RESULTS OF FISH PASSAGE MONITORING AT THE VERN FREEMAN DIVERSION FACILITY, SANTA CLARA RIVER, 1994

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1.0 INTRODUCTION

1.1 BACKGROUND

The Santa Clara is an intermittent river that drains portions of Los Angeles and Ventura counties in southern California. The mainstem Santa Clara River flows through a narrow alluvial valley onto a large coastal plain, and is fed by several tributaries that flow out of local mountains. The major tributaries are Santa Paula, Sespe and Piru creeks. Streamflow is typical of most southern California rivers; extremely low (often zero) during the dry summer and fall months, but can experience relatively high peak flows during winter storms. During the low flow period, a sand bar forms at the mouth of the Santa Clara River estuary, forming an intermittent barrier to fish migration to or from the ocean. Fish also are prevented from migrating through the lower Santa Clara River until sufficient rainfall in the basin provides adequate streamflow to allow for passage.

The Santa Clara River supplies water primarily through groundwater recharge for domestic, municipal and agricultural uses in the basin. Water is diverted at Saticoy, approximately 14.6 kilometers upstream from the ocean, by the United Water Conservation District (UWCD) into a series of percolation ponds to recharge the Oxnard Coastal Plain aquifers. Prior to 1989, the diversion consisted of an earthen dike. In 1991, the UWCD constructed the Freeman Diversion Improvement Project to improve the existing diversion work on the Santa Clara River in Ventura County, California. This action was taken at the direction of the State Water Resources Control Board to combat sea water intrusion in the Oxnard Coastal Plain aquifers resulting from groundwater overdrafting to supply water for irrigation, industry, and municipal uses. The improvements, consisting primarily of a permanent concrete riverbed stabilization structure, were necessary for the UWCD to maintain its ability to divert water to groundwater recharge basins in the Oxnard Plain Forebay Basin. Historic in-river aggregate mining destabilized and degraded the Santa Clara River bed, which had lowered approximately 22 feet opposite the diversion headworks since 1928, when diversions began. This down cutting of the river bed also contributed to repeated failures of the

previous sand dike diversion structure. The permanent concrete structure, completed in 1991, has since halted the headcutting, stabilized the river bed both upstream and downstream of the project, and improved the ability of the UWCD to divert streamflow to groundwater recharge basins.

The project was permitted through U.S. Army Corps of Engineers (COE) 404 Permit No. 86-116-T5. The Freeman Diversion also includes of a two-entrance denil fish ladder, a fish screen, and bypass facilities as described in Special Condition A of the COE 404 permit. Special Condition B of the 404 permit focuses on the fisheries mitigation features of the project, and states:

> "B. The District shall institute a plan for evaluation of the mitigation features of the project to determine their effectiveness at accomplishing their designated purpose. This evaluation process may include studies on fish movement, flows and timing and will be conducted for a period of 5 years after the project is completed. The plan is to be developed by the District within 18 months of permit issuance and is to be approved by the COE in consultation with the involved resource agencies. The implementation of the plan shall include the installation of some functional, mutually agreeable device for counting fish passage through the ladder."

An appropriate study plan (ENTRIX 1991) to monitor steelhead utilization of the fish ladder was developed and approved by the Department of Fish and Game (CDFG), United States Fish and Wildlife Service (USFWS) and the COE. The plan centered on the installation of a semi-permanent fish trap and counting device which became operational in February of 1993. Prior to the installation of the semi-permanent fish trap and counter, upstream fish migration was monitored with a temporary trap (described in ENTRIX 1991) in 1991 and 1992. A number of details pertaining to the operation of the semi-permanent fish trap and counting device required refinement after installation. As a result, an agreement was reached between the UWCD and the CDFG to view the 1993 trapping season as a preliminary year to work out the details of the operating procedures. The five year monitoring phase began with the 1994 water year. Accordingly, this report documents the first official year of the required five year study.

1.2 SPECIES COMPOSITION

The fish assemblage in the Santa Clara River is comprised of five native species (including two subspecies of stickleback), four species native to southern California streams which have been introduced into the system, and several species which are not native to California, but have been introduced into the system. Fish native to the Santa Clara River Basin include steelhead (rainbow) trout (*Oncorhynchus mykiss*), Pacific lamprey (*Lampetra tridentata*), partially armored threespine stickleback (*Gasterosteus aculeatus microcephalus*) and the unarmored threespine stickleback (*G. a. williamsoni*), a federally and state listed endangered species. The tidewater goby (*Eucyclogobius newberryi*) (also a federally listed endangered species) and Pacific staghorn sculpin (*Leptocottus armatus)* are primarily estuarine species which are seldom found upstream in freshwater habitats.

Fish found in the Santa Clara river that are native to southern California, but not to the Santa Clara River system include Santa Ana sucker (*Catostomus santaanae*) and the arroyo chub (*Gila orcutti*), both of which are considered species of special concern by Moyle et al. (1989) The native habitat of the arroyo chub and the Santa Ana sucker is the Los Angeles basin, and their native streams have been highly degraded as a result of urbanization. Two additional species native to California have established populations in the Santa Clara River, the Owens sucker (*C. fumeiventris*) and the prickly sculpin (*Cottus asper*). The Owens sucker, native to the Owens River, was apparently introduced through the transfer of water (through the Los Angeles Aqueduct) into the basin. The prickly sculpin is native to coastal streams as far south as the Ventura River (the next drainage to the north), but the population in the Santa Clara River is thought to have entered the basin through transfer of water (through the State Water Project into Pyramid Lake from the Sacramento River system) (Bell 1978). Several additional species have been stocked into reservoirs throughout the basin and are occasionally found in the river, including threadfin shad (*Dorosoma peteneses*), bullhead (*Ameiurus spp.*) and green sunfish (*Lepomis cyanellus*), as well as hatchery reared rainbow trout. Although the mainstem Santa Clara River provides habitat for several of the fish listed above, the lower Santa Clara River serves primarily as a migration corridor for steelhead and lamprey, with tributaries providing most of the spawning and rearing habitat (Puckett and Villa 1985).

1.2.1 STEELHEAD

Maintaining the steelhead trout population was the impetus for the construction of the fish ladder over the Vern Freeman diversion. The Santa Clara River historically supported a popular fishery for steelhead, although the size of the run was never quantified. Steelhead (and lamprey) use the lower Santa Clara River as a migration corridor and do not spawn or rear in this portion of the river (Puckett and Villa 1985). Spawning and rearing of the young takes place in upstream tributaries. Historically, Santa Paula, Sespe and Piru creeks were utilized as the primary spawning and rearing habitat, with several smaller streams also providing habitat.

Steelhead populations have declined as a result of water development, loss of habitat and drought. The old Vern Freeman Diversion may have impeded upstream migration and entrained emigrating smolts. The Santa Paula Diversion blocks upstream access on Santa Paula Creek and reduces or eliminates flow downstream of the diversion during the dry season. Santa Felicia Dam blocks upstream access on Piru Creek approximately 10 kilometers upstream of its confluence with the Santa Clara River. A minimum release of 5 cfs is maintained at the dam which may provide spawning and rearing habitat for steelhead in the lower creek. Sespe Creek has historically been heavily stocked with hatchery reared rainbow trout, but remains substantially undeveloped and probably provides the best existing spawning and rearing habitat for steelhead in the basin.

2.0 METHODS

The study design for this program is presented in ENTRIX (1991). The study was designed to monitor the upstream (adult) and downstream (juvenile) migrations of steelhead trout through the fish ladder. In 1993, a semi-permanent fish trap was installed in the fish ladder (prior to 1993, a temporary trap and fyke net were placed in the ladder during high flow events to monitor fish movement upstream through the diversion facility). Under agreement with the CDFG, USFWS and COE, the fish ladder is to be operated throughout the upstream migration period in the Santa Clara River at the Vern Freeman Diversion Dam provided certain headwater elevation criteria are met (i.e., the headwater elevation is between 160-164 feet per the COE 404 permit). The ladder is also occasionally closed during periods of high sediment transport associated with large storm events and when sand is flushed from the mouth of the diversion intake. Closing the ladder during these periods reduces the build up of sand and debris at the fish trap and allows for more consistent and efficient ladder operation.

2.1 UPSTREAM MIGRATION

A denil type fish ladder provides access for upstream migrating fish around the diversion structure. During periods of high streamflow, a relatively high velocity current is required to attract upstream migrating fish into the fish ladder. The water surface elevation inside the fish ladder (at the downstream fish entrance) is maintained 1.5 feet higher than the river outside the fish ladder. The head created by this elevational difference results in a water velocity flowing out of the fish ladder at a calculated eight feet per second.

Steelhead migrating upstream through the fish ladder are funneled by a series of guide bars which directs the fish into the counting tubes. The guide bars are spaced sufficiently far apart to allow lamprey (but not adult steelhead) to migrate unhindered past the trap. The counting tubes lead into a "live car." The live car can be enabled by closing a gate which blocks upstream migration of trout, forming a "fish trap." Thus, with the trap enabled (egress is blocked), fish can be captured in the trap to verify the counts recorded through

the counting tubes. The trap was designed with a low velocity holding compartment which allows fish to rest until they are released. A hoist lifts the live car/trap out of the trap assembly, which facilitates the removal of trapped fish.

Concern was expressed by CDFG that steelhead trout entering the upstream migrant trap may have been able to turn around and exit via the counting tubes (downstream). Thus, the steelhead would avoiding capture, and at the same time, be unable to migrate upstream. To correct this potential problem, a screen "funnel" (12 inches high by four inches wide) was placed at the upstream end of the counting tubes. The funnel would allow steelhead to easily move into the trap, while making it difficult for fish to move back out of the trap. In addition, the CDFG recommended removing the live car from the trap assembly. The new "trap" was formed by the upstream trash rack and downstream guide bars (metal slats) and their supports. This forms a holding compartment measuring approximately 10' by 15'. The spacing of the trash rack bars was designed to allow lamprey to pass upstream unhindered, but close enough to prevent adult steelhead from getting past. A few gaps were found that may have been sufficiently large to allow small adult steelhead to squeeze past. These gaps were subsequently closed with additional screening on April 8, 1994.

The trap was serviced at least once per day during the sampling season. During servicing, the fish ladder was drained, and the debris and sand that had collected around the trap was removed. The fish trap was checked during this time. In addition, the rest of the fish ladder was surveyed for fish stranded as a result of dewatering the ladder. Lamprey were often collected during these surveys.

Fish collected in the trap (or captured in the ladder during dewatering for trap maintenance) were identified to species and measured (fork length (FL) or total length (TL) depending upon caudal configuration of the individual species) to the nearest millimeter (mm). Photographs were taken of representative individuals. Scale samples were taken from rainbow trout for age determination. Trout and lamprey were then released upstream of the trap to continue their upstream migration.

Lamprey were counted in the ladder during dewatering for maintenance. Because lamprey are able to swim through the trap without being captured, these counts underestimate their true abundance. It is not known how long lamprey take to migrate through the ladder. If a lamprey remains in the fish ladder for more than one day, it may be counted on

consecutive days. To determine the proportion of lamprey which remain in the ladder for more than one day, 82 lamprey were marked with a small notch in the dorsal fin and released back into the ladder. The number of marked and unmarked lamprey were recorded each day to estimate the percentage remaining in the ladder for two or more days. Lamprey which were not marked were typically collected and released upstream of the diversion.

2.1.1 FISH COUNTER EFFICIENCY

The efficiency of the counting device to detect fish was tested by pulling hatchery rainbow trout (average length approximately 12 in., 300 mm FL) through the counting tubes. A plastic tie clip was attached through the mouth/gill of a hatchery-reared rainbow trout with two lines attached to the clip, one line running upstream and the second line running downstream through a counting tube. The fish were directed to the counting tube through a 12 inch PVC pipe, and pulled by means of the lines upstream and downstream through the tubes to test the counters ability to detect and record the passage of a fish. Both of the tubes were tested in this manner.

2.2 DOWNSTREAM MIGRATION

Downstream-migrating steelhead smolts entering the diversion facility are prevented from entering the diversion canal by a fish screen. A fish bypass allows the smolts to exit the diversion and return back to the river downstream of the diversion structure to continue their migration to the ocean. During periods when streamflow between the diversion and the ocean is not contiguous, fish are collected in a trap consisting of a mesh cage that can be lowered into the chamber adjacent to the weir, through which all bypass water (and fish) flows. During the 1994 season, the trap was enabled on 21 February, and continued throughout the sampling season to verify the existence of steelhead smolts in the system. Smolts collected in the bypass trap were counted, measured (FL) and a scale sample collected for age determination. The smolts were then either released into the river through the bypass, or, if flow was not contiguous to the lagoon, smolts were transported by truck to the lagoon.

Table 3-1. Results of fish trapping at the Vern Freeman Diversion Fish Ladder, Santa Clara River, March 26 Through April 2, 1991.

Date Surveyed	Species	Number
March 26[1]	Lamprey	0
March 27	Lamprey	0
March 28	Lamprey	0
March 29	Lamprey	9
March 30	Lamprey	16
March 31	Lamprey	34
April 1	Lamprey	15
April 2[2]	Lamprey	0
Season Total	**Lamprey**	**74**

[1]Trap enabled at 1700 hours

[2]Trap disabled at 1000 hours

Table 3-2. Fish ladder operating status during the 1993 monitoring period.

Time Period	Status	Comments
February 17	Closed	Trap installation
February 18-29	Open	
March 1-5	Closed	High sediment transport
March 6-26	Open	
March 27-28	Closed	High sediment transport
March 29-May 17	Open	

large storm events. The fish trap was enabled for two days (March 26 and 27) during the 1993 monitoring period, and no fish were captured.

No adult or juvenile steelhead trout were observed in or around the diversion facility during the 1993 monitoring period with the exception of one 248 mm FL hatchery rainbow trout collected in the fish ladder. The trout was believed to be of hatchery origin based on the heavily eroded nature of all of its fins and analysis of the scales. Most of the scales had been reabsorbed; those that had not been reabsorbed showed even growth throughout the life of the fish, indicative of having been raised in a constant environment (i.e., a hatchery).

Adult lamprey were observed in the fish ladder from 17 February (the first survey) through 7 May (Table 3-3). The fish trap was designed to allow lamprey to migrate upstream through the ladder without being trapped, therefore the size of the spawning lamprey population could not be estimated. Approximately 465 adult lamprey were observed in the ladder. However, it is not known how many, if any, of the lamprey were counted on more than one day (i.e., it is possible that some of the lamprey may have taken more than one day to negotiate the fish ladder). It is also unknown how many, if any, lamprey took less than one day to move through the fish ladder and avoided being counted.

The daily number of lamprey observed in the fish ladder ranged from 0 to approximately 30 with the exception of 17 February when the upstream gate had been closed for several days prior to this observation to facilitate the installation of the fish trap (80 lamprey were collected in the fish ladder and transported upstream of the diversion facility to continue their migration run). The daily number of lamprey observed in the fish ladder remained fairly constant between at least 7 March through 26 March. Lamprey were observed in the ladder through 7 May.

Two additional species were collected in the fish ladder, Santa Ana suckers and threadfin shad. Threadfin shad were collected in the fish ladder or observed in the diversion by-pass facility sporadically between 26 March and 17 May. Threadfin shad are not native to California, but have been stocked in a number of reservoirs throughout the state, including Castaic Reservoir in the Santa Clara River Drainage. Shad were most likely introduced into the Santa Clara River as a result of the spillage of basin reservoirs.

Table 3-3 Number of Pacific lamprey trapped in the fish ladder structure by month, Vern Freeman Diversion, Santa Clara River, 1991 - 1994.

Month	1991a	1992b	1993c	1994d
February	N/S	N/S	88	36
March	59	N/S	318	702
April	15	N/S	48	168
May	N/S	N/S	11	N/S
Total	74	N/S	465	906

a Fish ladder monitored from 26 March though 2 April.

b Fish ladder monitored for three days in 1992, therefore the run was not estimated.

c Fish ladder monitored from 17 February through 17 May.

d Fish ladder monitored from 7 February through 9.

3.4 RESULTS OF 1994 FISH TRAPPING

3.4.1 UPSTREAM MIGRATION

3.4.1.1 Steelhead

One adult steelhead measuring 475 mm length was captured in the fish trap on 31 March 1994. Scales analysis indicated a freshwater residency of one year and one year in the ocean before returning to spawn. The steelhead was released upstream of the diversion to continue its spawning migration.

3.4.1.2 Pacific Lamprey

Lamprey were observed in the fish ladder for the first time on 17 February, ten days after the sand bar at the mouth of the lagoon breached. Numbers of lamprey observed in the ladder were relatively low throughout February and the first two weeks of March (Table 3-3). As of 15 March, a total of 65 lamprey had been counted in the fish ladder. On 16 March, 142 lamprey were collected in the ladder and transported upstream of the diversion. Stream elevation on this date was below the level which required release through the fish ladder according to the 404 permit, and the fish ladder was closed. On 17 March, UWCD voluntarily reopened the fish ladder to allow the lamprey run to continue, and on 18 March, 118 lamprey were collected in the ladder and released upstream of the diversion. A total of 906 lamprey were counted in the ladder during the 1994 trapping season. Upstream migrating lamprey ranged in size from 530 to 710 mm in total length, averaging 610 mm (Figure 3-1).

The number of lamprey which remain in the ladder for more than one day is apparently small. Of the 82 lamprey marked during the 1994 run, 7 (8.5 percent) remained in the ladder the following day. One lamprey was captured in the ladder on two consecutive days, and one lamprey was captured on three consecutive days.

3.4.1.3 Trap Calibration and Results of Fish Counting Devices

The counting tubes were calibrated by pulling hatchery rainbow trout (approximately 12 in. 300 mm FL) through the tubes in both the upstream and downstream direction. Each tube was monitored by a separate counting device. The movement of trout through the tubes was detected only when the sensitivity setting was set to "10" (highest sensitivity setting), and this setting was used throughout the 1994 trapping season.

A total of 147 upstream counts (76 in the upper tube and 71 in the lower tube), and 42 downstream counts (27 in the upper tube and 15 in the lower tube) were recorded during the 1994 trapping season. Two potential causes for the apparently erroneous counts were identified and corrected for the 1995 season (see discussion section).

3.4.2 DOWNSTREAM MIGRATION

3.4.2.1 Steelhead Smolts

Eighty-three juvenile rainbow trout, presumably downstream migrating smolts, were captured at the Vern Freeman Diversion facility in 1994. The smolts, captured between 17 March and 11 May, ranged in size from 150 to 317 mm FL (average 190.2 mm) (Figure 3-2). Weekly catches of smolts peaked in early April, but remained fairly constant through late April (Table 3-4).

The majority (34 of 50) of the smolts were aged as being one year old (1+) (1993 cohort). Fifteen smolts were aged being as two years old (2+) (1992 cohort) and one was aged as being three years old (3+) (1991 cohort). However, the scales of many of the larger individuals were unreadable (i.e., the fish could not be aged from scale samples collected). In addition, scales were not collected from all specimens captured in the downstream migrant trap. Measurements were taken from an additional 24 smolts (nine smolts captured in the trap appeared to be "stressed." In these situations, these fish were released into the river as quickly as possible, thus length and scale data were not recorded). Since the majority of the unaged fish were greater than 200 mm in length, the remaining 33 smolts were assigned to an age class based on their length compared to smolts of a known

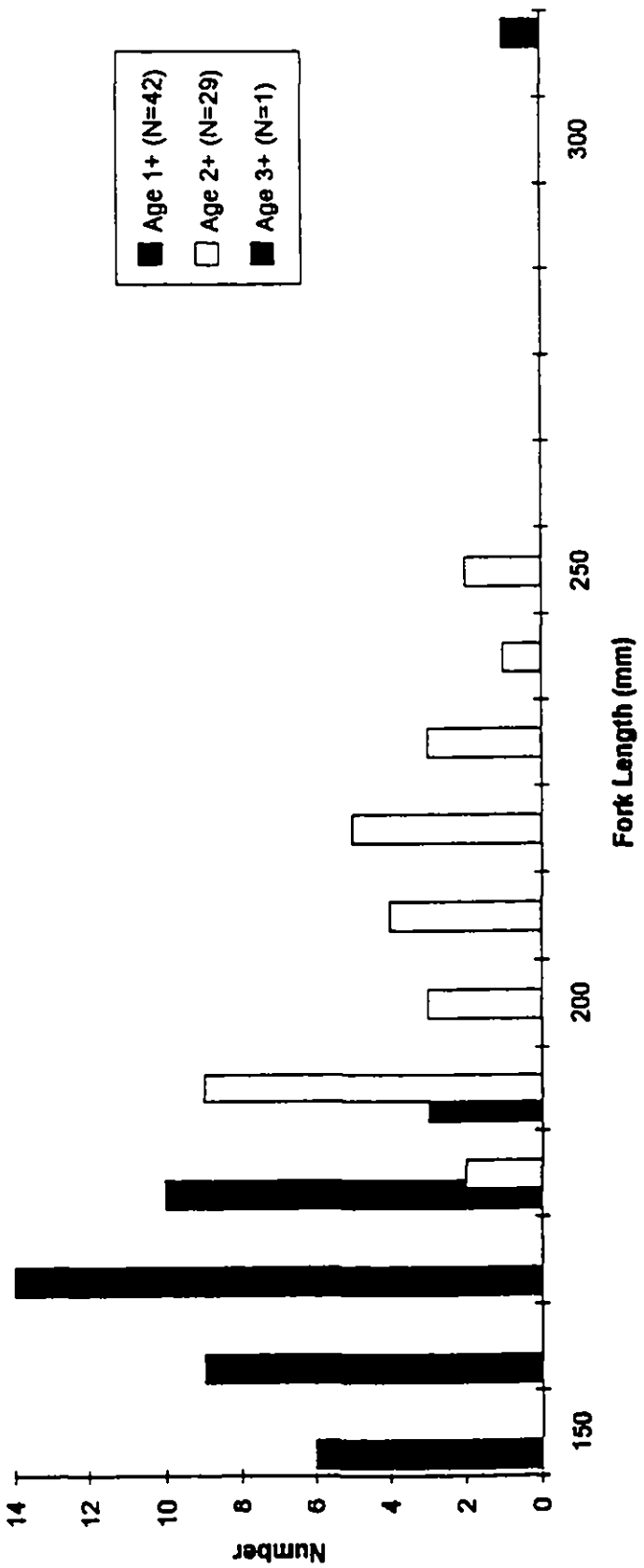

Figure 3-2. Length-frequency histogram of outmigrating smolts captured in the downstream migrant trap, Vern Freeman Diversion Dam, Santa Clara River, 1994.

Table 3-4 Weekly summary of steelhead smolt caught in the downstream migrant trap, Vern Freeman Diversion, Santa Clara River, 1994.

Month	Week	Smolts
February	1-7	0
	8-14	0
	15-21	0
	22-28	0
March	1-7	0
	8-14	0
	15-21	4
	22-28	10
April	29-4	23
	5-11	17
	12-18	8
	19-25	16
May	26-2	2
	3-9	2
	10-16	1
	17-23	0
	24-25[1]	0
Total		83

1 Downstream migrant trap closed on 25 May, 1994.

Table 3-5 **Weekly summary of juvenile Pacific lamprey caught in the downstream migrant trap, Vern Freeman Diversion, Santa Clara River, 1994.**

Month	Week	Lamprey
February	1-7	0
	8-14	0
	15-21	0
	22-28	0
March	1-7	0
	8-14	6
	15-21	25
	22-28	16
April	29-4	10
	5-11	6
	12-18	0
	19-25	5
May	26-2	0
	3-9	1
	10-16	0
	17-23	1
	24-25[1]	0
Total		70

1 Downstream migrant trap closed on 25 May, 1994.

Table 3-6 Non-anadromous fish collected in the Vern Freeman Diversion fish ladder and downstream migrant trap, Santa Clara River, during 1993 and 1994.

Month	Species	Numbers Collected 1993[1]	1994[2]
February	arroyo chub	0	5
	prickly sculpin	0	91
	Santa Ana sucker	0	0
	threespine stickleback	0	4
	bullhead	0	3
	green sunfish	0	0
March	arroyo chub	0	26
	prickly sculpin	0	38
	Santa Ana sucker	1	29
	threespine stickleback	0	4
	bullhead	0	14
	green sunfish	0	1
April	arroyo chub	0	48
	prickly sculpin	0	1
	Santa Ana sucker	1	3
	threespine stickleback	0	4
	bullhead	0	0
	green sunfish	0	0
	hatchery rainbow trout	1	0
May	arroyo chub	0	26
	prickly sculpin	0	0
	Santa Ana sucker	0	2
	threespine stickleback	0	1
	bullhead	0	3
	green sunfish	0	1
Season total	arroyo chub	0	105
	prickly sculpin	0	130
	Santa Ana sucker	2	34
	threespine stickleback	0	13
	hatchery rainbow trout	1	0
	bullhead	0	20
	green sunfish	0	2

1 1993 Monitoring season extended from 17 February through 17 May.
2 1994 Monitoring season extended from 7 February through 11 May.

4.0 DISCUSSION

Fish passage data have been collected at the Freeman Diversion for part or all of four years. Data collection activities in 1991 and 1992 were conducted prior to the completion of the upstream and downstream fish passage monitoring facilities. In addition, monitoring of fish passage during the entire period of streamflow in 1991 and 1992 was incomplete. In 1993, the upstream fish trap was installed, however, several difficulties were encountered operating the fish ladder. In light of these difficulties, 1993 was considered as a "test run," and not part of the five year monitoring study. Most of the technical difficulties encountered during 1993 were resolved prior to the 1994 trapping season, and 1994 marked the first year of the five year monitoring study.

4.1 FISH COUNTING DEVICE

The fish counters were checked each day the fish ladder was in operation, and a record was kept of daily counts (Appendix A). The counters were "zeroed", if necessary, each day that they were in operation. The trap calibration and subsequent monitoring of the counters during the 1993 and 1994 seasons revealed that the counters would occasionally register a count in the upstream direction shortly after they were turned on each day (the counters are turned off each day prior to dewatering of the fish ladder during routine maintenance). This problem was observed half-way through the 1994 trapping season, and may partially account for some of the apparently erroneous counts. After the problem was discovered, the trap monitor waited several minutes after restarting the counters each day to check for erroneous counts (if the counters register a count shortly after being turned on, the counters were reset at zero). In addition, if the counters were not turned off prior to dewatering of the fish ladder, they registered counts (several hundred to over 1,000 in some cases). Times when the ladder was dewatered prior to the counters being turned off were generally noted, and these counts were not added to the season total.

A total of 147 counts were recorded in the upstream direction, and 42 counts were recorded in the downstream direction during the 1994 trapping season, although only one

Eighty three rainbow trout were captured in the downstream migrant trap during the 1994 trapping year. The rainbow trout were presumably juvenile steelhead trout based on their size range, age, and general body shape and color, as well as their capture in the downstream migrant trap. Based on scale analysis, the outmigrants were comprised of three age cohorts (1991, 1992 and 1993). However, it is not known if steelhead trout successfully spawned in between 1991 and 1993, or if the observed smolts were offspring of resident fish or residualized anadromous fish. The coastal rainbow (resident) trout and the steelhead are both thought to be forms of a flexible life history pattern (Benke 1992).

The purpose of the downstream trap is to capture smolts when flow in the river between the diversion and the ocean is discontinuous. When streamflow is continuous to the ocean, fish which can be diverted into the facility are shunted through the fish by-pass and returned via a pipe back into the river downstream of the diversion structure. When streamflow is discontinuous (i.e., the entire flow is being diverted), the smolts are collected in the downstream migrant trap and transported downstream to the lagoon where they can continue their migration to the ocean. However, the downstream trap was monitored continuously in 1994 to document the presence of smolts in the river. Only the portion of the river which was diverted was sampled. Therefore, the results of the downstream migrant trapping are only indicative of the minimum number of smolts which migrated downstream.

The majority of the downstream migrating smolts were products of the 1993 year class (one year old at age of smolting). Two different growth patterns were observed on scales of different fish, suggesting that the trout reared in two or more streams.

4.3 PACIFIC LAMPREY

The 1994 upstream lamprey run began shortly (10 days) after the sand bar at the mouth of the river breached, allowing access into the river. The daily catch of lamprey ranged between 0 and 11 in the fish ladder between 17 February through 15 March (65 total). On March 16 and 18, 142 and 118 lamprey were collected in the fish ladder, and released upstream of the diversion, respectively. The fish ladder was closed on 16 March because the river elevation had declined below 160 feet per the 404 permit. The fish ladder was reopened on the morning of 17 March to allow the lamprey spawning migration to continue. In total, 345 lamprey were collected in the fish ladder during the week of March

15-21, accounting for 38 percent of the lamprey counted in the ladder. The fish ladder was closed on 9 April in accordance with the 404 permit. At the time the ladder was closed, adult lamprey were still being observed in the fish ladder in low numbers.

Adult lamprey are not thought to range far from their natal streams during the oceanic phase of their life history (Moyle 1976). The 1991 and 1994 data suggest that the lamprey are in close proximity to the mouth of Santa Clara River just prior to the spawning season based on their presence in the fish ladder (approximately 8.6 miles 13.8 kilometers inland) within two weeks of the sand bar breaching. The upstream migration of lamprey peaked in March in 1993 and 1994, and continued through 7 May in 1993. Adult lamprey collected in the fish ladder ranged in size from approximately 20.9 to 27.6 inches (530 to 700) mm in total length average 24 inches (610 mm).

In larger river systems (e.g., Trinity River), adult lamprey begin their upstream spawning migration in August and September (Moffett and Smith 1950, cited by Wang 1986), and spawning occurs between April and late July. The spawning migration in the Santa Clara River is regulated by streamflow, and spawning apparently begins shortly after arrival. Several apparently spawned out adult lamprey (open lesions on the lower half of their bodies, possibly caused by the digging of nest) were captured in the downstream migrant trap beginning on April 10. The upstream fish ladder was closed 9 April, therefore the lamprey captured in the downstream migrant trap could not have been late arriving adults which were swept downstream through the diversion canal (the upstream exit from the fish ladder and the diversion gate are located close together). The nearest spawning tributary is Sespe Creek, approximately 11.4 miles (18.1 kilometers) upstream of the diversion. Lamprey die after spawning, and the adults captured may have been spent spawners, slowly drifting downstream.

Juvenile lamprey were first captured in the downstream migrant trap on 10 March, and they were captured sporadically through 7 April. A total of 68 outmigrating lamprey were collected. The low number of outmigrating lamprey (compared to the number of returning adults the last two years) suggest that the majority of the run by-passes the diversion (flows over the dam). Juvenile lamprey are poor swimmers and tend to float with the current on their downstream migration (Wang pers. comm. 1994). During high streamflow, only a small portion of the river is diverted, and it is possible that lamprey (and other fish) are washed over the dam. Juvenile lamprey ranged in size from 15.6 to 18.86 inches (395 to 479 mm) total length, avaerage 16.6 inches (423 mm).

6.0
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Appendix A

DAILY FISH COUNTER READINGS, VERN FREEMAN DIVERSION, SANTA CLARA RIVER, 1994

Appendix A. Fish counter readings, Vern Freeman Diversion Santa Clara River, 1994

	Top tube Direction		Bottom tube Direction	
Date	Upstream	Downstream	Upstream	Downstream
February 4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	N/A			
8	N/A			
9	15	10	3	4
10	0	0	0	1
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	0	0	0	0
15	0	0	0	0
16	0	0	0	0
17	0	0	0	0
18	1	0	0	0
19	0	0	0	0
20	N/A[2]			
21	0	0	0	0
22	0	0	0	0
23	0	0	1	0
24	2	2	0	0
25	0	0	0	0
26	1	0	25	2
27	0	0	0	0
28	0	0	0	0
February total	19	12	29	7
March 1	1	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	0	0	0	0
9	0	1	0	0
10	2	0	0	0
11	0	0	0	0

Appendix A. Fish counter readings, Vern Freeman Diversion Santa Clara River, 1994

Date		Top tube Direction		Bottom tube Direction	
		Upstream	Downstream	Upstream	Downstream
	12	0	0	0	0
	13	0	0	0	0
	14	0	3	4	1
	15	1	1	4	1
	16	1	0	0	0
	17	N/A[1]			
	18	0	0	2	0
	19	N/A[2]			
	20	1	0	0	0
	21	0	0	0	0
	22	0	0	0	0
	23	16	0	4	0
	24	0	0	0	0
	25	N/A			
	26	N/A[1]			
	27	N/A[1]			
	28	20	8	9	1
	29	2	0	4	0
	30	0	0	2	0
	31	4	1	2	2
March total		48	14	31	5
April	1	0	0	6	2
	2	1	0	3	1
	3	7	0	0	0
	4	0	0	0	0
	5	0	0	0	0
	6	0	0	0	0
	7	1	1	2	0
	8	N/A[2]			
	9	N/A[3]			
April total		9	1	11	3
Season totals		76	27	71	15