 | 5 | 1 | 12 |
| 4163 | Temecula Valley | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 2 | 1 | 0* | 0 | 0* | 0* | -- | -- | -- | -- |
| 4164 | Banning Airport | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 25 | 5 | 4 | 16 |
| SAN BERNARDINO COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5175 | Northwest San Bernardino Valley | 139* | 151* | 138* | 135 | 131 | 139* | 113* | 120 | 115 | 110 | 111 | 101 | 122 | 97 | 64 | 67 | 81 | 55 | 79 | 67 | 35 | 12 | 30 | 4 | 10 | 14 |
| 5181 | Central San Bernardino Mountains | 47* | 142 | 123 | 139 | 125 | 131 | 121 | 117 | 139 | 114 | 117 | 119 | 128 | 127 | 103 | 90 | 103 | 88 | 107 | 65 | 62 | 29 | 57 | 30 | 17 | 26 |
| 5197 | Central San Bernardino Valley 1 | 145 | 160 | 155 | 164 | 146 | 147 | 96 | 127 | 136 | 126 | 121 | 116 | 124 | 112 | 92 | 74 | 88 | 65 | 91 | 57 | 38 | 10 | 32 | 4 | 7 | 13 |
| 5203 | Central San Bernardino Valley 2 | 112 | 139 | 138 | 140 | 130 | 134 | 111 | 117 | 125 | 111 | 108* | 117 | 121 | 115 | 78 | 79 | 85 | 65 | 96 | 61 | 63 | 32 | 39 | 14 | 7 | 18 |
| 5204 | East San Bernardino Valley 1 | 96 | 123 | 136 | 139 | 127 | 116 | 103 | 109 | 116 | 113 | 93 | 120 | 130 | 116 | 81 | 91 | 103 | 95 | 98 | 69 | 65 | 35 | 43 | 12 | 11 | 21* |
| | District Maximum | 145 | 160 | 155 | 164 | 146 | 147 | 126 | 134 | 139 | 141 | 148 | 135 | 148 | 127 | 103 | 91 | 118 | 96 | 107 | 73 | 68 | 35 | 57 | 30 | 17 | 26 |

a) Station relocated in 1986.
b) Station relocated in 1998.
* Less than 12 full months of data
** Salton Sea Air Basin

# TABLE A-5

## Ozone, 1976-2001

## Annual Number of Days of First/Second Stage Episodes

## (Days Maximum 1-Hour Average Ozone ≥ 0.20 ppm/≥ 0.35 ppm)

| STN# | LOCATION | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 060 | East San Gabriel Valley 1 | 47/1 | 64/0 | 76/5 | 71/10 | 74/7 | 65/2 | 40/1 | 63/3 | 55/0 | 48/1 | 45/0 | 26/0 | 33/0 | 30/0 | 13/0 | 12/0 | 16/0 | 11/0 | 2/0 | 3/0 | 1/0 | 0/0 | 1/0 | 0/0* | 0/0 | 0/0 |
| 069 | East San Fernando Valley | 43/1 | 11/0 | 30/0 | 26/2 | 30/1 | 18/0 | 12/0 | 34/0 | 5/0 | 17/0 | 14/0 | 6/0 | 4/0 | 5/0 | 1/0 | 4/0 | 8/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 |
| 072 | South Coastal Los Angeles County | 0/0 | 0/0 | 0/0 | 1/0 | 1/0 | 1/0 | 1/0 | 1/0 | 1/0 | 1/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0* | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 |
| 074 | West San Fernando Valley | 33/0 | 37/0 | 16/0 | 24/0 | 36/1 | 12/0 | 4/0 | 11/0 | 6/0 | 9/0 | 5/0 | 2/0 | 4/0 | 5/0 | 0/0 | 2/0 | 0/0 | 0/0 | 0/0 | 0/0 | 1/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 |
| 075 | Pomona/Walnut Valley 1 | 37/1 | 58/0 | 72/9 | 57/3 | 49/1 | 32/0 | 31/0 | 45/0 | 30/0 | 32/0 | 24/0 | 16/0 | 16/0 | 10/0 | 12/0 | 8/0 | 10/0 | 6/0 | 3/0 | 2/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 |
| 080 | Southeast Los Angeles County | 19/1 | 12/0 | 18/1* | 16/0 | 5/0 | 18/0 | 7/0 | 23/0 | 17/0 | 11/0 | 4/0 | 4/0 | 5/0 | 4/0 | 0/0 | 0/0 | 1/0 | 0/0 | -- | -- | -- | -- | -- | -- | -- | -- |
| 084 | South Central Los Angeles County | 2/0* | 0/0* | 0/0 | 6/0 | 0/0* | 1/0 | 2/0 | 3/0 | 4/0 | 1/0 | 1/0 | 1/0 | 1/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 |
| 085 | South San Gabriel Valley | 26/1* | 52/0 | 48/5 | 38/3 | 38/1 | 28/0 | 18/1 | 35/0 | 24/0 | 19/0 | 18/0 | 7/0 | 12/0 | 16/0 | 0/0 | 6/0 | 5/0 | 0/0 | 2/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 |
| 087 | Central Los Angeles | 11/0 | 3/0 | 16/0 | 14/0 | 10/0 | 8/0 | 7/1 | 12/0 | 8/0 | 9/0 | 8/0 | 2/0 | 2/0 | 1/0 | 2/0 | 0/0 | 1/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 |
| 088 | West San Gabriel Valley | 51/0 | 55/0 | 85/8 | 78/11 | 56/3 | 48/0 | 33/1 | 59/0 | 49/0 | 41/1 | 33/0 | 15/0 | 18/0 | 17/0 | 7/0 | 10/0 | 10/0 | 5/0 | 2/0 | 1/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 |
| 090 | Santa Clarita Valley | 38/0 | 59/0 | 45/0 | 59/0 | 46/2 | 37/0 | 17/0 | 19/0 | 18/0 | 15/0 | 15/0 | 2/0 | 28/0 | 11/0 | 6/0 | 8/0 | 4/0 | 3/0 | 6/0 | 1/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 |
| 091 | Northwest Coastal Los Angeles County | 4/0 | 0/0 | 10/0* | 7/0 | 3/0 | 3/0 | 3/0 | 6/0 | 5/0 | 4/0 | 1/0 | 1/0 | 2/0 | 1/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 |
| 094 | Southwest Coastal Los Angeles County | 1/0 | 0/0 | 2/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 1/0 | 0/0 | 0/0 | 1/0 | 1/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 |
| 108 | Pomona/Walnut Valley 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 3/0* | 2/0 | 0/0 | 0/0* | -- | -- | -- | -- | -- |
| 591 | East San Gabriel Valley 2 | -- | -- | -- | -- | 30/5* | 61/2 | 62/2 | 74/2 | 67/0* | 68/5 | 70/1 | 51/0 | 54/0 | 37/0 | 29/0 | 34/0 | 30/0 | 19/0 | 10/0 | 9/0 | 2/0 | 0/0 | 3/0 | 0/0 | 0/0 | 0/0 |
| 3176 | Central Orange County 1 | 4/0* | 0/0* | 13/0 | 5/0 | 6/0 | 5/0 | 7/0 | 10/0 | 5/0 | 11/0 | 1/0 | 3/0 | 3/0 | 4/0 | 0/0 | 2/0 | 1/0 | 0/0 | 1/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0* | 0/0 | 0/0* |
| 3177 | North Orange County | 15/0 | 8/0 | 24/1 | 21/1 | 14/0 | 15/0 | 12/0 | 15/0 | 15/0 | 13/0 | 8/0 | 6/0 | 3/0 | 5/0 | 4/0 | 1/0 | 1/0 | 0/0 | 2/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 |
| 3186 | Saddleback Valley | 3/0 | 2/0* | 10/0 | 6/0 | 3/0 | 5/0 | 3/0 | 10/0 | 3/0 | 7/0 | 1/0 | 1/0 | 2/0 | 2/0 | 0/0 | 1/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0* | -- |
| 3188 | Capistrano Valley | 2/0* | 1/0 | 2/0* | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0/0* | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3190 | Central Orange County 2 | 2/0 | 0/0* | 5/0 | 2/0 | 3/0 | 0/0 | 2/0 | 2/0 | 0/0 | 0/0 | 0/0 | 0/0 | 1/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | -- | -- | -- | -- | -- | -- | -- | -- |
| 3191 | North Orange County | 17/0 | 10/0 | 9/0 | 14/2 | 13/0 | 4/0* | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3195 | North Coastal Orange County | 0/0 | 0/0* | 3/0 | 1/0 | 0/0 | 1/0 | 0/0 | 2/0 | 1/0 | 1/0 | 0/0 | 0/0 | 0/0* | -- | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 |
| 4137 | Coachella Valley 1** | 3/0* | 5/0 | 3/0 | 3/0* | 4/0 | 0/0 | 0/0 | 0/0 | 1/0 | 2/0 | 0/0 | 0/0 | 1/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0* | 0/0 | 0/0 | 0/0 | 0/0 |
| 4141 | Hemet/San Jacinty Valley | 0/0 | 2/0 | 2/0* | -- | -- | -- | -- | -- | -- | 1/0 | 0/0 | 0/0 | 0/0 | 0/0 | 1/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0* | -- | -- | -- | -- | -- |
| 4144 | Metropolitan Riverside County | 46/2 | 66/1 | 62/2 | 55/0 | 67/4 | 34/0 | 26/0 | 42/1 | 29/0 | 35/1 | 19/0 | 20/0 | 16/0 | 18/0 | 15/0 | 17/0 | 6/0 | 5/0 | 2/0 | 3/0 | 1/0 | 0/0* | 1/0 | 0/0 | 0/0 | 0/0 |
| 4149 | Perris Valley | 13/0 | 39/0 | 38/0 | 26/0 | 20/0 | 18/0 | 10/0 | 13/0 | 6/0 | 8/0 | 3/0 | 1/0 | 1/0 | 4/0 | 0/0 | 5/0 | 1/0 | 3/0 | 0/0 | 1/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 |
| 4150 | Banning/San Gorgonio Pass | 20/0* | 13/0 | 22/0 | 22/0 | 13/0 | 7/0 | 3/0 | 12/0 | 5/0 | 8/0 | 1/0 | 3/0 | 7/0 | 6/0 | 4/0 | 1/0 | 0/0 | 0/0 | 1/0 | 0/0 | 0/0 | 0/0 | 0/0* | -- | -- | -- |
| 4155 | Norco/Corona | 26/0 | 31/1 | 34/2 | 24/0 | 32/0 | 24/1 | 15/1 | 29/1 | 19/0* | 20/1 | 12/0 | 9/0 | 7/0 | 3/0 | 0/0 | 7/0 | 1/0 | 0/0 | 0/0 | 0/0 | 0/0 | -- | -- | -- | -- | -- |
| 4157 | Coachella Valley 2** | 0/0* | 0/0 | 0/0 | 1/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 1/0 | -- | 0/0 | -- | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 |
| 4158 | Lake Elsinore | 1/0 | 10/0 | 7/0* | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0/0* | 4/0 | 0/0 | 1/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 |
| 4163 | Temecula Valley | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0/0 | 0/0 | 0/0* | 0/0 | 0/0* | 0/0* | -- | -- | -- | -- |
| 5175 | Northwest San Bernardino Valley | 61/1* | 85/2* | 68/2* | 59/2 | 73/4 | 62/1 | 0/0* | 59/1* | 41/0 | 39/0 | 38/0 | 23/0 | 25/1 | 19/0 | 12/0 | 14/0 | 15/0 | 7/0 | 7/0 | 6/0 | 2/0 | 0/0 | 1/0 | 0/0 | 0/0 | 0/0 |
| 5181 | Central San Bernardino Mountains | 11/0* | 63/0 | 73/0 | 80/3 | 54/0 | 49/1 | 29/0 | 48/0 | 49/0 | 41/0 | 34/0 | 22/0 | 38/0 | 30/0 | 16/0 | 15/0 | 22/0 | 5/0 | 12/0 | 6/0 | 4/0 | 1/0 | 10/0 | 0/0 | 0/0 | 0/0 |
| 5182 | East San Bernardino Valley 2 | 28/0 | 39/0 | 56/0 | 0/0* | 67/0 | 19/0* | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 5197 | Central San Bernardino Valley 1 | 69/1 | 98/6 | 98/11 | 95/9 | 84/6 | 73/1 | 34/0 | 56/0 | 45/0 | 48/0 | 42/0 | 28/0 | 23/0 | 28/0 | 20/0 | 16/0 | 19/0 | 5/0 | 9/0 | 2/0 | 1/0 | 0/0 | 1/0 | 0/0 | 0/0 | 0/0 |
| 5198 | Southwest San Bernardino Valley | 39/1 | 42/3 | 22/2* | -- | -- | -- | -- | -- | -- | 15/0 | 14/0 | 0/0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 5203 | Central San Bernardino Valley 2 | 51/0 | 70/1 | 72/1 | 62/0 | 72/2 | 58/1 | 38/0 | 49/0 | 36/0 | 30/0 | 41/0* | 27/0 | 31/0 | 22/0 | 8/0 | 9/0 | 17/0 | 4/0 | 7/0 | 4/0 | 2/0 | 1/0 | 1/0 | 0/0 | 0/0 | 0/0 |
| 5204 | East San Bernardino Valley 1 | 25/1 | 48/0 | 64/2 | 57/0 | 61/0 | 20/0 | 30/0 | 41/0 | 26/0 | 31/0 | 22/0 | 26/0 | 25/0 | 17/0 | 11/0 | 16/0 | 7/0 | 8/0 | 8/0 | 4/0 | 1/0 | 1/0 | 1/0 | 0/0 | 0/0 | 0/0* |

* Less than 12 full months of data.

** Salton Sea Air Basin.

# TABLE A-6

## Ozone - Annual Maximum 1-Hour, ppm 1955-2001

| LOCATION | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 087 Central Los Angeles | .68 | .47 | .53 | .61 | .61 | .41 | .45 | .50 | .50 | .46 | .58 | .50 | .36 | .46 | .30 | .33 | .24 | .25 | .52 | .25 | .25 | .34 | .21 |
| 060 East San Gabriel Valley 1 | - | - | .42 | .45 | .56 | .49 | .45 | .43 | .34 | .40 | .54 | .53 | .65 | .44 | .54 | .58 | .48 | .49 | .46 | .38 | .32 | .38 | .32 |
| 069 East San Fernando Valley | .30* | .33 | .43 | .39 | .47 | .33 | .33/ | .33 | .38 | .39 | .40 | .32 | .47 | .42 | .38 | .35 | .31 | .28 | .29 | .35 | .27 | .35 | .31 |
| 091 Northwest Coastal Los Angeles County | - | - | - | - | - | - | - | .40* | .40 | .32 | .39 | .29 | .36 | .44 | .30 | .24 | .26 | .19 | .39 | .19 | .19 | .28 | .18/ |
| 072 South Coastal Los Angeles County | - | - | - | .37 | .30 | .37 | .34 | .33/ | .28 | .27 | .34 | .27 | .21 | .33 | .22 | .18 | .27 | .17 | .20 | .27 | .14 | .16 | .15 |
| 074 West San Fernando Valley | - | - | - | - | - | - | - | - | - | - | .47 | .44 | .41 | .34 | .39 | .37 | .32 | .29 | .28 | .28 | .30 | .27 | .34 |
| 075 Pomona/Walnut Valley 1 | - | - | - | - | - | - | - | - | - | - | .44* | .44 | .43 | .49 | .45 | .48 | .35 | .37 | .32 | .31 | .33 | .36 | .32 |
| 076 Southwest Coastal Los Angeles County | - | - | - | - | - | - | - | - | - | - | .32 | .37 | .33 | .23 | .25 | .23 | .21 | .17 | .24 | .15 | .18 | .22 | .17 |
| 094 Southwest Coastal Los Angeles County | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 080 Southeast Los Angeles County | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .43* | .36 | .39 | .29 | .28 | .35 | .25 | .37 | .30 |
| 090 Santa Clarita Valley | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .20 | .41 | .30 | .29 | .36 | .26 | .30 | .33 | .33 |
| 088 West San Gabriel Valley | - | .46 | .36/ | .44* | .47 | .54 | .44 | .46 | .41 | .42 | .46 | .43 | .40/ | .48* | .52 | .51 | .53 | .38* | .45 | .34 | .32 | .34 | .32 |
| 084 South Central Los Angeles County 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .22* | .28 | .19 | .24 | .24 |
| 801 South Central Los Angeles County 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 085 South San Gabriel Valley | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .35 | .32 |
| 591 East San Gabriel Valley 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3176 Central Orange County 1 | - | - | - | - | - | - | - | - | .27 | .23 | .41 | .31 | .30 | .28 | .30 | .29 | .34 | .28 | .26 | .24 | .13* | .30 | .19 |
| 3177 North Orange County 1 | - | - | - | - | - | - | - | - | - | - | - | - | .23* | .26 | .43 | .30 | .34 | .32 | .30 | .44 | .28 | .30 | .25 |
| 3195 North Coastal Orange County | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .19 | .21 | .22 | .18 | .16 | .18 |
| 3186 Saddleback Valley 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .19 | .38 | .19 | .23 | .20 |
| 3812 Saddleback Valley 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3188 Capistrano Valley | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .20 | .25 | .18 | .20 | .22 |
| 3190 Central Orange County 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .14 | - | .27 | .21 | .26 | .18 |
| 3191 North Orange County 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .11 | .33 | .33 | .30 |
| 4137 Coachella Valley 1** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .31 | .25 | .25 | .24 | .21 | .22 | .21 |
| 4157 Coachella Valley 2** | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .26 | .20 | .17 | .18 | .20 | .16 | .19 |
| 4155 Norco/Corona | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .05* | .30 | .35 | .31 | .15* | .33 | .36 |
| 4141 Hemet/San Jacinto Valley | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .22 | .20 | .18 | .19 | .25 |
| 4144 Metropolitan Riverside County 1 | - | - | - | - | - | - | - | - | .28 | .40 | .29 | .31 | .40 | .34* | - | - | .45 | .40* | .31 | .32 | .35 | .36 | .35 |
| 4149 Perris Valley | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .27* | .26 | .27 | .22 | .28 |
| 4150 San Gorgonio Pass | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .37 | .19 | .26 | .32* | .24 | .27 | .28 | .27 |
| 4164 BanningAirport | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 4163 Temecula Valley | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .15 | .18 | .21 | .17 |
| 4158 Lake Elsinore | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .23* | .30 | .20 | .23 |
| 5203 Central San Bernardino Valley 2 | - | - | - | - | - | - | - | - | .28 | .32 | .32 | .31 | .33 | .28 | .27 | .36 | .26 | .34 | .34 | .27 | .38 | .32 | .37 |
| 5204 East San Bernardino Valley | - | - | - | - | - | - | - | - | - | - | - | - | .12* | .32 | .30 | .42 | .28 | .31 | .34 | .31 | .32 | .35 | .33 |
| 5171 Southwest San Bernardino Valley | - | - | - | - | - | - | - | - | - | - | - | .32* | .21 | .21 | .22 | .08* | - | - | .36 | .34 | .33 | .36 | .37 |
| 5175 Northwest San Bernardino Valley | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .48 | .51 | .39 | - | - |
| 5174 Northwest San Bernardino Valley (ARB) | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .51 | .44 | .41 | .38* | .38 |
| 5197 Central San Bernardino Valley 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .42* | .49 | .38 | .38 | .39 |
| 5177 Central San Bernardino Mountains 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .13* | .27 | .14* | .15 | .22 |
| 5181 Central San Bernardino Mountains 1 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .13* | .26* | .27 | .23 | .32 |
| District Maximum | .68 | .47 | .53 | .61 | .61 | .54 | .45 | .50 | .50 | .46 | .58 | .53 | .65 | .49 | .54 | .58 | .53 | .49 | .52 | .51 | .41 | .38 | .39 |

* Incomplete data. / Station location change

** Salton Sea Air Basin

## TABLE A-6 (continued)
Ozone - Annual Maximum 1-Hour, ppm 1955-2001

| LOCATION | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 087 Central Los Angeles | .30 | .31/ | .29 | .32 | .40 | .26 | .29 | .30 | .22 | .22 | .21 | .25 | .20 | .19 | .20 | .16 | .19 | .17 | .14 | .12 | .15 | .13 | .14 | .12 |
| 060 East San Gabriel Valley 1 | .40 | .45 | .41 | .35 | .36 | .39 | .31 | .36 | .31 | .30 | .30 | .33 | .23 | .28 | .27 | .24 | .25 | .21 | .20 | .16 | .20 | .14 | .17 | .19 |
| 069 East San Fernando Valley | .30 | .39 | .35 | .27 | .25 | .31 | .26 | .30 | .28 | .23 | .24 | .20 | .20 | .22 | .22 | .18 | .17 | .17 | .14 | .13 | .18 | .12 | .15 | .13 |
| 091 Northwest Coastal Los Angeles County | .24/ | .26 | .21 | .23 | .28 | .23 | .27/ | .27 | .20 | .28 | .24 | .25 | .16 | .18 | .17 | .18 | .16 | .14 | .14 | .11 | .13 | .12 | .10 | .10 |
| 072 South Coastal Los Angeles County | .19 | .21 | .20 | .23 | .22 | .30 | .27 | .23 | .18 | .17 | .16 | .16 | .12 | .11 | .15 | .14 | .16 | .11 | .11 | .10 | .12 | .13 | .12 | .09 |
| 074 West San Fernando Valley | .27 | .33 | .38 | .25 | .22 | .26 | .26 | .25 | .22 | .22 | .25 | .23 | .19 | .22 | .17 | .19 | .14 | .15 | .21 | .12 | .16 | .10 | .11 | .14 |
| 075 Pomona/Walnut Valley 1 | .41 | .35 | .37 | .33 | .31 | .34 | .31 | .33 | .27 | .29 | .29 | .25 | .24 | .24 | .26 | .21 | .24 | .22 | .19 | .16 | .18 | .14 | .15 | .14 |
| 076 Southwest Coastal Los Angeles County | .30 | .19 | .11 | .19 | .16 | .18 | .22 | .17/ | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 094 Southwest Coastal Los Angeles County | - | - | - | - | - | - | - | - | .19 | .20 | .22 | .19 | .10 | .11 | .15 | .13 | .11 | .12 | .13 | .11 | .09 | .15 | .10 | .10 |
| 080 Southeast Los Angeles County | .36 | .32 | .27 | .27 | .31 | .32 | .30 | .32 | .25 | .23 | .29 | .26 | .19 | .19 | .22 | .19 | - | - | - | - | - | - | - | - |
| 088 West San Gabriel Valley | .42 | .44 | .41 | .33 | .37/ | .34 | .30 | .37 | .26 | .28 | .29 | .27 | .26 | .23 | .27 | .22 | .26 | .21 | .17 | .14 | .17 | .12 | .16 | .16 |
| 090 Santa Clarita Valley | .32 | .32 | .36 | .29 | .26/ | .29 | .27 | .24 | .24 | .21 | .30 | .25 | .23 | .24 | .22 | .22 | .26 | .21 | .17 | .16 | .18 | .12 | .13/ | .18 |
| 084 South Central Los Angeles County 1 | .18 | .29 | .18 | .21 | .26 | .23 | .27 | .21 | .20 | .24 | .21 | .14 | .15 | .16 | .17 | .12 | .12 | .09 | .10 | .08 | .09 | .12 | .09 | .08 |
| 801 South Central Los Angeles County 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .13* | .11* | .12* | - |
| 085 South San Gabriel Valley | .43 | .39 | .39 | .35 | .39 | .33 | .27 | .31 | .24 | .28 | .30 | .26 | .19 | .26 | .26 | .19 | .22 | .18 | .14 | .13 | .18 | .12 | .14 | .13 |
| 591 East San Gabriel Valley 2 | - | - | .49 | .39 | .36 | .38 | .34 | .39 | .35 | .33 | .34 | .34 | .29 | .32 | .30 | .28 | .30 | .22 | .21 | .17 | .22 | .14 | .17 | .19 |
| 3176 Central Orange County 1 | .29 | .33 | .28 | .26 | .26 | .30 | .25 | .25 | .20 | .22 | .27 | .24 | .18 | .25 | .22 | .17 | .21 | .13 | .13 | .10 | .11 | .10* | .13 | .11 |
| 3177 North Orange County 1 | .35 | .38 | .31 | .27 | .32 | .27 | .32 | .34 | .25 | .24 | .29 | .26 | .21 | .21 | .21 | .19 | .25 | .16 | .15 | .13 | .18 | .12 | .14 | .11 |
| 3195 North Coastal Orange County | .22 | .21/ | .16 | .20 | .18 | .25 | .25 | .21 | .17 | .16 | .13 | - | .15 | .17 | .15 | .13 | .12 | .11 | .10 | .10 | .12 | .10 | .10 | .10 |
| 3186 Saddleback Valley 1 | .34 | .32 | .34 | .33 | .27 | .29 | .30 | .28 | .23 | .20 | .21 | .23 | .19 | .24 | .16 | .16 | .18 | .15 | .14 | .13 | .16 | .10 | .13 | - |
| 3812 Saddleback Valley 2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .15 | .13 |
| 3188 Capistrano Valley | .32 | - | - | - | - | - | - | .19 | - | - | - | .15* | - | - | - | - | - | - | - | - | - | - | - | - |
| 3190 Central Orange County 2 | .27 | .26 | .22 | .18 | .23 | .20 | .19 | .19 | .15 | .17 | .23 | .16 | .17 | .17 | .18 | .15 | - | - | - | - | - | - | - | - |
| 3191 North Orange County 2 | .27 | .39 | .33 | .23* | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 4137 Coachella Valley 1** | .20 | .24 | .21 | .19 | .19 | .19 | .20 | .24 | .18 | .17 | .20 | .19 | .17 | .18 | .15* | .17 | .17 | .16 | .16 | .16 | .17 | .13 | .12 | .14 |
| 4157 Coachella Valley 2 ** | .17 | .21 | .11 | .18 | .17 | .18 | .19 | .20 | - | .16 | - | .16 | .16 | .18 | .14 | .16 | .12 | .14 | .12 | .11 | .13 | .13 | .11 | .11 |
| 4155 Norco/Corona | .40 | .33/ | .34 | .37 | .35 | .35 | .30 | .35 | .27 | .24 | .25 | .23 | .17 | .22 | .23 | .16 | .17 | .19 | .16 | - | - | - | - | - |
| 4141 Hemet/San Jacinto Valley | .27 | - | - | - | - | - | .18* | .23 | .18 | .18 | .18 | .19 | .22 | .19 | .15 | .18 | .16 | .15 | .12 | - | - | - | - | - |
| 4144 Metropolitan Riverside County | .39 | .34 | .37 | .30 | .31 | .36 | .32 | .35 | .25 | .29 | .28 | .27 | .29 | .24 | .26 | .26 | .25 | .21 | .20 | .19 | .20 | .14 | .14 | .14 |
| 4149 Perris Valley | .32 | .25 | .29 | .24 | .28 | .26 | .22 | .29 | .22 | .20 | .23 | .21 | .19 | .20 | .21 | .20 | .18 | .20 | .18 | .14 | .15 | .11 | .16 | .15 |
| 4150 San Gorgonio Pass | .30 | .27 | .26 | .23 | .24 | .26 | .25 | .29 | .22 | .21 | .26 | .23 | .22 | .20 | .16 | .16 | .20 | .18 | .19 | .13 | .12/ | - | - | - |
| 4164 Banning Airport | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | .17 | .14 | .14 | .15 |
| 4163 Temecula Valley | .23 | - | - | - | - | - | - | - | - | - | - | - | - | .17* | .13 | .13 | .10* | .11 | .10 | .10* | - | - | - | - |
| 4158 Lake Elsinore | .30 | - | - | - | - | - | - | - | - | - | - | .24 | .19 | .20 | .17 | .19 | .19 | .19 | .15 | .16 | .17 | .14 | .13 | .15 |
| 5203 Central San Bernardino Valley 2 | .36 | .34 | .36 | .36/ | .30 | .32 | .30 | .27/ | .30 | .25 | .28 | .30 | .29 | .25 | .28 | .21 | .25 | .20 | .24 | .20 | .21 | .16 | .15 | .18 |
| 5204 East San Bernardino Valley | .39 | .34/ | .32 | .24 | .29 | .30 | .29 | .33/ | .29 | .24 | .29 | .27 | .30 | .25 | .27 | .27 | .23 | .24 | .22 | .20 | .22 | .15 | .15 | .17* |
| 5171 Southwest San Bernardino Valley | .36 | - | - | - | - | - | .32* | .32 | .25 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 5175 Northwest San Bernardino Valley | - | - | - | - | - | .36 | .32 | .33 | .29 | .28 | .35 | .32 | .29 | .27 | .28 | .24 | .25 | .24 | .22 | .19 | .21 | .15 | .18 | .17 |
| 5174 Northwest San Bernardino Valley (ARB) | .35 | .37 | .44 | .36 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 5197 Central San Bernardino Valley 1 | .42 | .42 | .42 | .35/ | .31 | .32 | .32 | .34 | .31 | .29 | .29 | .32 | .27 | .29 | .28 | .24 | .25 | .22 | .22 | .17 | .20 | .14 | .17 | .17 |
| 5177 Central San Bernardino Mountains 2 | .17 | - | - | - | - | - | - | .26 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 5181 Central San Bernardino Mountains 1 | .33 | .40 | .31 | .35 | .32 | .28 | .34 | .30 | .26 | .29 | .29 | .27 | .33 | .27 | .28 | .24 | .27 | .26 | .20 | .21 | .24 | .17 | .18 | .17 |
| District Maximum | .43 | .45 | .49 | .39 | .40 | .39 | .34 | .39 | .35 | .33 | .35 | .34 | .33 | .32 | .30 | .28 | .30 | .26 | .24 | .21 | .24 | .17 | .18 | .19 |

* Incomplete data. / Station location change

** Salton Sea Air Basin

# TABLE A-7

## Carbon Monoxide - Number of Days Maximum 8-Hour Average Exceeded the Federal Standard (≥ 9.5 ppm)

| STN# | LOCATION | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOS ANGELES COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 060 | East San Gabriel Valley | 1 | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 069 | East San Fernando Valley | 100 | 72 | 54 | 54 | 60 | 48 | 36 | 21 | 18 | 18 | 16 | 14 | 15 | 21 | 10 | 8 | 3 | 0 | 5 | 4 | 0* | 0 | 0 | 0 | 0 | 0 |
| 072 | South Coastal Los Angeles County | 52 | 41* | 31 | 20 | 8 | 3 | 4 | 8 | 1 | 5 | 4 | 0 | 1 | 2 | 0 | 0 | 0 | 0* | 0 | 0 | 0* | 0 | 0 | 0 | 0 | 0 |
| 074 | West San Fernando Valley | 52 | 45 | 47 | 28 | 28 | 30 | 26 | 17 | 8 | 10 | 12 | 2 | 4 | 13 | 12 | 9 | 1 | 0 | 4 | 2 | 0 | 1 | 0 | 0 | 1 | 0 |
| 075 | Pomona/Walnut Valley | 6 | 9 | 6 | 1 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 076 | Southwest Coastal Los Angeles County | 83 | 62 | 62 | 50 | 67 | 46 | 44 | 40 | 58 | 45 | a) | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | | |
| 080 | Southeast Los Angeles County | 41 | 33 | 28 | 18* | 19 | 10 | 10 | 6 | 0 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | -- | -- | -- | -- | -- | -- | | |
| 084 | South Central Los Angeles County 1 | 107 | 83 | 79 | 64 | 65 | 54 | 44 | 29 | 49 | 32 | 43 | 38 | 55 | 61 | 42 | 37 | 31 | 22 | 22 | 13 | 20 | 14 | 10 | 8 | 2 | 0 |
| 085 | South San Gabriel Valley | 24* | 41 | 39 | 26 | 19 | 6 | 4 | 5 | 0 | 4 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 087 | Central Los Angeles | 64 | 53 | 36 | 14 | 16 | 16 | 9 | 11 | 0 | 2 | 2 | 2 | 4 | 1* | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 088 | West San Gabriel Valley | 34 | 27 | 26 | 21 | 22 | 19 | 14 | 10 | 0 | 5 | 2 | 3 | 4 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 090 | Santa Clarita Valley | 0 | 2 | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 091 | Northwest Coastal Los Angeles County | 53 | 33 | 19* | 27 | 34 | 21 | 19 | 11 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 094 | Southwest Coastal Los Angeles County | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 16 | 15 | 25 | 24 | 10 | 7 | 7 | 3 | 5 | 0 | 5 | 1 | 0 | 0 | 0 | 0 |
| 801 | South Central Los Angeles County 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 8* | 6 | 1* | -- |
| ORANGE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3176 | Central Orange County | 60 | 30 | 21 | 31 | 44 | 17 | 1 | 4 | 4 | 3 | 1 | 0 | 5 | 6 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0* | 0 | 0* |
| 3177 | North Orange County | 70* | 50 | 17 | 18 | 19* | 10 | 10 | 8 | 1 | 6 | 2 | 3 | 3 | 7 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3186 | Saddleback Valley 1 | -- | -- | -- | -- | -- | 0* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0* | -- |
| 3195 | North Coastal Orange County | 55 | 15 | 7 | 16 | 6 | 5 | 2 | 1 | 1 | 5 | 3 | 0 | 2 | 6* | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0* | 0 |
| 3812 | Saddleback Valley 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0* | 0 |
| RIVERSIDE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4137 | Coachella Valley 1** | 0* | 0 | 0 | 0* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4144 | Metropolitan Riverside County 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0* | 0 | 0 | 0 | 0 |
| 4146 | Metropolitan Riverside County 2 | 1* | -- | -- | -- | -- | -- | -- | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0* | 0 | 0 |
| 4149 | Perris Valley | 0* | 0* | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4150 | San Gorgonio Pass | 0* | 0 | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4155 | Norco/Corona | 0 | 1* | 0* | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4157 | Coachella Valley 2** | 0* | 0* | 0 | 0* | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0* | -- |
| 4158 | Lake Elsinore | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0 | 0 |
| SAN BERNARDINO COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5175 | Northwest San Bernardino Valley | 0* | 0* | 0 | 0 | 0 | 0* | -- | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0* | -- | -- | -- | -- | -- | -- | -- | -- | 0 | 0 |
| 5181 | Central San Bernardino Mountains | 0* | 0* | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 5197 | Central San Bernardino Valley 1 | 0 | 0* | 1 | 1 | 0* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0* | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 5203 | Central San Bernardino Valley 2 | 0 | 2* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0* | 0* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0* | 0 | 0 | 0* | 0 |
| 5204 | East San Bernardino Valley 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

a) Station relocated in 1986.
* Incomplete data
** Salton Sea Air Basin

# TABLE A-8

## Carbon Monoxide - Number of Days Maximum 8-Hour Average Exceeded the Federal Alert Level (> 15 ppm)

| STN# | LOCATION | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOS ANGELES COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 060 | East San Gabriel Valley | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 069 | East San Fernando Valley | 30 | 12 | 6 | 3 | 12 | 11 | 9 | 4 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0* | 0 | 0 | 0 | 0 | 0 |
| 072 | South Coastal Los Angeles County | 0 | 1* | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0* | 0 | 0 | 0* | 0 | 0 | 0 | 0 | 0 |
| 074 | West San Fernando Valley | 13 | 12 | 8 | 3 | 9 | 13 | 4 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 075 | Pomona/Walnut Valley | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 076 | Southwest Coastal Los Angeles County | 28 | 14 | 9 | 8 | 18 | 7 | 3 | 7 | 7 | 9 | a) | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 080 | Southeast Los Angeles County | 0 | 0 | 1 | 0* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- |
| 084 | South Central Los Angeles County 1 | 37 | 21 | 17 | 12 | 25 | 10 | 7 | 7 | 7 | 10 | 7 | 7 | 14 | 13 | 4 | 3 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 085 | South San Gabriel Valley | 0* | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 087 | Central Los Angeles | 4 | 6 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 088 | West San Gabriel Valley | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 090 | Santa Clarita Valley | 0 | 0 | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 091 | Northwest Coastal Los Angeles County | 6 | 2 | 1* | 5 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 094 | Southwest Coastal Los Angeles County | -- | -- | -- | -- | -- | -- | -- | -- | -- | 3* | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 801 | South Central Los Angeles County 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0* | 0 | 0* | -- |
| ORANGE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3176 | Central Orange County | 5 | 3 | 1 | 0 | 11 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0* | 0 | 0* |
| 3177 | North Orange County | 38* | 7 | 0 | 0 | 0* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3186 | Saddleback Valley 1 | -- | -- | -- | -- | -- | 0* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0* | -- |
| 3195 | North Coastal Orange County | 15 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0* | 0 |
| 3812 | Saddleback Valley 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0* | 0 |
| RIVERSIDE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4137 | Coachella Valley 1** | 0* | 0 | 0 | 0* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0* | 0* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4144 | Metropolitan Riverside County 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0* | 0 | 0 | 0 | 0 |
| 4146 | Metropolitan Riverside County 2 | 0* | -- | -- | -- | -- | -- | -- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0* | 0 | 0 |
| 4149 | Perris Valley | 0* | 0* | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4150 | San Gorgonio Pass | 0* | 0 | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4155 | Norco/Corona | 0 | 0* | 0* | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4157 | Coachella Valley ** | 0* | 0* | 0* | 0* | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0* | -- |
| SAN BERNARDINO COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5175 | Northwest San Bernardino Valley | 0* | 0* | 0 | 0 | 0 | 0* | -- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0* | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 5181 | Central San Bernardino Mountains | 0* | 0* | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 5197 | Central San Bernardino Valley 1 | 0 | 0* | 0 | 0 | 0* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0* | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 5203 | Central San Bernardino Valley 2 | 0 | 0* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0* | 0* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0* | 0 | 0 | 0* | 0 |
| 5204 | East San Bernardino Valley 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | District Maximum | 38 | 21 | 17 | 12 | 25 | 13 | 9 | 7 | 7 | 10 | 7 | 7 | 14 | 13 | 4 | 3 | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |

a) Station relocated in 1986.
* Incomplete data.
** Salton Sea Air Basin

# TABLE A-9

## Carbon Monoxide
## Annual Maximum 8-Hour Average, ppm
## 1976-2001

| STN# | LOCATION | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOS ANGELES COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 060 | East San Gabriel Valley | 10.6 | 10.8 | 8.6 | 9.0 | 8.8 | 9.5 | 6.9 | 6.6 | 4.6 | 4.9 | 5.5 | 6.0 | 6.0 | 5.8 | 5.1 | 5.9 | 4.9 | 4.0 | 4.5 | 6.3 | 4.0 | 4.3 | 3.9 | 3.9 | 4.9 | 2.9 |
| 069 | East San Fernando Valley | 26.3 | 21.9 | 16.8 | 15.4 | 24.8 | 21.1 | 16.4 | 16.6 | 12.0 | 16.1 | 16.4 | 12.5 | 11.9 | 13.9 | 13.0 | 10.6 | 10.5 | 8.4 | 10.7 | 12.0 | 9.3 | 7.4 | 7.5 | 9.0 | 6.1 | 4.9 |
| 072 | South Coastal Los Angeles County | 14.6 | 17.3 | 16.8 | 12.1 | 12.9 | 11.3 | 11.6 | 12.1 | 10.3 | 15.7 | 10.3 | 9.4 | 10.3 | 10.1 | 9.1 | 9.3 | 8.1 | 6.9 | 8.9 | 6.6 | 6.9 | 6.7 | 6.6 | 5.4 | 5.8 | 4.7 |
| 074 | West San Fernando Valley | 20.9 | 20.5 | 24.3 | 19.5 | 19.5 | 21.6 | 19.4 | 16.0 | 11.0 | 14.1 | 15.7 | 12.1 | 13.1 | 12.5 | 14.9 | 13.5 | 9.9 | 9.0 | 10.8 | 10.3 | 8.5 | 9.8 | 9.3 | 7.6 | 9.8 | 6.0 |
| 075 | Pomona/Walnut Valley | 11.7 | 12.6 | 12.0 | 9.6 | 10.8 | 9.6 | 9.1 | 8.0 | 7.3 | 7.4 | 8.7 | 10.0 | 8.6 | 7.4 | 7.5 | 7.1 | 8.3 | 5.5 | 6.8 | 6.1 | 5.0 | 5.0 | 7.3 | 6.7 | 4.9 | 3.4 |
| 076 | Southwest Coastal Los Angeles County | 25.3 | 20.4 | 24.3 | 21.4 | 21.6 | 19.2 | 19.2 | 18.4 | 19.7 | 24.0 | a) | -- | -- | -- | -- | -- | -- | -- | -- | -- | | -- | -- | -- | -- | -- |
| 080 | Southeast Los Angeles County | 14.4 | 13.6 | 15.5 | 14.1 | 15.8 | 13.7 | 12.7 | 13.6 | 9.4 | 14.6 | 8.7 | 9.7 | 7.3 | 8.8 | 9.0 | 7.5 | 9.37 | 5.86 | 7.7 | -- | | -- | -- | -- | -- | -- |
| 084 | South Central Los Angeles County 1 | 23.3 | 27.4 | 21.1 | 23.4 | 25.8 | 25.3 | 21.3 | 20.9 | 18.9 | 27.7 | 19.7 | 19.6 | 27.5 | 21.8 | 16.8 | 17.4 | 18.75 | 14.63 | 18.10 | 13.86 | 17.3 | 17.0 | 13.4 | 11.0 | 10.0 | 7.7 |
| 085 | South San Gabriel Valley | 14.9 | 14.8 | 18.3 | 12.1 | 14.5 | 11.9 | 11.9 | 10.9 | 8.7 | 13.1 | 10.7 | 10.0 | 9.9 | 10.7 | 9.4 | 9.1 | 8.62 | 6.43 | 9.29 | 7.86 | 8.1 | 6.2 | 6.1 | 5.6 | 5.3 | 4.0 |
| 087 | Central Los Angeles | 17.0 | 21.3 | 15.4 | 15.7 | 14.0 | 14.9 | 11.9 | 13.1 | 9.1 | 9.9 | 11.6 | 10.9 | 11.4 | 9.8 | 9.9 | 9.0 | 9.50 | 6.75 | 8.43 | 8.37 | 8.4 | 7.9 | 6.1 | 6.3 | 6.0 | 4.6 |
| 088 | West San Gabriel Valley | 12.4 | 16.6 | 13.3 | 12.5 | 13.6 | 11.8 | 12.9 | 12.3 | 8.0 | 11.3 | 10.1 | 11.3 | 10.6 | 8.4 | 10.0 | 9.5 | 7.25 | 6.25 | 8.50 | 9.12 | 7.1 | 6.0 | 6.3 | 6.6 | 7.4 | 5.0 |
| 090 | Santa Clarita Valley | 6.8 | 10.8 | 5.8 | 6.4 | 4.5 | -- | -- | -- | -- | -- | -- | -- | -- | 5.4 | 4.6 | 5.1 | 3.71 | 3.86 | 3.86 | 4.12 | 3.9 | 6.8 | 3.4 | 3.6 | 4.9 | 3.1 |
| 091 | Northwest Coastal Los Angeles County | 17.3 | 16.1 | 15.5 | 19.3 | 16.3 | 14.8 | 14.6 | 12.9 | 11.6 | 10.7 | 8.6 | 7.5 | 8.6 | 8.0 | 8.0 | 6.1 | 5.87 | 5.43 | 6.00 | 5.62 | 4.5 | 4.4 | 4.5 | 3.8 | 4.3 | 3.0 |
| 094 | Southwest Coastal Los Angeles County | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 15.0 | 14.1 | 15.9 | 16.4 | 12.7 | 11.3 | 12.29 | 10.71 | 12.00 | 8.86 | 11.6 | 10.3 | 9.4 | 8.4 | 7.0 | 5.1 |
| 801 | South Central Los Angeles County 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 13.5 | 11.7 | 9.5 | -- |
| ORANGE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3176 | Central Orange County | 24.8 | 15.9 | 15.5 | 13.8 | 21.3 | 13.4 | 9.6 | 10.9 | 14.4 | 17.0 | 9.7 | 8.7 | 12.0 | 12.1 | 11.7 | 8.6 | 9.37 | 7.71 | 8.62 | 8.00 | 7.5 | 5.8 | 5.3 | 5.3 | 6.8 | 4.7 |
| 3177 | North Orange County | 24.0 | 21.6 | 13.5 | 13.0 | 13.8 | 13.0 | 11.9 | 11.7 | 9.6 | 14.0 | 10.3 | 10.6 | 9.9 | 10.7 | 9.6 | 8.0 | 9.14 | 6.00 | 8.75 | 6.62 | 6.9 | 6.0 | 6.1 | 5.3 | 6.1 | 4.7 |
| 3186 | Saddleback Valley 1 | -- | -- | -- | -- | -- | 7.0 | 5.3 | 5.7 | 6.1 | 7.7 | 4.9 | 6.3 | 5.1 | 5.1 | 5.6 | 4.8 | 7.25 | 4.13 | 5.37 | 4.00 | 4.0 | 3.6 | 3.1 | 2.5 | 2.3 | -- |
| 3195 | North Coastal Orange County | 20.6 | 12.4 | 12.8 | 15.9 | 13.9 | 11.7 | 10.4 | 10.6 | 9.6 | 13.3 | 10.4 | 8.4 | 11.6 | 12.7 | 10.7 | 8.1 | 9.14 | 7.33 | 7.86 | 6.57 | 7.3 | 5.8 | 7.0 | 6.4 | 6.3 | 4.6 |
| 3812 | Saddleback Valley 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 3.3 | 2.4 |
| RIVERSIDE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4137 | Coachella Valley 1** | 3.1 | 3.5 | 3.1 | 3.0 | 3.6 | 3.8 | 2.6 | 2.8 | 2.1 | 2.6 | 3.6 | 2.9 | 2.1 | 2.9 | 2.3 | 2.5 | 2.4 | 2.00 | 1.87 | 1.50 | 1.6 | 1.4 | 1.6 | 1.8 | 1.6 | 1.5 |
| 4144 | Metropolitan Riverside County 1 | 8.6 | 9.5 | 7.6 | 8.1 | 7.4 | 7.5 | 6.4 | 6.3 | 6.3 | 5.7 | 6.0 | 6.1 | 6.8 | 10.3 | 6.3 | 7.4 | 5.25 | 7.13 | 5.75 | 5.71 | 5.0 | 5.8 | 4.6 | 4.4 | 4.3 | 3.4 |
| 4146 | Metropolitan Riverside County 2 | 9.5 | -- | -- | -- | -- | -- | -- | 7.9 | 8.9 | 9.1 | 8.3 | 7.6 | 10.0 | 8.5 | 7.3 | 6.9 | 6.12 | 6.25 | 7.25 | 6.50 | 5.4 | 5.0 | 4.6 | 4.1 | 4.3 | 4.5 |
| 4149 | Perris Valley | 7.6 | 6.5 | 5.1 | 5.0 | 4.8 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4150 | San Gorgonio Pass | 4.6 | 4.8 | 3.1 | 5.0 | 2.1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4155 | Norco/Corona | 8.0 | 11.1 | 7.5 | 6.6 | 9.3 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4157 | Coachella Valley 2** | 7.1 | 6.0 | 6.5 | 4.8 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 2.1 | -- |
| 4158 | Lake Elsinore | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 2.0 | 2.0 |
| SAN BERNARDINO COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5175 | Northwest San Bernardino Valley | 6.8 | 5.4 | 6.4 | 6.3 | 9.0 | 6.6 | 1.9 | 12.5 | 5.6 | 6.3 | 6.6 | 5.1 | 5.0 | 5.4 | 6.6 | 4.6 | -- | -- | -- | -- | -- | -- | -- | -- | 2.6 | 1.8 |
| 5181 | Central San Bernardino Mountains | 5.6 | 5.9 | 6.8 | 6.3 | 4.1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 5197 | Central San Bernardino Valley 1 | 7.3 | 8.4 | 9.8 | 9.8 | 8.5 | 7.6 | 4.4 | 5.1 | 4.4 | 4.0 | 5.9 | 4.0 | 5.6 | 5.8 | 4.9 | 4.4 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 5203 | Central San Bernardino Valley 2 | 9.3 | 12.1 | 8.5 | 7.6 | 8.1 | 6.0 | 6.9 | 5.4 | 5.1 | 5.3 | 6.7 | 6.7 | 7.6 | 8.1 | 6.0 | 7.0 | 5.9 | 6.0 | 6.5 | 6.3 | 4.6 | 6.0 | 4.6 | 4.0 | 4.3 | 3.3 |
| 5204 | East San Bernardino Valley 1 | 9.1 | 8.4 | 6.4 | 6.8 | 4.4 | 4.9 | 3.0 | 3.0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | District Maximum | 26.3 | 27.4 | 24.3 | 23.4 | 25.8 | 25.3 | 21.3 | 20.9 | 19.7 | 27.7 | 19.7 | 19.6 | 27.5 | 21.8 | 16.8 | 17.4 | 18.8 | 14.6 | 18.1 | 13.9 | 17.3 | 17.0 | 13.5 | 11.7 | 10.0 | 7.7 |

a) Station relocated in 1986.

** Salton Sea Air Basin

# TABLE A-10

Suspended Particulates ($PM_{10}$)
Annual Arithmetic Mean, $\mu g/m^3$
1985-2001

| STN# | LOCATION | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOS ANGELES COUNTY: | | | | | | | | | | | | | | | | | | |
| 060 | East San Gabriel Valley 1 | 67 | 61 | 68 | 63 | 61 | 55 | 66 | 47 | 43 | 44 | 49 | 45 | 46 | 41 | 56 | 46 | 45 |
| 069 | East San Fernando Valley | 70 | 63 | 60 | 62 | 65 | 52 | 55 | 49 | 45 | 38 | 42 | 42 | 45 | 36 | 44 | 39 | 41 |
| 072 | South Coast Los Angeles County | 55 | 56 | 50 | 52 | 51 | 44 | 40 | 39 | 37 | 40 | 39 | 35 | 41 | 32 | 39 | 38 | 37 |
| 087 | Central Los Angeles | 70 | 59 | 57 | 58 | 61 | 53 | 57 | 48 | 47 | 45 | 43 | 41 | 43 | 37 | 45 | 40 | 44 |
| 090 | Santa Clarita Valley | -- | -- | -- | -- | 54 | 43 | 47 | 35 | 33 | 36 | 37 | 33 | 33 | 30 | 38 | 33 | 32 |
| 094 | Southwest Coastal Los Angeles County | -- | -- | -- | -- | 50 | 41 | 39 | 33 | 37 | 36 | 36 | 33 | 36 | 33 | 36 | 36 | 37 |
| 108 | Pomona/Walnut Valley | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 37 | 40 | -- | -- | -- | -- |
| ORANGE COUNTY: | | | | | | | | | | | | | | | | | | |
| 3176 | Central Orange County 1 | -- | -- | -- | -- | -- | 49 | 45 | 40 | 38 | 37 | 44 | 35 | 39 | 36 | 49 | 40 | 36 |
| 3186 | Saddleback Valley 1 | 47 | 37 | 40 | 38 | 42 | 43 | 37 | 34 | 34 | 33 | 38 | 30 | 35 | 31 | 37 | 29 | -- |
| 3190 | Central Orange County | 56 | 48 | 49 | 46 | 46 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3812 | Saddleback Valley 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 29 | 28 | 26 |
| RIVERSIDE COUNTY: | | | | | | | | | | | | | | | | | | |
| 4137 | Coachella Valley 1** | -- | -- | 33 | 29 | 45 | 35 | 43 | 30 | 27 | 28 | 27 | 29 | 26 | 26 | 29 | 24 | 27 |
| 4144 | Metropolitan Riverside County 1 | 96 | 86 | 90 | 95 | 94 | 78 | 76 | 63 | 72 | 66 | 69 | 61 | 65 | 56 | 72 | 60 | 63 |
| 4149 | Perris Valley | -- | -- | 49 | 59 | 61 | 59 | 49 | 45 | 50 | 45 | 47 | 40 | 45 | 38 | 50 | 41 | 41 |
| 4150 | San Gorgonio Pass | 51 | 41 | 44 | 42 | 47 | 35 | 38 | 34 | 33 | 35 | 30 | 34 | 38 | 28 | -- | -- | -- |
| 4155 | Norco/Corona | 45 | -- | -- | -- | -- | -- | -- | -- | 53 | 53 | 54 | 44 | 50 | 47 | 55 | 49 | -- |
| 4157 | Coachella Valley 2** | 68 | 50 | 51 | 48 | 90 | 79 | 69 | 43 | 46 | 49 | 52 | 51 | 49 | 48 | 53 | 52 | 50 |
| 4163 | Temecula Valley | -- | -- | -- | -- | -- | -- | 38 | 31 | 27 | 22 | -- | -- | -- | -- | -- | -- | -- |
| 4164 | Banning Airport | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 27 | 35 | 29 | 35 |
| SAN BERNARDINO COUNTY: | | | | | | | | | | | | | | | | | | |
| 5171 | Southwest San Bernardino Valley 1 | 74 | 76 | 70 | 78 | 79 | 72 | 68 | 79 | 58 | 50 | 54 | 51 | 51 | 47 | 55 | -- | -- |
| 5181 | Central San Bernardino Mountains | -- | -- | -- | -- | 39 | 37 | 39 | 33 | 31 | 26 | 20 | 24 | 24 | 25 | 27 | 24 | -- |
| 5197 | Central San Bernardino Valley 1 | 74 | 76 | 74 | 81 | 77 | 78 | 63 | 56 | 57 | 60 | 61 | 55 | 54 | 50 | 60 | 53 | 51 |
| 5203 | Central San Bernardino Valley 2 | -- | 85 | 70 | 80 | 81 | 65 | 61 | 57 | 56 | 54 | 57 | 53 | 51 | 46 | 57 | 50 | 52 |
| 5204 | East San Bernardino Valley | -- | -- | -- | -- | -- | -- | -- | -- | 45 | 47 | 48 | 46 | 43 | 41 | 47 | 46 | 47 |
| 5817 | Southwest San Bernardino Valley 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 66 | 50 | 52 |
| | District Maximum | 96 | 86 | 90 | 95 | 94 | 79 | 76 | 79 | 72 | 66 | 69 | 61 | 65 | 56 | 72 | 60 | 63 |

** Salton Sea Air Basin

# TABLE A-11

## Suspended Particulates ($PM_{10}$)
## Annual Geometric Mean, $\mu g/m^3$
## 1985-2001

| STN# | LOCATION | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOS ANGELES COUNTY: | | | | | | | | | | | | | | | | | | |
| 060 | East San Gabriel Valley 1 | 59 | 54 | 59 | 56 | 54 | 48 | 60 | 40 | 36 | 38 | 41 | 39 | 41 | 36 | 52 | 43 | 40 |
| 069 | East San Fernando Valley | 65 | 57 | 54 | 57 | 60 | 48 | 49 | 42 | 39 | 34 | 37 | 42 | 42 | 33 | 41 | 36 | 37 |
| 072 | South Coast Los Angeles County | 52 | 51 | 46 | 47 | 46 | 41 | 37 | 37 | 34 | 37 | 32 | 31 | 38 | 29 | 36 | 33 | 35 |
| 087 | Central Los Angeles | 66 | 54 | 51 | 53 | 56 | 48 | 51 | 44 | 43 | 41 | 36 | 37 | 39 | 34 | 42 | 37 | 40 |
| 090 | Santa Clarita Valley | -- | -- | -- | -- | 49 | 39 | 43 | 31 | 28 | 32 | 31 | 30 | 31 | 27 | 35 | 30 | 29 |
| 094 | Southwest Coastal Los Angeles County | -- | -- | -- | -- | 45 | 38 | 35 | 30 | 33 | 33 | 31 | 29 | 34 | 30 | 33 | 33 | 34 |
| 108 | Pomona/Walnut Valley | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 33 | 38 | -- | -- | -- | -- |
| ORANGE COUNTY: | | | | | | | | | | | | | | | | | | |
| 3176 | Central Orange County 1 | -- | -- | -- | -- | -- | 43 | 40 | 37 | 34 | 34 | 36 | 32 | 36 | 33 | 43 | 36 | 34 |
| 3186 | Saddleback Valley 1 | 43 | 34 | 36 | 35 | 38 | 40 | 34 | 32 | 30 | 30 | 32 | 27 | 33 | 28 | 34 | 27 | -- |
| 3190 | Central Orange County 2 | 52 | 44 | 42 | 40 | 42 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3812 | Saddleback Valley 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 28 | 26 | 24 |
| RIVERSIDE COUNTY: | | | | | | | | | | | | | | | | | | |
| 4137 | Coachella Valley 1** | -- | -- | 24 | 24 | 36 | 30 | 37 | 24 | 24 | 24 | 24 | 25 | 24 | 24 | 26 | 23 | 24 |
| 4144 | Metropolitan Riverside County 1 | 81 | 74 | 73 | 81 | 81 | 67 | 65 | 52 | 58 | 56 | 52 | 52 | 56 | 49 | 65 | 55 | 54 |
| 4149 | Perris Valley | -- | -- | 32 | 52 | 52 | 50 | 43 | 38 | 41 | 39 | 37 | 35 | 39 | 33 | 44 | 37 | 36 |
| 4150 | San Gorgonio Pass | 40 | 33 | 34 | 34 | 37 | 29 | 31 | 29 | 26 | 27 | 25 | 27 | 30 | 24 | -- | -- | -- |
| 4155 | Norco/Corona | -- | -- | -- | -- | -- | -- | -- | -- | 44 | 45 | 45 | 40 | 44 | 41 | 49 | 43 | 39 |
| 4157 | Coachella Valley 2** | 55 | 46 | 44 | 43 | 66 | 65 | 61 | 39 | 41 | 45 | 47 | 46 | 44 | 44 | 50 | 48 | 44 |
| 4163 | Temecula Valley | -- | -- | -- | -- | -- | -- | 36 | 28 | 24 | 19 | -- | -- | -- | -- | -- | -- | -- |
| 4164 | Banning Airport | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 24 | 30 | 25 | 27 |
| SAN BERNARDINO COUNTY: | | | | | | | | | | | | | | | | | | |
| 5171 | Southwest San Bernardino Valley 1 | 65 | 65 | 60 | 67 | 70 | 61 | 60 | 62 | 37 | 45 | 44 | 46 | 45 | 40 | 50 | -- | -- |
| 5181 | Central San Bernardino Mountains | -- | -- | -- | -- | 36 | 31 | 35 | 30 | 25 | 22 | 18 | 20 | 21 | 21 | 24 | 21 | -- |
| 5197 | Central San Bernardino Valley 1 | 63 | 63 | 58 | 67 | 68 | 63 | 58 | 49 | 46 | 53 | 51 | 48 | 48 | 43 | 54 | 47 | 44 |
| 5203 | Central San Bernardino Valley 2 | -- | 74 | 55 | 67 | 69 | 55 | 52 | 49 | 48 | 46 | 48 | 46 | 46 | 39 | 51 | 45 | 45 |
| 5204 | East San Bernardino Valley | -- | -- | -- | -- | -- | -- | -- | -- | 35 | 38 | 37 | 38 | 35 | 34 | 41 | 40 | 40 |
| 5817 | Southwest San Bernardino Valley 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 59 | 46 | 46 |
| | District Maximum | 81 | 74 | 73 | 81 | 81 | 67 | 65 | 62 | 58 | 56 | 52 | 52 | 56 | 49 | 65 | 55 | 54 |

** Salton Sea Air Basin

# TABLE A-12

Suspended Particulates ($PM_{10}$) - Percent of Sampling Days
Exceeding State Standard (50 µg/m$^3$)
And Federal Standard (150 µg/m$^3$),
1985-2001

| STN# | LOCATION | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOS ANGELES COUNTY: | | | | | | | | | | | | | | | | | | |
| 060 | East San Gabriel Valley 1 | 68/0 | 61/4 | 64/3 | 67/0 | 59/2 | 50/0 | 68/0 | 39/0 | 32/0 | 40/0 | 40/2 | 41/0 | 40/0 | 28/0 | 58/0 | 42/0 | 38/0 |
| 069 | East San Fernando Valley | 77/2 | 67/3 | 61/0 | 68/0 | 69/0 | 47/2 | 50/0 | 31/3 | 36/0 | 18/0 | 25/0 | 25/0 | 30/0 | 15/0 | 35/0 | 23/0 | 23/0 |
| 072 | South Coast Los Angeles County | 58/0 | 40/0 | 33/0 | 40/0 | 44/0 | 24/0 | 24/0 | 19/0 | 20/0 | 18/0 | 19/0 | 15/0 | 18/0 | 10/0 | 22/0 | 21/0 | 17/0 |
| 087 | Central Los Angeles | 85/0 | 66/2 | 62/2 | 57/0 | 57/0 | 52/2 | 54/2 | 36/0 | 43/0 | 33/0 | 23/0 | 18/0 | 25/0 | 17/0 | 33/0 | 25/0 | 33/0 |
| 090 | Santa Clarita Valley | -- | -- | -- | -- | 44/0 | 28/0 | 23/0 | 9/0 | 15/0 | 18/0 | 14/0 | 9/0 | 9/0 | 6/0 | 21/0 | 7/0 | 7/0 |
| 094 | Southwest Coastal Los Angeles County | -- | -- | -- | -- | 48/0 | 26/0 | 42/0 | 13/0 | 15/0 | 22/0 | 21/0 | 8/0 | 7/0 | 12/0 | 10/0 | 16/0 | 14/0 |
| 108 | Pomona/Walnut Valley | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 18/0 | 18/0 | -- | -- | -- | -- |
| ORANGE COUNTY: | | | | | | | | | | | | | | | | | | |
| 3176 | Central Orange County 1 | -- | -- | -- | -- | -- | 34/2 | 24/0 | 20/0 | 21/0 | 18/0 | 23/2 | 10/0 | 18/0 | 20/0 | 39/0 | 13/0 | 20/0 |
| 3186 | Saddleback Valley 1 | 37/0 | 8/0 | 25/0 | 18/0 | 33/0 | 29/0 | 15/0 | 8/0 | 12/0 | 12/0 | 18/0 | 7/0 | 7/0 | 10/0 | 10/0 | 3/0 | -- |
| 3190 | Central Orange County 2 | 57/0 | 33/0 | 36/2 | 26/0 | 38/0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3812 | Saddleback Valley 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 3/0 | 3/0 | 5/0 |
| RIVERSIDE COUNTY: | | | | | | | | | | | | | | | | | | |
| 4137 | Coachella Valley 1** | -- | -- | -- | 13/0 | 28/3 | 15/0 | 25/2 | 7/2 | 2/0 | 3/0 | 4/0 | 3/0 | 2/0 | 5/0 | 5/0 | 0/0 | 2/0 |
| 4144 | Metropolitan Riverside County 1 | 75/18 | 79/8 | 77/12 | 84/12 | 84/12 | 75/5 | 68/3 | 64/0 | 69/7 | 67/2 | 62/7 | 68/2 | 70/2 | 54/0 | 72/2 | 70/0 | 67/0 |
| 4149 | Perris Valley | -- | -- | 33/0 | 63/2 | 66/2 | 53/5 | 43/0 | 41/0 | 45/0 | 43/0 | 38/0 | 33/0 | 32/0 | 26/0 | 50/0 | 22/0 | 27/0 |
| 4150 | San Gorgonio Pass | 50/0 | 33/0 | 36/2 | 30/0 | 33/3 | 20/0 | 30/0 | 17/0 | 18/0 | 23/0 | 12/0 | 19/0 | 25/0 | 9/0 | -- | -- | -- |
| 4155 | Norco/Corona | -- | -- | -- | -- | -- | -- | -- | -- | 51/2 | 58/0 | 47/3 | 33/0 | 42/2 | 40/0 | 55/0 | 48/0 | 33/0 |
| 4157 | Coachella Valley 2** | 67/5 | 45/0 | 41/0 | 36/0 | 67/7 | 70/7 | 63/5 | 31/0 | 41/0 | 38/0 | 44/2 | 50/0 | 43/0 | 40/0 | 54/0 | 50/0 | 45/0 |
| 4163 | Temecula Valley | -- | -- | -- | -- | -- | -- | 21/0 | 4/0 | 3/0 | 0/0 | -- | -- | -- | -- | -- | -- | -- |
| 4164 | Banning Airport | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 4/0 | 12/0 | 8/0 | 13/2 |
| SAN BERNARDINO COUNTY: | | | | | | | | | | | | | | | | | | |
| 5171 | Southwest San Bernardino Valley 1 | 70/2 | 74/9 | 68/2 | 78/3 | 80/7 | 63/7 | 67/2 | 66/3 | 62/0 | 44/0 | 51/5 | 53/0 | 36/2 | 34/0 | 56/0 | -- | -- |
| 5181 | Central San Bernardino Mountains | -- | -- | -- | -- | 22/0 | 19/0 | 13/0 | 8/0 | 4/0 | 5/0 | 2/0 | 0/0 | 0/0 | 0/0 | 0/0 | 0/0 | -- |
| 5197 | Central San Bernardino Valley 1 | 60/7 | 68/7 | 63/5 | 77/7 | 77/3 | 73/5 | 65/0 | 59/0 | 57/0 | 63/0 | 57/3 | 57/0 | 48/0 | 47/0 | 61/0 | 52/0 | 57/0 |
| 5203 | Central San Bernardino Valley 2 | -- | 76/5 | 59/3 | 71/5 | 75/5 | 58/3 | 68/2 | 60/0 | 63/0 | 51/0 | 53/0 | 58/0 | 45/0 | 38/0 | 56/0 | 53/0 | 52/0 |
| 5204 | East San Bernardino Valley | -- | -- | -- | -- | -- | -- | -- | -- | 46/0 | 41/0 | 41/2 | 42/0 | 38/0 | 32/0 | 40/0 | 44/0 | 45/0 |
| 5817 | Southwest San Bernardino Valley 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 67/2 | 45/0 | 42/2 |

** Salton Sea Air Basin

# TABLE A-13

## Suspended Particulates ($PM_{10}$)

## Annual Maximum 24-Hour Average, $\mu g/m^3$

## 1985-2001

| STN# | LOCATION | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOS ANGELES COUNTY: | | | | | | | | | | | | | | | | | | |
| 060 | East San Gabriel Valley 1 | 149 | 183 | 188 | 127 | 172 | 127 | 137 | 107 | 101 | 127 | 157 | 100 | 116 | 87 | 103 | 94 | 106 |
| 069 | East San Fernando Valley | 165 | 211 | 147 | 138 | 133 | 161 | 133 | 222 | 93 | 114 | 135 | 110 | 92 | 75 | 82 | 74 | 86 |
| 072 | South Coast Los Angeles County | 106 | 136 | 113 | 149 | 119 | 119 | 92 | 67 | 86 | 97 | 146 | 113 | 87 | 69 | 79 | 105 | 91 |
| 087 | Central Los Angeles | 146 | 178 | 158 | 130 | 137 | 152 | 151 | 137 | 104 | 122 | 141 | 138 | 102 | 80 | 88 | 80 | 97 |
| 090 | Santa Clarita Valley | -- | -- | -- | -- | 100 | 93 | 81 | 84 | 75 | 66 | 87 | 91 | 67 | 60 | 75 | 64 | 62 |
| 094 | Southwest Coastal Los Angeles County | -- | -- | -- | -- | 133 | 127 | 79 | 67 | 91 | 81 | 136 | 107 | 79 | 66 | 69 | 74 | 75 |
| 108 | Pomona/Walnut Valley | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 103 | 67 | -- | -- | -- | -- |
| ORANGE COUNTY: | | | | | | | | | | | | | | | | | | |
| 3176 | Central Orange County 1 | -- | -- | -- | -- | -- | 158 | 146 | 88 | 92 | 106 | 172 | 101 | 91 | 81 | 122 | 126 | 93 |
| 3186 | Saddleback Valley 1 | 100 | 109 | 107 | 97 | 88 | 88 | 94 | 83 | 115 | 91 | 122 | 79 | 86 | 70 | 111 | 60 | -- |
| 3190 | Central Orange County 2 | 144 | 124 | 163 | 132 | 138 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3812 | Saddleback Valley 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 56 | 98 | 60 |
| RIVERSIDE COUNTY: | | | | | | | | | | | | | | | | | | |
| 4137 | Coachella Valley 1** | -- | -- | 121 | 77 | 292 | 83 | 197 | 175 | 58 | 55 | 68 | 130 | 63 | 72 | 104 | 44 | 53 |
| 4144 | Metropolitan Riverside County 1 | 208 | 294 | 219 | 252 | 252 | 207 | 179 | 126 | 231 | 161 | 219 | 162 | 163 | 116 | 153 | 139 | 136 |
| 4149 | Perris Valley | -- | -- | 187 | 164 | 187 | 250 | 113 | 115 | 131 | 112 | 145 | 87 | 139 | 98 | 112 | 87 | 86 |
| 4150 | San Gorgonio Pass | 135 | 135 | 163 | 113 | 194 | 89 | 87 | 89 | 87 | 96 | 138 | 122 | 227 | 76 | -- | -- | -- |
| 4155 | Norco/Corona | -- | -- | -- | -- | -- | -- | -- | -- | 164 | 139 | 177 | 94 | 158 | 93 | 136 | 129 | 109 |
| 4157 | Coachella Valley 2** | 358 | 111 | 115 | 115 | 712 | 520 | 340 | 117 | 125 | 97 | 199 | 117 | 144 | 114 | 119 | 114 | 149 |
| 4163 | Temecula Valley | -- | -- | -- | -- | -- | -- | 66 | 88 | 105 | 48 | -- | -- | -- | -- | -- | -- | -- |
| 4164 | Banning Airport | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 62 | 86 | 69 | 219 |
| SAN BERNARDINO COUNTY: | | | | | | | | | | | | | | | | | | |
| 5171 | Southwest San Bernardino Valley 1 | 157 | 272 | 182 | 192 | 254 | 185 | 158 | 649 | 138 | 138 | 167 | 129 | 208 | 92 | 112 | -- | -- |
| 5181 | Central San Bernardino Mountains | -- | -- | -- | -- | 87 | 88 | 105 | 62 | 73 | 67 | 53 | 45 | 47 | 45 | 47 | 49 | -- |
| 5197 | Central San Bernardino Valley 1 | 154 | 275 | 203 | 287 | 227 | 475 | 127 | 105 | 143 | 133 | 178 | 130 | 122 | 101 | 116 | 108 | 106 |
| 5203 | Central San Bernardino Valley 2 | -- | 285 | 211 | 289 | 271 | 235 | 163 | 136 | 139 | 147 | 148 | 136 | 108 | 114 | 134 | 108 | 106 |
| 5204 | East San Bernardino Valley | -- | -- | -- | -- | -- | -- | -- | -- | 109 | 138 | 172 | 128 | 103 | 97 | 92 | 109 | 102 |
| 5817 | Southwest San Bernardino Valley 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 124 | 166 |
| | District Maximum | 358 | 294 | 219 | 289 | 712 | 520 | 340 | 649 | 231 | 161 | 219 | 162 | 227 | 116 | 153 | 139 | 219 |

** Salton Sea Air Basin

# TABLE A-14

## Nitrogen Dioxide - Annual Average of All Hours, pphm, 1976-2001[a)]

## (To Be Compared to Federal Standard of 5.34 pphm, Annual Average of All Hours)

| STN# | LOCATION | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOS ANGELES COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 060 | East San Gabriel Valley 1 | 4.71 | 5.77 | 5.29 | 3.64 | 3.71 | 5.03 | 4.94 | 4.70 | 4.35 | 5.02 | 4.96 | 4.98 | 5.30 | 5.11 | 4.10 | 4.50 | 4.03 | 4.00 | 4.30 | 4.64 | 4.15 | 3.38 | 3.64 | 3.90 | 3.66 | 3.31 |
| 069 | East San Fernando Valley | 6.31 | 6.58 | 7.18 | 6.86 | 7.06 | 7.13 | 6.15 | 5.57 | 5.60 | 5.71 | 5.74 | 5.16 | 5.28 | 5.07 | 4.79 | 4.68 | 5.01 | 4.40 | 4.97 | 4.54 | 4.61 | 4.24 | 4.16 | 4.56 | 4.15 | 4.19 |
| 072 | South Coastal Los Angeles County | 6.50 | 6.34 | 5.81 | 6.04 | 4.87 | 5.38 | 5.12 | 4.56 | 4.98 | 4.99 | 5.29 | 4.32 | 4.75 | 4.28 | 3.93 | 4.11 | 3.89 | 3.57 | 3.46 | 3.67 | 3.42 | 3.33 | 3.39 | 3.42 | 3.13 | 3.08 |
| 074 | West San Fernando Valley | 4.88 | 5.19 | 4.59 | 5.29 | 4.99 | 4.90 | 4.50 | 4.41 | 3.89 | 3.85 | 2.77 | 3.19 | 3.78 | 3.90 | 3.40 | 3.99 | 3.17 | 3.06 | 3.39 | 3.17 | 3.07 | 2.60 | 2.66 | 2.87 | 2.85 | 2.66 |
| 075 | Pomona/Walnut Valley 1 | 5.98 | 6.30 | 6.20 | 5.18 | 5.03 | 5.06 | 5.50 | 5.20 | 5.16 | 5.41 | 5.58 | 5.47 | 5.61 | 5.71 | 5.55 | 5.50 | 5.07 | 4.99 | 4.80 | 4.56 | 4.26 | 4.33 | 4.33 | 5.03 | 4.35 | 3.71 |
| 076 | Southwest Coastal Los Angeles County | 6.36 | 6.08 | 5.49 | 5.75 | 5.79 | 5.90 | 5.27 | 4.44 | 4.61 | 4.32 | c) | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 080 | Southeast Los Angeles County | 6.36 | 6.49 | 6.13 | 6.04 | 5.10 | 5.48 | 5.35 | 5.16 | 4.48 | 4.79 | 5.04 | 4.86 | 4.98 | 4.44 | 4.28 | 3.94 | 3.76 | 3.76 | -- | -- | -- | -- | -- | -- | -- | -- |
| 084 | South Central Los Angeles County 1 | 4.67 | 5.70 | 4.68 | 5.39 | 5.00 | 5.74 | 4.96 | 4.62 | 5.45 | 5.23 | 5.28 | 4.29 | 4.78 | 4.59 | 4.08 | 4.37 | 4.55 | 4.09 | 4.99 | 4.63 | 4.12 | 4.28 | 3.93 | 4.28 | 3.86 | 3.69 |
| 085 | South San Gabriel Valley | 7.22 | 7.49 | 6.61 | 6.33 | 5.87 | 6.06 | 5.79 | 5.04 | 4.88 | 5.32 | 5.29 | 4.89 | 5.39 | 5.47 | 4.99 | 4.69 | 4.43 | 4.28 | 4.49 | 4.56 | 3.93 | 3.63 | 3.69 | 3.91 | 3.66 | 3.52 |
| 087 | Central Los Angeles | 6.40 | 7.73 | 6.64 | 5.82 | 6.10 | 6.68 | 6.02 | 5.88 | 5.67 | 5.99 | 6.12 | 5.37 | 6.13 | 5.53 | 4.67 | 4.93 | 4.04 | 3.32 | 4.76 | 4.50 | 4.36 | 4.30 | 3.98 | 3.91 | 4.04 | 3.78 |
| 088 | West San Gabriel Valley | 6.84 | 7.80 | 7.34 | 6.03 | 5.53 | 5.78 | 5.55 | 4.84 | 4.85 | 5.01 | 5.13 | 4.20 | 5.00 | 5.31 | 4.74 | 5.02 | 4.23 | 3.90 | 4.28 | 3.75 | 3.78 | 3.41 | 3.51 | 3.79 | 2.96 | 3.45 |
| 090 | Santa Clarita Valley | 2.39 | 3.10 | 3.18 | 2.18 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 3.16 | 3.24 | 2.76 | 2.89 | 3.27 | 3.05 | -- | -- | -- | 2.84 | 2.46 | 2.39 |
| 091 | Northwest Coastal Los Angeles County | 6.68 | 7.00 | 5.59 | 6.42 | 5.75 | 5.37 | 5.22 | 4.98 | 4.36 | 3.84 | 4.21 | 3.78 | 3.43 | 3.15 | 3.24 | 2.78 | 2.84 | 2.87 | 2.96 | 2.78 | 2.89 | 2.85 | 2.71 | 2.91 | 2.73 | 2.51 |
| 094 | Southwest Coastal Los Angeles County | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 4.20 | 3.53 | 3.58 | 3.74 | 3.39 | 2.98 | 3.20 | 3.00 | 3.22 | 3.05 | 2.85 | 2.80 | 2.95 | 2.95 | 2.75 | 2.50 |
| 108 | Pomona/Walnut Valley 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 4.58 | 4.53 | 3.82 | -- | -- | -- | -- | -- |
| 591 | East San Gabriel Valley 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 3.77 | 4.39 | 3.89 | 3.77 | 4.30 | 3.53 | 3.39 | 3.62 | 3.80 | 3.28 | 3.00 | 2.76 | 3.28 | 2.90 | 2.74 |
| 801 | South Central Los Angeles County 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 4.04 | 2.92 | -- |
| ORANGE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3176 | Central Orange County | 4.81 | 5.04 | 4.33 | 4.82 | 5.20 | 4.97 | 4.64 | 4.46 | 4.41 | 4.30 | 4.46 | 4.21 | 4.58 | 4.72 | 4.69 | 4.48 | 3.94 | 3.54 | 3.80 | 3.71 | 3.19 | 3.32 | 3.36 | 3.27 | 3.00 | |
| 3177 | North Orange County | 4.32 | 5.43 | 5.31 | 5.30 | 5.13 | 5.26 | 4.78 | 4.55 | 4.63 | 4.26 | 4.21 | 3.82 | 4.24 | 4.28 | 4.47 | 4.26 | 3.79 | 3.87 | 4.14 | 3.91 | 3.54 | 3.29 | 3.44 | 3.51 | 3.04 | |
| 3195 | North Coastal Orange County | 2.39 | 2.47 | 2.52 | 2.70 | 2.50 | 3.24 | 3.11 | 2.80 | 2.58 | 2.48 | 2.60 | 2.81 | 2.68 | 4.63 | 2.72 | 2.60 | 2.49 | 2.20 | 2.44 | 2.39 | 2.06 | 1.99 | 2.00 | 2.09 | 2.05 | |
| RIVERSIDE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4137 | Coachella Valley 1** | -- | -- | -- | 1.84 | 1.89 | 1.87 | 2.45 | 2.73 | 1.43 | 1.96 | 1.86 | 1.90 | 2.20 | 2.39 | 2.06 | 2.08 | 2.10 | 1.95 | 2.19 | 2.23 | 2.10 | 1.58 | 1.70 | 1.95 | 1.78 | 1.75 |
| 4144 | Metropolitan Riverside County | 3.17 | 4.19 | 3.13 | 3.25 | 3.42 | 3.63 | 3.36 | 3.44 | 3.54 | 3.53 | 3.16 | 2.69 | 3.68 | 3.64 | 3.36 | 3.51 | 3.04 | 2.98 | 3.20 | 3.06 | 2.94 | 2.62 | 2.25 | 2.25 | 2.36 | 2.47 |
| 4149 | Perris Valley | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 3.10 | 3.22 | 2.82 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4157 | Coachella Valley 2** | 1.99 | 1.75 | 1.52 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.99 | -- |
| 4158 | Lake Elsinore | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 2.12 | 2.08 | 1.82 | 1.65 | 1.74 | 2.00 | 1.75 | 1.85 |
| 4164 | Banning Airport | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 2.15 | 2.43 | 2.37 | 2.11 |
| SAN BERNARDINO COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5175 | Northwest San Bernardino Valley | 4.07 | 6.10 | 4.42 | 6.11 | 4.88 | 4.90 | -- | 4.20 | 4.05 | 3.98 | 4.23 | 4.72 | 4.72 | 4.48 | 4.11 | 4.28 | 3.96 | 4.21 | 4.15 | 4.64 | 3.87 | 3.41 | 3.59 | 3.98 | 3.80 | 3.84 |
| 5197 | Central San Bernardino Valley 1 | 3.53 | 3.40 | 4.25 | 3.39 | 3.90 | 4.24 | 3.68 | 3.36 | 3.78 | 3.73 | 4.18 | 3.83 | 3.69 | 3.63 | 3.43 | 3.77 | 3.44 | 3.72 | 4.03 | 4.24 | 3.86 | 3.65 | 3.62 | 3.88 | 3.64 | 3.58 |
| 5203 | Central San Bernardino Valley 2 | 2.15 | 2.67 | 2.57 | 3.16 | 4.79 | 4.86 | 4.33 | 3.60 | 4.00 | 3.79 | 4.37 | 4.30 | 4.21 | 4.09 | 3.93 | 3.55 | 3.56 | 3.76 | 4.11 | 4.04 | 3.84 | 3.53 | 3.39 | 3.58 | 3.25 | 3.03 |
| 5204 | East San Bernardino Valley | 2.17 | 2.78 | 2.45 | 1.83 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | District Maximum | 7.22 | 7.80 | 7.34 | 6.86 | 7.06 | 7.13 | 6.15 | 5.88 | 5.67 | 5.99 | 6.12 | 5.47 | 6.13 | 5.71 | 5.55 | 5.50 | 5.07 | 4.99 | 4.99 | 4.64 | 4.61 | 4.33 | 4.33 | 5.03 | 4.35 | 4.19 |

a) Data prior to 1980 have been multiplied by an adjustment factor of 0.877 to be made comparable to 1980-2001 data.

b) 1982 annual averages are based on the arithmetic mean of the monthly averages and may differ slightly from the annual average of all hours.

c) Station relocated in 1986.

**Salton Sea Air Basin.

# TABLE A-15

## Nitrogen Dioxide - Number of Days 1-Hour Average Exceeded the State Standard (> .25 ppm), 1976-2001

| STN# | LOCATION | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOS ANGELES COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 060 | East San Gabriel Valley 1 | 1 | 7 | 8 | 1 | 1 | 3 | 3 | 1 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 069 | East San Fernando Valley | 4 | 12 | 26 | 11 | 22 | 9 | 1 | 4 | 0 | 1 | 1 | 1 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 072 | South Coastal Los Angeles County | 25 | 14 | 4 | 7 | 4 | 10 | 3 | 3 | 5 | 3 | 1 | 1 | 1 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 074 | West San Fernando Valley | 1 | 5 | 5 | 3 | 2 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 075 | Pomona/Walnut Valley 1 | 5 | 7 | 4 | 2 | 1 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 076 | Southwest Coastal Los Angeles County | 6 | 16 | 6 | 6 | 2 | 8 | 3 | 3 | 1 | 0 | a) | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 080 | Southeast Los Angeles County | 7 | 13 | 8 | 6 | 4 | 10 | 4 | 4 | 2 | 3 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- |
| 084 | South Central Los Angeles County 1 | 3 | 4 | 0 | 4 | 1 | 5 | 0 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 085 | South San Gabriel Valley | 10 | 33 | 14 | 7 | 6 | 8 | 2 | 4 | 0 | 4 | 1 | 0 | 0 | 3 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 087 | Central Los Angeles | 16 | 42 | 15 | 8 | 15 | 16 | 8 | 4 | 0 | 2 | 6 | 4 | 6 | 1 | 3 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 088 | West San Gabriel Valley | 12 | 26 | 15 | 7 | 11 | 2 | 1 | 3 | 0 | 1 | 0 | 0 | 2 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 090 | Santa Clarita Valley | 0 | 0 | 0 | 1 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -- | -- | -- | 0 | 0 | 0 |
| 091 | Northwest Coastal Los Angeles County | 37 | 30 | 11 | 25 | 16 | 6 | 4 | 4 | 3 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 094 | Southwest Coastal Los Angeles County | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 108 | Pomona/Walnut Valley 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0 | 0 | 0 | -- | -- | -- | -- | -- |
| 591 | East San Gabriel Valley 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 801 | South Central Los Angeles County 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0 | 0 | -- |
| ORANGE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3176 | Central Orange County | 7 | 2 | 1 | 1 | 15 | 3 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3177 | North Orange County | 0 | 1 | 3 | 0 | 5 | 7 | 1 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3195 | North Coastal Orange County | 4 | 0 | 2 | 1 | 2 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| RIVERSIDE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4137 | Coachella Valley 1** | -- | -- | -- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4144 | Metropolitan Riverside County | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4149 | Perris Valley | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0 | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4157 | Coachella Valley 2** | 0 | 0 | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0 | -- |
| 4158 | Lake Elsinore | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4164 | Banning Airport | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 1 | 1 | 0 | 0 |
| SAN BERNARDINO COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5175 | Northwest San Bernardino Valley | 0 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5197 | Central San Bernardino Valley 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5203 | Central San Bernardino Valley 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5204 | East San Bernardino Valley | 0 | 0 | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | - | -- | -- | -- | -- | -- | -- |

a) Station relocated in 1986.

** Salton Sea Air Basin

# TABLE A-16

## Nitrogen Dioxide
## Annual Maximum 1-Hour, ppm[a)]
## 1976-2001

| STN# | LOCATION | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOS ANGELES COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 060 | East San Gabriel Valley 1 | .27 | .35 | .38 | .35 | .27 | .28 | .30 | .26 | .16 | .27 | .21 | .23 | .24 | .27 | .21 | .25 | .15 | .17 | .19 | .22 | .15 | .16 | .14 | .16 | .15 | .12 |
| 069 | East San Fernando Valley | .33 | .40 | .44 | .31 | .35 | .37 | .26 | .30 | .21 | .31 | .28 | .26 | .26 | .25 | .23 | .29 | .19 | .17 | .18 | .18 | .20 | .20 | .14 | .18 | .17 | .25 |
| 072 | South Coastal Los Angeles County | .38 | .38 | .35 | .41 | .31 | .37 | .30 | .37 | .35 | .35 | .26 | .26 | .28 | .27 | .27 | .28 | .18 | .20 | .20 | .21 | .17 | .20 | .16 | .15 | .14 | .13 |
| 074 | West San Fernando Valley | .26 | .35 | .46 | .27 | .32 | .24 | .24 | .23 | .21 | .21 | .22 | .15 | .20 | .18 | .19 | .17 | .17 | .15 | .17 | .14 | .16 | .20 | .14 | .12 | .11 | .09 |
| 075 | Pomona/Walnut Valley 1 | .28 | .31 | .32 | .30 | .27 | .31 | .32 | .21 | .20 | .23 | .25 | .22 | .20 | .26 | .21 | .22 | .18 | .20 | .17 | .18 | .18 | .15 | .15 | .16 | .14 | .13 |
| 076 | Southwest Coastal Los Angeles County | .34 | .38 | .34 | .33 | .38 | .42 | .34 | .32 | .27 | .24 | b) | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 080 | Southeast Los Angeles County | .46 | .61 | .44 | .32 | .47 | .38 | .30 | .32 | .29 | .31 | .28 | .25 | .22 | .29 | .23 | .22 | .21 | .20 | -- | -- | -- | -- | -- | -- | -- | -- |
| 084 | South Central Los Angeles County 1 | .34 | .29 | .23 | .32 | .29 | .32 | .24 | .27 | .27 | .31 | .26 | .26 | .31 | .34 | .26 | .26 | .25 | .23 | .20 | .21 | .25 | .20 | .16 | .18 | .14 | .15 |
| 085 | South San Gabriel Valley | .46 | .39 | .40 | .36 | .54 | .36 | .29 | .31 | .25 | .31 | .26 | .24 | .24 | .31 | .27 | .25 | .27 | .26 | .24 | .23 | .17 | .15 | .14 | .16 | .14 | .14 |
| 087 | Central Los Angeles | .46 | .53 | .37 | .41 | .44 | .45 | .41 | .33 | .23 | .27 | .33 | .42 | .54 | .28 | .28 | .38 | .30 | .21 | .22 | .24 | .25 | .20 | .17 | .21 | .16 | .14 |
| 088 | West San Gabriel Valley | .33 | .42 | .52 | .32 | .35 | .40 | .34 | .35 | .21 | .27 | .24 | .21 | .27 | .34 | .23 | .32 | .22 | .18 | .18 | .22 | .19 | .17 | .16 | .16 | .17 | .15 |
| 090 | Santa Clarita Valley | .11 | .29 | .18 | .25 | .10 | -- | -- | -- | -- | -- | -- | -- | -- | .13 | .15 | .17 | .11 | .13 | .12 | .16 | -- | -- | -- | .10 | .10 | .10 |
| 091 | Northwest Coastal Los Angeles County | .40 | .49 | .49 | .40 | .37 | .40 | .39 | .47 | .32 | .23 | .24 | .27 | .26 | .22 | .20 | .25 | .17 | .17 | .16 | .20 | .18 | .14 | .13 | .13 | .16 | .11 |
| 094 | Southwest Coastal Los Angeles County | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | .23 | .23 | .27 | .24 | .23 | .21 | .19 | .16 | .22 | .18 | .15 | .17 | .15 | .13 | .13 | .11 |
| 108 | Pomona/Walnut Valley 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 22 | .21 | .18 | -- | -- | -- | -- | -- |
| 591 | East San Gabriel Valley 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | .13 | .17 | .20 | .22 | .19 | .23 | .16 | .16 | .19 | .20 | .14 | .13 | .13 | .14 | .13 | .12 |
| 801 | South Central Los Angeles County 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | .16 | .11 | -- |
| ORANGE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3176 | Central Orange County | .40 | .25 | .26 | .29 | .43 | .30 | .20 | .24 | .24 | .28 | .21 | .22 | .28 | .28 | .21 | .20 | .21 | .20 | .19 | .18 | .15 | .10 | .13 | .12 | .13 | .12 |
| 3177 | North Orange County | .25 | .34 | .33 | .21 | .42 | .36 | .28 | .33 | .25 | .30 | .20 | .22 | .24 | .23 | .22 | .20 | .17 | .18 | .23 | .20 | .16. | .15 | .13 | .16 | .12 | .13 |
| 3195 | North Coastal Orange County | .30 | .20 | .26 | .25 | .31 | .29 | .23 | .27 | .22 | .24 | .20 | .19 | .26 | .22 | .22 | .16 | .15 | .14 | .16 | .18 | .14 | .12 | .12 | .12 | .11 | .08 |
| RIVERSIDE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4137 | Coachella Valley 1** | -- | -- | -- | .09 | .13 | .09 | .15 | .16 | .09 | .08 | .08 | .08 | .11 | .09 | .09 | .09 | .09 | .15 | .08 | .09 | .08 | .07 | .07 | .07 | .07 | .08 |
| 4144 | Metropolitan Riverside County | .20 | .24 | .19 | .18 | .20 | .32 | .16 | .19 | .17 | .16 | .16 | .21 | .19 | .16 | .16 | .16 | .23 | .14 | .18 | .15 | .11 | .12 | .10 | .13 | .10 | .15 |
| 4149 | Perris Valley | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | .14 | .14 | .11 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4157 | Coachella Valley 2** | .08 | .13 | .11 | .08 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | .06 | -- |
| 4158 | Lake Elsinore | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | .11 | .21 | .10 | .11 | .09 | .11 | .08 | .09 |
| 4164 | Banning Airport | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | .26 | .31 | .21 | .24 |
| SAN BERNARDINO COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5175 | Northwest San Bernardino Valley | .11 | .26 | .24 | .26 | .35 | .19 | .20 | .25 | .15 | .18 | .24 | .20 | .21 | .20 | .19 | .21 | .14 | .16 | .17 | .20 | .15 | .15 | .14 | .13 | .15 | .13 |
| 5197 | Central San Bernardino Valley 1 | .26 | .20 | .26 | .16 | .25 | .19 | .18 | .16 | .16 | .14 | .18 | .18 | .21 | .18 | .20 | .19 | .14 | .16 | .18 | .17 | .17 | .14 | .15 | .15 | .12 | .13 |
| 5203 | Central San Bernardino Valley 2 | .11 | .17 | .12 | .20 | .25 | .20 | .19 | .19 | .20 | .15 | .18 | .19 | .19 | .18 | .20 | .16 | .13 | .15 | .16 | .16 | .15 | .14 | .11 | .14 | .10 | .11 |
| 5204 | East San Bernardino Valley | .22 | .21 | .18 | .17 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | District Maximum | .46 | .61 | .52 | .41 | .54 | .45 | .41 | .47 | .35 | .35 | .33 | .42 | .54 | .34 | .28 | .38 | .30 | .26 | .22 | .24 | .25 | .20 | .26 | .31 | .21 | .25 |

a) Data prior to 1980 have been multiplied by an adjustment factor of 0.877 to be made comparable to 1980-2001 data.

b) Station relocated in 1986.

** Salton Sea Air Basin

# TABLE A-17

## Sulfur Dioxide - Annual Average, pphm

## 1976-2001

| STN# | LOCATION | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOS ANGELES COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 060 | East San Gabriel Valley 1 | 1.02 | 1.03 | 0.75 | 0.71 | 0.62 | 0.32 | 0.31 | 0.21 | 0.23 | 0.29 | 0.30 | 0.24 | 0.22 | 0.17 | 0.11 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 069 | East San Fernando Valley | 0.81 | 1.37 | 1.07 | 1.04 | 0.67 | 0.52 | 0.58 | 0.47 | 0.52 | 0.51 | 0.34 | 0.30 | 0.22 | 0.20 | 0.18 | 0.09 | 0.10 | 0.12 | 0.07 | 0.01 | 0.04 | 0.03 | 0.02 | 0.01 | 0.01 | 0.07 |
| 072 | South Coastal Los Angeles County | 1.51 | 1.45 | 1.33 | 0.90 | 1.08 | 0.95 | 1.07 | 0.89 | 0.98 | 0.81 | 0.84 | 0.58 | 0.68 | 0.46 | 0.31 | 0.43 | 0.37 | 0.36 | 0.31 | 0.23 | 0.25 | 0.24 | 0.18 | 0.27 | 0.15 | 0.22 |
| 074 | West San Fernando Valley | 0.77 | 0.95 | 0.47 | 0.33 | 0.48 | 0.44 | 0.45 | 0.43 | 0.41 | 0.25 | 0.33 | 0.26 | 0.17 | 0.18 | 0.15 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 075 | Pomona/Walnut Valley 1 | 1.02 | 1.41 | 1.16 | 0.60 | 0.41 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 076 | Southwest Coastal Los Angeles County | 1.70 | 1.78 | 0.64 | 0.81 | 1.14 | 1.05 | 1.06 | 0.95 | 1.04 | 0.74 | a) | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 080 | Southeast Los Angeles County | 1.88 | 1.73 | 1.30 | 2.33 | 0.99 | 0.70 | 0.80 | 0.58 | 0.60 | 0.43 | 0.43 | 0.42 | 0.55 | 0.36 | 0.16 | 0.16 | 0.08 | 0.07 | -- | -- | -- | -- | -- | -- | -- | -- |
| 084 | South Central Los Angeles County 1 | 1.22 | 1.04 | 0.84 | 0.64 | 0.82 | 0.91 | 0.70 | 0.66 | 0.84 | 0.70 | 0.51 | 0.59 | 0.69 | 0.42 | 0.33 | 0.30 | 0.31 | 0.23 | 0.26 | 0.30 | -- | -- | -- | -- | -- | -- |
| 085 | South San Gabriel Valley | 0.77 | 0.80 | 0.63 | 0.76 | 0.55 | 0.55 | 0.54 | 0.56 | 0.70 | 0.50 | 0.34 | 0.36 | 0.48 | 0.45 | 0.43 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 087 | Central Los Angeles | 1.94 | 2.01 | 1.74 | 1.16 | 1.28 | 0.71 | 0.79 | 0.61 | 0.85 | 0.53 | 0.42 | 0.43 | 0.41 | 0.22 | 0.17 | 0.17 | 0.15 | 0.03 | 0.07 | 0.10 | 0.15 | 0.07 | 0.08 | 0.23 | 0.09 | 0.28 |
| 088 | West San Gabriel Valley | 1.52 | 1.53 | 1.48 | 1.05 | 0.61 | 0.38 | 0.47 | 0.35 | 0.33 | 0.25 | 0.19 | 0.28 | 0.23 | 0.22 | 0.15 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 090 | Santa Clarita Valley | 1.12 | 1.11 | 0.93 | 0.90 | 0.49 | -- | -- | -- | -- | -- | -- | -- | -- | 0.09 | 0.09 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 091 | Northwest Coastal Los Angeles County | 0.79 | 0.87 | 1.12 | 0.88 | 0.66 | 0.40 | 0.28 | 0.23 | 0.27 | 0.32 | 0.33 | 0.28 | 0.22 | 0.24 | 0.21 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 094 | Southwest Coastal Los Angeles County | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.50 | 0.38 | 0.48 | 0.47 | 0.35 | 0.40 | 0.57 | 0.31 | 0.22 | 0.27 | 0.25 | 0.14 | 0.39 | 0.40 | 0.17 | 0.41 |
| ORANGE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3176 | Central Orange County 1 | 0.67 | 0.62 | 0.45 | 0.63 | 0.67 | 0.41 | 0.56 | 0.50 | 060 | 0.32 | 0.32 | 0.30 | 0.41 | 0.31 | 0.18 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3177 | North Orange County | 0.61 | 0.75 | 0.73 | 0.6 | 0.8 | 0.53 | 0.51 | 0.55 | 0.6 | 0.51 | 0.5 | 0.49 | 0.38 | 0.21 | 0.11 | 0.12 | 0.06 | 0.06 | 0.09 | 0.09 | -- | -- | -- | -- | -- | -- |
| 3186 | Saddleback Valley | 0.12 | 0.14 | 0.14 | 0.18 | 0.06 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3190 | Central Orange County 2 | 0.96 | 0.88 | 0.66 | 0.76 | 0.90 | 0.46 | 0.45 | 0.36 | 0.40 | 0.30 | 0.27 | 0.30 | 0.29 | 0.27 | 0.19 | 0.11 | 0.11 | 0.08 | -- | -- | -- | -- | -- | -- | -- | -- |
| 3195 | North Coastal Orange County | 0.63 | 0.59 | 0.42 | 0.42 | 0.54 | 0.34 | 0.35 | 0.25 | 0.29 | 0.28 | 0.15 | 0.20 | 0.18 | 0.15 | 0.07 | 0.07 | 0.06 | 0.05 | 0.07 | 0.07 | 0.01 | 0.03 | 0.04 | 0.07 | 0.05 | 0.15 |
| RIVERSIDE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4137 | Coachella Valley 1** | -- | -- | -- | 0.65 | 0.54 | 0.07 | 0.01 | 0.07 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4144 | Metropolitan Riverside County | 0.50 | 1.00 | 0.89 | 0.93 | 0.40 | 0.13 | 0.17 | 0.14 | 0.00 | 0.14 | 0.07 | 0.22 | 0.14 | 0.07 | 0.03 | 0.02 | 0.02 | 0.03 | 0.02 | 0.01 | 0.01 | 0.03 | 0.11 | 0.14 | 0.08 | 0.09 |
| 4157 | Coachella Valley 2** | -- | 0.01 | 0.74 | 0.44 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SAN BERNARDINO COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5175 | Northwest San Bernardino Valley | -- | -- | 0.75 | 0.85 | 0.49 | 0.51 | 0.65 | 0.25 | 0.16 | 0.08 | 0.07 | 0.14 | 0.17 | 0.14 | 0.12 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 5197 | Central San Bernardino Valley 1 | 2.71 | 2.60 | 0.98 | 0.85 | 0.53 | 0.47 | 0.51 | 0.21 | 0.11 | 0.10 | 0.14 | 0.18 | 0.16 | 0.05 | 0.01 | 0.05 | 0.12 | 0.00 | 0.02 | 0.06 | 0.01 | 0.00 | 0.07 | 0.18 | 0.18 | 0.21 |
| 5203 | Central San Bernardino Valley 2 | 0.82 | 1.50 | 1.15 | 1.00 | 0.21 | 0.09 | 0.15 | 0.10 | 0.21 | 0.17 | 0.34 | 0.26 | 0.18 | 0.06 | 0.01 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | District Maximum | 2.71 | 2.60 | 1.74 | 2.33 | 1.28 | 1.05 | 1.07 | 0.95 | 1.04 | 0.81 | 0.84 | 0.59 | 0.69 | 0.47 | 0.43 | 0.43 | 0.57 | 0.36 | 0.31 | 0.30 | 0.25 | 0.24 | 0.39 | 0.40 | 0.18 | 0.41 |

a) Station relocated in 1986.

** Salton Sea Air Basin

# TABLE A-18
## Sulfur Dioxide
## Annual Maximum 1-Hour Average, ppm
## 1976-2001

| STN# | LOCATION | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOS ANGELES COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 60 | East San Gabriel Valley | .10 | .06 | .05 | .06 | .05 | .04 | .06 | .03 | .04 | .02 | .03 | .03 | .03 | .02 | .03 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 69 | East San Fernando Valley | .09 | .10 | .06 | .06 | .04 | .04 | .09 | .04 | .05 | .04 | .02 | .03 | .02 | .03 | .02 | .01 | .03 | .02 | .03 | .01 | .01 | .04 | .01 | .01 | .01 | .01 |
| 72 | South Coastal Los Angeles County | .13 | .13 | .19 | .13 | .10 | .14 | .09 | .12 | .32 | .08 | .07 | .06 | .05 | .11 | .05 | .14 | .11 | .05 | .04 | .14 | .04 | .04 | .08 | .05 | .05 | .05 |
| 74 | West San Fernando Valley | .04 | .06 | .05 | .03 | .03 | .03 | .03 | .03 | .03 | .02 | .02 | .02 | .02 | .02 | .02 | - | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 75 | Pomona/Walnut Valley | .06 | .08 | .06 | .05 | .03 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 76 | Southwest Coastal Los Angeles County | .18 | .30 | .09 | .10 | .08 | .07 | .08 | .09 | .06 | .06 | a) | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 80 | Southeast Los Angeles County | .15 | .18 | .10 | .14 | .16 | .09 | .09 | .09 | .06 | .05 | .06 | .07 | .10 | .04 | .04 | .07 | .03 | .03 | -- | -- | -- | -- | -- | -- | -- | -- |
| 84 | South Central Los Angeles County | .09 | .12 | .13 | .09 | .08 | .09 | .06 | .06 | .07 | .06 | .13 | .06 | .06 | .04 | .04 | .05 | .06 | .03 | .02 | .03 | -- | -- | -- | -- | -- | -- |
| 85 | South San Gabriel Valley | .05 | .08 | .05 | .10 | .07 | .05 | .05 | .08 | .09 | .07 | .03 | .09 | .05 | .04 | .04 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 87 | Central Los Angeles | .12 | .09 | .09 | .05 | .06 | .05 | .05 | .07 | .07 | .04 | .03 | .03 | .04 | .03 | .02 | .02 | .05 | .01 | .02 | .01 | .01 | .02 | .14 | .05 | .08 | .03 |
| 88 | West San Gabriel Valley | .06 | .07 | .06 | .06 | .05 | .04 | .04 | .05 | .03 | .03 | .02 | .02 | .03 | .02 | .02 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 90 | Santa Clarita Valley | .10 | .04 | .05 | .05 | .03 | -- | -- | -- | -- | -- | -- | -- | -- | .02 | .01 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 91 | Northwest Coastal Los Angeles County | .07 | .05 | .08 | .04 | .04 | .04 | .03 | .06 | .05 | .03 | .02 | .03 | .03 | .02 | .02 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 94 | Southwest Coastal Los Angeles County | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | .09 | .03 | .15 | .09 | .31 | .12 | .15 | .07 | .04 | .06 | .06 | .10 | .03 | .09 | .17 | .04 |
| ORANGE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3176 | Central Orange County 1 | .11 | .09 | .07 | .07 | .08 | .04 | .04 | .05 | .08 | .03 | .03 | .09 | .06 | .03 | .02 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3177 | North Orange County | .11 | .12 | .10 | .09 | .09 | .04 | .04 | .05 | .04 | .05 | .06 | .05 | .05 | .03 | .03 | .04 | .02 | .02 | .02 | .02 | -- | -- | -- | -- | -- | -- |
| 3186 | Saddleback Valley | .05 | .07 | .10 | .09 | .06 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3190 | Central Orange County 2 | .25 | .14 | .16 | .11 | .14 | .06 | .08 | .05 | .06 | .02 | .03 | .04 | .04 | .07 | .03 | .03 | .10 | .02 | -- | -- | -- | -- | -- | -- | -- | -- |
| 3195 | North Coastal Orange County | .13 | .10 | .07 | .07 | .06 | .08 | .06 | .04 | .04 | .05 | .02 | .03 | .03 | .03 | .02 | .04 | .02 | .01 | .02 | .02 | .01 | .03 | .02 | .02 | .02 | .01 |
| RIVERSIDE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4137 | Coachella Valley 1** | -- | -- | -- | .03 | .03 | .01 | .01 | .01 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4144 | Metropolitan Riverside County | .08 | .12 | .08 | .08 | .07 | .02 | .02 | .02 | .02 | .02 | .02 | .04 | .02 | .02 | .03 | .02 | .02 | .02 | .02 | .01 | .01 | .04 | .03 | .03 | .11 | .02 |
| 4157 | Coachella Valley 2** | -- | .02 | .04 | .04 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SAN BERNARDINO COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5175 | Northwest San Bernardino Valley | -- | -- | .10 | .08 | .07 | .04 | .05 | .03 | .02 | .02 | .01 | .03 | .03 | .03 | .01 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 5197 | Central San Bernardino Valley 1 | .25 | .40 | .12 | .14 | .11 | .11 | .14 | .06 | .03 | .02 | .02 | .03 | .04 | .03 | .01 | .05 | .02 | .01 | .03 | .02 | .01 | .01 | .02 | .01 | .02 | .01 |
| 5203 | Central San Bernardino Valley 2 | .07 | .35 | .09 | .08 | .03 | .02 | .02 | .02 | .03 | .02 | .05 | .07 | .02 | .03 | .01 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | District Maximum | .25 | .40 | .19 | .14 | .16 | .14 | .14 | .12 | .32 | .08 | .13 | .09 | .15 | .11 | .31 | .14 | .15 | .07 | .04 | .14 | .06 | .10 | .14 | .09 | .17 | .05 |

a) Station relocated in 1986.

** Salton Sea Air Basin

# TABLE A-19

## Sulfate - Percent of Sampling Days Exceeding the State Standard

## (≥ 25 µg/m³, 24-hour Average)

## 1976-2001[a)]

| STN# | LOCATION | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOS ANGELES COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 60 | East San Gabriel Valley | 5 | 11 | 8 | 0 | 6 | 0 | 2 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 69 | East San Fernando Valley | -- | -- | -- | -- | -- | -- | -- | -- | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | -- | -- | -- | -- | -- | -- |
| 72 | South Coastal Los Angeles County | -- | -- | -- | -- | 10 | 2 | 2 | 2 | 0 | 2 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 |
| 74 | West San Fernando Valley | 2 | 5 | 7 | 0 | 5 | 0 | 5 | 0 | 0 | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 75 | Pomona/Walnut Valley | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 76 | Southwest Coastal Los Angeles County | 11 | 14 | 6 | 5 | 11 | 2 | 3 | 0 | 2 | 0 | b) | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 80 | Southeast Los Angeles County | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 84 | South Central Los Angeles County | 5 | 13 | 7 | 8 | 12 | 0 | 3 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 85 | South San Gabriel Valley | -- | 13 | 8 | 5 | 12 | 2 | 3 | 2 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 |
| 87 | Central Los Angeles | 7 | 13 | 7 | 3 | 8 | 0 | 4 | 2 | 2 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 88 | West San Gabriel Valley | 8 | 11 | 8 | 2 | 7 | 2 | 4 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 90 | Santa Clarita Valley | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 91 | Northwest Coastal Los Angeles County | 0 | 2 | 9 | 0 | 5 | 2 | 4 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 94 | Southwest Coastal Los Angeles County | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ORANGE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3176 | Central Orange County 1 | 5 | 5 | 3 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -- | -- | -- | -- | -- | -- |
| 3177 | North Orange County | 2 | 5 | 8 | 3 | 8 | 2 | 2 | 0 | 0 | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3186 | Saddleback Valley | -- | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3190 | Central Orange County 2 | 3 | 7 | 5 | 2 | 4 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- |
| 3195 | North Coastal Orange County | 2 | 5 | 3 | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| RIVERSIDE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4137 | Coachella Valley 1** | -- | -- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4144 | Metropolitan Riverside County 1 | 4 | 2 | 8 | 5 | 5 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4146 | Metropolitan Riverside County 2 | -- | -- | -- | -- | -- | -- | -- | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4149 | Perris Valley | -- | -- | -- | -- | -- | -- | -- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4150 | San Gorgonio Pass | -- | -- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4155 | Norco/Corona | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4157 | Coachella Valley 2** | -- | -- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SAN BERNARDINO COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5171 | Southwest San Bernardino Valley | -- | -- | -- | -- | -- | -- | -- | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 5175 | Northwest San Bernardino Valley | 6 | 2 | 7 | -- | 8 | 2 | -- | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5181 | Central San Bernardino Mountains | -- | -- | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 5197 | Central San Bernardino Valley 1 | 4 | 2 | 16 | 13 | 6 | 7 | 5 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5203 | Central San Bernardino Valley 2 | 3 | 2 | 8 | 8 | 10 | 0 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5204 | East San Bernardino Valley | 0 | 0 | 5 | 0 | 5 | 2 | 2 | 0 | 0 | 0 | 0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

a) Data from 1982 onward are based on new filter type.

b) Station relocated in 1986.

** Salton Sea Air Basin

# TABLE A-20

## Sulfate - Maximum 24-Hour Averages, 1976-2001[a)]

## (To Be Compared to State Standard of 25 $\mu g/m^3$, 24-Hour Average)

| STN# | LOCATION | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOS ANGELES COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 60 | East San Gabriel Valley | 29.8 | 38.3 | 36.7 | 24.5 | 38.2 | 23.0 | 26.2 | 25.8 | 27.6 | 15.4 | 14.6 | 15.4 | 23.6 | 16.9 | 16.0 | 19.2 | 16.8 | 19.1 | 17.5 | 12.9 | 17.1 | 12.7 | 10.2 | 17.8 | 17.2 | 14.1 |
| 69 | East San Fernando Valley | -- | -- | -- | -- | -- | -- | -- | -- | -- | 21.6 | 19.1 | 17.5 | 33.6 | 22.1 | 25.9 | 18.6 | 12.9 | 20.1 | 18.3 | 13.7 | -- | -- | -- | -- | -- | -- |
| 72 | South Coastal Los Angeles County | -- | -- | -- | -- | 40.7 | 32.7 | 30.4 | 30.8 | 22.2 | 31.0 | 25.2 | 17.6 | 27.8 | 20.0 | 22.6 | 19.9 | 22.6 | 15.6 | 17.1 | 16.9 | 19.9 | 11.4 | 14.5 | 13.7 | 26.7 | 15.9 |
| 74 | West San Fernando Valley | 30.2 | 27.3 | 57.8 | 22.9 | 35.6 | 24.1 | 29.2 | 22.5 | 22.9 | 19.0 | 11.7 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 75 | Pomona/Walnut Valley | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 76 | Southwest Coastal Los Angeles County | 37.2 | 43.6 | 44.4 | 36.1 | 34.0 | 26.2 | 37.3 | 24.8 | 26.7 | 24.4 | b) | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 80 | Southeast Los Angeles County | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 84 | South Central Los Angeles County | 42.4 | 38.0 | 38.1 | 28.1 | 34.2 | 24.0 | 36.8 | 27.6 | 24.9 | 24.0 | 22.4 | 18.2 | 27.1 | 19.6 | 28.1 | 22.4 | 18.7 | 13.7 | 23.1 | 18.8 | 16.0 | 11.4 | 12.0 | 15.6 | 11.4 | 15.4 |
| 85 | South San Gabriel Valley | -- | 40.8 | 47.2 | 30.6 | 34.3 | 27.1 | 30.8 | 34.8 | 20.6 | 19.2 | 22.1 | 17.8 | 28.1 | 32.0 | 21.1 | 21.6 | 17.0 | 15.5 | 26.2 | 16.3 | 13.7 | 13.1 | 12.0 | 25.6 | 13.1 | 14.5 |
| 87 | Central Los Angeles | 34.4 | 47.2 | 45.0 | 29.7 | 32.8 | 23.7 | 27.7 | 25.7 | 27.4 | 20.0 | 20.4 | 14.5 | 26.6 | 23.0 | 25.3 | 23.1 | 19.4 | 17.6 | 21.7 | 15.5 | 12.8 | 14.3 | 10.6 | 17.9 | 16.4 | 15.9 |
| 88 | West San Gabriel Valley | 33.8 | 38.2 | 53.4 | 26.4 | 38.4 | 27.8 | 26.6 | 26.8 | 25.4 | 20.9 | 15.6 | 14.0 | 24.4 | 18.0 | 28.4 | 20.1 | 11.5 | 18.8 | 14.5 | 13.2 | 12.0 | 11.6 | 9.2 | 16.4 | 13.9 | 13.4 |
| 90 | Santa Clarita Valley | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 91 | Northwest Coastal Los Angeles County | 22.6 | 28.7 | 41.2 | 23.5 | 34.9 | 25.3 | 26.0 | 20.0 | 26.4 | 22.5 | 16.9 | 15.2 | 17.4 | 19.6 | 24.8 | 20.9 | 12.3 | 18.1 | 26.8 | 13.3 | 12.2 | 14.0 | 11.2 | 13.9 | 14.1 | 15.6 |
| 94 | Southwest Coastal Los Angeles County | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 25.2 | 20.6 | 19.0 | 22.6 | 24.8 | 24.7 | 17.6 | 20.5 | 26.7 | 20.4 | 18.4 | 14.4 | 13.5 | 18.8 | 16.2 | 20.6 |
| ORANGE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3176 | Central Orange County 1 | 29.3 | 37.7 | 30.7 | 24.4 | 37.2 | 24.7 | 22.6 | 24.4 | 20.1 | 19.4 | 18.5 | 14.6 | 23.1 | 17.7 | 18.3 | 20.6 | 16.0 | 15.3 | 14.5 | 12.8 | -- | -- | -- | -- | -- | -- |
| 3177 | North Orange County | 26.0 | 34.5 | 34.7 | 26.2 | 35.0 | 25.6 | 28.8 | 19.7 | 21.9 | 22.8 | 10.1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3186 | Saddleback Valley | 22.6 | 32.9 | 26.7 | 21.5 | 21.2 | 20.0 | 13.4 | 21.2 | 14.9 | 21.2 | 14.9 | 14.3 | 16.2 | 16.5 | 13.4 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3190 | Central Orange County 2 | 35.9 | 37.0 | 31.0 | 26.6 | 34.6 | 26.0 | 24.5 | 26.3 | 19.5 | 22.4 | 23.6 | 18.2 | 27.3 | 17.4 | 16.8 | 16.9 | 16.0 | 14.7 | -- | -- | -- | -- | -- | -- | -- | -- |
| 3195 | North Coastal Orange County | 28.2 | 37.8 | 27.2 | 24.2 | 13.5 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| RIVERSIDE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4137 | Coachella Valley 1** | 16.7 | 12.1 | 13.9 | 12.0 | 11.9 | 12.8 | 11.4 | 13.3 | 8.9 | 9.1 | 8.8 | 10.4 | 11.2 | 12.1 | 5.6 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4144 | Metropolitan Riverside County 1 | 44.3 | 33.4 | 55.9 | 28.1 | 39.2 | 30.4 | 23.1 | 27.7 | 22.8 | 21.0 | 18.4 | 16.1 | 23.6 | 16.9 | 19.9 | 14.8 | 12.3 | 13.7 | 20.4 | 26.3 | 14.9 | 13.1 | 10.1 | 10.7 | 11.0 | 10.7 |
| 4146 | Metropolitan Riverside County 2 | -- | -- | -- | -- | -- | -- | -- | 27.5 | 22.6 | 21.1 | 18.5 | 19.7 | 19.0 | 16.6 | 19.3 | 12.8 | 12.1 | 15.1 | 15.7 | 22.9 | 17.0 | 10.4 | 12.8 | 10.6 | 10.2 | 9.2 |
| 4149 | Perris Valley | -- | -- | -- | -- | -- | -- | -- | 17.9 | 15.9 | 14.1 | 14.0 | 15.6 | 11.5 | 15.9 | 12.9 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4150 | San Gorgonio Pass | 31.6 | 15.6 | 20.7 | 20.0 | 18.5 | 19.6 | 22.9 | 20.1 | 22.2 | 12.3 | 11.3 | 15.2 | 10.6 | 13.8 | 8.6 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4155 | Norco/Corona | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4157 | Coachella Valley 2** | 19.9 | 10.6 | 11.4 | 13.9 | 16.9 | 13.5 | 11.7 | 12.3 | 11.7 | 8.4 | 7.9 | 10.3 | 8.4 | 18.3 | 7.0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SAN BERNARDINO COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5171 | Southwest San Bernardino Valley | 48.6 | 29.4 | 30.0 | -- | -- | -- | -- | 27.2 | 28.3 | 18.5 | 19.8 | 17.8 | 21.1 | 16.4 | 19.9 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 5175 | Northwest San Bernardino Valley | 34.0 | 64.7 | 37.0 | 32.0 | -- | -- | -- | 25.5 | 22.6 | 15.3 | 15.7 | 18.0 | 18.5 | 13.9 | 18.7 | 19.0 | 13.2 | 17.1 | 15.8 | 12.5 | 13.6 | 9.7 | 10.5 | 11.7 | 11.5 | 10.7 |
| 5181 | Central San Bernardino Mountains | 8.2 | 13.2 | 9.8 | 13.9 | 37.3 | 14.2 | 13.3 | 10.3 | 10.3 | 7.1 | 8.0 | 13.1 | 13.4 | 10.2 | 6.6 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 5197 | Central San Bernardino Valley 1 | 32.7 | 30.2 | 51.7 | 32.8 | 40.0 | 42.4 | 32.5 | 33.1 | 23.8 | 16.4 | 18.1 | 18.7 | 28.1 | 14.9 | 18.3 | 20.2 | 13.4 | 16.7 | 15.5 | 13.4 | 13.6 | 10.2 | 10.1 | 12.4 | 10.7 | 10.7 |
| 5203 | Central San Bernardino Valley 2 | 27.5 | 28.5 | 47.1 | 31.7 | 42.8 | 38.8 | 29.6 | 27.1 | 23.4 | 19.4 | 17.8 | 17.6 | 15.8 | 17.8 | 17.3 | 18.3 | 12.9 | 17.2 | 14.9 | 12.5 | 11.2 | 9.1 | 11.5 | 10.9 | 12.4 | 12.4 |
| 5204 | East San Bernardino Valley | 21.5 | 23.7 | 32.7 | 23.7 | 37.3 | 31.0 | 28.5 | 24.1 | 21.0 | 16.2 | 9.9 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | District Maximum | 48.6 | 64.7 | 57.8 | 36.1 | 42.8 | 42.4 | 37.3 | 34.8 | 28.3 | 31 | 25.2 | 20.6 | 33.6 | 32 | 28.4 | 24.7 | 22.6 | 20.5 | 26.8 | 26.3 | 19.9 | 14.4 | 14.5 | 25.6 | 26.7 | 20.6 |

a) Data from 1982 onward are based on new filter type.

b) Station relocated in 1986.

** Salton Sea Air Basin

# TABLE A-21

## Lead - Highest Calendar Quarter Mean, µg/m³
## (To Be Compared to Federal Standard of 1.5 µg/m³, Calendar Quarter Average)
## 1976-2001

| STN# | LOCATION | 1976 | 1977 | 1978 | 1979 | 198 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 199 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOS ANGELES COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 60 | East San Gabriel Valley | 1.96 | 2.68 | 1.44 | 1.08 | 0.91 | 0.74 | 0.69 | 0.50 | 0.43 | 0.21 | 0.18 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 69 | East San Fernando Valley | -- | -- | -- | -- | -- | -- | -- | -- | 0.65 | 0.49 | 0.33 | 0.20 | 0.20 | 0.10 | 0.07 | 0.07 | 0.09 | 0.05 | 0.05 | 0.04 | -- | -- | -- | -- | -- | -- |
| 72 | South Coastal Los Angeles County | -- | -- | -- | -- | -- | 1.12 | 0.92 | 0.70 | 0.69 | 0.36 | 0.31 | 0.22 | 0.15 | 0.08 | 0.07 | 0.07 | 0.05 | 0.05 | 0.04 | 0.04 | 0.08 | 0.03 | 0.04 | 0.05 | 0.04 | 0.04 |
| 74 | West San Fernando Valley | 3.37 | 3.40 | 2.42 | 1.73 | 1.68 | 0.97 | 0.79 | 0.67 | 0.55 | 0.27 | 0.15 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 75 | Pomona/Walnut Valley | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | - | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 76 | Southwest Coastal Los Angeles County | 7.52 | 5.34 | 4.06 | 3.21 | 2.55 | 1.57 | 1.63 | 1.03 | 1.02 | 0.60 | a) | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 80 | Southeast Los Angeles County | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 84 | South Central Los Angeles County | 5.30 | 4.59 | 3.27 | 2.98 | 2.15 | 1.40 | 1.36 | 1.03 | 1.02 | 0.63 | 0.44 | 0.24 | 0.19 | 0.11 | 0.11 | 0.10 | 0.08 | 0.06 | 0.07 | 0.06 | 0.05 | 0.07 | 0.04 | 0.09 | 0.06 | 0.12 |
| 85 | South San Gabriel Valley | -- | 5.52 | 2.77 | 2.00 | 1.96 | 1.27 | 1.12 | 0.86 | 0.72 | 0.49 | 0.40 | 0.26 | 0.22 | 0.12 | 0.11 | 0.14 | 0.10 | 0.11 | 0.08 | 0.06 | 0.06 | 0.06 | 0.05 | 0.09 | 0.06 | 0.05 |
| 87 | Central Los Angeles | 3.76 | 4.46 | 2.38 | 2.69 | 2.04 | 1.30 | 1.04 | 0.80 | 0.72 | 0.47 | 0.28 | 0.18 | 0.14 | 0.12 | 0.09 | 0.14 | 0.11 | 0.07 | 0.07 | 0.06 | 0.06 | 0.07 | 0.04 | 0.07 | 0.05 | 0.05 |
| 88 | West San Gabriel Valley | 4.49 | 4.37 | 3.01 | 2.28 | 1.65 | 1.08 | 0.73 | 0.56 | 0.56 | 0.29 | 0.19 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 90 | Santa Clarita Valley | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 91 | Northwest Coastal Los Angeles County | 2.17 | 2.14 | 2.00 | 1.81 | 1.68 | 1.28 | 0.89 | 0.60 | 0.58 | 0.26 | 0.15 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 94 | Southwest Coastal Los Angeles County | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.25 | 0.17 | 0.11 | 0.07 | 0.06 | 0.06 | 0.05 | 0.04 | 0.04 | 0.04 | 0.03 | 0.05 | 0.04 | 0.04 | 0.05 | 0.04 |
| ORANGE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3176 | Central Orange County 1 | 3.49 | 3.28 | 2.00 | 1.60 | 1.44 | 0.90 | 0.75 | 0.54 | 0.56 | 0.27 | 0.20 | 0.13 | 0.09 | 0.08 | 0.06 | 0.06 | 0.03 | 0.04 | 0.03 | 0.04 | -- | -- | -- | -- | -- | -- |
| 3177 | North Orange County | 3.46 | 3.20 | 2.11 | 1.67 | 1.34 | 0.97 | 0.88 | 0.59 | 0.58 | 0.33 | 0.18 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3186 | Saddleback Valley | -- | 1.58 | 0.85 | 0.65 | 0.60 | 0.41 | 0.32 | 0.27 | 0.24 | 0.15 | 0.09 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3190 | Central Orange County 2 | 4.57 | 3.25 | 2.70 | 2.08 | 1.52 | 0.85 | 0.97 | 0.55 | 0.60 | 0.31 | 0.22 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3195 | North Coastal Orange County | 3.39 | 2.66 | 2.00 | 1.38 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| RIVERSIDE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4137 | Coachella Valley 1** | -- | -- | 0.47 | 0.34 | 0.25 | 0.21 | 0.13 | 0.12 | 0.14 | 0.10 | 0.06 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4144 | Metropolitan Riverside County 1 | 2.31 | 1.95 | 1.53 | 1.18 | 0.84 | 0.64 | 0.46 | 0.41 | 0.40 | 0.21 | 0.16 | 0.12 | 0.07 | 0.05 | 0.05 | 0.05 | 0.03 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 0.05 | 0.03 |
| 4146 | Metropolitan Riverside County 2 | -- | -- | -- | -- | -- | -- | -- | 0.54 | 0.55 | 0.30 | 0.21 | 0.14 | 0.09 | 0.06 | 0.05 | 0.06 | 0.03 | 0.04 | 0.03 | 0.03 | 0.03 | 0.04 | 0.05 | 0.04 | 0.03 | 0.03 |
| 4149 | Perris Valley | -- | -- | -- | -- | -- | -- | -- | 0.25 | 0.26 | 0.13 | 0.10 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4150 | San Gorgonio Pass | -- | -- | 0.50 | 0.49 | 0.27 | 0.23 | 0.23 | 0.17 | 0.18 | 0.09 | 0.08 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4155 | Norco/Corona | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4157 | Coachella Valley 2** | -- | -- | 0.50 | 0.36 | 0.28 | 0.22 | 0.13 | 0.17 | 0.20 | 0.14 | 0.12 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SAN BERNARDINO COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5171 | Southwest San Bernardino Valley | -- | -- | -- | -- | -- | -- | -- | 0.36 | 0.50 | 0.26 | 0.17 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 5175 | Northwest San Bernardino Valley | 2.07 | 1.84 | 1.35 | 1.09 | -- | -- | -- | 0.47 | 0.36 | 0.23 | 0.17 | 0.11 | 0.07 | 0.08 | 0.05 | 0.07 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.05 | 0.05 | 0.04 |
| 5181 | Central San Bernardino Mountains | -- | 1.02 | -- | 0.35 | 0.26 | 0.19 | 0.15 | 0.13 | 0.13 | 0.07 | 0.05 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 5197 | Central San Bernardino Valley 1 | 1.40 | 1.53 | 0.99 | 0.87 | 0.60 | 0.46 | 0.46 | 0.35 | 0.27 | 0.17 | 0.16 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 5203 | Central San Bernardino Valley 2 | 1.87 | 1.41 | 2.47 | 1.22 | 1.04 | 0.73 | 0.51 | 0.41 | 0.37 | 0.20 | 0.19 | 0.13 | 0.08 | 0.07 | 0.05 | 0.05 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.03 | 0.05 | 0.05 | 0.04 |
| 5204 | East San Bernardino Valley | 1.33 | 1.80 | 1.06 | 0.66 | 0.45 | 0.36 | 0.32 | 0.27 | 0.22 | 0.15 | 0.07 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | District Maximum | 7.52 | 5.52 | 4.06 | 3.21 | 2.55 | 1.57 | 1.63 | 1.03 | 1.02 | 0.63 | 0.44 | 0.26 | 0.22 | 0.12 | 0.11 | 0.14 | 0.11 | 0.11 | 0.08 | 0.06 | 0.08 | 0.07 | 0.05 | 0.09 | 0.06 | 0.12 |

a) Station relocated in 1986.

** Salton Sea Air Basin

# TABLE A-22

## Lead - Highest Monthly Averages, µg/m³
## (To Be Compared to State Standard of 1.5 µg/m³, Monthly Average)
## 1976-2001

| STN# | LOCATION | 1976 | 1977 | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOS ANGELES COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 60 | East San Gabriel Valley | 2.27 | 3.06 | 1.59 | 1.48 | 1.45 | 0.92 | 0.72 | 0.55 | 0.45 | 0.25 | 0.19 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 69 | East San Fernando Valley | -- | -- | -- | -- | -- | -- | -- | -- | 0.90 | 0.60 | 0.41 | 0.29 | 0.35 | 0.20 | 0.08 | 0.10 | 0.16 | 0.05 | 0.06 | 0.05 | -- | -- | -- | -- | -- | -- |
| 72 | South Coastal Los Angeles County | -- | -- | -- | -- | 2.01 | 1.22 | 1.09 | 1.08 | 0.94 | 0.52 | 0.43 | 0.33 | 0.21 | 0.11 | 0.09 | 0.08 | 0.07 | 0.06 | 0.06 | 0.05 | 0.08 | 0.05 | 0.07 | 0.06 | 0.05 | 0.05 |
| 74 | West San Fernando Valley | 3.96 | 4.50 | 3.05 | 2.24 | 1.71 | 1.62 | 1.01 | 0.96 | 0.68 | 0.32 | 0.19 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 75 | Pomona/Walnut Valley | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 76 | Southwest Coastal Los Angeles County | 10.04 | 6.77 | 5.48 | 3.91 | 3.44 | 1.91 | 1.70 | 1.29 | 1.38 | 0.90 | a) | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 80 | Southeast Los Angeles County | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 84 | South Central Los Angeles County | 8.13 | 5.74 | 4.42 | 3.67 | 3.02 | 1.83 | 1.55 | 1.36 | 1.43 | 0.91 | 0.58 | 0.32 | 0.31 | 0.15 | 0.14 | 0.17 | 0.11 | 0.08 | 0.09 | 0.07 | 0.09 | 0.07 | 0.04 | 0.17 | 0.09 | 0.23 |
| 85 | South San Gabriel Valley | -- | 6.68 | 4.02 | 2.24 | 2.34 | 1.59 | 1.18 | 1.14 | 0.93 | 0.65 | 0.57 | 0.31 | 0.29 | 0.19 | 0.13 | 0.19 | 0.15 | 0.15 | 0.10 | 0.07 | 0.09 | 0.08 | 0.07 | 0.21 | 0.09 | 0.07 |
| 87 | Central Los Angeles | 4.90 | 5.06 | 2.71 | 2.82 | 2.68 | 1.75 | 1.05 | 1.04 | 0.89 | 0.61 | 0.42 | 0.23 | 0.22 | 0.17 | 0.09 | 0.21 | 0.16 | 0.10 | 0.11 | 0.07 | 0.08 | 0.07 | 0.06 | 0.13 | 0.06 | 0.06 |
| 88 | West San Gabriel Valley | 5.61 | 4.73 | 4.16 | 2.54 | 1.72 | 1.43 | 0.90 | 0.84 | 0.73 | 0.38 | 0.24 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 90 | Santa Clarita Valley | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 91 | Northwest Coastal Los Angeles County | 2.98 | 2.63 | 2.90 | 2.17 | 2.02 | 1.83 | 1.00 | 0.82 | 0.78 | 0.33 | 0.23 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 94 | Southwest Coastal Los Angeles County | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.35 | 0.26 | 0.18 | 0.13 | 0.08 | 0.08 | 0.05 | 0.05 | 0.05 | 0.04 | 0.04 | 0.06 | 0.06 | 0.05 | 0.08 | 0.04 |
| ORANGE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3176 | Central Orange County 1 | 4.62 | 4.60 | 2.96 | 1.90 | 2.05 | 1.13 | 0.78 | 0.72 | 0.65 | 0.32 | 0.27 | 0.14 | 0.11 | 0.15 | 0.10 | 0.08 | 0.05 | 0.07 | 0.06 | 0.04 | -- | -- | -- | -- | -- | -- |
| 3177 | North Orange County | 4.55 | 4.07 | 3.20 | 1.89 | 1.72 | 1.31 | 0.96 | 0.95 | 0.71 | 0.44 | 0.23 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3186 | Saddleback Valley | 2.11 | 2.66 | 1.36 | 0.72 | 0.69 | 0.61 | 0.36 | 0.32 | 0.31 | 0.20 | 0.10 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3190 | Central Orange County 2 | 6.38 | 4.68 | 4.04 | 2.71 | 1.88 | 1.14 | 1.08 | 0.93 | 0.86 | 0.39 | 0.28 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 3195 | North Coastal Orange County | 4.16 | 3.63 | 3.11 | 1.90 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| RIVERSIDE COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4137 | Coachella Valley 1** | -- | -- | 0.73 | 0.44 | 0.35 | 0.31 | 0.18 | 0.16 | 0.17 | 0.13 | 0.10 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4144 | Metropolitan Riverside County 1 | 2.94 | 2.45 | 1.80 | 1.30 | 1.07 | 0.85 | 0.55 | 0.57 | 0.54 | 0.27 | 0.17 | 0.14 | 0.10 | 0.07 | 0.08 | 0.06 | 0.03 | 0.05 | 0.06 | 0.04 | 0.088 | 0.07 | 0.08 | 0.06 | 0.06 | 0.04 |
| 4146 | Metropolitan Riverside County 2 | 4.37 | 3.90 | -- | -- | -- | -- | -- | 0.77 | 0.65 | 0.37 | 0.24 | 0.18 | 0.12 | 0.07 | 0.08 | 0.08 | 0.03 | 0.04 | 0.04 | 0.05 | 0.05 | 0.07 | 0.10 | 0.05 | 0.04 | 0.03 |
| 4149 | Perris Valley | -- | -- | -- | -- | -- | -- | -- | 0.28 | 0.31 | 0.18 | 0.11 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4150 | San Gorgonio Pass | -- | -- | 0.59 | 0.61 | 0.31 | 0.27 | 0.27 | 0.24 | 0.21 | 0.10 | 0.10 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4155 | Norco/Corona | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4157 | Coachella Valley 2** | -- | -- | 0.63 | 0.52 | 0.36 | 0.40 | 0.16 | 0.24 | 0.24 | 0.19 | 0.16 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SAN BERNARDINO COUNTY: | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5171 | Southwest San Bernardino Valley | 5.30 | -- | -- | -- | -- | -- | -- | 0.44 | 0.67 | 0.36 | 0.22 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 5175 | Northwest San Bernardino Valley | 2.60 | 2.47 | 1.68 | 1.43 | -- | -- | -- | 0.54 | 0.43 | 0.26 | 0.20 | 0.13 | 0.10 | 0.11 | 0.07 | 0.08 | 0.04 | 0.05 | 0.05 | 0.06 | 0.04 | 0.04 | 0.05 | 0.07 | 0.07 | 0.05 |
| 5181 | Central San Bernardino Mountains | 0.30 | 0.78 | 0.36 | 0.48 | 0.31 | 0.29 | 0.18 | 0.17 | 0.14 | 0.12 | 0.08 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 5197 | Central San Bernardino Valley 1 | 2.10 | 3.15 | 1.19 | 1.20 | 0.86 | 0.52 | 0.53 | 0.39 | 0.34 | 0.22 | 0.17 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 5203 | Central San Bernardino Valley 2 | 2.40 | 1.83 | 3.33 | 1.49 | 1.30 | 1.01 | 0.62 | 0.52 | 0.47 | 0.31 | 0.23 | 0.15 | 0.12 | 0.09 | 0.07 | 0.06 | 0.05 | 0.05 | 0.04 | 0.05 | 0.06 | 0.04 | 0.05 | 0.07 | 0.06 | 0.05 |
| 5204 | East San Bernardino Valley | 1.80 | 1.59 | 1.25 | 0.82 | 0.57 | 0.47 | 0.34 | 0.32 | 0.30 | 0.19 | 0.10 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | Disctrict Maximum | 10.04 | 6.77 | 5.48 | 3.91 | 3.44 | 1.91 | 1.70 | 1.36 | 1.43 | 0.91 | 0.58 | 0.33 | 0.35 | 0.20 | 0.14 | 0.21 | 0.16 | 0.15 | 0.11 | 0.07 | 0.09 | 0.08 | 0.10 | 0.21 | 0.09 | 0.23 |

a) Station relocated in 1986.

** Salton Sea Air Basin