ASSESSMENT OF STEELHEAD HABITAT IN THE VENTURA RIVER / MATILIJA CREEK BASIN

Stage Two: Quantitative Stream Survey

Final Report

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Cover Photo: Waterfall on Matilija Creek approximately 8.2 mi above Matilija Dam. Photo by Sean Thobaben, Thomas R. Payne & Associates.

ABSTRACT

A qualitative stream survey identified 17 stream reaches containing fish habitat potentially accessible to steelhead in the Matilija Creek Basin above Matilija Dam, and three reaches in the Lower North Fork Matilija Creek (TRPA 2003). Detailed habitat measurements were collected or estimated for 18 variables as part of a Habitat Suitability Index (HSI) study in nine reaches above Matilija Dam, in three reaches in the Lower North Fork, and in five reaches in the Ventura River below Matilija Dam. The HSI variables from each study reach were input into a model that estimates the overall habitat "quality" for rearing steelhead, resulting in a score ranging from 0 (no habitat) to 1.0 (optimal habitat). The individual reach scores were weighted by the amount of available habitat (under three different flow scenarios) to compare overall HSI scores representing the lower basin reaches (below Matilija Dam) and the upper basin reaches (above Matilija Dam and the Lower North Fork).

Initial HSI scores were zero for all reaches due to the model's temperature suitability graphs that did not appear to be applicable to populations of southern steelhead. Consequently, several HSI graphs were modified in an attempt to better represent habitat suitability in warmer climates. Following modification all HSI scores were positive, but the lowest HSI scores occurred in the lowest mainstem reaches and the highest HSI scores occurred in the upper mainstem and tributary reaches. Reach-specific HSI scores in the lower basin reaches ranged from 0.36 to 0.53, and resulted in a weighted average score of 0.50. For the upper basin reaches, individual HSI scores ranged from 0.52 to 0.83 with a weighted average of 0.72. Most of the low HSI scores were due to high temperatures during egg incubation and smolt outmigration. Some scores were also reduced by unsuitable velocities over spawning gravels.

Overall the HSI study verified the qualitative observations from earlier stream surveys and showed that portions of the upper basin contains relatively high quality habitat for rearing steelhead, whereas most of the lower basin contains relatively marginal quality habitat. Providing access for steelhead above the existing migrational barriers at Robles Diversion Dam, Wheeler Gorge, and Matilija Dam would significantly increase available spawning and rearing habitat in the Southern California Coastal Steelhead ESU.

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INTRODUCTION

The upper Matilija Creek watershed and the Coyote/ Santa Anna Creek watershed have both provided historic steelhead spawning and rearing habitats in the Ventura River system. Matilija Dam was constructed in 1947 on lower Matilija Creek for the purpose of supplying water storage and flood control, but reservoir sedimentation and construction of newer projects has reduced the necessity of the dam (Figure 1). When built, Matilija Dam blocked access of anadromous steelhead (*Oncorhynchus mykiss*) to upstream spawning areas. In subsequent years, the Robles Diversion Dam was constructed downstream of Matilija Dam and further blocked access. Declines in local steelhead populations led to a federal listing of steelhead as “endangered” in the Southern California Steelhead ESU. In attempts to help restore the Ventura Basin steelhead population, efforts are underway to provide access across Robles Diversion Dam, which would again allow migratory fish to reach Matilija Dam as well as the Lower North Fork Matilija Creek.

Because of Matilija Dam’s limited function, an Ecosystem Restoration Feasibility Study was conducted by a multidisciplinary team to determine the ecological benefits of removing Matilija Dam for steelhead and other riverine dependent species. One recommendation of the feasibility study was to acquire additional data assessing the habitat quality of the Matilija Basin above the existing dam for spawning and rearing steelhead. An independent study is also being conducted in the Ventura River to assess the streamflow requirements below Robles Diversion Dam (Entrix 2002). While the original scope of this study included only the area above Matilija Dam, the habitat survey was later extended downstream below Matilija Dam to encompass the full length of Matilija Creek and the Ventura River in order to provide a comparison of steelhead habitat above and below the dam (Figure 1).

In recent years, information has been assembled indicating that Matilija Creek above the dam may provide an abundance of high quality habitat if access is provided to upstream migrant steelhead (Chubb 1997). The Ventura County Flood Control District requested qualified fisheries professionals to verify qualitative data described from previous studies and to generate quantitative estimates of habitat quality and quantity. Consequently, this

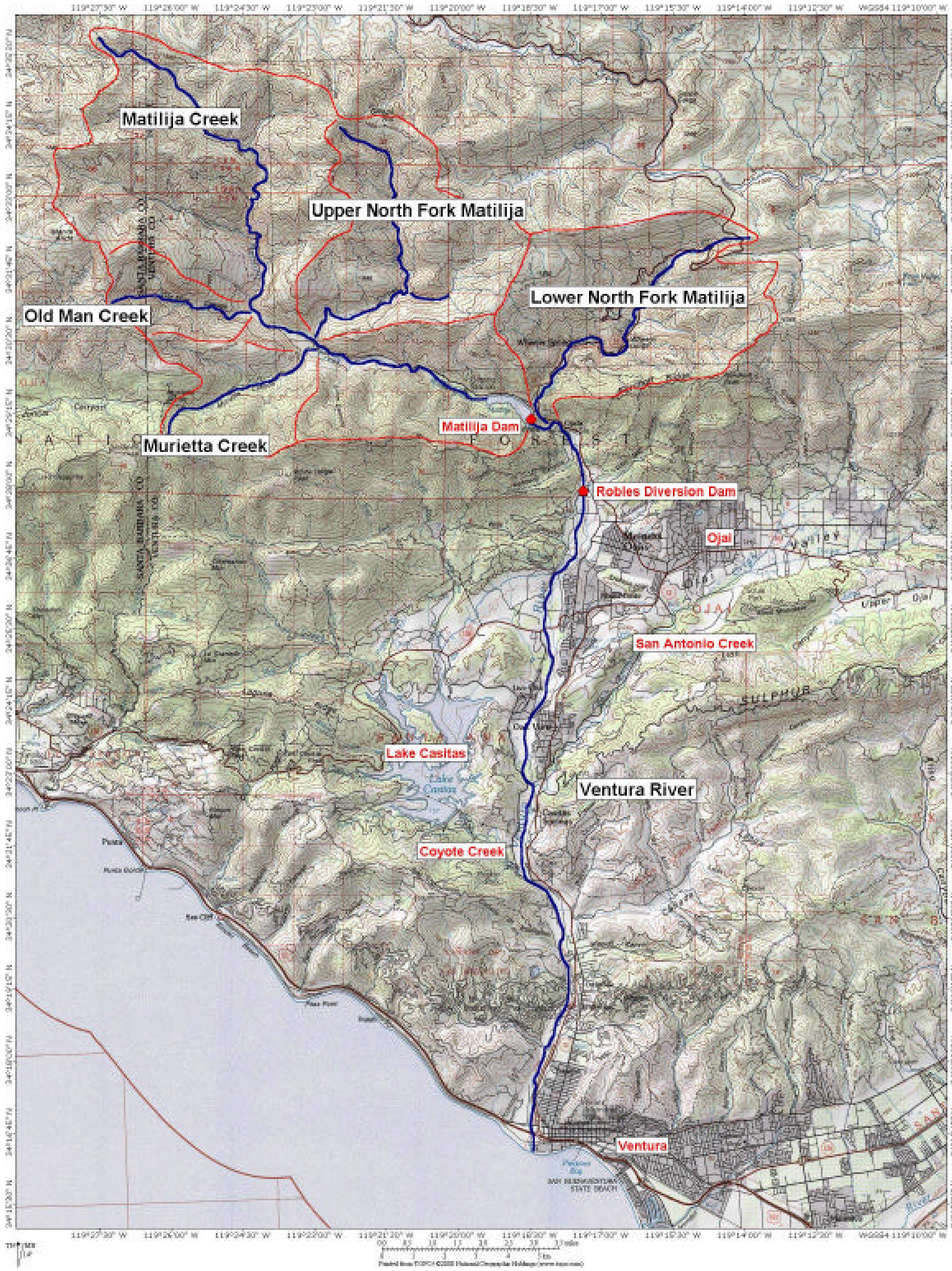


Figure 1. Map of study area showing study streams, upper watershed boundaries, and geographic features.

project was designed as a two-stage program with an initial generalized survey to produce a qualitative verification of historical work, while also providing a sampling framework for the second, more quantitative survey. The qualitative first-stage survey was conducted in March 2003 and was reported in a previous document (TRPA 2003). This quantitative second-stage survey assigns numerical "suitability" values to the fish habitat according to stream reach, which can be used to compare streams within the Ventura River/Matilija Creek Basin (hereafter the Ventura/Matilija Basin).

Numerous methodologies have been devised to assess habitat quality for stream fishes (Wesche and Rechard 1980, Fausch et al. 1988), however habitat assessments are rarely standardized beyond basic tools such as channel typing (Rosgen 1985) or habitat typing (Flosi and Reynolds 1994, McCain et al. 1990). Although various habitat rating systems have been applied towards Southern California steelhead streams, including the Ventura River (Entrix 2002) and the Topanga Creek watershed (Dagit et al. 2003), comparison of results is difficult due to differences in methodologies and subjectivity in the interpretation of results. The U.S. Fish and Wildlife Service developed the ***H***abitat ***E***valuation ***P***rocedures (HEP) in order to provide standardized assessment tools for use in multiple geographic locations and for a multitude of aquatic species (USFWS 1980). A component of the HEP process produces a ***H***abitat ***S***uitability ***I***ndex (HSI) value that rates overall habitat quality on a scale of 0 (no habitat) to 1 (optimal habitat), based on a model incorporating 18 individual variables.

The combination of a generalized first-stage survey (TRPA 2003) with a more quantitative and standardized second-stage survey produced detailed information on stream channel character, riparian composition, location and quantity of spawning habitat, identification and descriptions of potential barriers, and a numerical score describing habitat "quality" using a wide suite of habitat variables known to influence the success of steelhead spawning and rearing. This numerical score is used to compare habitat quality of stream reaches within the Ventura/Matilija Basin, and could be used to compare habitat quality with other streams having similar information and containing populations of self-sustaining steelhead.

THE HSI METHODOLOGY

The habitat variables measured in each selected habitat unit were specified following consultation with biologists representing all interested parties (e.g., County, NMFS, CDFG, and other Environmental Workgroup [EWG] participants), and the selection of the USFWS HSI methodology for rainbow trout (Raleigh et al. 1984). The HSI methodology was recommended because this method utilizes a wide range of habitat variables that are summarized into a single quantitative value (the HSI score) that can be easily compared with other streams having a similar analysis. The rainbow trout HSI incorporates several variables that are particularly important to southern steelhead populations, such as water temperature, pool habitat characteristics, and riparian coverage.

Uncertainty in the HSI Methodology

Although the HSI methodology has been routinely applied in other areas of the United States, validation of this model for southern steelhead has not, to our knowledge, been accomplished. Validation studies for other salmonid populations have not always been successful (see Discussion for more details and reviews), and for several reasons the expected correlations between reach-specific HSI scores and fish populations may not be consistently strong for southern steelhead.

For example, the Ventura/Matilija Basin is near the southern limit of the natural range for steelhead. Consequently both the habitat conditions experienced by southern steelhead and, it is conventionally believed, the fish's ability to withstand extreme conditions, are both not representative of steelhead populations on the whole. It is thus possible that the relative importance of the various habitat parameters as modeled in the HSI formulae may not be appropriate to southern steelhead, which may require, for example, greater emphasis on pool habitat characteristics, flow variability, temperature regimes, etc. Also, the suitability curves for some of the variables included in the model do not appear to be accurate for southern steelhead, such as the various temperature curves (see individual variable descriptions for more details).

Although many of the HSI variables can be quantitatively measured with associated estimates of uncertainty, other variables must be eye-estimated (typically with calibration, see below), estimated from other areas, or adjusted to represent other conditions. For example, measurement of water velocities over spawning gravels would require visiting each HSI location during higher flow conditions (which are highly variable and unpredictable in southern California), yet most variables are best measured during base flow conditions in summer. The prohibitive cost of conducting two separate surveys led us to estimate spawning velocities by adjusting measurements made under low flow conditions. Such adjustments, as well as eye-estimation of other variables, and estimation of variables from other watersheds, all contribute to errors and unmeasured uncertainty in the overall HSI scores. Some sensitivity testing was conducted for modified HSI variables (described later in the report), which helps to determine the potential effects of such errors, however not all estimated variables were thus tested.

An additional limitation of the HSI methodology occurs when combining the HSI scores (which represents habitat quality only) with estimates of habitat quantity in an attempt to estimate overall habitat "value". Simple multiplication of the quality and quantity scores may produce the same value for a large amount of low quality habitat as for a smaller amount of higher quality habitat. Although such a relationship may exist, it is highly unlikely to be a linear relationship and thus comparison of quality/quantity scores can be misleading. For example, a large quantity of low quality habitat can, in effect, overshadow the presence and/or importance of a smaller amount of higher quality habitat. For this study, overall habitat "value" scores were calculated by weighting reach-specific habitat quality values (the HSI scores) by habitat quantity only within each respective sub basin (i.e., upper basin versus lower basin), which was anticipated to give a clearer comparison of average habitat quality scores in addition to facilitating the comparison of overall habitat value between the upper and lower basin areas.

The successful validation of the HSI methodology for southern steelhead would be further complicated by the high variability in annual recruitment and/or survival of steelhead in southern streams due to the highly dynamic and unpredictable rainfall and streamflow characteristics of this arid region. It is likely that a validation exercise would require several years of fish sampling (using a statistically valid sampling protocol) in order to account for the expected variability in steelhead abundance. Despite the above limitations, reach-specific HSI scores can be qualitatively validated using professional judgment of fish habitat quality, and with comparison with existing fish population and physical habitat data.

METHODS

First-Stage (Qualitative) Survey

The first-stage survey occurred during March 2003 and was fully described in a previous report (TRPA 2003), thus only a summary will be included here. The survey involved one or two fisheries biologists walking the full length of all targeted stream reaches, including the mainstem Matilija Creek above the reservoir and it's principal tributaries: Murietta Creek, Old Man Creek, Upper North Fork Matilija Creek, and the Lower North Fork Matilija Creek (below Matilija Dam). The first-stage survey was used to visually assess the nature of and changes in stream flow, water temperature, channel type, riparian type, substrate composition, frequency and gross size of gravel deposits suitable for steelhead spawning, general appearance of resting and rearing pools, and the types and frequency of instream cover. In addition to the above variables, the biologists also noted the number and size range of observed salmonids and other significant aquatic species (e.g., frogs and turtles), water diversions or other man-made structures, springs, and tributary confluences. Detailed information was collected on all potential barriers to upstream migrating adult steelhead.

The first-stage survey was used to accomplish four principal goals:

1) to provide detailed first-hand knowledge of the entire study area
2) to provide qualitative evaluations of habitat characteristics and quality for comparison with earlier work (e.g., Chubb 1997, Moore 1980a)
3) to fully describe the length of habitat accessible to anadromous steelhead, and
4) to adequately describe the sampling "universe" for the second-stage survey; from this information, efficient habitat stratifications can be employed to accurately estimate stream habitat characteristics in a statistically rigorous manner (i.e., to produce valid and comparable total and mean values with minimal variances)

The first-stage survey only encompassed Matilija Creek and its tributaries above Matilija Dam, and the Lower North Fork Matilija Creek. The Ventura River was not included in the first-stage survey because considerable information was already available to characterize the stream channel, riparian vegetation, and general instream habitat in the lower basin (e.g., Mertes et al. 1995).

Second-Stage (Quantitative) Survey

The principal objective of the second-stage survey was to develop comparable HSI scores for various reaches of the Ventura/Matilija Basin. Comparison of the HSI scores among reaches, and of the habitat area within each reach, will help to assess the relative potential value of each reach if steelhead regain access to the entire basin.

Reach Stratification

The first-stage survey identified reaches where significant changes in channel and habitat characteristics occurred within the longitudinal profiles of each study stream, and also identified barriers defining the upper limits to expected production of steelhead (TRPA 2003). Principal factors effecting reach delineation included presence or absence of surface flow, channel type, riparian type, and location of migrational barriers. With this information, each of the upper basin study streams (the mainstem Matilija Creek, the Upper North Fork Matilija Creek, Murieta Creek, Old Man Creek, and the Lower North Fork Matilija Creek) was stratified into one or more reaches of various lengths (Table 1). The stratifications served to reduce variation in major habitat components within each reach, so that reach mean values could be estimated with minimal variance, and differences in reach mean values could be more easily detected (Cochran 1977).

The mainstem Matilija was thus divided into eight reaches that varied in length from 1,900 ft to 9,018 ft (Figures 2 and 3). Murietta Creek was stratified into four reaches ranging in length from 469 ft to 7,154 ft. Old Man Creek was stratified into five reaches varying in length from 710 ft to 4,146 ft. The Upper North Fork Matilija Creek was stratified into five reaches ranging in length from 3,743 ft to 6,649 ft. Below Matilija Dam, the Lower North Fork Matilija Creek was stratified into three reaches with lengths of 13,830 ft, 8,663 ft and 18,675 ft, respectively (Table 1, Figure 4). Additional details for each reach can be found in Appendix A.

The Ventura was stratified using physical stream features taken from topographic maps as well as personal comments from NMFS personnel familiar with the Ventura River. This resulted in stratification of six reaches ranging in length from 3,379 ft to 34,426 ft (Table 1, Figures 5 and 6). The uppermost reach between Matilija Dam and the Lower North Fork Matilija Creek is technically not the Ventura River proper, which begins at the confluence with the Lower North Fork. However the reach immediately below the dam was sampled in conjunction with the lower Ventura study sites, therefore that reach was labeled as a Ventura River reach and will be described in association with the lower river data.

Table 1. Reach and study site characteristics used in the second-stage survey. Ventura River study sites were mapped in July 2003, all other sites were mapped in March and April 2003. Gravel density (ft2/1,000 ft) is based on definitions from the first-stage survey (TRPA 2003).

Stream	Reach	HSI Study Site	HSI Study Site Waypoints	River Mile	Reach Length (ft)	Flow Status	Gravel Density	Notes
Ventura River	VEN 1	VEN 1	VEN1B-VEN1T	0.00-1.57	8,025	flowing	701	1
	VEN 2	VEN 2	VEN2B-VEN2T	1.57-4.60	15,945	flowing	228	2
	VEN 3	VEN 3	VEN3B-VEN3T	4.60-7.54	15,523	flowing	200	3
	*VEN 4	none	-	7.54-14.06	34,425	dry	-	4
	VEN 5	VEN 5	VEN5B-VEN5T-6B	14.06-15.67	8,500	flowing	345	5
(Matilija Creek)	VEN 6	VEN 6	VEN5T-6B-VEN6T	15.67-16.31	3,225	flowing	31	6
Lower NF Matilija	LNF low	LNF xtra	LNFLOWB-LNFLOWT	0.00-2.62	13,830	flowing	393	
	LNF mid	LNF 1	LNFMIDB-LNFMIDT	2.62-4.26	8,663	flowing	199	
	LNF up	LNF 2	LNFUPB-LNFUPT	4.26-6.85	13,675	flowing	17	7
Matilija Creek	*MAT 1	none	-	0.00-0.36	1,900	flowing	372	8
	*MAT 2	none	-	0.36-1.14	4,100	flowing	0	9
	MAT 3	MAT 3	MAT3B1-T1,MAT3B2-T2	1.14-2.80	8,779	flowing	14	10,11
	MAT 4	MAT 5	-	2.80-4.10	6,860	flowing	n/a	12
	MAT 5	MAT 5	MAT5B-MAT5T	4.10-5.01	4,826	flowing	51	
	MAT 6	MAT 6	MAT6B-MAT6T	5.01-6.48	7,731	flowing	68	
	MAT 7	MAT 7	MAT7B-MAT7T	6.48-8.18	9,018	flowing	67	
	*MAT 8	none	-	8.18-8.60	2,171	flowing	0	13
Murietta	MUR 1	MUR 3	-	0.00-0.17	909	flowing	0	14
	*MUR 2	none	-	0.17-0.26	467	dry	0	15
	MUR 3	MUR 3	MUR3B-MUR3T	0.26-1.62	7,154	flowing	83	
	*MUR 4	none	-	1.62-2.13 *	2,700	intermittent/dry	0	15,16
Old Man	*OLD 1	none	-	0.00-0.37	1,960	intermittent/dry	0	15
	OLD 2	OLD 2	OLD2B-OLD2T	0.37-1.16	4,146	flowing	51	
	*OLD 3	none	-	1.16-1.67	2,737	dry	136	15
	OLD 4	OLD 2	-	1.67-2.15	2,532	flowing	11	
	*OLD 5	none	-	2.15-2.29 *	710	dry	n/a	15,16
Upper NF Matilija	UNF 1	UNF low	UNFLOWB-UNFLOWT	0.00-1.26	6,649	flowing	81	17
	UNF 2	UNF 2	UNF2B-UNF2T	1.26-1.99	3,851	flowing	0	
	UNF 3	UNF low	-	1.99-2.70	3,743	flowing	18	17
	UNF 4	UNF up	UNFUPB-UNFUPT1 &	2.70-4.08	7,291	flowing	16	18
Upper NF Trib	UNFT 1	UNF up	-UNFUPT2	0.00-0.82	4,318	flowing	43	18

NOTES:

1 start at 101 bridge
2 gravel overlaid w thick brown algae
3 good gravel below San Antonio Crk
4 flow re-emerged in lower 4,000 ft within 2-5 split channels
5 gravel becoming cemented
6 water visibility <1ft near dam
7 LNF 2 survey completed in rainstorm
8 reach appeared to be backwater (lake) influenced
9 most of reach w/in historic lake zone and thus likely to be modified after dam removal
10 4,909 ft of this mapped reach is private, HSI study site selection restricted to remaining 3,870 ft
11 HSI study site was split around the private land
12 private land not mapped, reach length estimated from map
13 reach above definite barrier, will not provide steelhead habitat
14 flowing section short, therefore excluded from selection for HSI study site
15 channel dry or intermittent during spring survey, therefore not expected to provide summer rearing habitat
16 reach length includes additional dry channel above last WP
17 reaches 1 and 3 similar, therefore combined prior to selection of HSI study site
18 5,870 ft of UNF above a highly probable barrier, therefore HSI site selected from lower 1,421 ft and UNFT 1 (tributary) combined

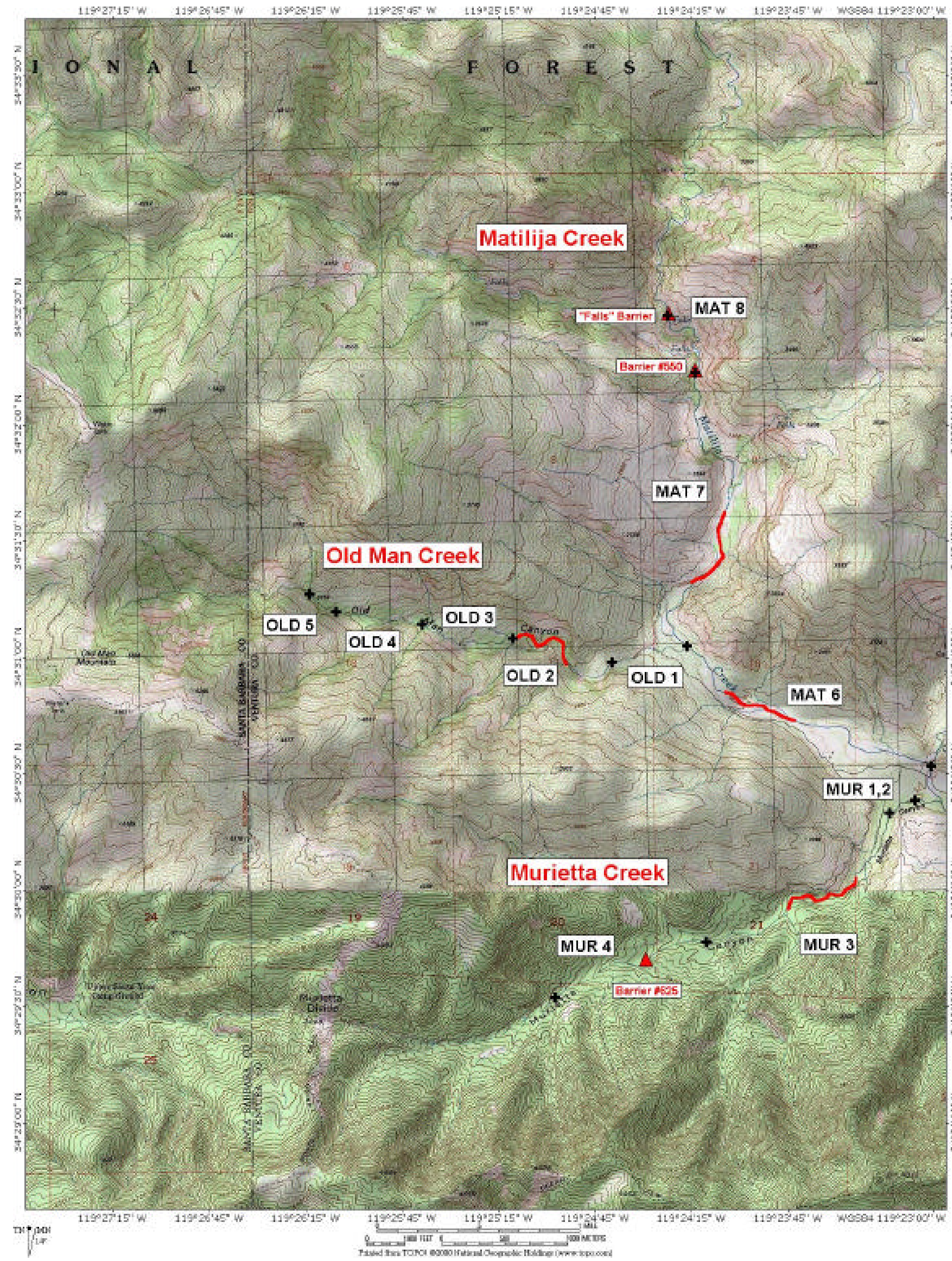


Figure 2. Map of HSI study sites (thick red lines) in the upper portion of Matilija Creek. Reach boundaries are shown as black pluses. Definite barriers to steelhead migration are shown as red triangles (TRPA 2003).

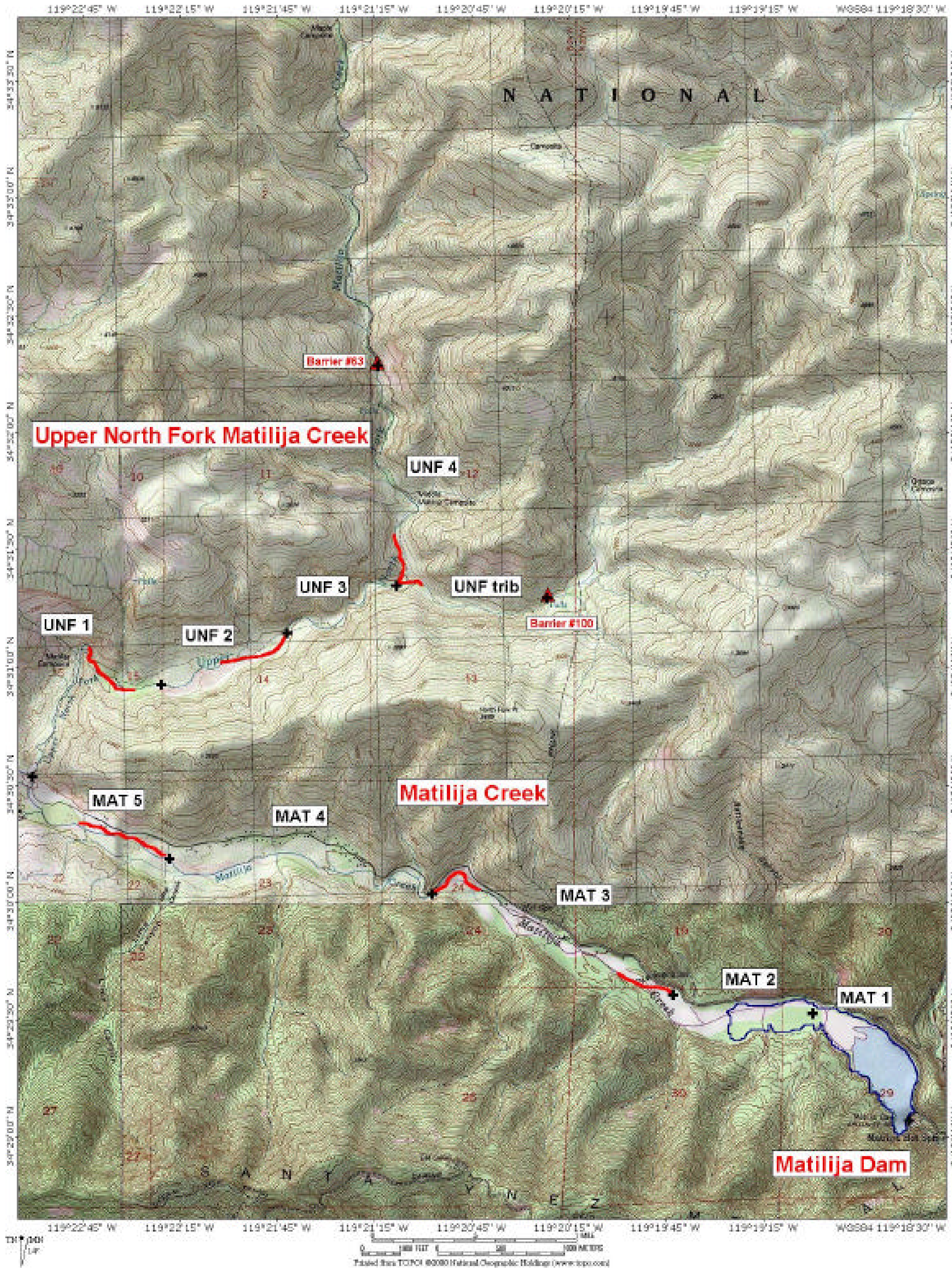


Figure 3. Map of HSI study sites (thick red lines) in the lower portion of Matilija Creek. Reach boundaries are shown as black pluses. Definite barriers to steelhead migration are shown as red triangles (TRPA 2003). The approximate location of the original lake bed is also shown.

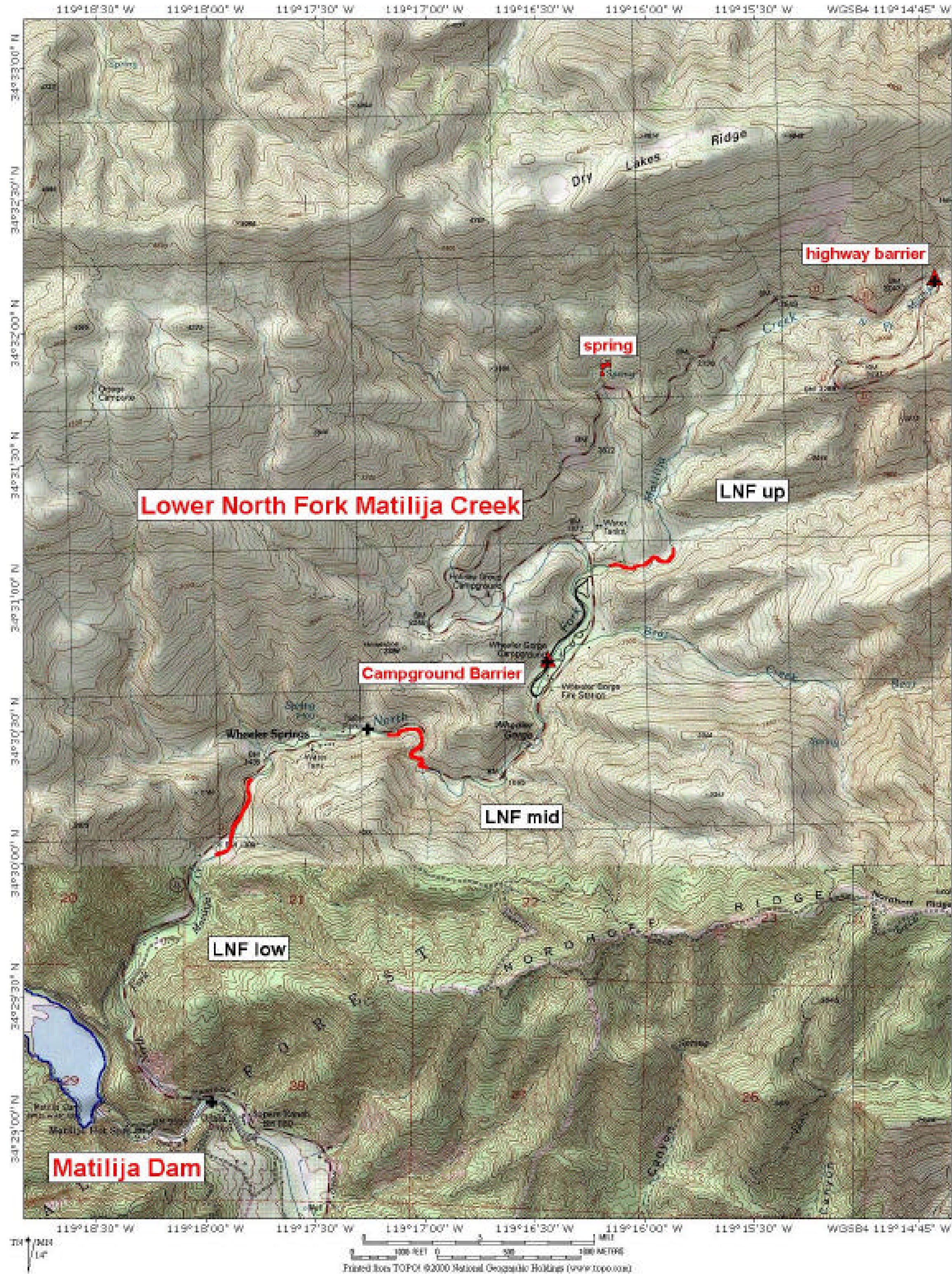


Figure 4. Map of HSI study sites (thick red lines) in the Lower North Fork Matilija Creek. Reach boundaries are shown as black pluses. Definite barriers to steelhead migration are shown as red triangles (TRPA 2003).

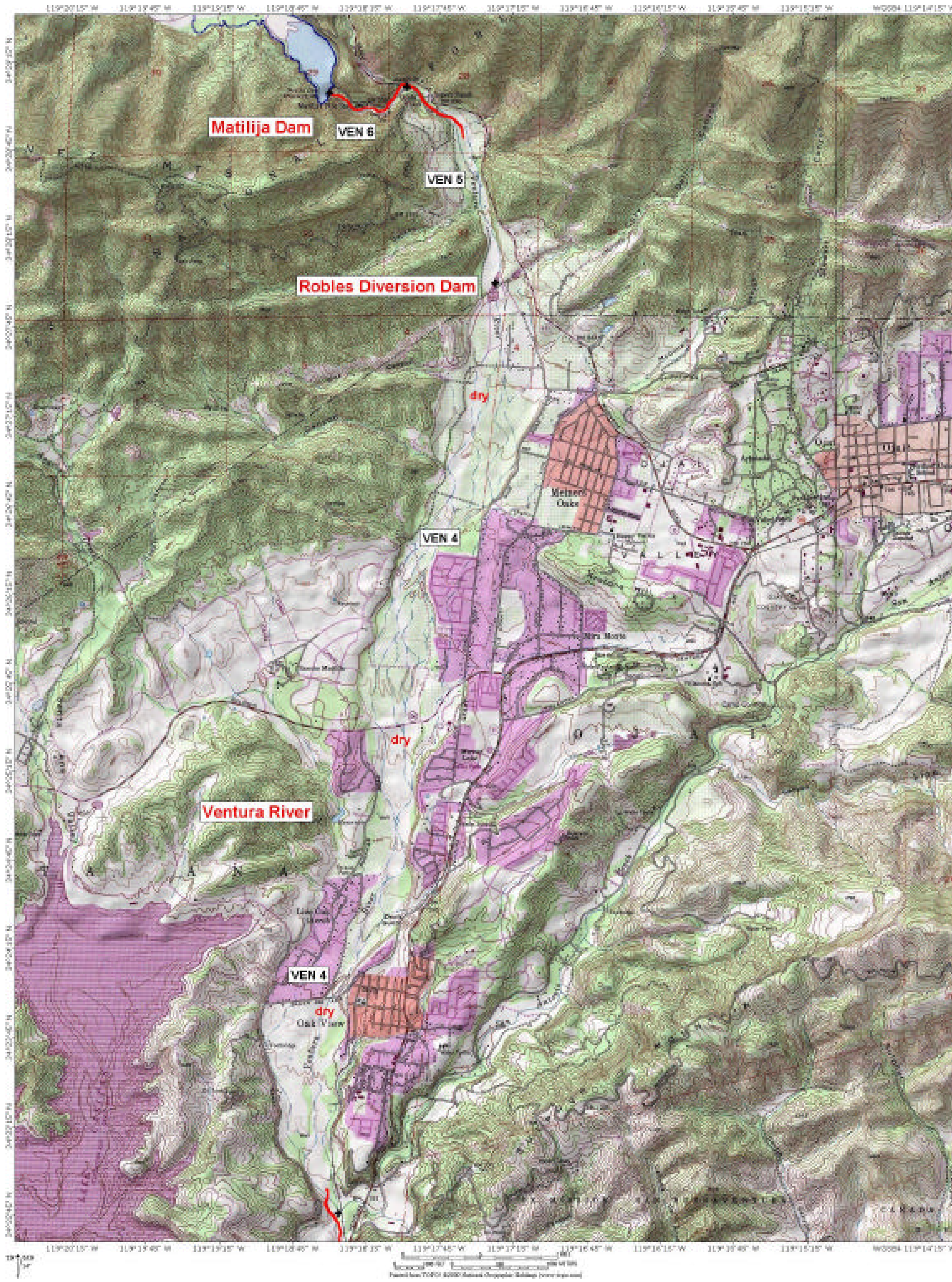


Figure 5. Map of HSI study sites (thick red lines) in the upper portion of the Ventura River. Reach boundaries are shown as black pluses.

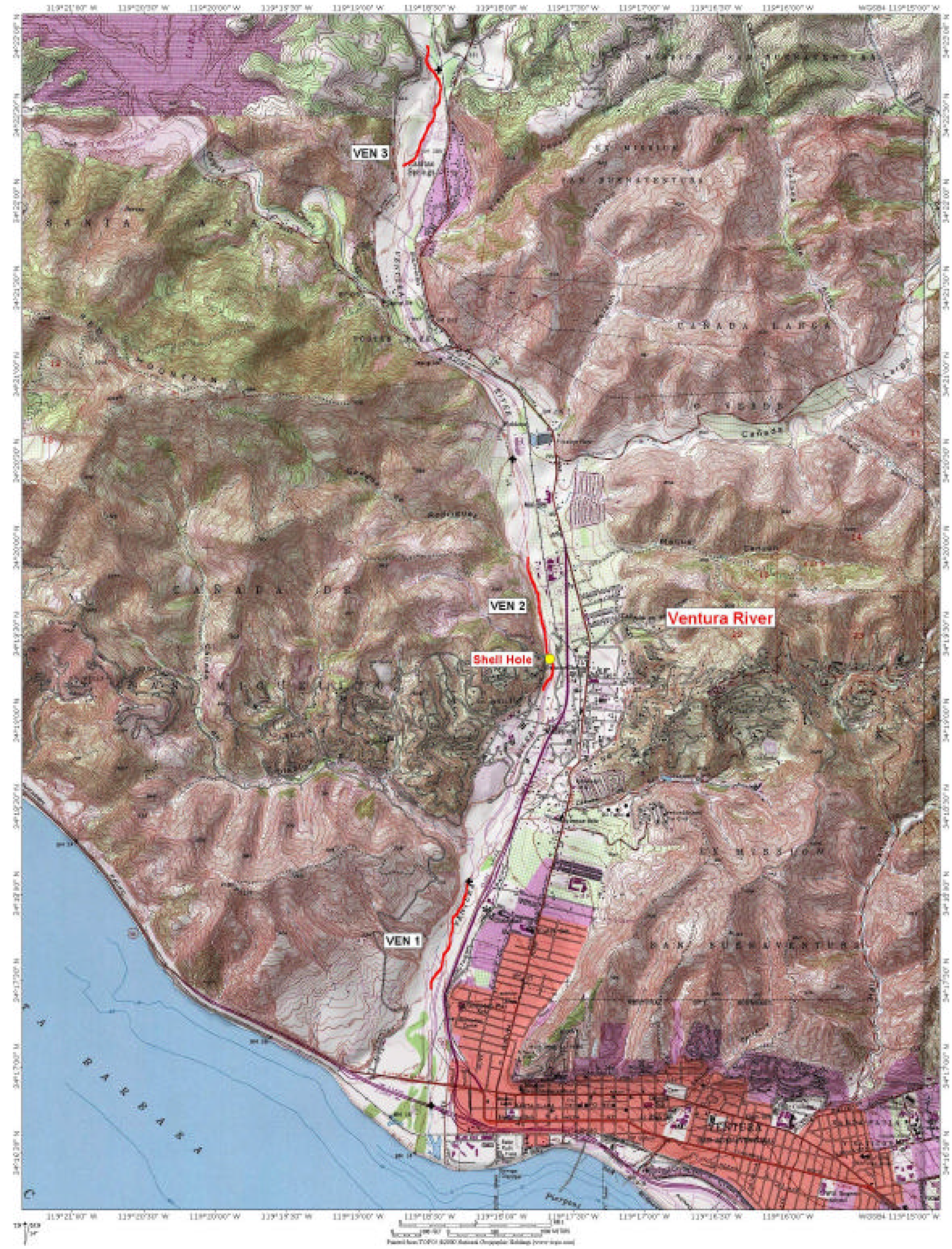


Figure 6. Map of HSI study sites (thick red lines) in the lower portion of the Ventura River. Reach boundaries are shown as black pluses.

Selection of HSI Study Sites

HSI data was collected within HSI study sites from selected reaches. Study sites were not selected from reaches that were anticipated to provide no steelhead rearing habitat during summer low flow conditions, because many HSI variables cannot be measured in a dry channel and HSI scores would be zero for channels that go dry in most years. However, some dry reaches were included in a wet year analysis, described below. Two reaches in the lower mainstem Matilija Creek were also excluded from HSI data collection due to reservoir influence (Table 1). Reach MAT 1 appeared to be directly affected by the downstream reservoir, as indicated by distinct changes in substrate character. MAT 2 was also excluded because, if Matilija Dam is removed, that reach (and MAT 1) will undergo significant reconstruction, and therefore any HSI scores derived for that reach would be invalid. MAT 8 was not included because it exists above a definite barrier and would thus not provide steelhead habitat. All other flowing, accessible reaches were included in the HSI analysis.

For those reaches that were felt to contain significant summer rearing habitat, the reaches were divided into segments of approximately equal length, delineated using map-determined GPS coordinates or hip chain distances from the first-stage survey. The length of the segments varied among reaches due to estimated differences in habitat unit lengths. In general, segment lengths were selected to yield an expected value of 60-80 individual habitat units per segment. Segments in larger channels, such as those in the Ventura River, were thus longer than segments in upper basin reaches where habitat units were shorter. Segment lengths in larger channels were typically 3,000 ft to 5,000 ft in length, whereas segments in most smaller channels were 2,000 ft long. Because estimates of unit mean length were not exact, and because the location of map-derived GPS coordinates for segment boundaries also contained error, the actual number of habitat units in selected segments ranged from 40 units to 120 units, although most segments contained approximately 60 to 80 units as desired. GPS coordinates for the top and bottom boundaries of each HSI study site are given in Appendix B.

After partitioning the selected stream reaches into segments of approximately equal length, one segment was randomly selected within each of the reaches. The selected segment became the HSI "study site" for that reach. In some short reaches, only a single segment was available for selection. Non-random selection of a segment also occurred in one reach where a specific habitat feature was desired for inclusion. In the VEN 2 reach (Table 1), the third segment was intentionally selected in order to include the "Shell Hole" and another bedrock pool, both of which are unique habitat features in the Ventura River.

In four cases, a single HSI study site was selected to represent two different reaches. This was done because of access problems in the mainstem Matilija Creek, and because limited budget and similarity among some reaches required pooling reaches prior to segment selection. For example, the HSI study site selected in the MAT 5 reach was used to represent habitat in the MAT 4 reach, which was all privately owned and was not surveyed. In both Murietta and Old Man Creeks, two reaches were available for sampling, but a single segment was selected to represent both reaches. In the Upper North Fork Matilija Creek, reaches UNF 1 and UNF 3 were also very similar; consequently a single segment was selected to represent both of those reaches. The relationship between reaches and their associated HSI study sites (or, lack thereof) is described in Table 1.

Habitat Typing

The full length of each of the selected HSI study sites were habitat typed using the California Department of Fish and Game stream habitat classification that identified 19 main channel habitat types (Table 2) among pool, flat water, and riffles categories (Flosi and Reynolds 1994). Edgewater and secondary channel habitat units were not typed. This habitat typing classification is highly similar to that used by USFS Region 5 (McCain et al. 1990). The relative proportions (by length) of each habitat type were qualitatively compared among study sites.

Table 2. Habitat type codes used in second-stage survey. See Flosi et al. (1998) for habitat type definitions.

Category	Code	Habitat Type
POOLS	TRP	trench pool
	MCP	mid-channel pool
	CCP	channel confluence pool
	STP	step pool
	CRP	corner pool
	LSL	lateral scour pool - log enhanced
	LSR	lateral scour pool - root wad enhanced
	LSBk	lateral scour pool - bedrock formed
	LSBo	lateral scour pool - boulder formed
	PLP	plunge pool
	DPL	dammed pool
FLAT WATERS	POW	pocketwater
	GLD	glide
	RUN	run
	SRN	step run
RIFFLES	LGR	low gradient riffle (<4%)
	HGR	high gradient riffle (>4%)
	CAS	cascade
	BRS	bedrock sheet

Selection of HSI Habitat Units

Specific HSI data was collected from a sample of habitat units within each HSI study site. Individual habitat units were selected using stratified random sampling with an expected sample size goal of 20 units per study site. The actual number of units selected in each study site ranged from 16 to 23 units.

HSI Variables

The HSI model for rainbow trout / steelhead consists of 5 components with 18 variables (Raleigh et al. 1984). The 5 components address 4 lifestages (adult, juvenile, fry, and embryo), with an "other" component that includes additional variables not specific to a single lifestage (Figure 7, Table 3). Most of the variables are best measured during low flow conditions that typically exist in

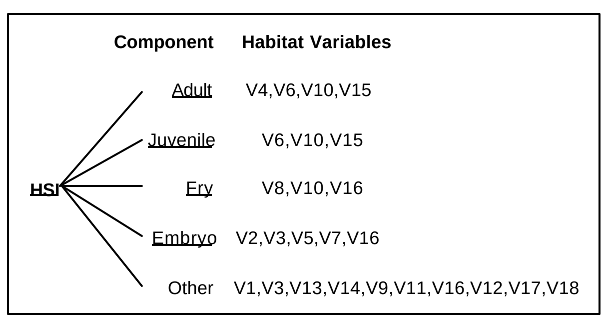


Figure 7. Relationship between HSI model components and habitat variables.

summer, however some of the spawning-related variables are best estimated or calibrated during moderate flow conditions of late-winter or early spring. Some variables cannot be directly measured except during specific times and would require a lengthy and extended period of sampling (i.e. average maximum temperature, average daily flow). Therefore we estimated these variables using professional judgment and supplementary data from other Ventura/Matilija Basin studies or nearby watersheds.

Table 3. HSI model variables with methods of determination. See below for variable descriptions, and Raleigh et al. (1984) for model formulae.

Variable Label	Variable Description	Model Component	Steelhead Lifestage	Variable Determination
V1 r,a	Avg Max Water Temperature	Adult, Other	migration (adult), rearing	modified
V2 e,s	Avg Max Water Temp (Eggs & Smolts)	Embryo, Juvenile	incubation, migration (smolt)	modified
V3 e,r	Avg Min Dissolved Oxygen	Embryo, Other	incubation, rearing	measured
V4	Avg Thalweg Depth	Adult	rearing	measured
V5	Avg Velocity Over Spawning Areas	Embryo	incubation	calibrated
V6 a,j	% Instream Cover	Adult, Juvenile	rearing	measured
V7	Avg Substrate Size in Spawning Areas	Embryo	incubation	measured
V8	% Substrate 10-40cm in Diameter	Fry	overwintering, rearing	modified
V9	Dominant Substrate in Riffles	Other	food production	measured
V10	% Pools	Adult, Fry, Juvenile	rearing	measured
V11	Avg % Vegetation & Canopy Coverage	Other	food production	measured
V12	Avg % Rooted Veg or Rock on Banks	Other	all	measured
V13	Annual Max/Min pH	Other	all	measured
V14	Avg Annual Base Flow	Other	rearing	estimated
V15	Pool Class Rating	Adult, Juvenile	rearing	measured
V16 i,f	% Fines in Riffles and Spawning Areas	Fry, Embryo, Other	incubation, food prod	measured
V17	% Overhead Shading	Other	rearing, food prod	modified
V18	Avg % Flow During Adult Migration	Other	adult migration	estimated

Most of the HSI variables listed in Table 3 were measured (or eye-estimated) on-site during the second-stage survey under relatively low flow conditions, then directly compared to the HSI curves given in Raleigh et al. (1984) and shown in Figures 8-10. Some variables were measured using a modified procedure, were calibrated prior to comparison to the HSI curve, or were applied to a modified HSI curve. Other variables were estimated using data from nearby sources. A description of each variable, how it was determined, and how it was applied to the HSI curves (including curve modifications) is provided below. Please refer to Raleigh et al. (1984) for additional details about the curve derivations and for the specific model formulae.

As noted below, many of the variables measured on-site were eye-estimated following a calibration exercise where a preliminary sample of diverse habitat units was selected to compare actual measured values with eye-estimated values. The comparisons of actual versus estimated values helped the biologists to identify biases and to correct for them

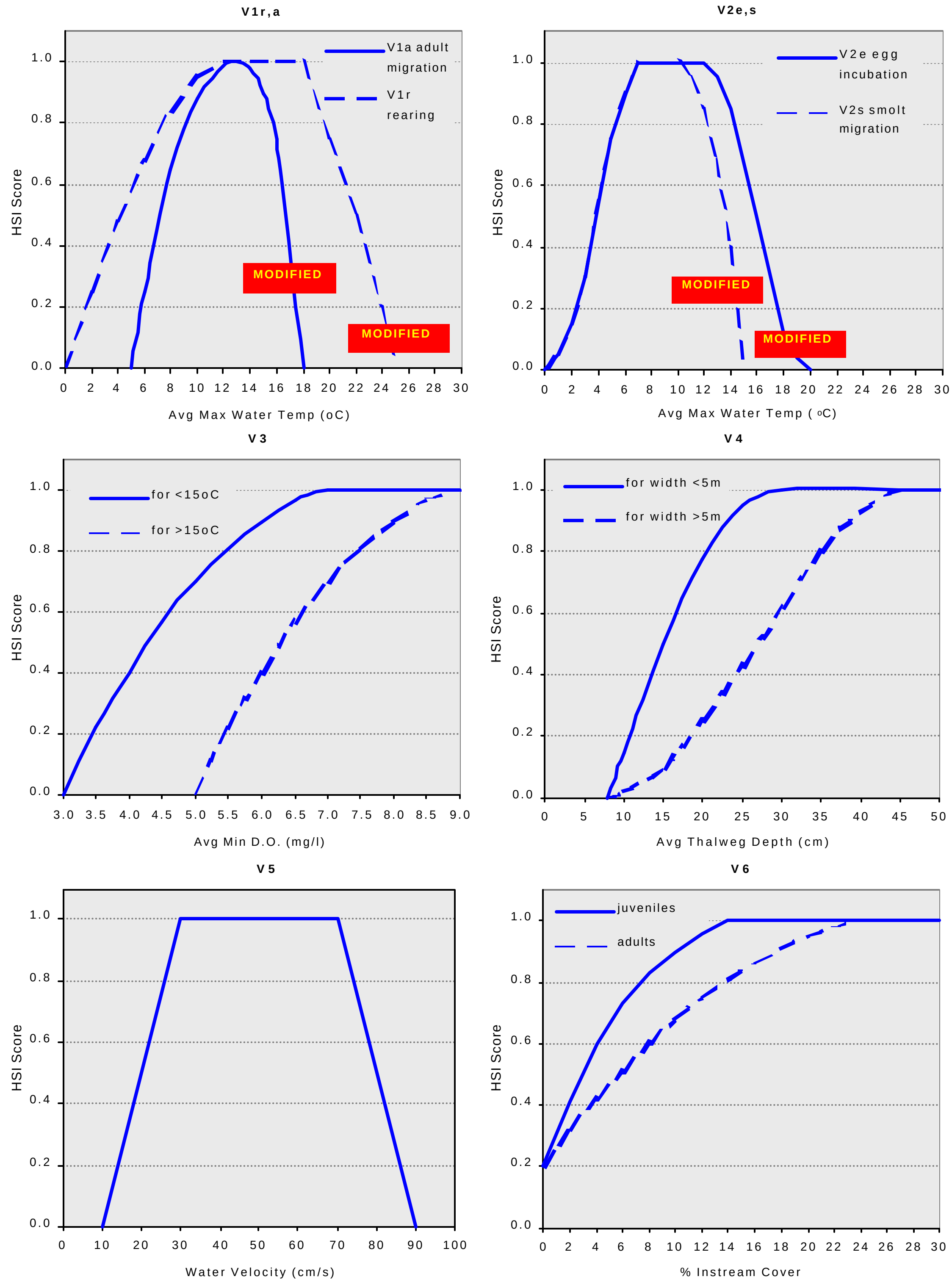


Figure 8. HSI variable curves from Raleigh et al. (1984). Curves selected for modification are shown.

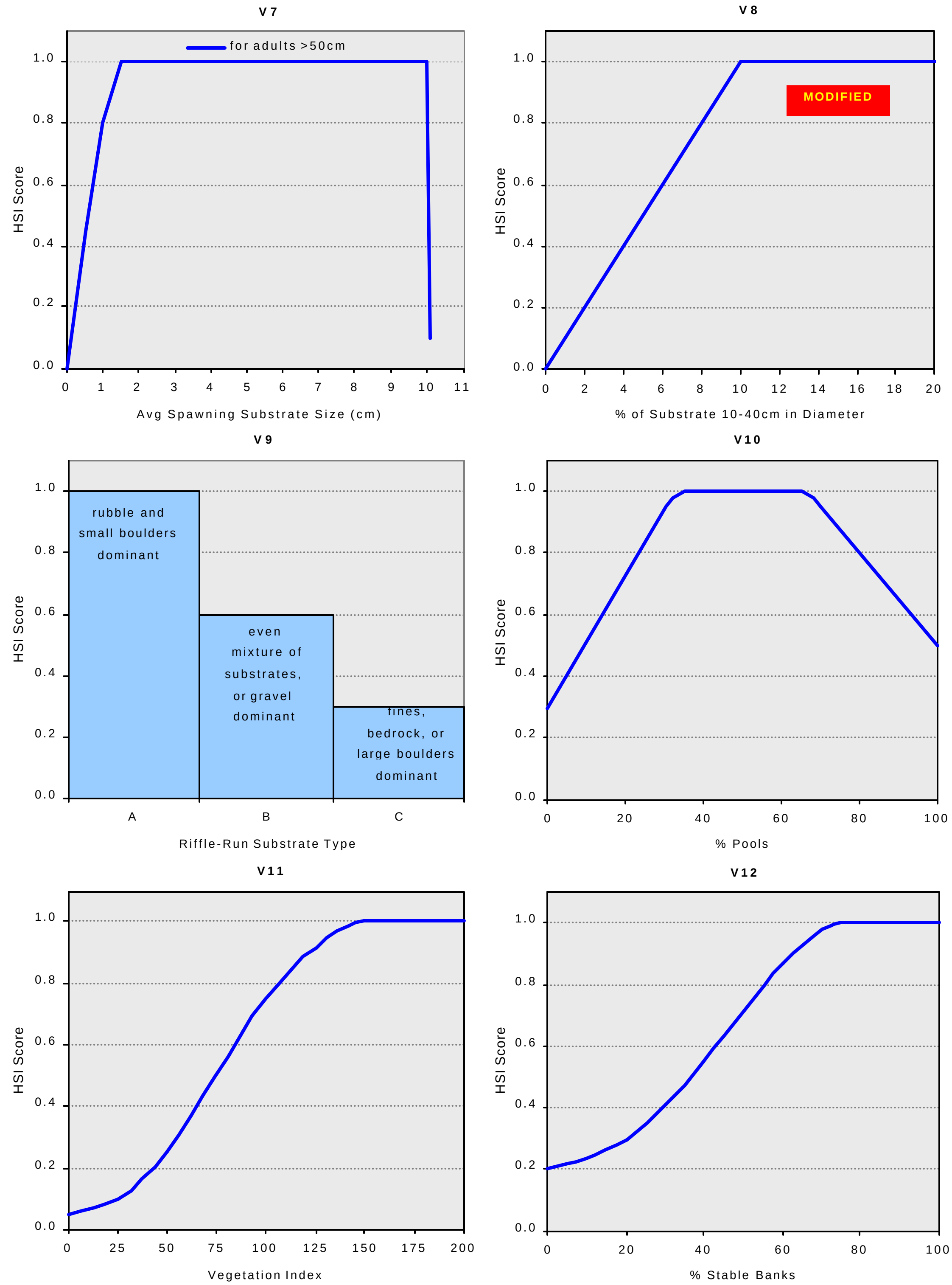


Figure 9. HSI variable curves from Raleigh et al. (1984). Curves selected for modification are shown.

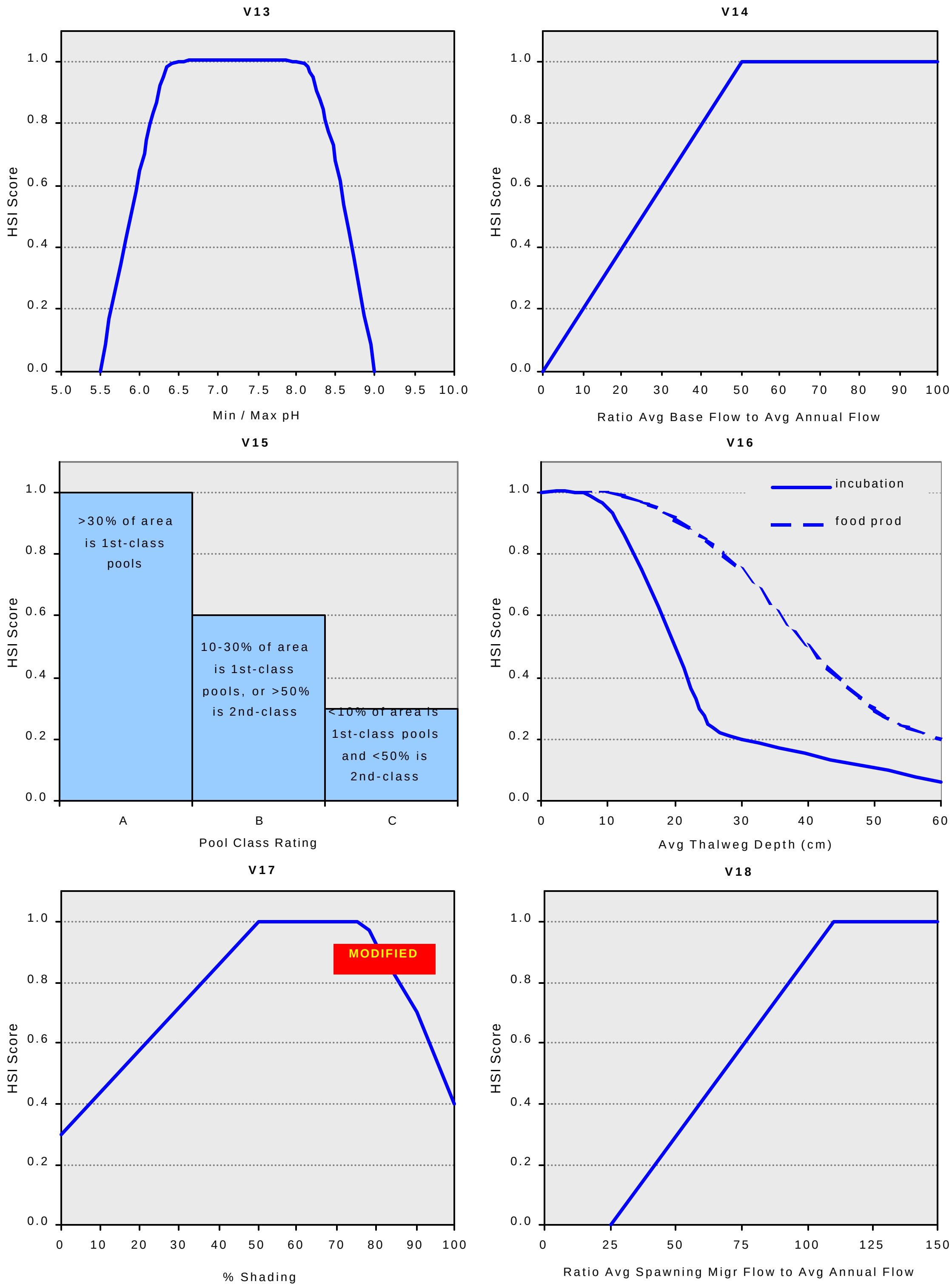


Figure 10. HSI variable curves from Raleigh et al. (1984). Curves selected for modification are shown.

prior to data collection. Similar calibration exercises were conducted in two South-Central California steelhead streams for a previous HSI study (TRPA 2000).

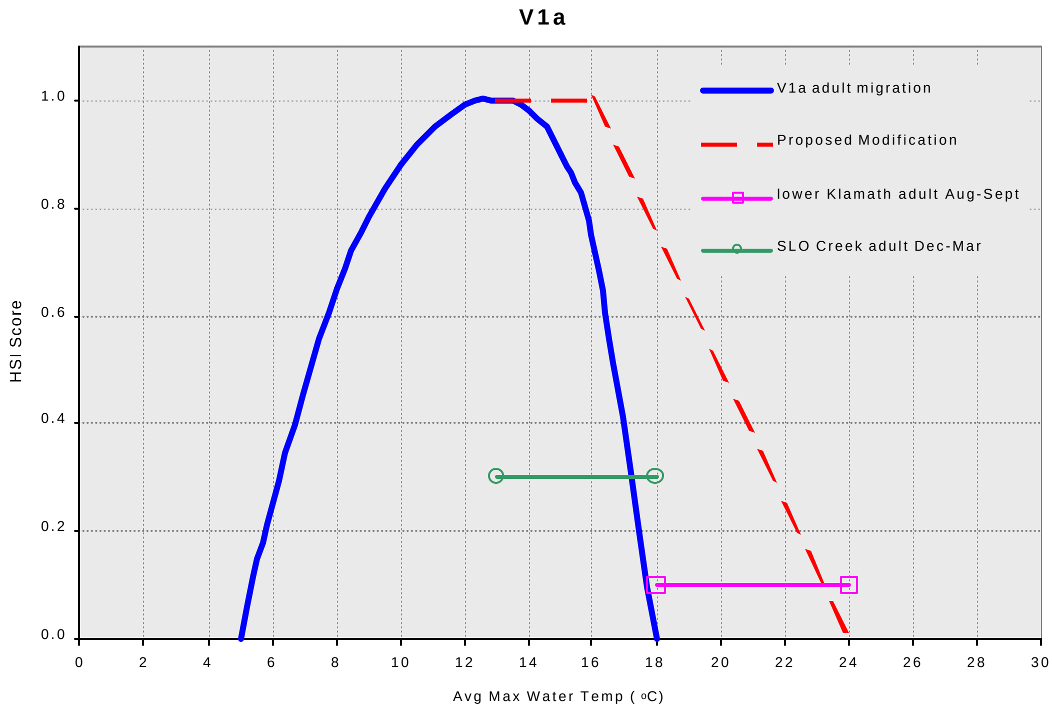
Individual Variable Descriptions

Average Maximum Water Temperature for Adult Upstream Migration (*V1a*) and for Rearing (*V1r*): Water temperatures were repeatedly measured during both the first-stage survey in March 2003 and during the second-stage survey in April 2003 (above Matilija Dam and LNF Matilija) and July 2003 (Ventura River). Because the April water temperatures were not expected to provide a good estimate of average maximum water temperatures, the measured values were calibrated with estimates from other sources of water temperature data, from Ventura County and the USGS gage station (#11118500), to better estimate maximum values. The warm stream temperatures prevalent throughout most of the Ventura/Matilija Basin (and most other Southern California steelhead streams) and the "cool" temperature HSI curves (Figure 8) produced zero HSI scores for all reaches. Given the continued presence of steelhead in the Ventura River and in other nearby watersheds, the Raleigh et al. (1984) HSI curves did not appear to adequately represent temperature suitability for southern steelhead.

Consequently, because of the high genetic variability and the ability of Southern California Steelhead to exist in seemingly unfavorable environments (Moyle 2000), the HSI curves for average maximum temperatures (*V*1 and *V*2) were modified from those in Raleigh et al. (1984). These curves were modified using professional judgment and temperature data from several warm streams in California known to contain abundant steelhead. For example, the adult migration curve (*V1a*) was modified using ambient temperature data during the steelhead migrations in the Lower Klamath River from August to September (US Fish & Wildlife Service, Arcata, CA, website data, http://arcata.fws.gov/fisheries/tempdata.html), and temperature data during the adult migration in San Luis Obispo Creek from December to March (TRPA, unpublished data). Those observed temperature ranges were overlaid with the original HSI curve (using an arbitrary y-coordinate), and then a new, "modified" curve was drawn by eye to include the given data (Figure 11).

As a result of the above modification procedure, the zero point of the adult migration curve was shifted from the original 18°C to 24°C (Figure 11, top). The rearing curve (*V1r*) was likewise modified using available temperature data from the Ventura River (Moore 1980b, USACE 2002), San Luis Obispo Creek (TRPA unpublished data), the upper Klamath River (PacifiCorp relicensing information), the Lower Klamath River at Iron Gate dam and at Seiad Valley (USFWS Arcata, website data), and the maximum tolerable temperature as reported in Moyle (2000). The zero point of the *V1r* rearing curve was only slightly changed based on available data, from 25°C to 26°C (Figure 11, bottom).

It is recognized that these modifications are not based on rigorous scientific evidence, and they may not account for a fish's ability to actively seek out temperature refuges and thereby avoid some of the maximum temperatures described above. Although the temperature requirements of southern steelhead during various life stages is poorly



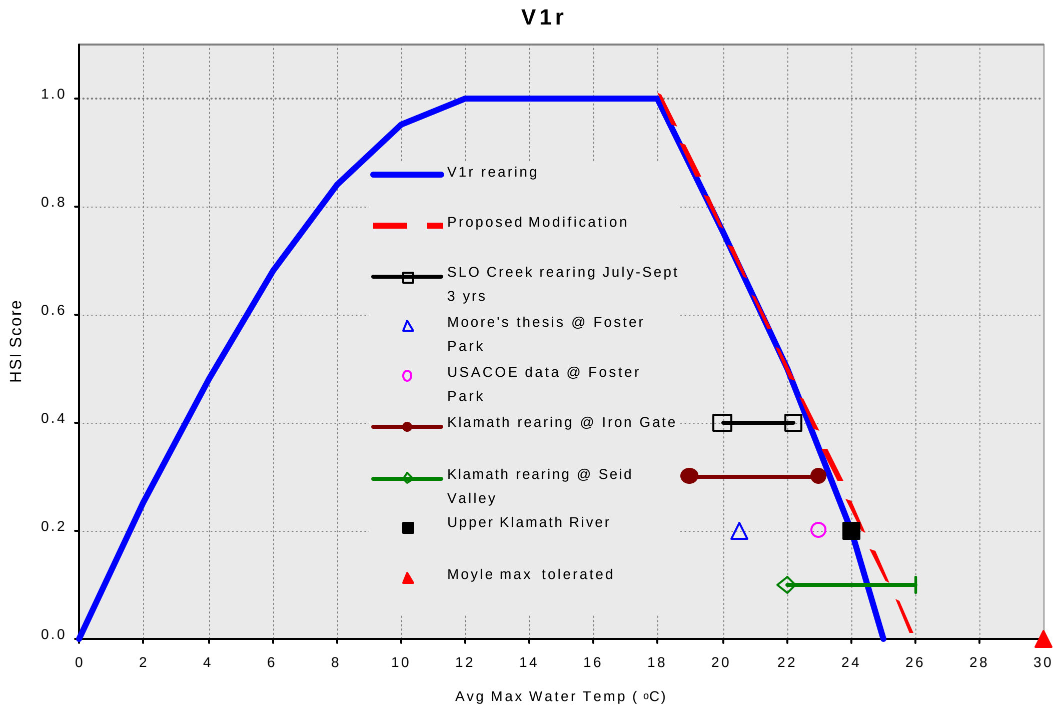


Figure 11. Modified HSI variable curves, showing modified line and supporting data.

understood, it appears that the temperature graphs presented by Raleigh et al. (1984) are inappropriate for southern populations of steelhead for both adult migration (*V1a*) and smolt migration (*V2s*) (see variable description below).

Average Maximum Water Temperature for Incubation (*V2e*) and Smolt Outmigration (*V2s*): As described above, water temperatures were repeatedly measured during both the first-stage survey in March 2003 and during the second-stage survey in April 2003 (above Matilija Dam and LNF Matilija) and July 2003 (Ventura River), however the original HSI curves again produced zero suitability values in all reaches. Suitable temperatures shown in the smolt HSI curve, in particular, fell well below temperatures present in Southern California streams during the spring months. Consequently, the same modification procedures described for variable *V1* were again applied to variable *V2*.

Information was not collected on incubation temperatures in warm steelhead streams, therefore the shown modification was drawn entirely by eye and the proposed change is relatively minor, giving a shift in the zero point from 20^{o}C to 22^{o}C (Figure 12, top). The smolt migration curve (*V2a*) was modified using temperature data from smolt trapping studies on three coastal streams in Northern California: Redwood Creek (Sparkman 2002a, 2003a, and 2004), Mad River (Sparkman 2002b and 2003b), and Bear River (Ricker 2002). Temperature data during smolt migration was also found for the Lower Klamath River (USFWS, Arcata, website data) and from San Luis Obispo Creek (TRPA, unpublished data). All of those streams are known to support wild steelhead populations. The zero point of the smolt migration curve was shifted significantly into warmer water, from 15^{o}C to 24^{o}C (Figure 12, bottom).

Average Minimum Dissolved Oxygen for Rearing (r) and Egg Incubation (e) (*V3*). A portable YSI meter was used to measure D.O. levels during first-stage and second stage surveys, and that data was used to calibrate estimates in combination with available data from other sources, such as D.O. measurements from the USGS gage station on the lower Ventura River, to best estimate minimum values.

Thalweg Depth (*V4*). This variable was derived by measuring depths with an incremented depth rod at 3-5 thalweg locations along the length of each selected habitat unit, with the number of measurements depending upon unit length.

Spawning Area Velocity (*V5*). Velocities over potential spawning areas were measured using a pygmy flow meter attached to a wooden dowel. Because this data was collected during the second-stage survey at flows lower than what a spawning fish would likely encounter, an expansion factor was derived by using a limited set of comparative velocity measurements taken at specific locations during both the first-stage survey (during moderate flow conditions) and the second-stage survey (at lower flow conditions). Four locations were selected on gravel patches and marked with stakes in the Upper North Fork Matilija Creek. The second-stage survey occurred following a major flood event, and only two of the four locations appeared relatively unaltered; therefore comparative velocities were obtained from those positions. The final expansion (or, calibration) factor

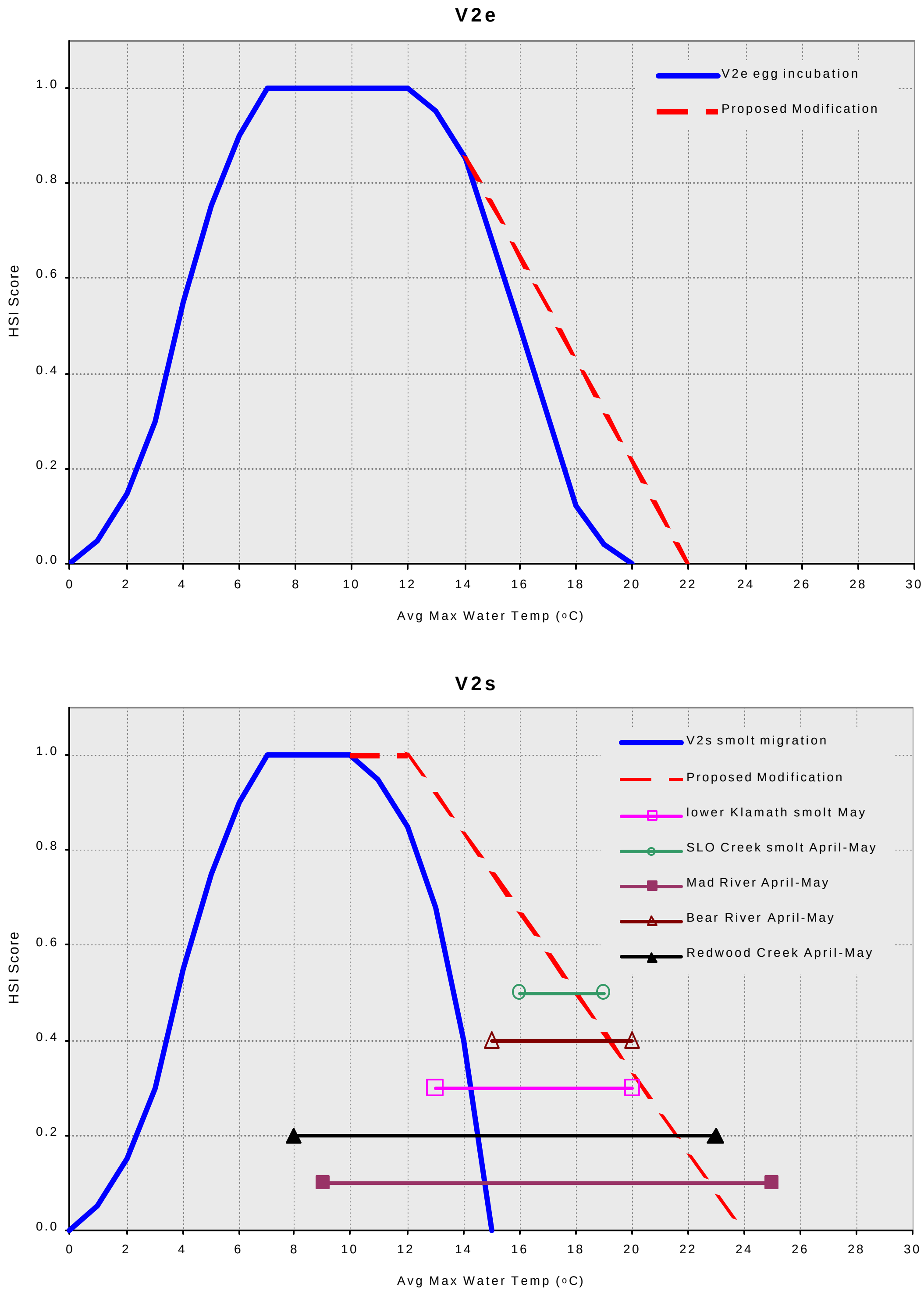


Figure 12. Modified HSI variable curves, showing modified line and supporting data.

of 2.0 was calculated as the mean ratio of the high flow velocity:low flow velocity for each of the comparative measurements.

Percent Instream Cover (*V6j,a*). This eye-estimated variable included any physical object or turbulence that is deemed capable of hiding a juvenile steelhead (*V6j*) or adult trout (*V6a*). Area classified as instream cover must also meet depth and velocity criteria of >0.5 ft and <0.5 fps, respectively. The minimum depth of six inches is undoubtedly too shallow for use with adult steelhead (which would require deeper water), however this criterion was not modified and thus the given areas of adult cover were likely over-estimated. Because instream cover is a highly subjective variable that is very difficult to accurately measure, eye estimates were made within a preliminary sample of test habitat units and calibrated against actual area measurements of individual cover components within the same habitat unit.

Spawning Gravel Size (*V7*). Average substrate sizes in spawning areas were eye estimated with reference to a measuring rod incremented with substrate size classes.

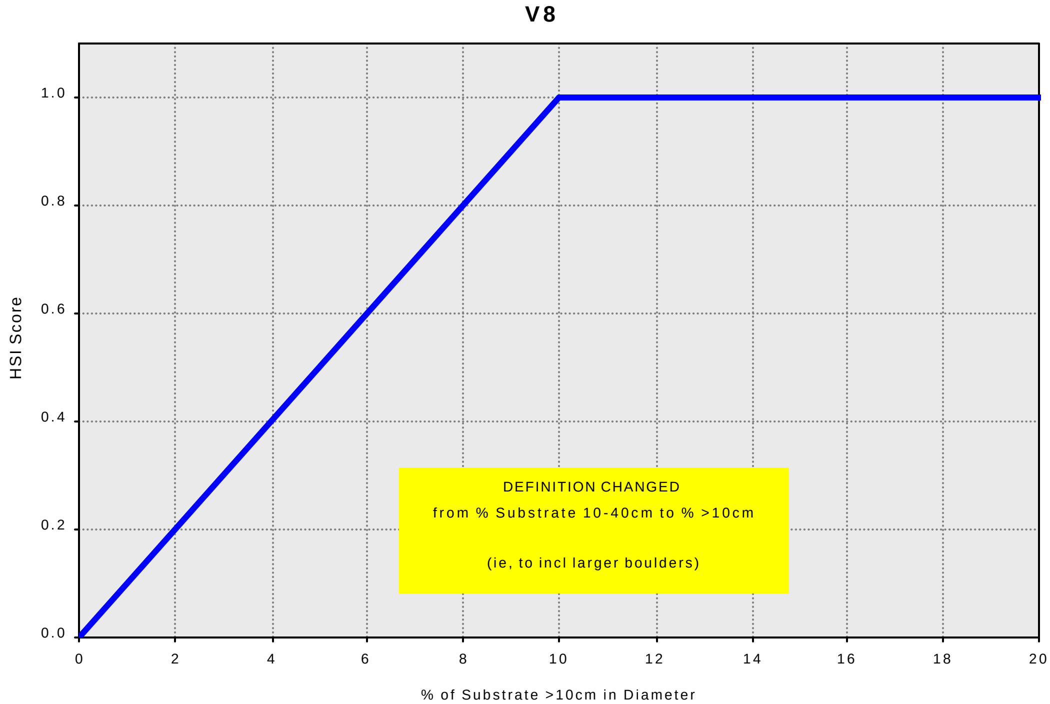
Percent Large Rearing Substrate (*V8*). Winter hiding substrate was defined by Raleigh at al. (1984) as substrate particles 10cm to 40cm in diameter. Following discussions with personnel from the EWG, we re-defined winter cover as any substrate particle >10cm in diameter, thus including larger boulders (Figure 13, top). This variable was eye estimated with reference to a measuring rod incremented with substrate size classes. Eye-estimated values for this variable was also calibrated with actual area measurements within a preliminary sample of test habitat units, as described for percent instream cover.

Dominant Substrate in Riffles (*V9*). Dominant substrate is characterized according to three categories: A = rubble and small boulders dominate; B = gravel dominant, or fines, gravel, rubble, and boulders equally dominant; or C = fines, large boulders, or bedrock dominant. Dominant substrate class was eye-estimated with reference to a measuring rod incremented with substrate size classes.

Percent Pools (*V10*). This value was directly estimated by comparing total length from pools with lengths of all measured habitat units.

Percent Vegetative and Canopy Cover (*V11*). Percent vegetation coverage of each streambank was eye-estimated within three classes, % shrubs, % grasses, and % trees. These three estimates are combined to produce a vegetation index that is related to the amount of allochthonous materials deposited into the stream. Eye-estimates were calibrated in test habitat units, prior to sampling, by measuring the total bank distance containing each vegetation type.

Percent Rooted Vegetation or Rock (*V12*). This bank stability rating was eye-estimated and calibrated according to the procedures described above for vegetation.



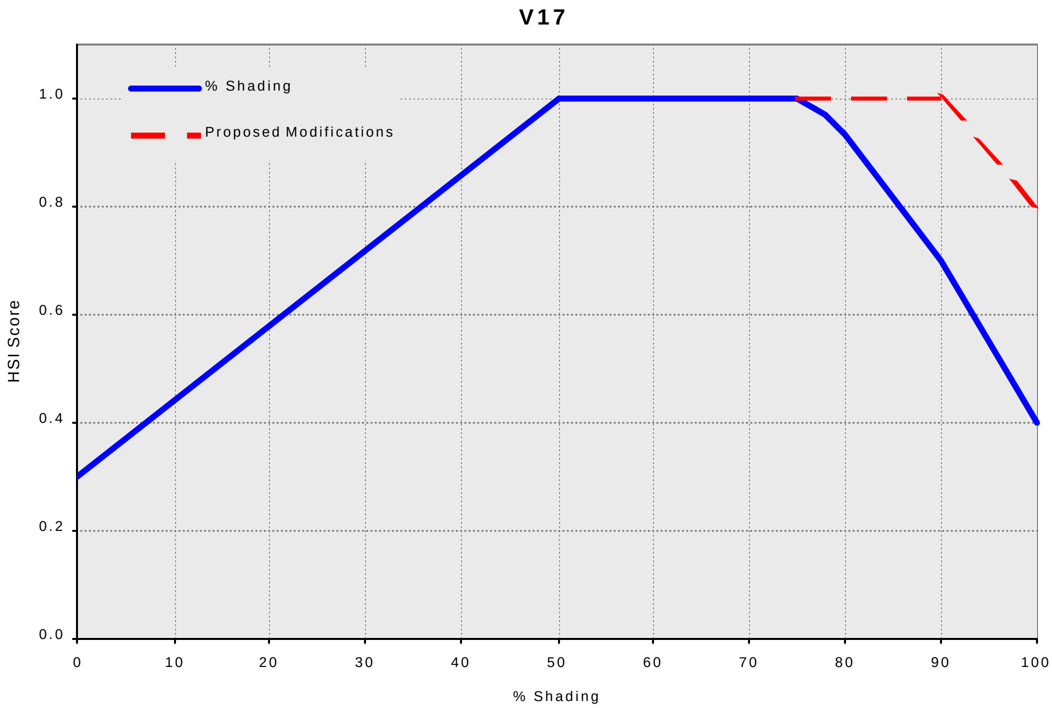


Figure 13. Modified HSI variable curves, showing modified line or definition.

<u>Annual Maximum / Minimum pH</u> (*V13*). pH values were measured in each study site during the second-stage survey using a Pinpoint pH monitor.

<u>Average Annual Base Flow</u> (*V14*). This variable is a ratio of the mean low flow to the mean annual flow and was estimated using historical streamflow data available from the USGS gaging stations in the Matilija Basin. Historical flow data (1959-2002) from the USGS Gage station on the Ventura River at Foster park (#11118500) was used to calculate this ratio for the lower Ventura River reaches, using the months of August through October to represent the base flow period. Historical flow data (1927-1988) from the gage below Matilija Dam (#11115500) was used to estimate this ratio for the VEN 6 reach. Historical data (1928-1983) from the gage on Lower North Fork Matilija Creek (#11116000) was used to estimate the ratio for the Lower North Fork reaches, and was applied to the upper reaches Matilija Creek and it's tributaries. The ratio for the lower reaches of the mainstem Matilija (MAT 3 and MAT 5) was derived from historical data (1948-1969) from the gage above Matilija Dam (#11114500).

<u>Pool Class Rating</u> (*V15*). Pool class is a subjective assessment based on maximum depth (a measured variable), % bottom obscurity (an eye-estimated variable), and pool size (a measured variable). The overall score is based on the proportion of pools that score as 1st class or 2nd class. A general description of a 1st class pool is large and deep, with >30% of bottom not visible, or maximum depth >1.5m for streams <5m wide (or, depth >2m for wider streams). A 2nd class pool is moderate in size and depth, with 5-30% of bottom not visible. A 3rd class pool is small and shallow with little cover and the entire bottom visible.

<u>Percent Fines in Riffles and Spawning Areas</u> (*V16i,f*). This percentage was estimated using 3 to 5 "random" tosses of the 1 ft^2 metal square as described for % winter substrate. The square contains a wire-mesh grid with 50 intersections. The number of intersections directly overlaying fine substrate (defined as sand or smaller particles) was multiplied by two to produce a percentage of fines. An average value was then calculated over the 3 to 5 samples per habitat unit.

<u>Percent Overhead Shading</u> (*V17*). Midday shading was eye-estimated from several locations in each selected habitat unit, with the number depending upon unit size and riparian complexity. This estimate was also calibrated from a preliminary sample of test habitat units using a spherical densiometer to estimate "true" canopy closure. The HSI curve used in this study was modified from the original curve presented in Raleigh et al. (1984), by extending the area of maximum habitat suitability to include areas with greater canopy closure (Figure 13, bottom). Although closed canopies would typically result in lower invertebrate production, the added benefit of cooling the water temperatures in Southern California streams might be expected to offset the reduced food production. Consequently, the HSI score of 1.0 was extended to include shade values from 75% to 90%.

Average Migration Flow (*V18*). This variable is a ratio of the mean flow during upstream migration (defined as December to March) to the annual mean flow, and is intended to represent suitability for migrating adult steelhead. This variable was estimated using the same historical streamflow data as *V14*.

Distance/Size Estimates. Habitat unit lengths and widths were measured using a hip-chain for lengths and either a stadia rod or a hand-held laser rangefinder for widths.

Photographs were taken during the second-stage surveys to document habitat and channel characteristics of each selected habitat unit (Appendix C).

Analysis of HSI Data

The variables described above were evaluated according to standard HSI procedures described in Raleigh et al. (1984), and by using visual assessments of graphical output and comparison of mean values among study sites. The HSI procedures allow the user to select from several different model options. We utilized the "Riverine Model" calculated with the "Equal Component Value Method". The equal component method assumes that all components (e.g., adult, juvenile, fry, incubation, and other, Figure 7) have equal importance in determining the overall HSI score. As such, all of the 18 HSI variables were included in the HSI score calculations. See Raleigh et al. (1984) for the specific formulas used. The overall HSI score ranges from a low value of 0.0 to a maximum of 1.0. As such, the higher the score, the higher the assumed suitability of the overall habitat. Although the overall HSI scores cannot be directly translated into fish densities without fish population sampling and model verification, the assumption is that higher HSI scores represent habitat that could potentially support a higher abundance of fish. Also, HSI scores can be compared among different streams or stream reaches to assess the relative suitability of each area, and perhaps to identify which areas would most benefit from habitat enhancement. In addition, the HSI scores for individual habitat parameters can be compared to see which values are most responsible for producing a low overall HSI score.

Because the HSI score is determined independently of habitat area, the score value does not account for the effects of habitat quantity. A qualitative comparison of habitat "value" based on both quality (the HSI score) and quantity (total area, represented by reach length) was made among tributaries or stream reaches by calculating a "habitat value score". The true "value" of the aquatic habitat cannot be precisely quantified and it depends on a myriad of factors not included in the HSI model, such as abundance of other aquatic and riparian species, recreational and aesthetic uses, and many other factors.

For the purpose of this steelhead study, the habitat value score was calculated by weighting each stream or reach's HSI score by the surface area (in ft^2) of habitat available within that stream or reach according to sub basin. The lower sub basin was defined as the mainstem Ventura River below Matilija Dam (including the short reach of Matilija Creek between the dam and the Lower North Fork, Figure 5), and the upper sub basin included Matilija Creek and tributaries above the dam, and the Lower North Fork

Matilija Creek (which in physical characteristics is more similar to the upper sub basin despite its location below Matilija Dam). Although this value is dimensionless, it assumes that a large area of lower quality habitat may be roughly equivalent to a small area of higher quality habitat. Such a simplistic relationship may not be accurate, but it may provide guidance in assessing overall habitat value and in directing future restoration efforts.

Alternative Habitat Area Scenarios

In addition to the standard (or, "original") HSI analysis described above, alternative HSI scores were developed in an effort to estimate habitat "value" above and below Matilija Dam during more optimal and during less optimal conditions. This analysis was conducted in recognition that streamflow and habitat conditions in southern California may vary dramatically from year to year, and the HSI data collected in 2003 may not be representative of habitat conditions in other years. Optimal and sub optimal scenarios were created by varying the amount of habitat available via assumed changes in streamflow and changes in assessment of migrational barriers, however it was assumed the physical habitat producing the HSI scores did not change. Thus, stream thalweg depths, spawning area velocities, etc. were held constant under each scenario, even though such variables would change with differences in streamflow. Estimating such changes would require additional HSI measurements under different flow conditions, which was beyond the scope of this study. Consequently the alternative habitat area results give only qualitative estimates of the potential changes in habitat value under different water years.

To estimate habitat value during more optimal conditions, it was assumed that the area available for rearing was greater due to higher streamflows (i.e., a wet year). This analysis assumed that all reaches classified as dry or intermittent and without habitat value for the original analysis (Table 1) were now available for rearing. Consequently, the new habitat areas (estimated by reach length from the nearest wetted channel) were multiplied by the HSI scores from the nearest appropriate study site. To estimate habitat value under less-optimal conditions (i.e., a drier year), several of the reaches included in the original analysis were assumed to go dry, and thus the habitat areas were reduced (but the HSI scores for the remaining reaches did not change). Also, it was assumed that all barriers classified during the first-stage survey as "probable" were effective barriers, thus all areas above such barriers were eliminated from available habitat. Habitat values were then recalculated using the new area definitions for above and below Matilija Dam.

Alternative HSI Curve Modifications

The modification of HSI curves as described above was expected to produce significant changes in the overall HSI scores. However, because considerable uncertainty existed in how the modified curves were drawn, and the subsequent effects of those changes on the overall score was not clearly understood, a qualitative sensitivity test was performed using the two variables that were most highly modified (variables *V1a* and *V2s*). To test the sensitivity of the proposed modifications, two additional temperature lines were

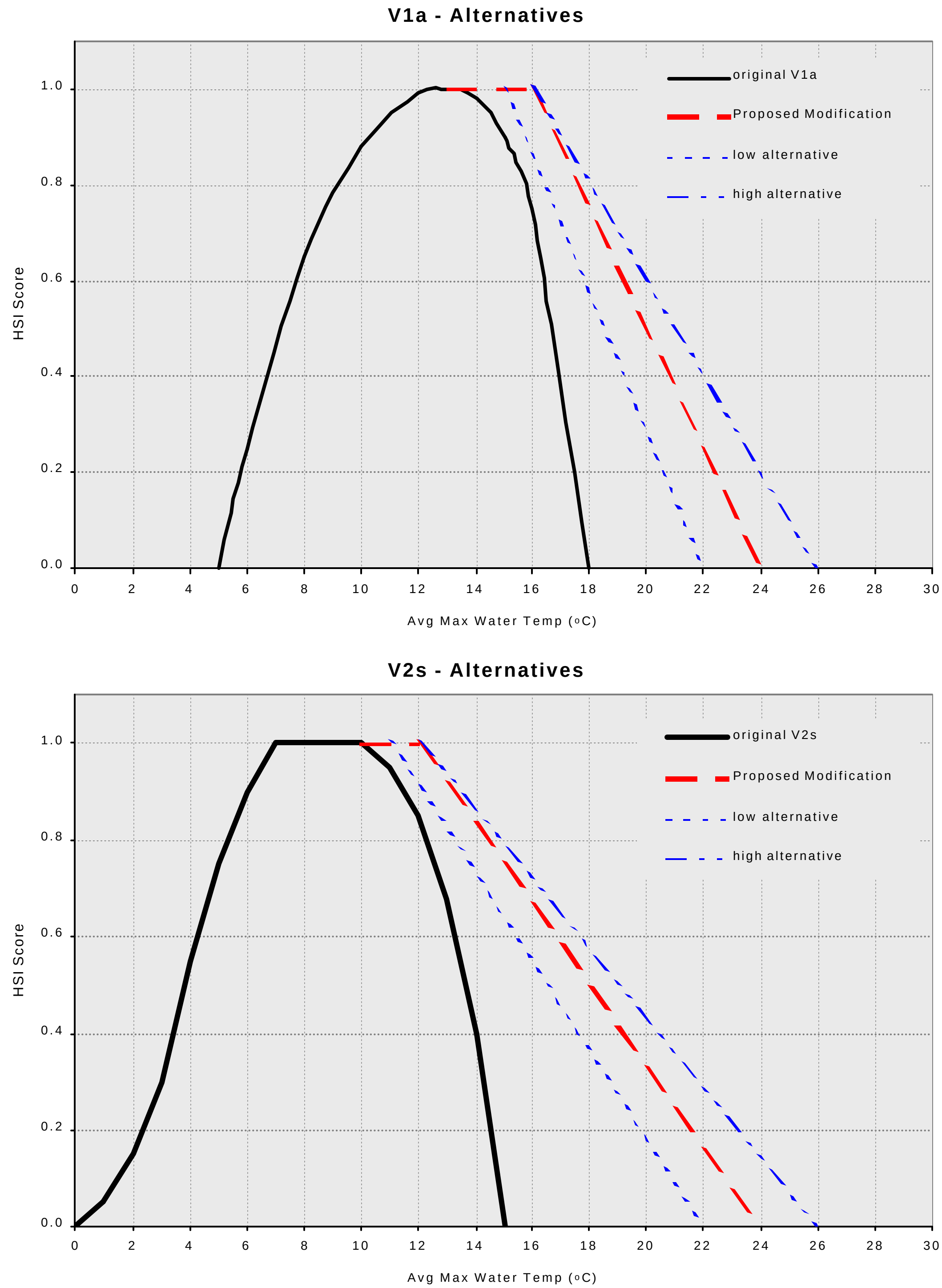


Figure 14. Modified HSI curves showing alternative lines used in sensitivity test of curve modifications.

drawn for each variable, one line giving lower suitability for high temperatures and the other line giving higher suitability for high temperatures (Figure 14). The low and high alternative lines bracket and are approximately parallel to the proposed modification line, and were drawn by eye without reference to specific data. The sensitivity comparison did not include the original Raleigh line because those curves produced zero suitability in all reaches. This sensitivity test was not performed for all HSI study sites, but for six of the 17 sites. Three study sites (VEN 1, VEN 6, MAT 3) were selected to represent lower river mainstem habitat, and three sites (MAT 7, LNF low, UNF up) were selected to represent upper basin habitat.

RESULTS

Stream Conditions During HSI Surveys

Streamflows in Southern California steelhead streams are highly variable and subject to extreme fluctuations. Streamflows respond rapidly to rainfall events, but flows typically subside quickly when precipitation ceases. Significant rainfall events in Southern California are frequently intense, but they are typically of short duration, occur relatively infrequently, and are highly unpredictable from year to year. Consequently, seasonal streamflows in streams such as the Matilija are highly dynamic and difficult to characterize using conventional parameters such as "mean" flow.

This HSI study was performed in April 2003 following a very dry water year with precipitation only $^{1}/_{3}$ of the long-term average; consequently the spring streamflow conditions were expected to adequately represent base flow conditions for a normal water year. Flow duration curves for Upper Matilija Creek, Lower North Fork Matilija Creek, and the Lower Ventura River (Bureau of Reclamation 2003) show that flows measured during this study (12.4 cfs, 3.9 cfs, and ~12 cfs, respectively) are exceeded only 20% to 32% of the time, and thus appear similar to base flow conditions during a normal summer (Figure 15).

A more direct comparison of historical mean monthly flows during March for the Upper Matilija Basin and Lower North Fork Matilija Creek with measured flows during the first-stage survey, shows that flows during the 2003 study were well below mean flows and similar to other dry years, which again suggests that the spring HSI data might be more representative of summer base flow conditions (Figure 16). A similar comparison of mean July flows in the Lower Ventura River with an eye-estimated flow during the second-stage survey suggests a somewhat higher than normal flow in those reaches, however it is unclear how the Foster Park diversion affects the historical data shown here. Figure 16 clearly shows the highly variable nature of mean monthly flows, and how a mean value calculated from the period of record would produce a much higher value than what appears to be "typical" for those months.

A frequency analysis of the mean flows again shows that the measured flows in 2003 were typical of low flow years for the upper basin reaches, but that summer flows in the Lower Ventura River may have been higher than normal (Figure 17).

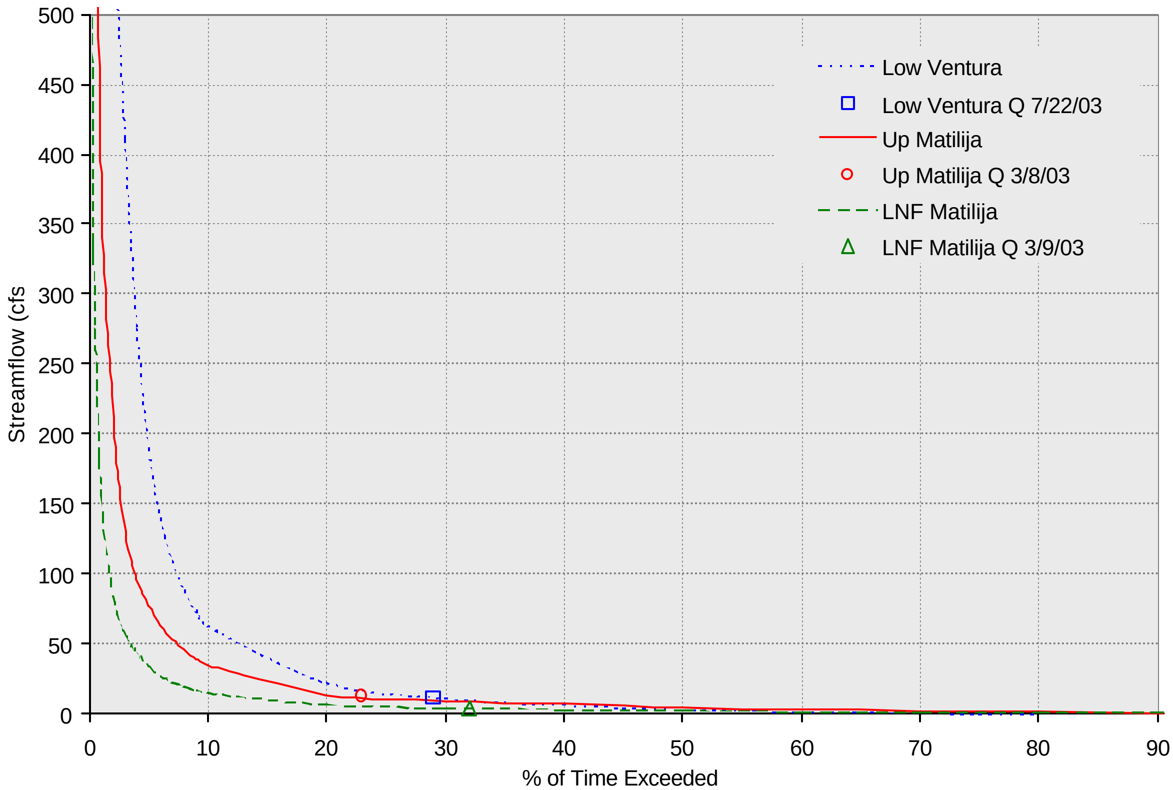


Figure 15. Flow exceedance curves for the Ventura River, Matilija Creek, and North Fork Matilija Creek. Data from Bureau of Reclamation (2003).

General Habitat Characteristics of HSI Study Sites

General Stream Conditions

HSI surveys were conducted in the upper Matilija Creek Basin and the Lower North Fork Matilija Creek in April 2003, and in the lower Ventura River July 2003 (Table 4). Estimated flows in the Ventura River ranged from a low of 4 cfs in the VEN 6 reach immediately below Matilija Dam, to a high of 13 cfs in the VEN 3 reach. Water temperatures in the Ventura River ranged from a morning low of 65°F to an afternoon high of 84°F during the July survey. Estimated flows in the upper Matilija Basin ranged from zero surface flow in portions of Old Man Creek and Murietta Creek, to 14 cfs in the mainstem above the reservoir. Eye-estimated flows during the April HSI survey appeared slightly higher than measured flows during the March first-stage survey, due to spring rainfall events that occurred during the interim period. Measured temperatures in April ranged from a low of 50°F in the Upper North Fork to a high of 70°F in the lower mainstem Matilija.

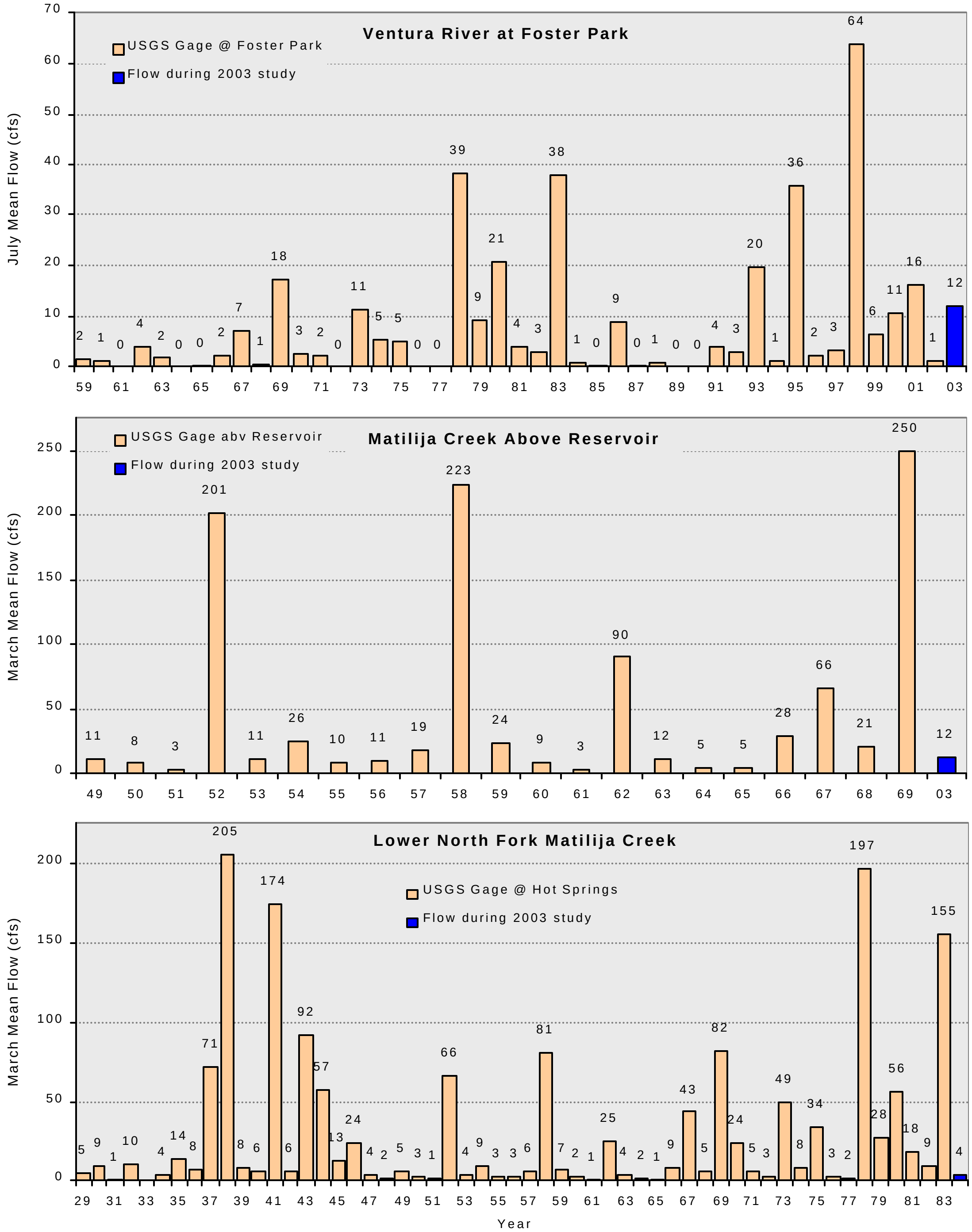


Figure 16. Mean monthly flows for the lower Ventura River in July (upper graph), Matilija Creek in March (middle graph), and North Fork Matilija Creek in March (lower graph). Streamflows measured during the HSI surveys in 2003 are also shown.

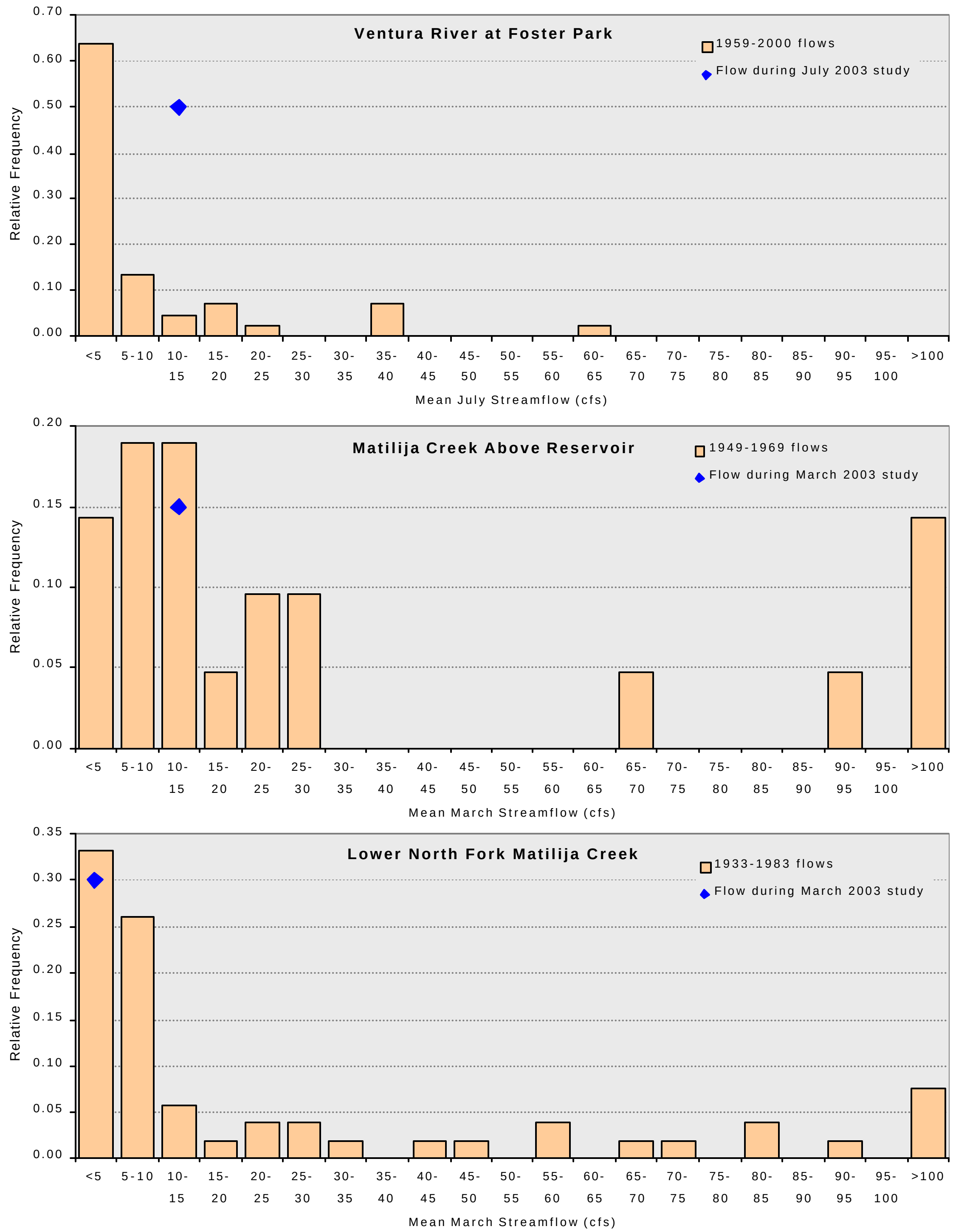


Figure 17. Frequency distribution of mean monthly flows for the lower Ventura River in July (upper graph), Matilija Creek in March (middle graph), and North Fork Matilija Creek in March (lower graph). The relative positions of streamflows measured during the HSI surveys in 2003 are also shown.

Table 4. Sampling statistics and habitat characteristics for the HSI study sites.

HSI Study Site	Sampling Date	Est. Flow	Water Temps (°F) min	max	Study Site Length	# Habitat Units Avail	# Units Selected for HSI Measurement Pools	Flatwaters	Riffles	Total
VEN 1	7/22/03	12	71	78	4,325	56	5	8	5	18
VEN 2	7/22/03	7	69	78	5,247	48	3	6	8	17
VEN 3	7/23/03	13	65	77	5,430	40	3	11	5	19
VEN 5	7/25/03	6	72	84	3,100	63	6	5	5	16
VEN 6	7/25/03	4	-	78	3,225	67	4	8	5	17
LNF xtra	4/16/03	8	-	60	1,945	72	4	9	5	18
LNF low	4/16/03	5	51	-	2,076	69	5	10	8	23
LNF up	4/16/03	3	-	58	1,888	120	7	9	4	20
MAT 3	4/9/03	14	59	66	1,459	57	0	18	2	20
MAT 5	4/9/03	14	-	70	2,413	59	3	14	4	21
MAT 6	4/10/03	5	59	63	2,012	77	2	10	8	20
MAT 7	4/10/03	5	-	63	2,269	66	11	8	3	22
MUR 3	4/11/03	4	54	57	2,163	84	6	6	9	21
OLD 2	4/11/03	0.5	56	59	2,038	105	9	4	8	21
UNF low	4/12/03	3	-	60	2,173	80	3	13	4	20
UNF 2	4/17/03	5	50	-	1,709	80	8	8	4	20
UNF up	4/17/03	5	-	54	1,804	84	7	9	5	21

Habitat Proportions

The lengths of the 17 individual HSI study sites ranged from a minimum of 1,459 ft for the MAT 3 site (most of that reach was on private property) to a maximum of 5,430 ft for the VEN 3 site (Table 4). Study sites contained between 40 and 120 individual habitat units, with 16 to 23 habitat units randomly selected in each HSI study site for collection of HSI data. Habitat mapping data for each study site is provided in Appendix D.

A comparison of the primary habitat types (e.g., pools, flat waters, riffles, Table 2) among the HSI study sites shows several general trends. The relative proportion of pools varied from a low of 7% (by length) in the lower Matilija (MAT 3) to a high of 38% in Old Man Creek, but in most study sites pools comprised at least 20% of the available habitat. Flat water habitats dominated most study sites with an average of 40% to 60% of the habitat (range = 26% in OLD 2 to 75% in MAT 3). Riffles comprised between 20% and 40% of the available habitat in all study sites except MAT 3, which contained 18% riffles.

Comparing the above proportions to the numbers of pools, flat waters, and riffles randomly selected for collection of HSI data in each study site shows good similarity (Table 4), even for the unusual distributions seen in MAT 3 and OLD 2. Consequently, the overall HSI scores calculated from each study site should be representative of that site.

When the primary habitat types are partitioned into the 19 main channel habitat types (Table 2) it can be seen that main channel pools (MCP) are predominant in all study sites (Figures 18-20). Lateral scour pools formed by boulders (LSBo) or bedrock (LSBk) were also found in many study sites, whereas step-pools (STP) were typically only seen in the

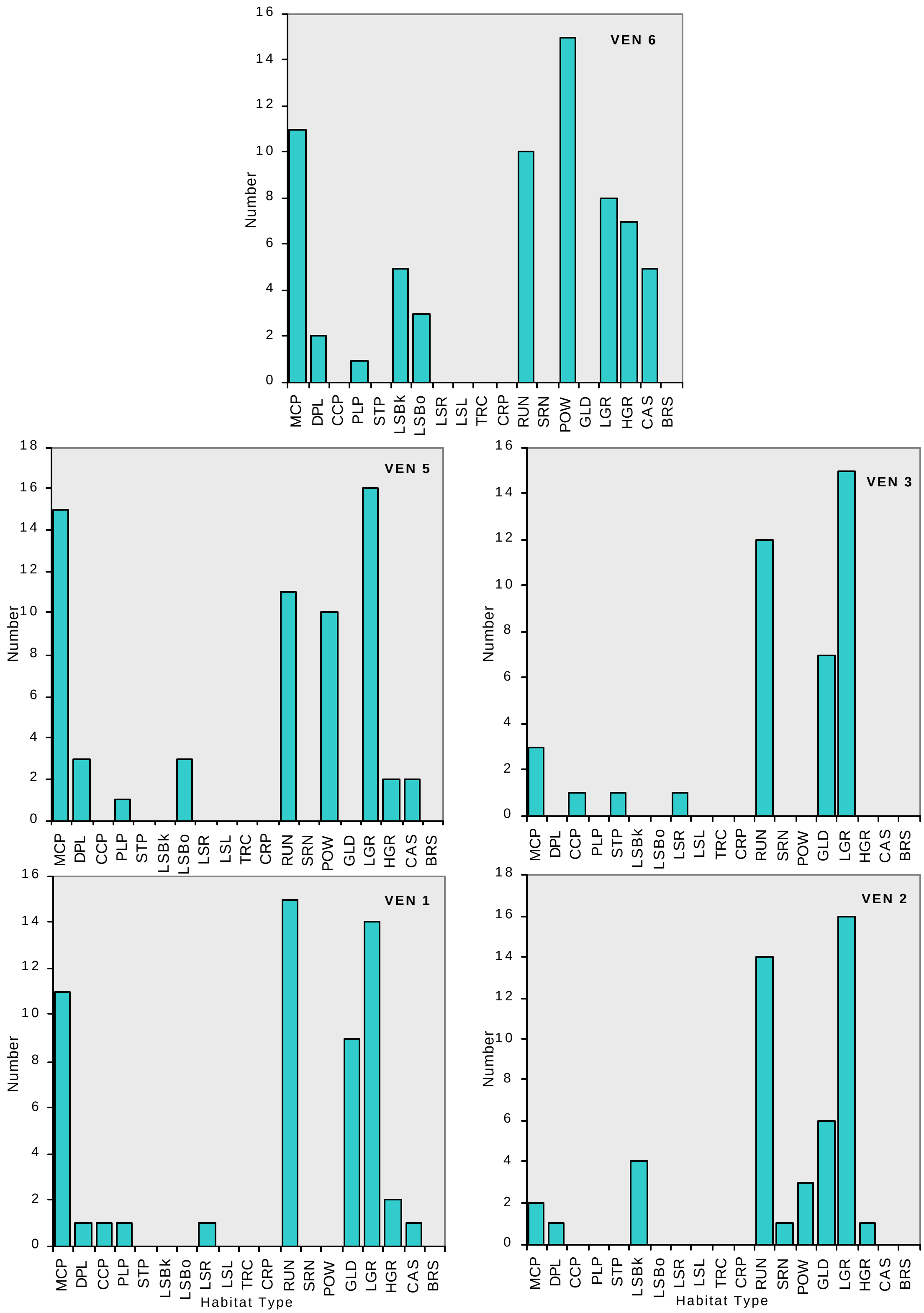


Figure 18. Frequency distribution of habitat types in HSI study reaches in the Ventura River. See Table 2 for habitat type codes.

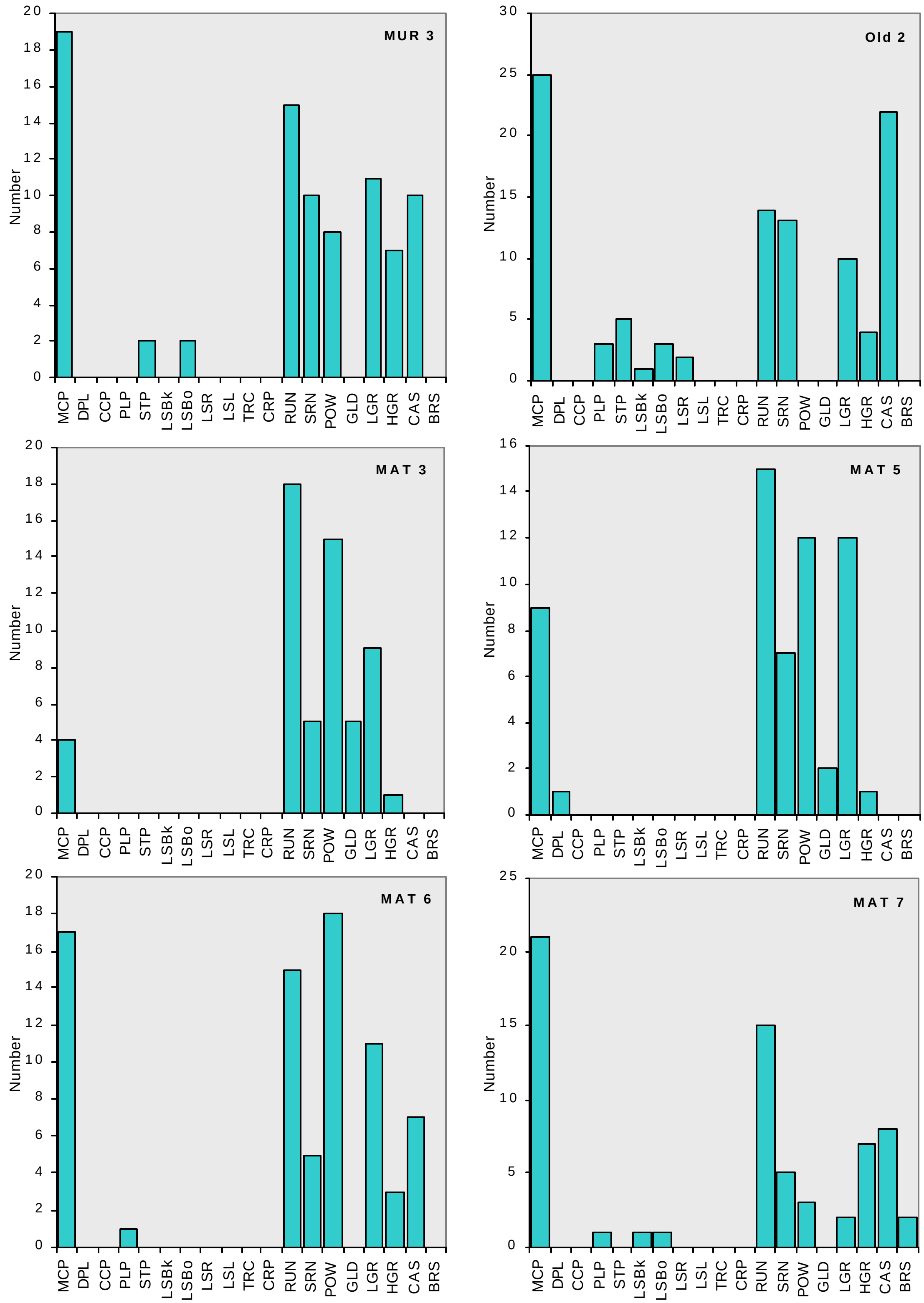


Figure 19. Frequency distribution of habitat types in HSI study reaches in the upper Matilija Basin. See Table 2 for habitat type codes.

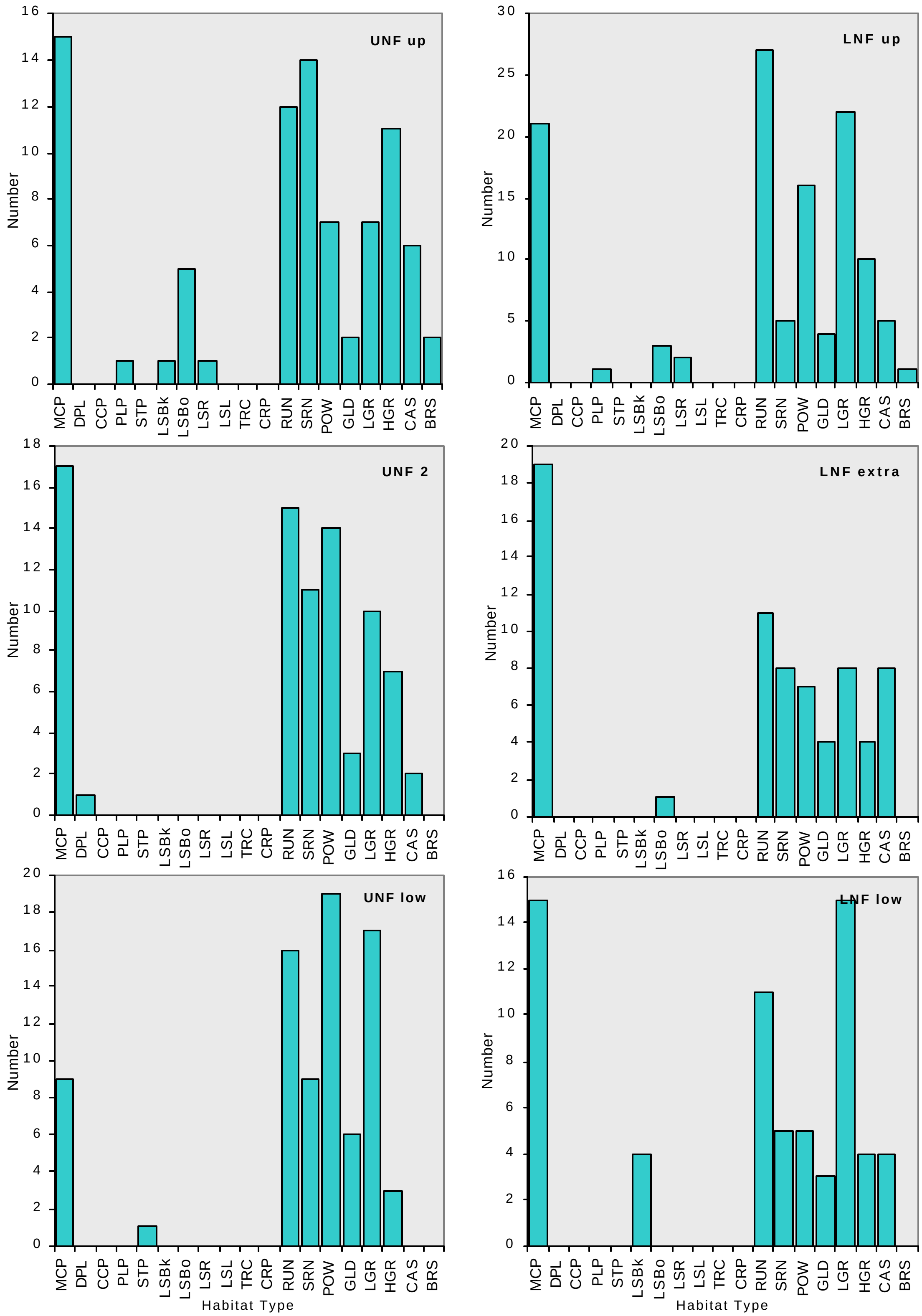


Figure 20. Frequency distribution of habitat types in HSI study reaches in the Upper and Lower North Forks of Matilija Creek. See Table 2 for habitat type codes.

smaller, higher gradient sites like OLD 2 and MUR 3. The relative scarcity of woody-debris formed pools is evident by the lack of those habitat types (LSR and LSL), of which only seven were observed. Dammed pools (DPL) and plunge-pools (PLP) were occasionally seen at some sites. Flat water habitats were dominated by runs (RUN), pocketwaters (PO, or POW), and, in steeper sites, step-runs (SRN). Glides (GLD) were common in the lower Ventura River sites, but were a minor component of flat water habitat at most other sites. Among the riffle habitats, low-gradient riffles (LGR, <4% slope) dominated in the lower Ventura River and lower Matilija Creek study sites, but high gradient riffles (HGR) and cascades (CAS) increased in abundance in the upper study sites, and became dominant in some locations such as OLD 2 and MAT 7. Bedrock sheets (BRS) were only observed in the highest study sites in Matilija Creek (MAT 7) and in both North Forks (UNF up and LNF up).

Physical Habitat Measurements

A visual comparison of the specific habitat parameters measured in each randomly selected habitat unit shows high similarities in some variables, but wide variation in others (Table 5). For example, habitat unit lengths consistently averaged between 25 ft and 50 ft in all study sites except in the lower Ventura River, where units averaged between 70 ft and 130 ft (Figure 21). Mean widths varied as predicted with wider habitat units in lower stream reaches and narrower units in upper stream reaches. The narrow widths measured in the VEN 1 study site may be related to the relatively thick vegetation (mostly shrubs) that bordered both banks and appeared to confine the wetted channel. Mean thalweg depth was between 1 ft and 2 ft in all 17 study sites, although the maximum depths were much greater in the mainstem sites, particularly in VEN 2 and VEN 6 which both contained large, bedrock-formed pools. Maximum pool depth similarly shows the greater depths in the two Ventura River sites mentioned above, as well as in the MAT 6 and MAT 7 sites that contained numerous midchannel pools.

In general, the cover-related variables showed a lot of variability among study sites (Table 5, Figure 22). Surprisingly, the highest mean values for % juvenile cover occurred in the two lowest Matilija Creek study sites. The relative lack of pool habitat and preponderance of riffle and run habitat in MAT 3 may in part explain this result, as does the relatively low estimates for percentage fines which would otherwise embed the substrate materials and prevent juvenile fish from using it as instream cover. The lowest values of instream cover occurred in the VEN 3 site and the lowest site in the Lower North Fork Matilija Creek (LNF xtra). Adult cover was typically low (<10%) in all study sites, but the maximum values show some units that contained abundant cover in several sites, including VEN 2 and VEN 6 which contained large, deep bedrock pools. High values were also recorded for units in the Lower North Fork Matilija Creek and in Murietta Creek.

The percentage of overwintering cover is largely based on the amount of larger substrate particles (>10cm in diameter) that are unembedded by fines, but also occur in slow velocities. The highest mean values occurred in the VEN 6, MAT 3, and MAT 5 study sites (Table 5, Figure 22). The lowest values occurred in the VEN 1 and the LNF xtra

Table 5. Physical habitat statistics for HSI variables measured in HSI study sites. See text for description of HSI variables. 95% C.I. is for the mean.

Study Site	statistic	Unit Length	Unit Width	Surface Area	Thalweg Depth	% Juv Cover	% Adlt Cover	% Wint Substr	% Shrubs	% Grass	% Trees	%Stable Bank	% OVH Shade	RF/RN % Fines	Spawn Velocity	Gravel Size	Gravel % Fines	Gravel S. Area	%PL Btm Obscur	PL Max Depth
VEN 1	n	18	18	18	18	18	18	18	18	18	18	18	18	13	9	9	9	9	5	5
	Min	20	6.3	222	0.8	5	0	0	0	0	0	50	0	5	0.5	0.5	5	60	0	1.7
	Max	220	44.8	5,191	2.7	80	40	60	100	10	80	100	100	95	3.0	2.5	30	600	80	4.2
	Median	54	14.5	670	1.4	15	5	8	75	0	5	95	23	10	2.0	1.5	10	100	40	2.0
	Mean	73	16.9	1,431	1.5	20	7	13	69	1	20	87	34	25	2.0	1.3	11	177	38	2.5
	Variance	2456	94.9	2167259	0.2	443	124	250	843	10	584	268	1193	712	0.6	0.4	61	27769	1120	1.0
	+/-95% C.I.	25	4.8	732	0.2	10	6	8	14	2	12	8	17	16	0.6	0.5	6	128	42	1.2
VEN 2	n	17	17	17	17	17	17	17	17	17	17	17	17	14	6	7	7	7	3	3
	Min	21	14.3	301	0.8	5	0	0	0	0	0	70	5	5	0.5	0.5	10	50	20	5.0
	Max	324	64.8	18,063	6.2	95	80	80	100	40	70	100	90	70	1.5	2.0	30	650	80	8.0
	Median	138	26.3	3,623	1.1	25	5	40	40	0	20	100	10	5	1.0	0.8	25	100	30	5.0
	Mean	125	29.9	4,389	1.7	34	10	35	46	5	22	96	19	19	1.0	0.8	21	279	43	6.0
	Variance	6318	231.9	20569993	2.1	734	426	873	561	125	419	75	656	534	0.1	0.3	73	70714	1033	3.0
	+/-95% C.I.	41	7.8	2,332	0.7	14	11	15	12	6	11	4	13	13	0.3	0.5	8	246	80	4.3
VEN 3	n	19	19	19	19	19	19	19	19	19	19	19	19	16	8	8	8	8	3	3
	Min	31	18.0	558	0.9	5	0	0	5	0	0	80	0	5	0.8	0.3	5	375	5	3.0
	Max	285	73.7	16,728	3.3	30	10	70	60	70	70	100	30	65	1.5	2.0	50	1800	5	4.8
	Median	106	33.5	4,256	1.6	10	5	30	40	10	30	100	5	20	1.5	1.1	18	600	5	4.0
	Mean	131	38.0	5,504	1.6	14	4	29	39	22	26	97	8	23	1.3	1.1	23	716	5	3.9
	Variance	7369	260.4	26846641	0.5	69	15	517	259	478	368	43	67	239	0.1	0.4	342	208025	0	0.8
	+/-95% C.I.	41	7.8	2,497	0.3	4	2	11	8	11	9	3	4	8	0.3	0.5	15	381	0	2.2
VEN 5	n	16	16	16	16	16	16	16	16	16	16	16	16	10	1	6	6	6	6	6
	Min	10	13.7	200	0.8	5	0	5	10	0	0	60	0	0	1.0	0.5	25	100	0	1.6
	Max	155	56.0	8,680	2.9	40	15	75	50	80	50	100	80	45	1.0	0.8	60	750	25	3.9
	Median	34	22.8	806	1.3	28	5	40	20	35	30	90	20	20	1.0	0.5	40	175	8	2.0
	Mean	45	26.7	1,417	1.4	25	6	44	21	29	26	87	24	21	1.0	0.5	41	283	10	2.3
	Variance	1302	137.8	4076417	0.3	85	20	435	153	558	240	173	484	210	-	0.0	124	64667	80	0.8
	+/-95% C.I.	19	6.3	1,076	0.3	5	2	11	7	13	8	7	12	10	-	0.1	12	267	9	0.9
VEN 6	n	17	17	17	17	17	17	17	17	17	17	17	17	13	0	0	0	0	4	4
	Min	9	7.0	105	0.6	0	0	20	0	0	0	10	5	0	-	-	-	-	10	2.6
	Max	99	48.3	4,059	4.1	70	50	95	60	100	100	100	100	25	-	-	-	-	70	5.0
	Median	34	21.0	703	1.7	20	10	70	0	40	10	100	15	5	-	-	-	-	25	3.3
	Mean	35	22.3	869	1.9	25	12	71	13	39	25	91	26	7	-	-	-	-	33	3.5
	Variance	597	112.2	874778	1.0	334	203	466	347	706	776	506	656	73	-	-	-	-	825	1.1
	+/-95% C.I.	13	5.4	481	0.5	9	7	11	10	14	14	12	13	5	-	-	-	-	46	1.7
LNF xtra	n	18	18	18	18	18	18	18	18	18	18	18	18	14	12	12	12	12	4	4
	Min	8	7.5	111	0.9	0	0	0	0	0	45	75	5	0	0.4	0.3	2	10	5	2.0
	Max	52	24.5	1,152	2.9	35	10	55	60	70	100	100	95	25	1.6	2.0	38	525	40	4.4
	Median	30	15.5	456	1.2	10	0	15	23	8	80	95	68	4	0.9	0.9	25	28	25	2.1
	Mean	27	15.7	440	1.3	11	2	21	27	22	76	91	56	8	0.9	0.9	21	72	24	2.7
	Variance	128	19.8	66893	0.2	88	11	291	456	673	398	95	1060	87	0.1	0.4	177	21080	273	1.4
	+/-95% C.I.	6	2.2	129	0.2	5	2	8	11	13	10	5	16	5	0.2	0.4	8	92	26	1.9
LNF low	n	23	23	23	23	23	23	23	23	23	23	23	23	19	5	5	5	5	4	4
	Min	12	9.3	194	0.5	0	0	0	0	0	5	10	0	0	0.3	0.5	4	10	5	2.3
	Max	76	22.3	1,022	3.0	80	75	75	70	95	85	100	80	50	1.3	1.5	12	216	25	3.6
	Median	26	15.4	458	1.6	15	0	25	8	15	50	100	25	5	1.0	0.8	6	32	23	2.7

Table 5. (continued)

Study Site	statistic	Unit Length	Unit Width	Surface Area	Thalweg Depth	% Juv Cover	% Adlt Cover	% Wint Substr	% Shrubs	% Grass	% Trees	%Stable Bank	% OVH Shade	RF/RN % Fines	Spawn Velocity	Gravel Size	Gravel % Fines	Gravel S. Area	%PL Btm Obscur	PL Max Depth
	Mean	30	15.9	465	1.6	22	5	30	20	33	45	95	33	12	0.8	0.9	8	77	19	2.8
	Variance	243	10.6	44518	0.3	451	285	485	531	1018	720	349	661	286	0.2	0.2	11	7726	90	0.4
	+/-95% C.I.	7	1.4	91	0.2	9	7	10	10	14	12	8	11	8	0.5	0.6	4	109	15	1.0
LNF up	n	20	20	20	20	20	20	20	20	20	20	20	20	14	2	2	2	2	6	6
	Min	6	4.9	49	0.6	0	0	0	0	0	0	55	5	0	0.3	0.5	18	18	5	1.4
	Max	24	16.2	340	2.1	75	25	75	100	80	100	100	100	55	0.4	0.8	20	44	45	3.4
	Median	16	8.9	146	1.0	13	0	33	73	10	0	97	38	2	0.4	0.6	19	31	25	2.3
	Mean	16	9.3	154	1.1	21	2	33	70	20	19	93	47	8	0.4	0.6	19	31	24	2.3
	Variance	21	7.1	6101	0.2	582	32	453	1054	560	877	114	1161	211	0.0	0.0	2	338	264	0.6
	+/-95% C.I.	2	1.3	37	0.2	11	3	10	15	11	14	5	16	8	0.1	1.6	13	165	17	0.8
MAT 3	n	20	20	20	20	20	20	20	20	20	20	20	20	20	2	2	2	2	0	0
	Min	20	15.4	354	0.9	5	1	10	0	0	1	70	0	0	0.7	0.5	6	12	-	-
	Max	119	57.2	5,822	1.9	95	25	95	60	10	100	100	15	35	1.2	0.8	8	16	-	-
	Median	39	28.4	1,205	1.4	75	5	70	30	5	50	100	1	4	1.0	0.6	7	14	-	-
	Mean	50	31.8	1,734	1.4	67	7	67	29	5	41	97	2	7	1.0	0.6	7	14	-	-
	Variance	831	190.7	2269657	0.1	622	40	448	592	12	1005	56	12	68	0.2	0.0	2	8	-	-
	+/-95% C.I.	13	6.5	705	0.1	12	3	10	11	2	15	4	2	4	3.7	1.6	13	25	-	-
MAT 5	n	20	20	20	20	20	20	20	20	20	20	20	20	18	2	2	2	2	3	3
	Min	10	14.5	278	0.9	20	0	15	10	0	0	70	0	0	0.0	0.5	30	27	5	2.2
	Max	88	46.3	2,407	2.0	90	30	100	85	35	75	100	35	18	0.5	0.5	40	80	15	2.4
	Median	33	27.6	903	1.4	65	2	78	15	1	2	100	0	5	0.3	0.5	35	54	10	2.4
	Mean	35	28.0	977	1.4	61	7	69	26	6	16	95	7	6	0.3	0.5	35	54	10	2.3
	Variance	312	60.3	327161	0.1	369	73	600	456	105	718	62	163	32	0.1	0.0	50	1405	25	0.0
	+/-95% C.I.	8	3.6	268	0.2	9	4	11	10	5	13	4	6	3	3.3	0.0	64	337	12	0.3
MAT 6	n	20	20	20	20	20	20	20	20	20	20	20	20	18	0	0	0	0	2	2
	Min	8	5.9	47	0.9	0	0	0	0	0	0	85	0	0	-	-	-	-	20	4.2
	Max	53	41.2	1,647	3.0	85	35	85	30	10	40	100	5	18	-	-	-	-	30	4.4
	Median	22	16.4	369	1.3	40	1	23	10	0	0	100	0	5	-	-	-	-	25	4.3
	Mean	24	16.5	457	1.4	36	5	30	12	1	6	98	1	6	-	-	-	-	25	4.3
	Variance	138	71.8	159830	0.2	729	82	662	69	9	98	20	3	32	-	-	-	-	50	0.0
	+/-95% C.I.	5	4.0	187	0.2	13	4	12	4	1	5	2	1	3	-	-	-	-	64	1.3
MAT 7	n	22	22	22	22	22	22	22	22	22	22	22	22	11	4	4	4	4	11	11
	Min	10	6.0	95	0.8	0	0	0	0	0	5	85	0	0	0.0	0.6	4	27	2	2.6
	Max	59	31.7	1,424	3.0	90	40	75	45	35	85	100	95	40	0.4	2.0	14	32	75	10.0
	Median	34	16.3	504	1.9	20	2	30	13	2	38	100	10	1	0.3	0.9	9	29	10	3.1
	Mean	34	16.2	585	1.8	32	6	33	17	5	43	98	22	4	0.2	1.1	9	29	26	3.8
	Variance	196	47.4	164129	0.4	955	88	811	206	58	497	26	802	141	0.0	0.4	17	5	791	4.4
	+/-95% C.I.	6	3.1	180	0.3	14	4	13	6	3	10	2	13	8	0.3	1.0	7	4	19	1.4
MUR 3	n	21	21	21	21	21	21	21	21	21	21	21	21	15	2	2	2	2	6	6
	Min	9	7.2	74	0.8	0	0	15	0	0	0	92	1	0	0.1	0.8	6	20	5	1.8
	Max	48	22.6	1,084	2.4	89	50	99	99	40	100	100	99	36	0.3	1.3	14	32	60	3.4
	Median	24	10.5	252	1.3	35	2	48	40	1	85	100	62	1	0.2	1.0	10	26	20	2.7
	Mean	26	11.4	316	1.4	35	5	51	30	6	73	99	57	9	0.2	1.0	10	26	26	2.6
	Variance	119	11.5	49801	0.2	630	117	722	896	96	956	5	1363	201	0.0	0.1	32	72	391	0.3
	+/-95% C.I.	5	1.5	102	0.2	11	5	12	14	4	14	1	17	8	1.2	3.2	51	76	21	0.6

Table 5. (continued)

Study Site	*statistic*	Unit Length	Unit Width	Surface Area	Thalweg Depth	% Juv Cover	% Adlt Cover	% Wint Substr	% Shrubs	% Grass	% Trees	%Stable Bank	% OVH Shade	RF/RN % Fines	Spawn Velocity	Gravel Size	Gravel % Fines	Gravel S. Area	%PL Btm Obscur	PL Max Depth
OLD 2	n	21	21	21	21	21	21	21	21	21	21	21	21	12	5	5	4	5	9	9
	Min	9	4.7	42	0.5	0	0	5	0	0	15	60	2	0	0.0	0.5	2	12	5	1.3
	Max	50	12.1	514	2.6	40	15	90	80	50	70	100	99	20	0.6	2.5	20	48	50	4.6
	Median	17	8.2	150	1.2	15	0	30	2	1	45	100	92	1	0.0	1.0	6	16	18	2.8
	Mean	21	8.4	182	1.3	20	3	33	23	6	43	94	78	3	0.2	1.2	9	22	19	2.8
	Variance	117	3.9	13639	0.3	147	29	582	904	219	388	156	843	35	0.1	0.6	62	215	210	0.9
	+/-95% C.I.	5	0.9	53	0.3	6	2	11	14	7	9	6	13	4	0.3	1.0	13	18	11	0.7
UNF low	n	20	20	20	20	20	20	20	20	20	20	20	20	17	2	3	3	3	3	3
	Min	15	9.8	163	0.6	0	0	5	0	0	60	72	45	1	0.3	0.5	18	54	5	2.7
	Max	67	30.8	1,229	2.3	70	15	89	90	100	100	100	100	42	1.0	0.8	26	176	60	4.0
	Median	25	13.0	307	1.3	25	0	39	33	38	98	98	88	4	0.6	0.8	22	56	15	2.8
	Mean	28	14.4	401	1.3	29	2	43	32	37	91	92	80	11	0.6	0.7	22	95	27	3.2
	Variance	143	23.8	53987	0.2	342	15	696	837	925	196	84	360	180	0.2	0.0	16	4881	858	0.5
	+/-95% C.I.	6	2.3	109	0.2	9	2	12	14	14	7	4	9	7	4.4	0.4	10	174	73	1.8
UNF 2	n	20	20	20	20	20	20	20	20	20	20	20	20	12	3	3	3	3	8	8
	Min	10	8.5	98	0.8	2	0	5	5	0	0	20	0	0	0.8	0.5	22	20	5	1.7
	Max	53	25.7	741	2.3	60	25	75	100	50	30	100	40	12	1.8	1.5	22	30	45	3.2
	Median	24	13.7	321	1.4	15	0	30	65	5	0	88	5	3	1.0	1.5	22	24	18	2.6
	Mean	24	14.0	343	1.4	19	3	36	66	14	4	79	15	4	1.2	1.2	22	25	20	2.5
	Variance	76	14.0	24889	0.2	218	39	526	590	310	68	499	242	18	0.3	0.3	0	25	157	0.3
	+/-95% C.I.	4	1.7	74	0.2	7	3	11	11	8	4	10	7	3	1.4	1.4	0	13	10	0.5
UNF up	n	21	21	21	21	21	21	21	21	21	21	21	21	13	1	1	1	1	7	7
	Min	8	6.2	59	0.5	0	0	0	0	0	50	60	45	0	0.9	1.9	16	32	10	1.9
	Max	46	16.1	523	1.9	60	15	85	60	60	100	100	100	35	0.9	1.9	16	32	35	2.9
	Median	20	10.9	170	1.2	10	0	20	0	1	95	100	95	1	0.9	1.9	16	32	25	2.2
	Mean	20	10.3	208	1.2	18	2	32	8	8	86	96	91	5	0.9	1.9	16	32	26	2.3
	Variance	69	6.6	12561	0.1	304	18	955	206	225	325	88	160	102	-	-	-	-	95	0.1
	+/-95% C.I.	4	1.2	51	0.2	8	2	14	7	7	8	4	6	6	-	-	-	-	9	0.3

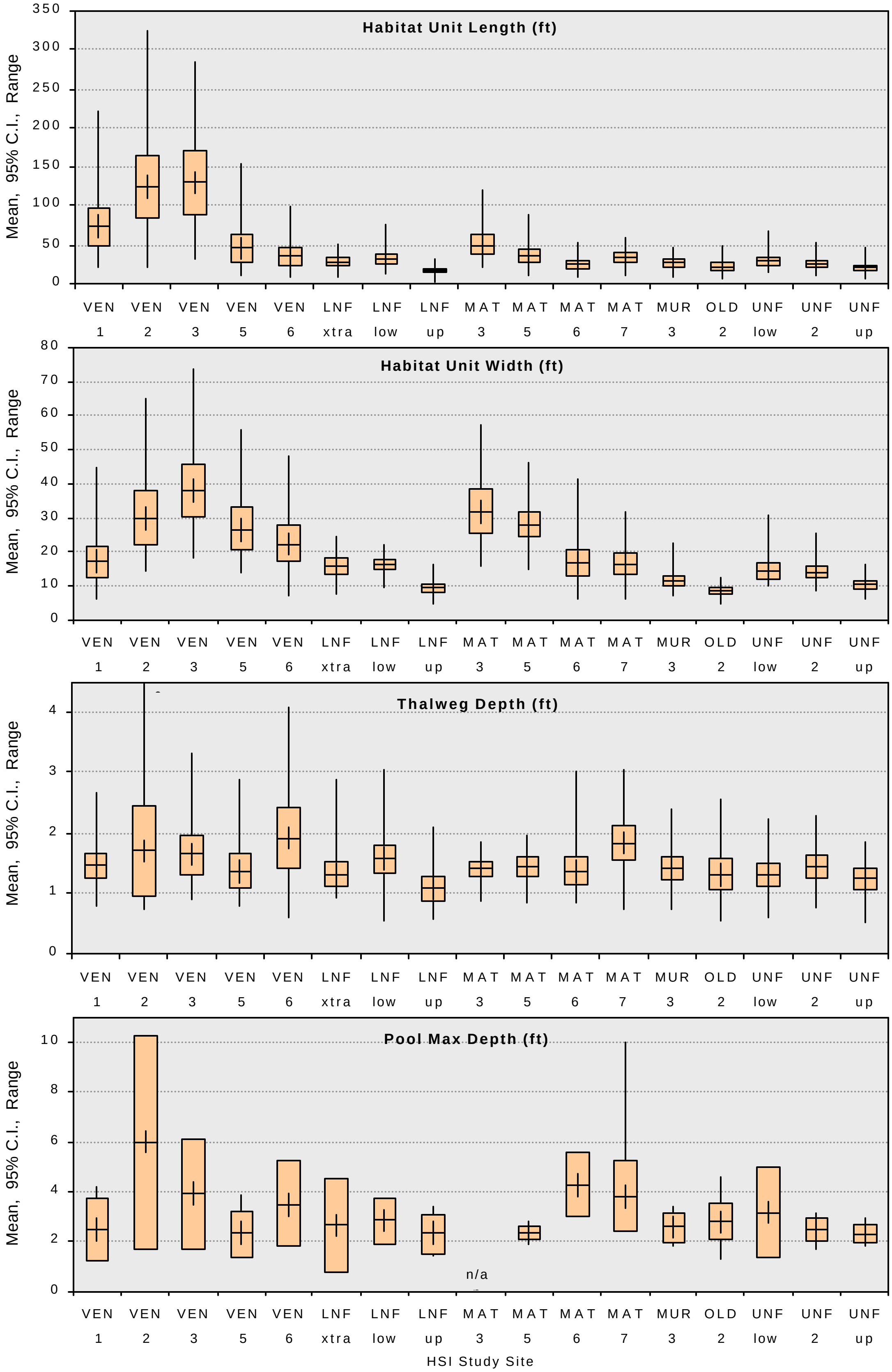


Figure 21. Mean (plus), 95% C.I. for the mean (boxes), and range (whiskers) for habitat dimension variables measured in HSI study sites.

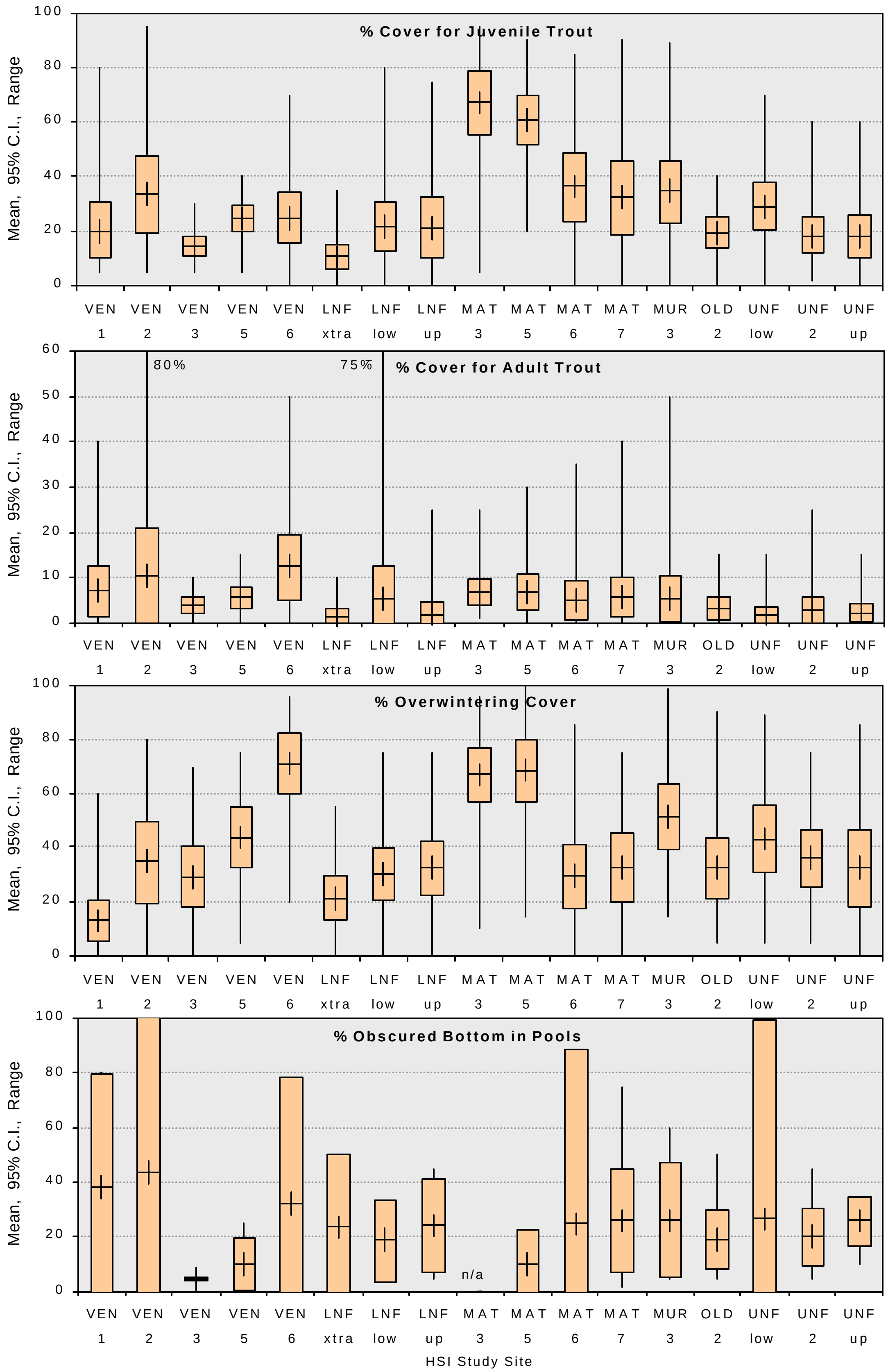


Figure 22. Mean (plus), 95% C.I. for the mean (boxes), and range (whiskers) for cover related habitat variables measured in HSI study sites.

sites. The percentage of obscured bottom in pools was highest in the VEN 2 and VEN 6 sites, as expected, but a high mean value also occurred in the VEN 1 site. Both pool-related variables (i.e., maximum depth and % obscured bottom) are subject to effects of low sample sizes (Table 4), so estimated means typically have wide confidence intervals and comparisons should thus be made with caution.

The percentage of stable banks in habitat units showed relatively little variation in mean values, with all but one site (UNF 2) having means between 80% and 90% (Table 5). However, several study sites (e.g., VEN 6, LNF low, and UNF 2) showed wide variability among individual habitat units with some highly eroded banks (Figure 23). Other locations known to have highly eroded banks, such as the mainstem Matilija Creek just below the uppermost road crossing, were not randomly selected as an HSI study site.

The percentage of fines in riffle and run habitat was consistently below 20% in all study sites except for the lowest four sites in the Ventura River (Table 5, Figure 23). Those sites yielded higher estimated values of 19-25%. Other study sites, including two sites in the Lower North Fork Matilija Creek and the lowest site in Upper North Fork Matilija Creek, contained some habitat units with a high percentage (>40%) of fines.

The percentage of vegetation coverage is shown according to the three vegetation classes used in the HSI model: grass, shrubs, and trees (Table 5, Figure 23). Sites VEN 1, LNF up, and UNF 2 were clearly dominated by shrubs, whereas sites LNF xtra, MUR 3, UNF low and UNF up were clearly dominated by trees. All other sites had more even proportions of the three vegetative classes, although in most sites grass was less common than shrubs and trees.

HSI Analysis

HSI Component Scores

HSI scores were calculated for each HSI study site for each of the model components (adult, juvenile, fry, incubation, and other, Figure 24) and for an overall score (Table 6). A full list of all individual HSI variable scores can be found in Appendix E. Comparing the component scores among reaches shows relatively little variation for the adult component, with all values exceeding 0.7. In general, HSI scores for adults were lowest (<0.8) in the Ventura River sites and in the MAT 3 site, and were highest (>0.9) in the uppermost Matilija Creek site and all tributary sites (Figure 24). The lower scores appeared to the result of high estimated water temperatures during adult upstream migration, assuming that some steelhead hold-over in the warmer Ventura River.

The juvenile component scores showed much greater variation among study sites, with relatively few scores exceeding 0.7 (Table 6, Figure 24). Lowest scores ((<0.5) occurred in the Ventura River and the lower mainstem Matilija Creek sites, and the highest scores (>0.7) occurred in the upper Matilija Creek site (MAT 7), the Murietta Creek site, and the three Upper North Fork Matilija Creek sites. Juvenile component scores in the Ventura River and lower Matilija Creek sites were depressed largely due to the relatively high

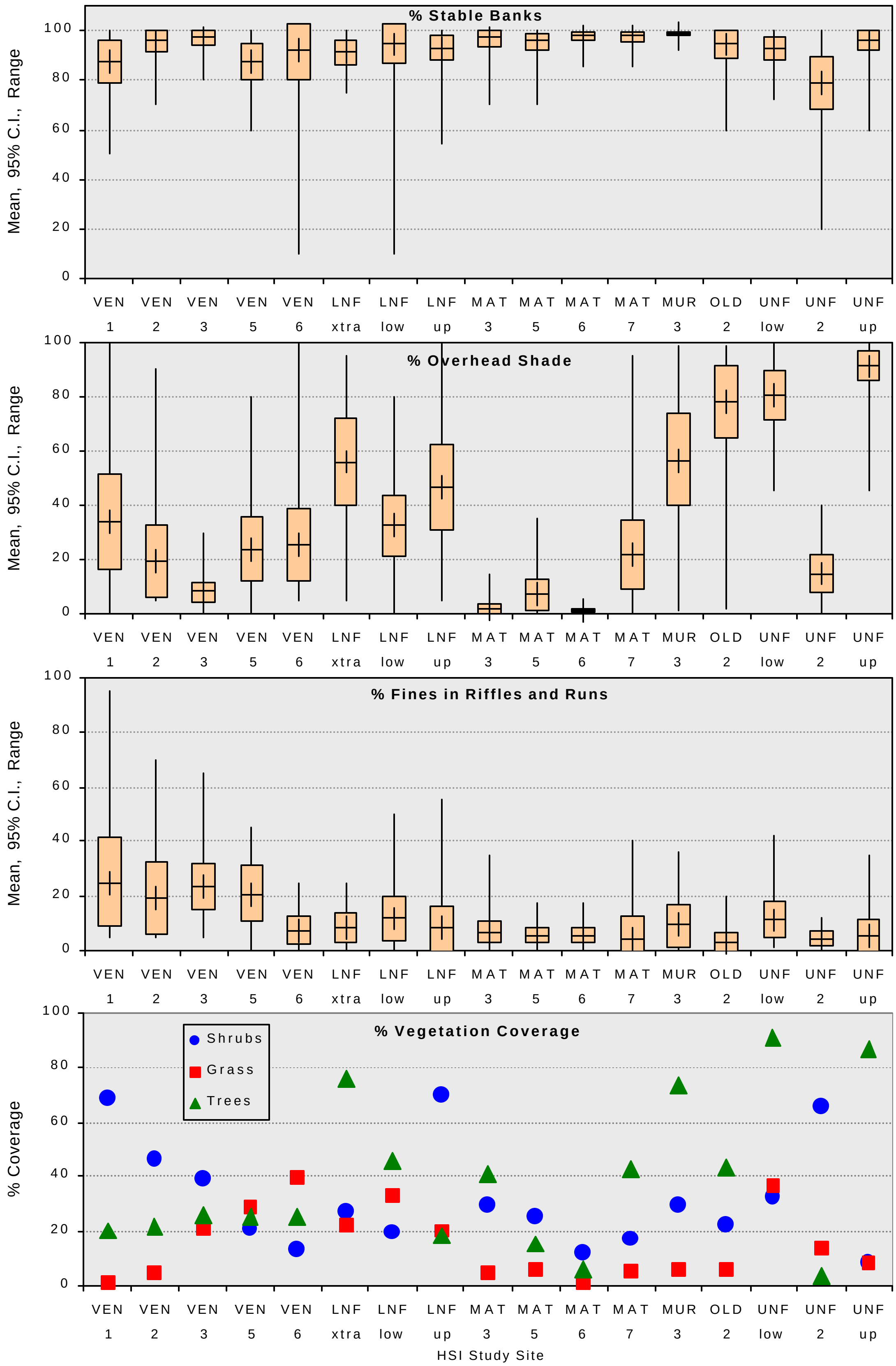


Figure 23. Mean (plus), 95% C.I. for the mean (boxes), and range (whiskers) for habitat variables measured in HSI study sites.

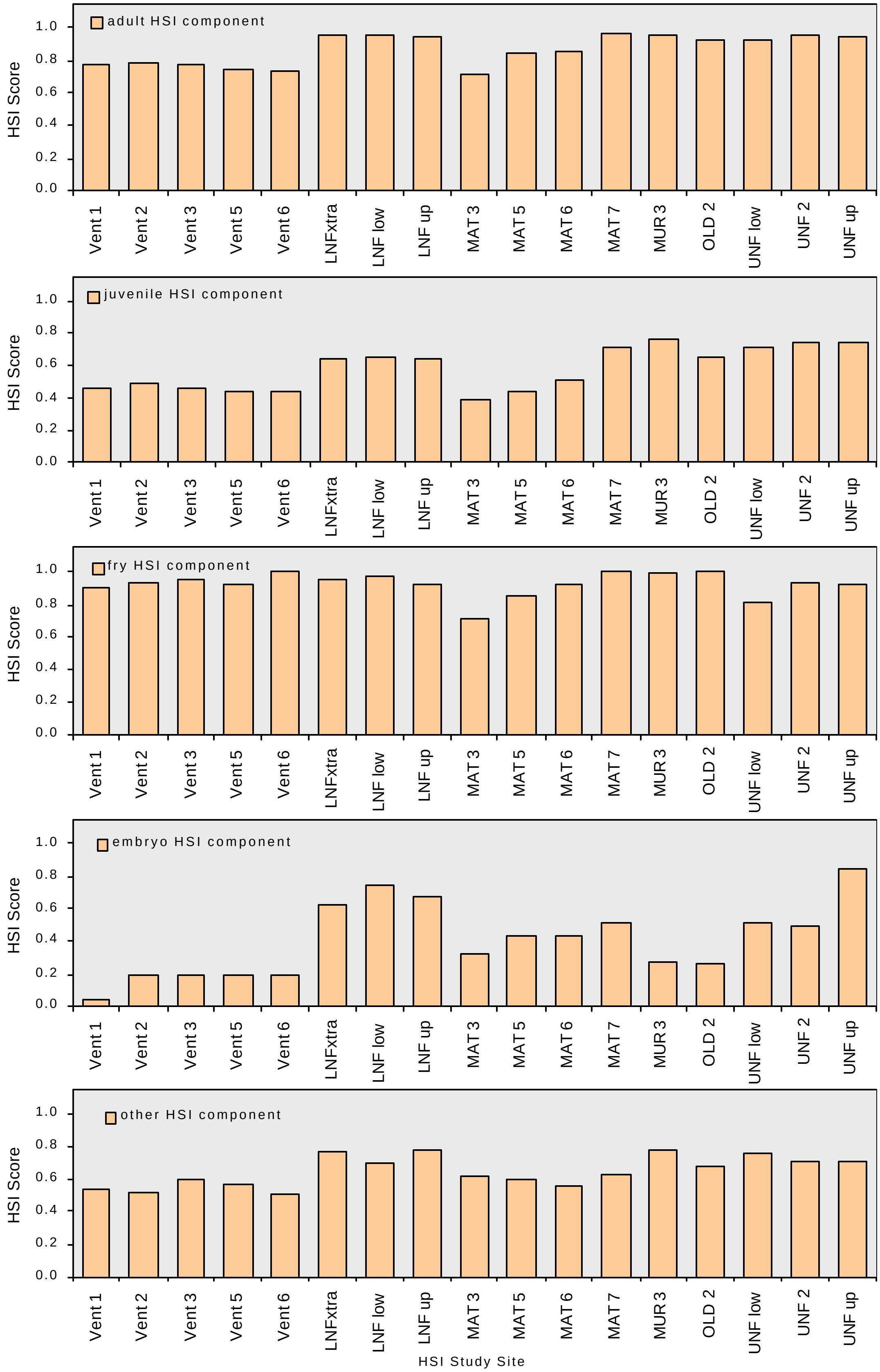


Figure 24. HSI component scores according to study site.

smolt migration temperatures estimated for those sites, which resulted in scores of 0.25 for that variable. The MAT 3 score was also affected by a low pool-class rating.

Table 6. HSI scores and habitat area information according to study site and reach.

HSI Study Site	HSI Model Components Adult	Juvenile	Fry	Embryo	Other	Overall HSI Score
Vent 1	0.77	0.47	0.90	0.04	0.54	**0.364**
Vent 2	0.79	0.49	0.94	0.20	0.52	**0.520**
Vent 3	0.77	0.46	0.96	0.20	0.60	**0.528**
Vent 5	0.74	0.43	0.92	0.20	0.57	**0.507**
Vent 6	0.74	0.44	1.00	0.20	0.51	**0.506**
LNF extra	0.95	0.64	0.95	0.63	0.77	**0.776**
LNF low	0.95	0.65	0.97	0.75	0.70	**0.794**
LNF up	0.95	0.64	0.93	0.68	0.78	**0.784**
MAT 3	0.72	0.39	0.71	0.32	0.62	**0.522**
MAT 5	0.85	0.44	0.85	0.43	0.60	**0.608**
MAT 6	0.86	0.52	0.93	0.43	0.56	**0.631**
MAT 7	0.96	0.71	1.00	0.51	0.63	**0.736**
MUR 3	0.96	0.76	0.99	0.27	0.77	**0.685**
OLD 2	0.92	0.66	1.00	0.27	0.68	**0.643**
UNF low	0.93	0.71	0.82	0.52	0.76	**0.732**
UNF 2	0.95	0.74	0.94	0.49	0.70	**0.744**
UNF up	0.95	0.74	0.93	0.85	0.71	**0.829**

The fry component of the HSI model was relatively consistent among study sites with most values exceeding 0.9 (Table 6, Figure 24). Three sites (VEN 6, MAT 7, and OLD 2) resulted in "perfect" scores of 1.0! The MAT 3 study site yielded a distinctly lower score of 0.71, due to the low percentage of pool habitat in that site.

The incubation or embryo component of the HSI model produced the greatest variability among study sites, with seven HSI scores <0.3, and four scores >0.6 (Table 6, Figure 24). The highest scores occurred in the Lower North Fork Matilija Creek and in the highest Upper North Fork Matilija Creek site. The lowest scores occurred for the Ventura River sites and for the two smallest tributary sites (Murietta Creek and Old Man Creek), with the score for VEN 1 almost zero (0.04). These low scores were produced in part by high incubation temperatures, and also by estimated velocities over spawning gravels being either too low (Murietta Creek and Old Man Creek) or too high (VEN 1). The spawning velocity variable utilized an expansion factor of 2.0, as described in the methods, in order to predict velocities under higher flow conditions. In the VEN 1 study site, water primrose (*Rorippa nasturtium-aquaticum*) grew well out into the wetted channel and essentially "funneled" the flow, which produced high velocity measurements over gravel patches. After expansion, those velocities exceeded the optimum levels as described by the HSI curve (*V5*). Measurement of velocities during actual winter/spring spawning flows could produce significantly different HSI scores for the incubation component of the reach scores, however the effects on overall HSI scores would be less.

The final model component ("other") produced moderate suitability values (0.5-0.8) for all study sites, with the lowest values occurring in the Ventura River sites and the highest values in the upper Matilija Basin sites (Table 6, Figure 24). The high estimated rearing temperatures were largely responsible for the lower HSI scores.

Overall HSI Scores

Overall HSI scores ranged from a low of 0.36 for the VEN 1 study site to a maximum of 0.83 for the UNF up site (Table 6, Figure 25). Overall scores in all of the Ventura River sites and in the lower mainstem Matilija Creek were all <0.6, whereas scores in both North Forks and the highest Matilija Creek site (MAT 7) all exceeded 0.7. Intermediate values (0.6-0.7) occurred for the middle sites in the mainstem Matilija Creek, and for the smaller tributaries, Murietta Creek and Old Man Creek. Based on HSI scores alone, these results are consistent with the qualitative results from the first-stage survey (TRPA 2003), which identified the upper basin mainstem and tributaries as having the highest suitability for rearing steelhead. The lower suitability values for the Ventura River and the lower Matilija Creek sites are largely due to high estimated temperatures, which with unmodified HSI curves produced zero suitability scores (in fact, all sites produced zero scores). Even with the modified temperature curves, the warmer water in the lower basin areas was judged to reduce the quality of steelhead habitat.

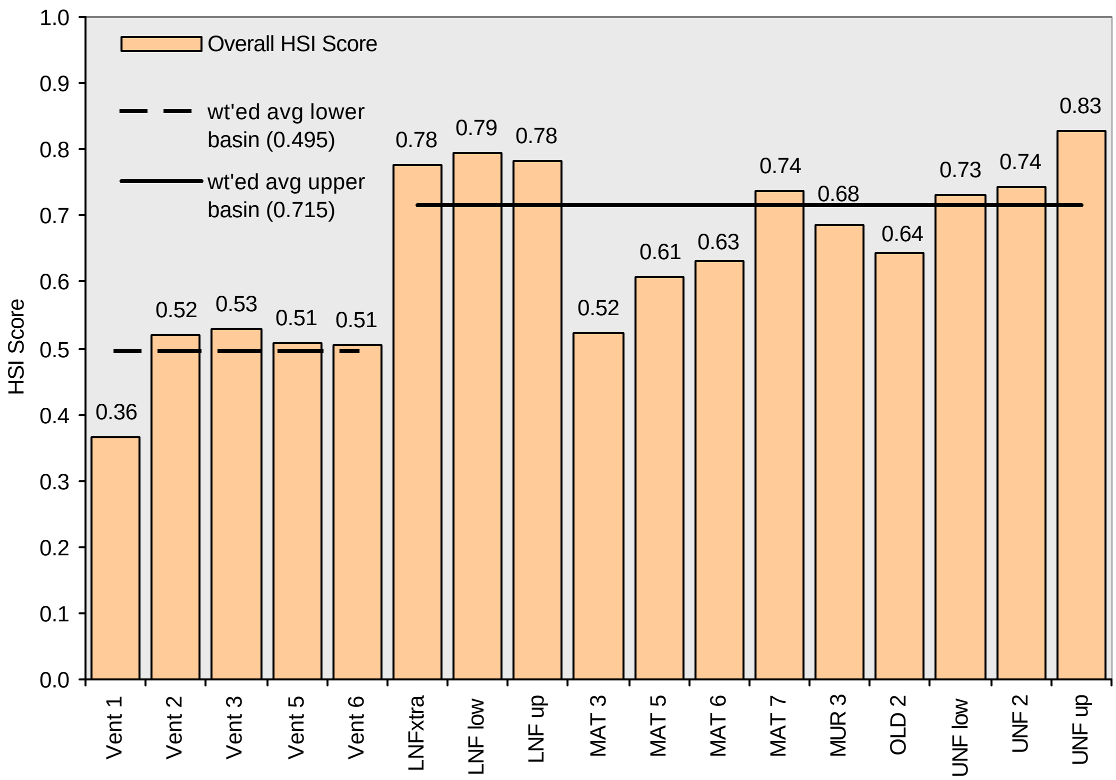


Figure 25. Overall HSI scores according to stream reach (bars). Also shown are the weighted average scores according to subbasin (horizontal lines).

Habitat Value

Habitat values scores were created by weighting each reach score by the reach area (represented by reach length) according to sub basin. This result is dimensionless because the HSI score is dimensionless. The habitat value result also assumes that a large area of low quality habitat is equivalent to a small area of high quality habitat, which is an assumption that is frequently debated.

The weighted means clearly show the higher quality of habitat in the upper sub basin with a mean score of 0.7, versus the lower quality habitat in the lower sub basin with a mean score 0.5 (Figure 25, Table 7).

Table 7. Calculation of habitat value scores according to subbasin.

SubBasin Location	HSI Study Site	Overall HSI Score	Reach Length (ft)
Lower	Vent 1	0.364	8,026
Lower	Vent 2	0.520	15,946
Lower	Vent 3	0.528	15,523
Lower	Vent 5	0.507	8,501
Lower	Vent 6	0.506	3,379
		Total Habitat:	51,375
		Weighted Means:	**0.495**
Upper	LNF extra	0.776	13,830
Upper	LNF low	0.794	8,663
Upper	LNF up	0.784	13,675
Upper	MAT 3	0.522	8,779
Upper	MAT 4+5	0.608	11,686
Upper	MAT 6	0.631	7,731
Upper	MAT 7	0.736	9,018
Upper	MUR 1+3	0.685	8,063
Upper	OLD 2+4	0.643	6,678
Upper	UNF low	0.732	10,392
Upper	UNF 2	0.744	3,851
Upper	UNF up	0.829	11,609
		Total Habitat:	113,975
		Weighted Means:	**0.715**

Habitat Values Under Different Scenarios

Annual precipitation is highly variable in Southern California watersheds, and consequently the Ventura watershed exhibits wide fluctuations in the extent of surface flow and instream habitat. Because of this variation, alternative habitat value scores were estimated in an attempt to represent the possible changes in area that may occur during very wet years or very dry years.

A "minimum habitat" scenario was created by assuming that all study reaches that contained extremely low flows during the March and April surveys (but were included as habitat for the HSI analysis presented above) would be dry and therefore provide no habitat (Table 8). It was also assumed that all migrational barriers described as "probable" (TRPA 2003) represented the upstream limit to steelhead migration. Neither of these assumptions was made for the "normal" HSI analysis described above. These assumptions only affected the habitat area scores, the HSI scores for included habitat were not adjusted. As a result of these conditions, HSI reaches MAT 4, MAT 5, MUR 1, OLD 4, and LNF up (above the spring confluence, Figure 4) were assumed to be dry and provide no habitat. Also, probable barriers reduced the length of available habitat in reaches MAT 7, MUR 3, and UNF 4. The total estimated length of available habitat under the dry year scenario was 80,980 ft of channel for the upper sub basin, versus 113,975 ft under the normal year scenario (Tables 7 and 8). No adjustments were made to the habitat areas (51,375 ft) in the Ventura River as a large length of the river was already dry during the July 2003 survey.

A “maximum habitat” scenario was created by assuming that all channels contained flowing water and thus provided habitat for spawning and rearing (but only up to “definite” barriers, as assumed for the “normal” HSI analysis). Consequently, habitat was assumed to occur in reaches VEN 4 and all reaches in Murietta Creek and Old Man Creek (Table 8). Reaches MAT 1 and MAT 2, which were excluded from the “normal” HSI analysis due to the effects of the reservoir (or removal thereof), were also included for the “maximum habitat” scenario. Habitat quality values were assigned to the new habitat areas using an HSI score from an adjacent HSI study site. Adjusted habitat value scores using the two scenarios were then combined according to location either above Matilija Dam or below the dam. Estimated habitat areas under the maximum habitat scenario were 85,799 ft of channel in the lower sub basin and 128,549 ft in the upper sub basin (Table 8). The estimated changes in available habitat under the dry, normal, and wet year scenarios had very minor effects on the weighted mean habitat value scores (Tables 7 and 8).

Table 8. Calculation of alternate habitat value scores according to subbasin assuming minimum habitat (i.e.dry year) and maximum habitat (i.e., wet year).

SubBasin Location	HSI Study Site	Overall HSI Score	Minimum Length (ft)	Maximum Length (ft)
Lower	Vent 1	0.364	8,026	8,026
Lower	Vent 2	0.520	15,946	15,946
Lower	Vent 3	0.528	15,523	15,523
Lower	Vent 4+5	0.507	8,501	42,925
Lower	Vent 6	0.506	3,379	3,379
		Total Habitat:	51,375	85,799
		Weighted Means:	**0.495**	**0.500**
Upper	LNF extra	0.776	13,830	13,830
Upper	LNF low	0.794	8,663	8,663
Upper	LNF up	0.784	9,187	13,675
Upper	MAT 1-3	0.522	8,779	14,779
Upper	MAT 4+5	0.608	0	11,686
Upper	MAT 6	0.631	7,731	7,731
Upper	MAT 7	0.736	5,438	9,018
Upper	MUR 1-4	0.685	3,960	11,230
Upper	OLD 1-5	0.643	4,146	12,085
Upper	UNF low	0.732	10,392	10,392
Upper	UNF 2	0.744	0	3,851
Upper	UNF up	0.829	8,854	11,609
		Total Habitat:	80,980	128,549
		Weighted Means:	**0.724**	**0.702**

HSI Score Sensitivity

A significant aspect of this HSI study involved the modification of several HSI curves presented in Raleigh et al. (1984). Use of unmodified temperature curves resulted in HSI scores of zero for all study reaches, which was an unrealistic conclusion given the presence of steelhead in the Ventura River, and residualized rainbow trout in the Matilija

Basin. It was apparent that the temperature HSI curves presented in the original model were not adequately representative of habitat requirements for southern steelhead.

In order to produce HSI scores more representative of the Matilija Basin, six of the HSI curves were modified (Figures 11-13). Because these modifications were made without rigorous scientific studies, considerable uncertainty exists in choosing appropriate modifications, and in how sensitive the HSI model is to slight changes in the modified curves. Consequently, we conducted a qualitative sensitivity test on the effects of altering HSI curves on the overall HSI score. For this test we created two alternative modification lines on the modified adult rearing temperature curve (*V1a*) and on the modified smolt migration temperature curve (*V2s*). These two variable curves were chosen because they had the greatest degree of modification among the six curves modified for this study (Figures 11-13). For each curve a low temperature alternative and high temperature alternative was created that essentially bracketed the original modification lines (Figure 14). The alternative modification curves were applied to six HSI study sites, three of which produced lower HSI scores under the original analysis (VEN 1, VEN 6, and MAT 3), and three sites that produced higher original scores (MAT 7, UNF up, and LNF low).

The sensitivity test shows that the high temperature alternative produced very little change in HSI scores for any of the six tested sites (Figure 26). The low temperature alternatives did noticeably reduce the HSI scores for study sites that scored low originally, however alternative scores for sites with a high original score were not different. In sum, the warmer, lower river reaches were most sensitive to the tested alternative HSI curves, whereas the upper sub basin reaches with more suitable temperature conditions were less affected. If the low temperature alternative curves had been used in this study, more disparity would have occurred in the habitat value scores between the upper sub basin and the lower sub basin, which would have further emphasized the potential benefits of removing Matilija Dam.

DISCUSSION

The applicability of the Raleigh et al. (1984) HSI model for Southern California steelhead streams is currently unknown. Most applications of the HSI methodology appear to have occurred in eastern streams with different habitat conditions and species compositions (Terrell 1984), although some salmonid applications have been found with varying success. For example, Trial et al. (1984) found that ranks of HSI scores produced for brook trout (*Salvelinus fontinalis*) and Atlantic salmon (*Salmo salar*) were significantly correlated with ranks of standing crops, and concluded some of the HSI models may be valid predictors of present and future carrying capacity. However, Persons and Buckley (1984) tested the riverine HSI model for cutthroat trout (*O. clarki*) and found that it did not accurately predict standing crops in the four streams examined. They also noted that the model failed to predict standing crops of rainbow trout in three of the streams. Li et al. (1984) found that suitability indices for cutthroat trout and coho salmon (*O. kisutch*) did not seem to be generally applicable to streams other than the stream from which the original HSI data was derived.

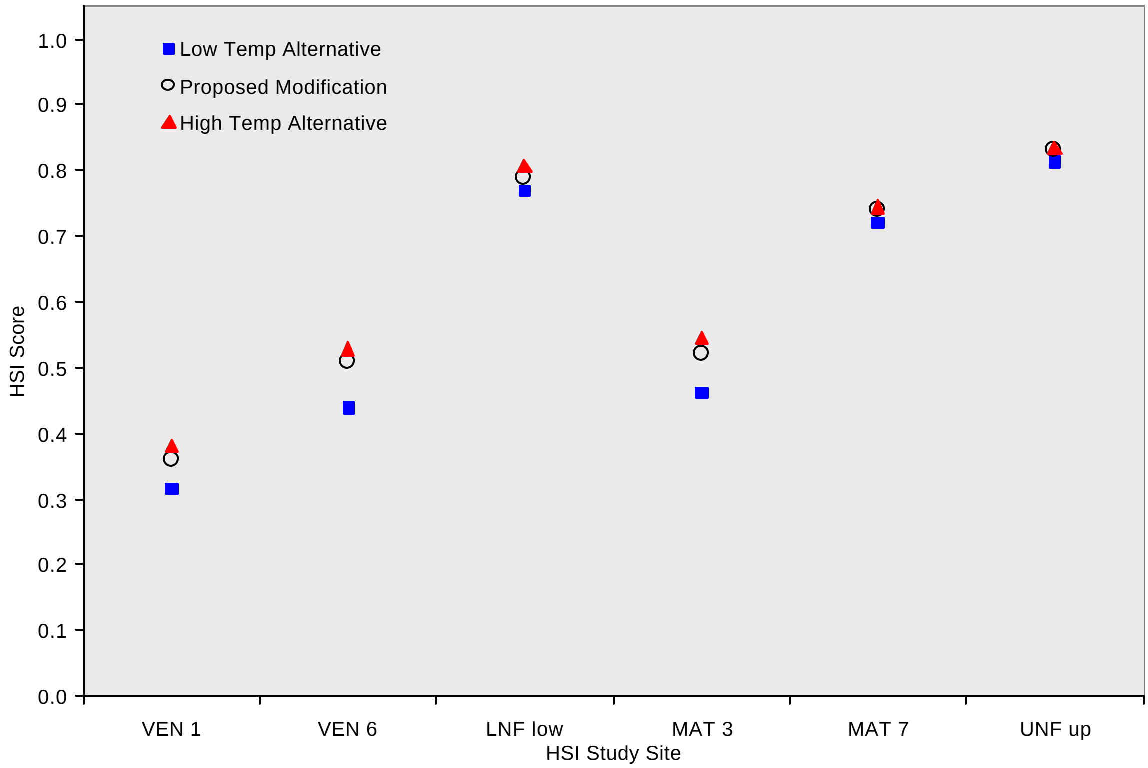


Figure 26. Comparison of overall HSI scores for 6 study sites using the originally modified HSI curves, versus alternative modified curves (for variables V1a and V2s only).

An HSI study was recently completed in two streams in the South-Central Coastal California ESU (TRPA 2000). HSI scores were developed for lower San Luis Obispo Creek and for Coon Creek, a small, pristine coastal stream entering the Pacific just north of San Luis Obispo. HSI scores were recalculated using the modified curves described in this report, yielding overall scores of 0.927 for Coon Creek and 0.600 for San Luis Obispo Creek. Intensive fish sampling has occurred in San Luis Obispo Creek, where densities of juvenile steelhead in pool habitats in year 2000 were estimated at 1,000 to 1,200 fish/mile of pools (TRPA, unpublished data). Unfortunately, quantitative fish sampling has not been conducted in Coon Creek, so a direct comparison of the relationship between the two HSI scores and associated fish densities cannot be made. These limited results, most of which do not directly apply to steelhead at the extreme southern edge of their range, suggest caution when interpreting the HSI scores. A great need exists for validation of the HSI methodology with fish abundance sampling in Southern California streams. Because of the extreme variability that occurs in southern steelhead populations due to limited recruitment and extremely harsh environmental conditions, such a validation exercise should be performed using rigorous population sampling methodologies that would allow statistical comparison of variability among reaches. The sampling program would also need to account for wide variation in water years and its effects on fish colonization of stream channels subject to very low flows.

Despite the limitations of this (or most any other) habitat model in Southern California steelhead streams, a comparison of habitat features alone will provide information on expected habitat quality, sensitivity of the model to curve modifications, and similarity or dissimilarity with other studies or other, nearby streams.

Comparison of HSI Scores With Historical Data

1980 Stream Surveys

Moore (1980a) conducted extensive habitat surveys on the mainstem Matilija Creek, Upper North Fork Matilija Creek, Lower North Fork Matilija Creek, and Murietta Creek during the summer of 1979. Moore divided the mainstem into three sections: lower (approximately from confluence with the Upper North Fork to confluence with Old Man Creek), middle (Old Man Creek to the "Main" falls, see "falls" barrier in Figure 2), and upper (above the main falls). The lower and middle sections roughly correspond to the HSI MAT 6 and MAT 7 reaches, respectively, with HSI scores of 0.63 and 0.74. Moore gave these mainstem reaches an overall rating of "good", and notes that the lower section has generally poor summer conditions for trout due to warm water temperatures, insufficient holding water with suitable cover and loss of flow in stretches during the late summer. He did, however, note trout in deeper pools during his survey on 18 July 1979. In July 2003, streamflow in MAT 6 was estimated to be only 0.16 cfs, whereas flow just upstream in MAT 7 was measured at 1.29 cfs. The similar HSI scores for these two reaches thus may not adequately reflect the more unstable flow characteristics of MAT 6. The HSI study did not survey above the main falls, however Moore designated this upper section as "good" habitat.

Moore (1980a) divided the Upper North Fork Matilija Creek into three segments: lower (consisting of HSI reaches UNF1 and UNF 2), middle (includes UNF 3 and part of UNF 4), and upper (containing the upper part of UNF 4 and above). Moore refers to the tributary UNFT 1 as the "East Fork" Upper North Fork and includes this as part of his middle section. Moore notes abundant trout in the lower and middle sections and "none seen" in the upper section. He also mentions three possible barriers just above the "East" Fork, and says that trout are "very scarce" (emphasis Moore's) above these barriers. HSI scores exceeded 0.7 for all of these reaches.

Moore (1980a) designated Murietta Creek as good habitat. Murietta was divided into upper and lower sections at the confluence with the "South Fork" of Murietta Creek. The lower section contain HSI reaches MUR 1, MUR 2, and the lower portion of MUR 3, while the upper section contains the upper potion of MUR 3 and all of MUR 4 (Figure 2). During his survey both the lower and upper sections had abundant trout, but he also noted that 3,000 fingerling trout had been stocked in the spring before the survey. The stream channel was also dry and intermittent in locations similar to March first-stage survey (TRPA 2003). The HSI score of 0.68 for the MUR 3 reach suggests good habitat, however trout were rarely observed during the March survey.

Moore (1980a) divided the Lower North Fork Matilija Creek into lower and upper sections that roughly correspond to HSI reaches LNF low and LNF mid, respectively (Figure 4). Moore evaluated the lower section as having "good" habitat conditions, but described trout as "few". HSI scores for the Lower North Fork reaches were 0.78 to 0.79, and trout and spawning redds were frequently observed in the lower two reaches (TRPA 2003).

1997 Chubb Report

The presented HSI data also seems, in general, to agree with the Chubb (1997) report assessment of habitat in the Matilija Basin. In her report (which appeared to be somewhat based on Moore's stream surveys), Chubb (1997) states that the lower North Fork and a short section of the mainstem Matilija provide the most suitable spawning areas, and that "the most useful spawning habitat resides in the mid sections of the side forks and tributaries." This is supported by our embryo component data, which gives the highest scores in the Lower North Fork Matilija Creek and in the mainstem MAT 7 site (Figure 2). The Chubb report also suggests that much of the Upper North Fork Matilija Creek contains fair spawning habitat while the HSI scores indicate that most of the Upper North Fork would provide some of the best spawning habitat in the watershed. With regard to rearing habitat Chubb finds "excellent" habitat in the lower and upper sections of the Upper North Fork and in a small portion of Murietta Creek, "good" habitat only in the lower section of the Lower North Fork, with the most of the remaining Matilija watershed rated as "fair". While the HSI model does not have a rearing component, per se, the fry, juvenile, adult, and "other" component scores would indicate that the Lower North Fork Matilija Creek and the upper sites of the mainstem Matilija should receive a rating of "good" or better, which is consistent with the general conclusions described in the first-stage report (TRPA 2003).

Capelli Angling Study

Capelli (1997) conducted a survey of trout in the Ventura River below the Robles diversion from April 18 through May 27, 1995 during an above average rainfall year, and caught a total of 52 trout by angling. Of that total catch, only eight trout were caught in segments of the river that do not maintain surface flow throughout an average water year. In contrast, 44 trout were captured in reaches of the Ventura River that do, typically, maintain surface flows throughout the year (HSI reaches VEN 2 and VEN 3, Figure 6). No fish were captured in Capelli's Section VI (HSI reach VEN 1) during his study, however, one rainbow trout was captured in June 1995 by the California Department of Fish and Game Wild Trout Crew. In general, the number of trout caught and fishing success increased from the lower reaches of the Ventura River to the upper reaches, which is consistent with the HSI scores reported in this study.

Entrix Habitat Evaluation

Entrix (2002) conducted an evaluation of steelhead habitat in the Ventura watershed that covered the same streams as our current HSI study. They used a scale from 0 (inaccessible habitat with no value) to 5 (excellent habitat) to represent overall steelhead habitat value in reference to historic conditions. For their reach 2 (Ventura River from Main Street Bridge to Foster Park), which is equivalent to reaches VEN 1 and VEN 2 in this study, Entrix gives a score of 2 (poor) for existing habitat condition and function. HSI scores calculated for these sites were 0.36 and 0.52, respectively, which would probably be considered poor to fair. Entrix gave reach 3 (Foster Park to San Antonio creek), which is equivalent to the VEN 3 reach, a habitat condition score of 3 (fair), which compares well with the overall HSI score of 0.52. It is also noted in the Entrix report that reach 3 is, "currently among the most important to steelhead", providing migration, spawning, and rearing habitat.

This portion of the Ventura River was the site of Moore's 1980 thesis, and is strongly influenced by geologic features that cause subsurface flows from upstream reaches to emerge and produce instream habitat throughout the summer low flow period. In July 2003, HSI mapping in the VEN 3 study site revealed good flows and instream habitat for a distance of approximately 1,600 ft above the confluence with San Antonio Creek. Above that point, the channel braided and surface flow dwindled to near zero over the following ¼ to ½ mile. The Ventura River channel remained dry over the next 5¾ miles to Robles Diversion Dam.

Entrix (2002) characterized reaches 4 (San Antonio creek to Highway 150 Bridge) and 5 (Highway 150 Bridge to Robles diversion) with a habitat value of 2 (poor) primarily due to a lack of flow during the summer. We did not produce an HSI score for this stretch of the Ventura River (except for the ¼ mi above San Antonio Creek, which contained flow) because it was dry during the HSI survey. The Entrix reach 6 (from Robles Diversion to Matilija Dam) received a score of 0 due to the current steelhead barrier at Robles Diversion, but they did note that this reach contained "moderate" spawning and rearing habitat, which is consistent with the overall HSI scores for VEN 5 (0.51) and VEN 6 (0.51).

Entrix (2002) assigned all reaches above Matilija Dam scores of 0 due to inaccessibility, however they did provide some qualitative judgments of potential steelhead habitat. For example, Entrix characterized Matilija Creek from the reservoir up to the headwaters as good habitat. The lower portion of this reach is equivalent to the HSI reaches MAT 3, MAT 4, and MAT 5, which produced overall HSI scores of 0.52 and 0.61, which would probably be best described as fair to good. The Entrix Reach 9 (upper Matilija Creek headwaters) was characterized as potentially excellent habitat. HSI scores for MAT 6, MAT 7, Murietta Creek, and the Upper North Fork Matilija yielded overall HSI values ranging from 0.63 to 0.83, which would be characterized as good to excellent.

Moore 1980 Thesis

Moore (1980b) also conducted a study of the growth and survival rates of juvenile rainbow trout in the Ventura River. The study area, from the confluence of San Antonio Creek to Foster Park, was selected because it retains perennial surface flow and is believed to provide the principal spawning and rearing habitat currently accessible to steelhead. This study area is roughly the upper half of the HSI reach VEN 3, and the actual HSI study site for this reach was within Moore's study area. Moore concluded that this area proved to be highly productive, with rapid growth rates observed under summer and fall base flow conditions. Moore (1980b) also used a two-pass removal method to estimate the population of wild steelhead and resident rainbow trout within the study area in December 1976 and in the summer and fall of 1977 and 1978. The estimate of wild salmonids in December 1976 was 943, in July 1977 it was 3,458, in October 1977 it was 666, in July 1978 it was 532, and in October 1978 it was 423. The low number of wild salmonids in July 1978 was attributed to unusually heavy flooding earlier in the year. The HSI score for that reach was the highest of the Ventura River reaches at 0.53, which supports the conclusions of Moore (1980b) that this portion of the Ventura River continues to provide important rearing habitat to salmonid fishes.

CONCLUSIONS

HSI scores were developed for 17 study sites in the Ventura River and the Matilija Creek Basin during April and July 2003 under near base flow conditions. HSI scores were derived from a habitat quality model that utilizes 18 habitat parameters related to suitability for the adult, juvenile, fry, and incubation life stages of rainbow trout and steelhead (Raleigh et al. 1984). Some of the habitat parameters did not appear to be applicable to southern steelhead, consequently modifications were made to several HSI curves prior to calculation of HSI scores. Higher HSI scores (nearer to 1.0) are assumed to represent optimal habitat, whereas lower scores (nearer to 0.0) are assumed to provide marginal or no habitat.

HSI scores ranged from a low of 0.36 for the lowest reach in the Ventura River, to a high of 0.83 for the highest reach in the Upper North Fork Matilija Creek. Most lower Ventura River reaches yielded HSI scores between 0.5 and 0.6, with the highest scores in the upstream reaches. Most HSI scores in the upper basin and tributaries were 0.7 to 0.8; only the lowest mainstem Matilija reach (Mat 3) produced a score less than 0.6. Habitat "value" scores were then generated for the upper sub basin reaches (Matilija Creek and tributaries above Matilija Dam, and the Lower North Fork Matilija Creek) and for the lower sub basin reaches (the Ventura River below Matilija Dam) by weighting the reach-specific HSI scores by their respective lengths. The resulting habitat value score for the upper sub basin (weighted mean score of 0.72) was nearly 50% greater than the score for the lower sub basin (mean score = 0.50).

Although most of the upper sub basin reaches are relatively undisturbed by human activities, the Ventura River reaches have all been subject to extensive alterations related to water withdrawal, agricultural and industrial activities, and other land use impacts. Historical information suggests that significant numbers of steelhead once spawned and reared in the downstream reaches of the Ventura River. Thus it is expected that current HSI scores for those reaches reflect a degraded condition, and may not represent the full potential of the lower Ventura River reaches to rear steelhead.

Because the HSI model has not been validated for steelhead in the southern portion of their range, and because considerable uncertainty remains in the applicability of several HSI variable curves (particularly the temperature curves), it is unknown how well the reach-specific HSI scores would correlate with production of steelhead. However the reach specific HSI scores were compared with historical habitat assessments and with professional judgment of steelhead habitat requirements and showed, in general, good agreement.

In conclusion, this HSI analysis supports previous qualitative assessments that the highest quality habitat for steelhead occurs in the upper Matilija Creek Basin, including the North Fork Matilija Creek. The mainstem Ventura River continues to provide some rearing habitat, as well as an essential corridor for upstream and downstream migrant steelhead. Granting access for steelhead to the upper sub basin beyond Robles Diversion Dam and above Matilija Dam would be expected provide a significant amount of quality spawning and rearing habitat for the Southern steelhead ESU.

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Appendix A. Additional descriptions of HSI study reaches, study sites, and HSI scores.

VEN 1: The VEN 1 reach extended 8,026 ft upstream from the 101 highway bridge. The VEN 1 HSI study site produced an overall HSI value of 0.364. This low score is primarily the result of a very low score of 0.04 in the embryo component and a low score of 0.47 in the juvenile component. The embryo component score is the result of the spawning velocities in being too great, in almost all of the spawning areas sampled, after applying the expansion factor. The juvenile component score is primarily the result of the high smolt migration temperature (V2a) of 21°C. The score of 0.54 for the "other" component is primarily the result of low scores for the adult rearing temperature and the ratio of low Q:Average Q, which are fairly similar throughout the Ventura River reaches of this study. The adult and fry components have HSI values of 0.77 and 0.90 respectively.

VEN 2: The VEN 2 reach was 15,946 ft long and ended at the sewage treatment plant. The VEN 2 study site produced an overall HSI score of 0.520. The lowest of the component scores (embryo at 0.20) is the result of the maximum incubation temperature. The juvenile and other components had relatively low scores of 0.49 and 0.52 respectively. These components were affected by the same variables as those mentioned in the VENT 1 components. The adult and fry components both had relatively high scores of 0.79 and 0.94.

VEN 3: The VEN 3 reach was 15,523 ft long and terminated just above San Antonio Creek. The VEN 3 study site produced an overall HSI score of 0.528. The reasons for this score are essentially the same as those mentioned in the VENT 2 site above. The component scores ranged from 0.96 (fry) to 0.20 (embryo).

VEN 4: This reach was 34,426 ft in length and extended upstream to the Robles Diversion Dam. All but the lower ¼ to ½ mile of this reach was dry in July 2003; consequently an HSI study site was not selected for this reach.

VEN 5: The VEN 5 reach was 8,501 ft long and extended from the Robles Diversion Dam pool to the confluence with the Lower North Fork Matilija Creek. The VEN 5 study site produced and overall HSI score of 0.507 with component scores ranging from 0.97 (fry) to 0.20 (embryo). These results are due to the same factors mentioned in the previous two sites.

VEN 6: The VEN 6 reach, which is actually considered Matilija Creek, extended 3,379 ft upstream to the base of Matilija Dam. The VEN 6 study site produced an overall HSI score of 0.506 with component scores ranging from 1.00 (fry) to 0.20 (embryo). These results are due to the same factors mentioned in the previous three sites.

LNF low: The LNF low reach included the Lower North Fork Matilija Creek from its confluence upstream for 13,830 ft to a point where the channel becomes more confined (but downstream of Wheeler Gorge). The study site LNF extra was selected to represent this reach. The LNF extra site produced an overall HSI score of 0.776. The embryo and juvenile components give the lowest scores of 0.63 and 0.64 respectively. The low score for the juvenile component is the result of the relatively high smolt migration temperature (V2a) of 18^{o}C. The score for the embryo component seems to be because of a relatively high percentage of fines in several of the spawning areas that reduces the spawning variable for this site. The adult, fry and "other" components all had relatively high scores of 0.95, 0.95 and 0.77 respectively.

LNF mid: This reach was 8,663 ft long and extended to the impassible road crossing barrier at Wheeler Gorge Campground. The HSI study site LNF low produced an overall HSI score of 0.794. The juvenile component score of 0.65 is the lowest of the five components, and is primarily the result of the relatively high smolt migration temperature (V2a). The adult, fry, embryo and "other" components all scored relatively well with values of 0.95, 0.97, 0.75 and 0.70 respectively.

LNF up: This reach extended upstream18,675 ft to an impassible barrier under the Highway 33 bridge. The LNF up site produced an overall HSI score of 0.784. The juvenile component score of 0.64 is the lowest of the five components, and is primarily the result of the relatively high smolt migration temperature (V2a). The embryo component score of 0.68 is the result of relatively low scores in the spawning velocities and % fines in the spawning areas. The adult, fry and "other" components gave scores of 0.95, 0.93 and 0.78 respectively.

MAT 1: This reach was 1,900 ft in length and appeared to be lake influenced, therefore it was not included in the HSI study.

MAT 2: Most of the MAT 2 reach (4,100 ft) is within the historic lake zone and is likely to change after dam removal and is, therefore, excluded from the HSI study.

MAT 3: Only 3,870 ft of MAT 3 was available for HSI study site selection, because the remaining 4,909 ft was on private land. The entire 8,779 ft of MAT 3, however, is represented in the final HSI score, as the HSI reach brackets the area of private land. The MAT 3 HSI data produced an overall score of 0.522 with low scores in the embryo and the juvenile components having the most significant impact. The juvenile component score of 0.39 was most strongly affected by the relatively high smolt migration temperature of 21^{o}C, which resulted in a score of 0.25 for that variable. The low score in the embryo component is the direct result of the maximum incubation temperature which resulted in a score 0.32 for that component. The remaining components, adult, fry and "other", all scored relatively high with values of 0.72, 0.71 and 0.62 respectively.

MAT 4: At 6,860 ft, this reach was not included in the HSI site selection because it is entirely on private land and was, therefore, not mapped during the first stage survey. This reach was, however, represented by the HSI score from MAT 5.

MAT 5: The HSI study site for MAT 5 was randomly selected from the 4,826 ft reach and, as was mentioned earlier, was used to represent both the MAT 5 and MAT 4 reaches; which totaled 11,686 ft of stream. The top of the MAT 5 reach extended to the confluence with the Upper North Fork Matilija Creek. The MAT 5 data produced a slightly higher overall HSI score of 0.608 with the juvenile and embryo components again providing the most significant limiting factors. The juvenile component score of 0.44 was limited by the same high smolt migration temperature as MAT 3, while the embryo component score of 0.43 was the sole result of the maximum incubation temperature of 18.3^{o}C. The remaining components, adult, fry and "other" produced higher scores of 0.85, 0.85 and 0.60 respectively.

MAT 6: The MAT 6 reach extended upstream 7,731 ft from the Upper North Fork Matilija Creek to Old Man Creek. The MAT 6 site produced an overall HSI score of 0.631. The lowest of the component scores were juvenile (0.52), embryo (0.43) and "other" (0.56). The juvenile and embryo scores were, once again, the result of the smolt migration temperature and the incubation temperature, while the lower "other" score is primarily the due to the low scores for % vegetation, % shade and the ratio of low Q:average Q. The adult and fry components both had high scores of 0.86 and 0.93 respectively. The embryo component of this site is based only on the minimum values between maximum incubation temperature and minimum D.O. values, because there were no spawning areas in the units selected for HSI.

MAT 7: The MAT 7 reach included 9,018 ft of available stream and extended upstream from Old Man Creek to an impassible barrier, approximately 2,000 ft below the "falls" barrier. The MAT 7 site produced a relatively high overall HSI score of 0.736. The embryo and the "other" component provided the lowest scores of 0.51 and 0.63 respectively. The embryo component score is the result of the spawning variable (V_s) which is a combination of average spawning velocity, spawning substrate size and % fines in spawning areas. The "other" component score resulted from low values for the average riffle substrate (0.30) and the ratio of low Q:Average Q (0.26). The remaining components, adult, juvenile and fry, all had relatively high scores of 0.96, 0.71 and 1.00 respectively.

MAT 8: This reach was 2,171 ft long but was determined to be above a definite barrier. Therefore, it was not included in the HSI study.

MUR 1: This lowest reach on Murietta Creek was only 909 ft long and was too short to include an HSI study site. However, this reach was represented by the HSI score from MUR 3.

MUR 2: The MUR 2 reach consisted of 486 ft of dry channel during the first stage survey and was not thought to provide summer rearing habitat.

MUR 3: The 7,154 ft of MUR 3 was the only reach of sufficient flow and size, during the first stage survey, to be included for HSI site selection. The MUR 3 site produced an overall HSI score of 0.685 with the embryo component giving the lowest value (0.27). This low score is the result of low velocities at one of the sampled spawning areas. The adult, juvenile, fry and "other" components all had relatively high scores of 0.96, 0.76, 0.99 and 0.77 respectively.

MUR 4: The 2,700 ft of MUR 4 were intermittent or dry during the first stage survey and not thought to provide sufficient summer rearing habitat for inclusion in the second stage HSI study.

OLD 1: The OLD 1 reach is 1,900 ft long and was not included in the HSI selection because this reach was mostly dry during the first stage mapping.

OLD 2: The 4,146 ft OLD 2 reach is the only section from Old Man Creek to be included for HSI selection, because it is the only reach that exhibited sufficient flow. The OLD 2 site produced an overall HSI score of 0.643. The lowest of the component scores (embryo at 0.27) is the result of low values for the spawning variable. The 0.27 value of the spawning variable is the result of three of the five gravel patches sampled having very low velocities that, in turn, resulted in zero values for those three gravel patches. The juvenile component score of 0.66 is the result of the relatively high smolt migration temperature (V2a) of 18^{o}C. The adult, fry and "other" components all had relatively high HSI scores of 0.92, 1.00 and 0.68 respectively.

OLD 3: This reach consisted of 2,737 ft of dry channel and was, therefore, excluded from HSI selection.

OLD 4: The OLD 4 reach is 2,532 ft long with very minimal flow and was not expected to provide important summer rearing habitat. However, the OLD 4 reach was represented by the OLD 2 HSI study site.

OLD 5: The OLD 5 reach is 710 ft long and was dry during the first survey and, therefore, not included in the HSI study.

UNF 1: The lowest reach in the Upper North Fork Matilija Creek was 6,649 ft long. The associated HSI study site (UNF low) was selected from the UNF 1 and UNF 3 reaches due to their similarity in habitat character. The UNF low site produced an overall HSI score of 0.732 with all of the components, except the embryo component, scoring relatively high. The embryo component score of 0.52 is the result of the spawning variable. The adult, juvenile, fry and "other" components resulted in scores of 0.93, 0.71, 0.82 and 0.76 respectively.

UNF 2: This reach occurred in an open channel area and was 3,851 ft long. The UNF 2 site produced an overall HSI score of 0.744. This is, again, due to the spawning variable of the embryo component that resulted in a score of 0.49. The reason for this low score is specifically the result of the spawning velocity being to high at one gravel patch which gave a score of 0.0 for that spawning patch, and thereby reducing the overall variable. The remaining four variables all produced relatively high scores of 0.95, 0.74, 0.94 and 0.70.

UNF 3: this reach was 3,743 ft in length and, as stated above, was combined with UNF 1 prior to selection of the common HSI study site, UNF low.

UNF 4: This highest reach extended 7,291 ft upstream from the confluence of a tributary (UNFT) to an impassible barrier. This reach and UNFT was represented by a single HSI study site (UNF up) that was selected from the lower 1,421 ft of UNF 4 and included a portion of the UNFT reach. The UNF up site produced an overall HSI score of 0.829, which is the highest score of any site in this survey. The lowest of the component scores ("other" at 0.71) resulted from low values for the average riffle substrate (0.30) and the ratio of low Q:Average Q (0.26). The juvenile component produced a score of 0.74, which is primarily the result of the smolt migration temperature value of 0.67. The adult, fry and embryo components gave relatively high scores of 0.95, 0.93 and 0.85 respectively.

UNFT 1: This reach encompassed the prominent tributary to the Upper North Fork Matilija Creek upstream 4,318 ft to an impassible barrier. As stated above, this reach was represented by HSI study site UNF up.

Appendix B. GPS waypoint coordinates (WGS 84) for upstream and downstream boundaries of HSI study sites.

HSI Study Site	Location	Waypt	Latitude Deg	Latitude Min	Latitude Sec	Longitude Deg	Longitude Min	Longitude Sec
UNF up	trib top	UNFUPT2	34	31	21	-119	21	5
	mainstem top	UNFUPT1	34	31	33	-119	21	9
	mainstem btm	UNFUPB	34	31	21	-119	21	8
UNF 2	top	UNF2T	34	31	6	-119	21	44
	bottom	UNF2B	34	31	1	-119	22	2
UNF low	top	UNFLOWT	34	30	55	-119	22	27
	bottom	UNFLOWB	34	31	5	-119	22	43
OLD 2	top	OLD2T	34	31	6	-119	25	8
	bottom	OLD2B	34	31	0	-119	24	55
MUR 3	top	MUR3T	34	29	56	-119	23	46
	bottom	MUR3B	34	30	4	-119	23	25
MAT 7	top	MAT7T	34	31	37	-119	24	5
	bottom	MAT7B	34	31	20	-119	24	14
MAT 6	top	MAT6T	34	30	52	-119	24	3
	bottom	MAT6B	34	30	43	-119	23	42
MAT 5	top	MAT5T	34	30	20	-119	22	46
	bottom	MAT5B	34	30	12	-119	22	19
MAT 3	top upper segment	MAT3T2	34	30	2	-119	20	59
	btm upper segment	MAT3B2	34	30	0	-119	20	43
	top lower segment	MAT3T1	34	29	41	-119	20	0
	btm lower segment	MAT3B1	34	29	37	-119	19	43
LNF up	top	LNFUPT	34	31	11	-119	15	52
	bottom	LNFUPB	34	31	8	-119	16	10
LNF mid	top	LNFMIDT	34	30	22	-119	16	59
	bottom	LNFMIDB	34	30	29	-119	17	11
LNF low	top	LNFLOWT	34	30	19	-119	17	48
	bottom	LNFLOWB	34	30	2	-119	17	57
VEN 6	top	VEN6T	34	29	4	-119	18	31
VEN 5	top of 5, btm of 6	VEN5T-6B	34	29	7	-119	18	0
	bottom	VEN5B	34	28	50	-119	17	35
VEN 3	top	VEN3T	34	22	54	-119	18	31
	bottom	VEN3B	34	22	13	-119	18	41
VEN 2	top	VEN2T	34	19	58	-119	17	49
	bottom	VEN2B	34	19	10	-119	17	43
VEN 1	top	VEN1T	34	18	4	-119	18	14
	bottom	VEN1B	34	17	27	-119	18	30

Appendix C. Photographs of habitat units selected for collection of HSI data. Photos are labeled according to the HSI study site designation, then with the habitat unit number (see Appendix D for habitat unit information). Photos are only available on a CD.

Appendix D. Habitat mapping data from HSI study sites. See text for reach locations and description of habitat types.

Stream	HSI Study Site	Habitat Unit #	Habitat Type	Distance Upstream	Unit Length	Comments
Ventura	VEN 1	1	RUN	220	220	thick both banks
Ventura	VEN 1	2	DPL	251	31	old culvert MC, high eroding bank above LB
Ventura	VEN 1	3	LGR	263	12	some 4" fish darting, many 1-2",10" carp
Ventura	VEN 1	4	CCP	369	106	10x30 gravel RB w/in 6"
Ventura	VEN 1	5	LGR	425	56	SC Q 60:40
Ventura	VEN 1	6	RUN	479	54	
Ventura	VEN 1	7	MCP	510	31	
Ventura	VEN 1	8	RUN	530	20	
Ventura	VEN 1	9	HGR	573	43	chutes and plunges
Ventura	VEN 1	10	MCP	593	20	sc ends @ top
Ventura	VEN 1	11	GLD	645	52	grav/cob/sand @ tail 20x20
Ventura	VEN 1	12	MCP	806	161	
Ventura	VEN 1	13	GLD	889	83	transient camp - skipped HSI unit
Ventura	VEN 1	14	MCP	956	67	SC Q 60:40
Ventura	VEN 1	15	RUN	1,030	74	camp up to LGR
Ventura	VEN 1	16	LGR	1,130	100	15x30 gravel w/in 6", 25X30 w/in 1'
Ventura	VEN 1	17	GLD	1,300	170	sc ends @btm 15x20 gravel @ btm
Ventura	VEN 1	18	MCP	1,433	133	
Ventura	VEN 1	19	RUN	1,525	92	deep, pool like
Ventura	VEN 1	20	LGR	1,560	35	
Ventura	VEN 1	21	RUN	1,633	73	
Ventura	VEN 1	22	LGR	1,678	45	gravel 30x20
Ventura	VEN 1	23	MCP	1,876	198	
Ventura	VEN 1	24	GLD	1,934	58	lrg gravel bar 20x60 all in water
Ventura	VEN 1	25	RUN	2,057	123	gravel 10x120 IW
Ventura	VEN 1	26	MCP	2,109	52	possible redd @tail cobble out of water
Ventura	VEN 1	27	LGR	2,139	30	15x30 IW
Ventura	VEN 1	28	RUN	2,177	38	10x20
Ventura	VEN 1	29	LGR	2,204	27	20x20 all IW
Ventura	VEN 1	30	GLD	2,249	45	10x20 all IW
Ventura	VEN 1	31	MCP	2,417	168	
Ventura	VEN 1	32	GLD	2,532	115	15x20 gravel all w/in 6" @top
Ventura	VEN 1	33	LGR	2,614	82	trv @btm barking dogs up by levee
Ventura	VEN 1	34	RUN	2,666	52	bld @ top
Ventura	VEN 1	35	LGR	2,681	15	break
Ventura	VEN 1	36	RUN	2,718	37	
Ventura	VEN 1	37	LGR	2,735	17	bld @ top
Ventura	VEN 1	38	RUN	2,803	68	
Ventura	VEN 1	39	LGR	2,844	41	
Ventura	VEN 1	40	LSR	2,868	24	tree formed?
Ventura	VEN 1	41	LGR	2,885	17	sc 15x20 gravel
Ventura	VEN 1	42	RUN	3,080	195	split @btm gravel 5x25 IW
Ventura	VEN 1	43	LGR	3,115	35	narrow and deep
Ventura	VEN 1	44	RUN	3,144	29	
Ventura	VEN 1	45	MCP	3,406	262	12" carp?
Ventura	VEN 1	46	GLD	3,523	117	
Ventura	VEN 1	47	LGR	3,558	35	
Ventura	VEN 1	48	PLP	3,605	47	
Ventura	VEN 1	49	CAS	3,610	5	concrete sill
Ventura	VEN 1	50	MCP	3,754	144	~10 carp 8-10"
Ventura	VEN 1	51	RUN	3,790	36	concrete ? In bottom
Ventura	VEN 1	52	HGR	3,860	70	trv w/ split 50:50, mapped LB
Ventura	VEN 1	53	GLD	3,950	90	
Ventura	VEN 1	54	RUN	4,037	87	
Ventura	VEN 1	55	GLD	4,209	172	sc @ btm
Ventura	VEN 1	56	MCP	4,325	116	end @ 1341; bedrock LB
Ventura	VEN 2	1	LSBk	154	154	OVH xing @ PL below,visib less than Seg1
Ventura	VEN 2	2	RUN	178	24	top of pool, more brown algae than Seg1
Ventura	VEN 2	3	LGR	208	30	sc Q 70:30
Ventura	VEN 2	4	RUN	229	21	
Ventura	VEN 2	5	LGR	409	180	
Ventura	VEN 2	6	POW	600	191	wide and shallow
Ventura	VEN 2	7	RUN	764	164	w/ boulders, like below but narrower
Ventura	VEN 2	8	GLD	825	61	
Ventura	VEN 2	9	LSBk	1,034	209	ovh lines-sediment is black under algae

Appendix D. (continued)

Stream	HSI Study Site	Habitat Unit #	Habitat Type	Distance Upstream	Unit Length	Comments
Ventura	VEN 2	10	LGR	1,075	41	sc
Ventura	VEN 2	11	RUN	1,125	50	sc, stratified cliff on LB
Ventura	VEN 2	12	LGR	1,163	38	cliff
Ventura	VEN 2	13	GLD	1,202	39	cliff
Ventura	VEN 2	14	LGR	1,254	52	cliff
Ventura	VEN 2	15	RUN	1,295	41	BW continue up bedrock
Ventura	VEN 2	16	LGR	1,403	108	turns away from Brk, OVH lines @ top
Ventura	VEN 2	17	GLD	1,668	265	scattered gravel ~20x20
Ventura	VEN 2	18	LGR	1,770	102	
Ventura	VEN 2	19	RUN	1,800	30	like POW
Ventura	VEN 2	20	LGR	1,938	138	like POW
Ventura	VEN 2	21	RUN	2,033	95	
Ventura	VEN 2	22	GLD	2,112	79	
Ventura	VEN 2	23	MCP	2,364	252	many carp
Ventura	VEN 2	24	RUN	2,425	61	10x30 gravel w/ in 6"
Ventura	VEN 2	25	LGR	2,460	35	
Ventura	VEN 2	26	GLD	2,515	55	tail of pool
Ventura	VEN 2	27	MCP	2,887	372	bedrock LB top
Ventura	VEN 2	28	LGR	2,933	46	bedrock LB
Ventura	VEN 2	29	SRN	3,010	77	steps from bedrock
Ventura	VEN 2	30	DPL	3,049	39	
Ventura	VEN 2	31	HGR	3,092	43	sc @ btm Q 90:10
Ventura	VEN 2	32	RUN	3,123	31	
Ventura	VEN 2	33	LGR	3,274	151	wide @ top, 5x10 gravel @ 0-1' ow
Ventura	VEN 2	34	POW	3,456	182	sc @ btm, wide and shallow
Ventura	VEN 2	35	GLD	3,703	247	
Ventura	VEN 2	36	LSBk	4,027	324	OVH lines, Shell Hole ?
Ventura	VEN 2	37	RUN	4,102	75	10x10 gravel, silt/algae at top
Ventura	VEN 2	38	LSBk	4,153	51	sc coming in @ top
Ventura	VEN 2	39	LGR	4,196	43	trv w/ 3 channels
Ventura	VEN 2	40	POW	4,351	155	RC is LGR
Ventura	VEN 2	41	RUN	4,471	120	5x40 IW,5x25 gravel w/in6",10x25 w/in1'
Ventura	VEN 2	42	LGR	4,550	79	good gravel 15x60 w/in 6", 25x60 w/in 1'
Ventura	VEN 2	43	RUN	4,620	70	15x30 w/in 6", 25x30 w/in 1'
Ventura	VEN 2	44	LGR	4,647	27	10x20 w/in 6"
Ventura	VEN 2	45	RUN	4,740	93	8x20 W/in 6"
Ventura	VEN 2	46	LGR	4,932	192	bedrock ledges, oil dome up RB
Ventura	VEN 2	47	RUN	5,088	156	gravel 10x10, cemented w algae
Ventura	VEN 2	48	LGR	5,247	159	trv
Ventura	VEN 3	1	GLD	106	106	3 channels, Q's 50:10:40
Ventura	VEN 3	2	CCP	159	53	water clearer-green algal mats, not brown
Ventura	VEN 3	3	LGR	253	94	
Ventura	VEN 3	4	RUN	293	40	
Ventura	VEN 3	5	LGR	464	171	runs beneath arundo, Top end split w grav
Ventura	VEN 3	6	GLD	690	226	
Ventura	VEN 3	7	MCP	1,364	674	super long, narrow and deeper at top
Ventura	VEN 3	8	RUN	1,439	75	
Ventura	VEN 3	9	LGR	1,518	79	
Ventura	VEN 3	10	RUN	1,549	31	opposite lower end of trailer park
Ventura	VEN 3	11	LGR	1,661	112	trailer park
Ventura	VEN 3	12	RUN	1,722	61	trailer park
Ventura	VEN 3	13	LGR	1,765	43	TRV
Ventura	VEN 3	14	RUN	1,884	119	5x40 gravel
Ventura	VEN 3	15	GLD	1,936	52	trailer park
Ventura	VEN 3	16	LGR	2,064	128	lrg gravel deposit
Ventura	VEN 3	17	GLD	2,230	166	top trailer park, ~20x40 gravel/sml cobble
Ventura	VEN 3	18	LSR	2,502	272	lrg grav bar on LB @~1.5' OW, RR on RB
Ventura	VEN 3	19	RUN	2,680	178	RR on RB, sc slough LB Q 90:10
Ventura	VEN 3	20	LGR	2,702	22	
Ventura	VEN 3	21	RUN	2,748	46	
Ventura	VEN 3	22	LGR	2,872	124	w runs, arundo below top
Ventura	VEN 3	23	RUN	2,921	49	
Ventura	VEN 3	24	LGR	2,996	75	sc ends at top
Ventura	VEN 3	25	GLD	3,064	68	rt half LGR
Ventura	VEN 3	26	LGR	3,130	66	good gravel
Ventura	VEN 3	27	GLD	3,417	287	ovh wires

Appendix D. (continued)

Stream	HSI Study Site	Habitat Unit #	Habitat Type	Distance Upstream	Unit Length	Comments
Ventura	VEN 3	28	RUN	3,577	160	slow, top end of RR, old redds?
Ventura	VEN 3	29	STP	3,816	239	man-made, org flag "spawn 2-run-1/10/03" w/ rebar
Ventura	VEN 3	30	LGR	3,875	59	
Ventura	VEN 3	31	RUN	3,963	88	
Ventura	VEN 3	32	LGR	4,070	107	art pool upper RC
Ventura	VEN 3	33	GLD	4,141	71	
Ventura	VEN 3	34	MCP	4,426	285	
Ventura	VEN 3	35	RUN	4,468	42	
Ventura	VEN 3	36	LGR	4,564	96	
Ventura	VEN 3	37	RUN	4,665	101	
Ventura	VEN 3	38	LGR	4,909	244	Santa Ana Rd visib up LB
Ventura	VEN 3	39	MCP	5,150	241	road access at top
Ventura	VEN 3	40	LGR	5,430	280	sc Q 60:40 (starts in mcp)
Ventura	VEN 5	1	LSBo	21	21	WSEL is 0.25ft abv marks on rocks
Ventura	VEN 5	2	RUN	62	41	substr has sign more mineral deposits
Ventura	VEN 5	3	HGR	72	10	
Ventura	VEN 5	4	LSBo	91	19	
Ventura	VEN 5	5	LGR	117	26	
Ventura	VEN 5	6	DPL	137	20	
Ventura	VEN 5	7	CAS	165	28	avg. unit L=23', change sampling rate
Ventura	VEN 5	8	DPL	200	35	small sc
Ventura	VEN 5	9	LGR	220	20	
Ventura	VEN 5	10	PLP	245	25	gravel 8x5,8x12, sc
Ventura	VEN 5	11	CAS	250	5	
Ventura	VEN 5	12	RUN	268	18	RC
Ventura	VEN 5	13	MCP	414	146	gravel 5x20
Ventura	VEN 5	14	LGR	437	23	should be pw like
Ventura	VEN 5	15	POW	474	37	
Ventura	VEN 5	16	MCP	573	99	5x15 gravel
Ventura	VEN 5	17	POW	614	41	
Ventura	VEN 5	18	LGR	678	64	
Ventura	VEN 5	19	RUN	721	43	10x20 gravel-very cemented
Ventura	VEN 5	20	MCP	747	26	
Ventura	VEN 5	21	RUN	783	36	IFIM "TR #5 RUN kc/dp"
Ventura	VEN 5	22	LGR	807	24	
Ventura	VEN 5	23	MCP	865	58	
Ventura	VEN 5	24	POW	945	80	
Ventura	VEN 5	25	DPL	974	29	
Ventura	VEN 5	26	POW	996	22	
Ventura	VEN 5	27	RUN	1,040	44	
Ventura	VEN 5	28	LGR	1,123	83	
Ventura	VEN 5	29	RUN	1,259	136	
Ventura	VEN 5	30	LGR	1,312	53	
Ventura	VEN 5	31	POW	1,467	155	lrg gravel deposit just below bridge RB
Ventura	VEN 5	32	MCP	1,509	42	bridge formed
Ventura	VEN 5	33	RUN	1,539	30	
Ventura	VEN 5	34	MCP	1,554	15	lrg gravel deposit above bridge
Ventura	VEN 5	35	LGR	1,605	51	20x30, (25x30 w/in 1')
Ventura	VEN 5	36	RUN	1,643	38	20x25 gravel
Ventura	VEN 5	37	POW	1,720	77	
Ventura	VEN 5	38	MCP	1,747	27	10x10, (1/2 w/in 6")
Ventura	VEN 5	39	LGR	1,772	25	
Ventura	VEN 5	40	MCP	1,792	20	
Ventura	VEN 5	41	LGR	1,805	13	
Ventura	VEN 5	42	MCP	1,831	26	
Ventura	VEN 5	43	LGR	1,953	122	5x10 gravel, (5x15 w/in 1')
Ventura	VEN 5	44	POW	2,135	182	gravel 10x10,10x20,10x20
Ventura	VEN 5	45	MCP	2,162	27	
Ventura	VEN 5	46	RUN	2,198	36	10x20 gravel (1/2 w/in 1')
Ventura	VEN 5	47	LGR	2,224	26	
Ventura	VEN 5	48	POW	2,279	55	~5" trout, possibly fry also
Ventura	VEN 5	49	MCP	2,340	61	footbridge to houses LB
Ventura	VEN 5	50	LGR	2,480	140	"TR #9 rn/sp"
Ventura	VEN 5	51	MCP	2,512	32	flag "poten HGR"
Ventura	VEN 5	52	LGR	2,578	66	
Ventura	VEN 5	53	POW	2,656	78	sc

Appendix D. (continued)

Stream	HSI Study Site	Habitat Unit #	Habitat Type	Distance Upstream	Unit Length	Comments
Ventura	VEN 5	54	MCP	2,688	32	slow wide part of pow, 3" trout
Ventura	VEN 5	55	POW	2,764	76	15x15 gravel
Ventura	VEN 5	56	LSBo	2,806	42	
Ventura	VEN 5	57	RUN	2,829	23	
Ventura	VEN 5	58	LGR	2,835	6	short step
Ventura	VEN 5	59	MCP	2,917	82	school of baby bass
Ventura	VEN 5	60	RUN	2,984	67	
Ventura	VEN 5	61	LGR	3,023	39	
Ventura	VEN 5	62	MCP	3,076	53	
Ventura	VEN 5	63	HGR	3,100	24	confluence w/ LNF
Ventura	VEN 6	1	LSBo	25	25	10x10 (from LNF), LNF 70 deg, ~1.5cfs
Ventura	VEN 6	2	HGR	36	11	
Ventura	VEN 6	3	POW	103	67	
Ventura	VEN 6	4	MCP	143	40	
Ventura	VEN 6	5	POW	198	55	deep (5') holes under lg boulders
Ventura	VEN 6	6	RUN	221	23	
Ventura	VEN 6	7	HGR	235	14	
Ventura	VEN 6	8	MCP	287	52	
Ventura	VEN 6	9	POW	310	23	
Ventura	VEN 6	10	LSBo	344	34	
Ventura	VEN 6	11	HGR	360	16	
Ventura	VEN 6	12	MCP	412	52	IFIM TR ?
Ventura	VEN 6	13	HGR	421	9	
Ventura	VEN 6	14	POW	461	40	IFIM TR # "rn/pw unit 11"
Ventura	VEN 6	15	MCP	525	64	
Ventura	VEN 6	16	RUN	562	37	
Ventura	VEN 6	17	LGR	571	9	
Ventura	VEN 6	18	MCP	618	47	short break between pools
Ventura	VEN 6	19	MCP	652	34	rock buttress LB
Ventura	VEN 6	20	LGR	722	70	
Ventura	VEN 6	21	RUN	744	22	
Ventura	VEN 6	22	LGR	759	15	
Ventura	VEN 6	23	RUN	767	8	old gage
Ventura	VEN 6	24	LSBk	846	79	cliff LB-deep and shady, 6' max, photo 84
Ventura	VEN 6	25	HGR	856	10	
Ventura	VEN 6	26	DPL	875	19	no gps coverage
Ventura	VEN 6	27	HGR	889	14	thick arundo
Ventura	VEN 6	28	POW	907	18	
Ventura	VEN 6	29	LSBk	985	78	cliff LB
Ventura	VEN 6	30	CAS	995	10	pic 88, 5 ft high concrete w 45 deg slope
Ventura	VEN 6	31	LSBk	1,137	142	pic 87, new gage
Ventura	VEN 6	32	CAS	1,156	19	sc
Ventura	VEN 6	33	RUN	1,190	34	
Ventura	VEN 6	34	POW	1,220	30	
Ventura	VEN 6	35	LGR	1,235	15	
Ventura	VEN 6	36	POW	1,330	95	split through thick arundo
Ventura	VEN 6	37	LSBo	1,388	58	looks deep, huge boulder mc
Ventura	VEN 6	38	RUN	1,421	33	
Ventura	VEN 6	39	POW	1,455	34	small springs, access by rd
Ventura	VEN 6	40	CAS	1,469	14	
Ventura	VEN 6	41	RUN	1,486	17	
Ventura	VEN 6	42	POW	1,585	99	deep and slow
Ventura	VEN 6	43	RUN	1,635	50	
Ventura	VEN 6	44	LGR	1,653	18	
Ventura	VEN 6	45	POW	1,729	76	slow
Ventura	VEN 6	46	LSBk	1,774	45	along Matilija Reserve property
Ventura	VEN 6	47	POW	1,850	76	" " "
Ventura	VEN 6	48	MCP	1,891	41	" " "
Ventura	VEN 6	49	POW	2,030	139	HSI unit not sampled-pvt prop
Ventura	VEN 6	50	LGR	2,168	138	w/ casades, mapping difficult
Ventura	VEN 6	51	POW	2,459	291	dense arundo thicket
Ventura	VEN 6	52	RUN	2,507	48	
Ventura	VEN 6	53	LSBk	2,675	168	pic 94 visibility ~1'
Ventura	VEN 6	54	CAS	2,690	15	
Ventura	VEN 6	55	PLP	2,700	10	
Ventura	VEN 6	56	CAS	2,720	20	thick arundo

Appendix D. (continued)

Stream	HSI Study Site	Habitat Unit #	Habitat Type	Distance Upstream	Unit Length	Comments
Ventura	VEN 6	57	DPL	2,749	29	" "
Ventura	VEN 6	58	RUN	2,805	56	" "
Ventura	VEN 6	59	MCP	2,848	43	" "
Ventura	VEN 6	60	POW	2,929	81	" "
Ventura	VEN 6	61	MCP	2,955	26	" "
Ventura	VEN 6	62	HGR	2,968	13	" "
Ventura	VEN 6	63	POW	3,010	42	Q notch at top
Ventura	VEN 6	64	MCP	3,043	33	
Ventura	VEN 6	65	LGR	3,074	31	arundo thicket
Ventura	VEN 6	66	MCP	3,150	76	visib ~6"
Ventura	VEN 6	67	LGR	3,225	75	arundo impenetrable-top at dam pool
Low NF Matilija	LNF extra	1	MCP	19	19	
Low NF Matilija	LNF extra	2	RUN	41	22	
Low NF Matilija	LNF extra	3	MCP	54	13	
Low NF Matilija	LNF extra	4	HGR	71	17	split
Low NF Matilija	LNF extra	5	SRN	97	26	split
Low NF Matilija	LNF extra	6	POW	120	23	
Low NF Matilija	LNF extra	7	GLD	131	11	good gravel entire unit
Low NF Matilija	LNF extra	8	MCP	157	26	
Low NF Matilija	LNF extra	9	POW	187	30	
Low NF Matilija	LNF extra	10	HGR	220	33	
Low NF Matilija	LNF extra	11	RUN	252	32	good gravel throughout unit
Low NF Matilija	LNF extra	12	LGR	273	21	gravel most of unit
Low NF Matilija	LNF extra	13	LSBo	298	25	
Low NF Matilija	LNF extra	14	POW	342	44	
Low NF Matilija	LNF extra	15	SRN	379	37	
Low NF Matilija	LNF extra	16	LGR	403	24	
Low NF Matilija	LNF extra	17	RUN	431	28	gravel most of unit
Low NF Matilija	LNF extra	18	MCP	455	24	
Low NF Matilija	LNF extra	19	CAS	463	8	
Low NF Matilija	LNF extra	20	MCP	490	27	
Low NF Matilija	LNF extra	21	RUN	519	29	
Low NF Matilija	LNF extra	22	MCP	542	23	
Low NF Matilija	LNF extra	23	RUN	586	44	
Low NF Matilija	LNF extra	24	LGR	617	31	Large substrate
Low NF Matilija	LNF extra	25	MCP	635	18	
Low NF Matilija	LNF extra	26	SRN	682	47	
Low NF Matilija	LNF extra	27	POW	708	26	turtle
Low NF Matilija	LNF extra	28	CAS	723	15	
Low NF Matilija	LNF extra	29	POW	754	31	
Low NF Matilija	LNF extra	30	MCP	772	18	
Low NF Matilija	LNF extra	31	HGR	787	15	
Low NF Matilija	LNF extra	32	SRN	808	21	split @ top L
Low NF Matilija	LNF extra	33	CAS	817	9	
Low NF Matilija	LNF extra	34	SRN	853	36	
Low NF Matilija	LNF extra	35	LGR	864	11	
Low NF Matilija	LNF extra	36	RUN	899	35	
Low NF Matilija	LNF extra	37	POW	926	27	
Low NF Matilija	LNF extra	38	CAS	939	13	
Low NF Matilija	LNF extra	39	MCP	960	21	
Low NF Matilija	LNF extra	40	SRN	989	29	
Low NF Matilija	LNF extra	41	LGR	1,005	16	
Low NF Matilija	LNF extra	42	GLD	1,057	52	some gravel, most cemented
Low NF Matilija	LNF extra	43	MCP	1,084	27	
Low NF Matilija	LNF extra	44	SRN	1,120	36	
Low NF Matilija	LNF extra	45	GLD	1,150	30	lots of cementing
Low NF Matilija	LNF extra	46	RUN	1,175	25	
Low NF Matilija	LNF extra	47	POW	1,207	32	
Low NF Matilija	LNF extra	48	RUN	1,253	46	
Low NF Matilija	LNF extra	49	HGR	1,268	15	
Low NF Matilija	LNF extra	50	RUN	1,285	17	
Low NF Matilija	LNF extra	51	MCP	1,304	19	
Low NF Matilija	LNF extra	52	LGR	1,321	17	
Low NF Matilija	LNF extra	53	GLD	1,356	35	heavy cementing; pool tail
Low NF Matilija	LNF extra	54	MCP	1,391	35	
Low NF Matilija	LNF extra	55	CAS	1,408	17	

Appendix D. (continued)

Stream	HSI Study Site	Habitat Unit #	Habitat Type	Distance Upstream	Unit Length	Comments
Low NF Matilija	LNF extra	56	MCP	1,442	34	
Low NF Matilija	LNF extra	57	SRN	1,475	33	
Low NF Matilija	LNF extra	58	RUN	1,492	17	heavy cementing @ top
Low NF Matilija	LNF extra	59	MCP	1,520	28	>4' deep, bdrk RB
Low NF Matilija	LNF extra	60	HGR	1,536	16	
Low NF Matilija	LNF extra	61	RUN	1,577	41	
Low NF Matilija	LNF extra	62	MCP	1,592	15	
Low NF Matilija	LNF extra	63	CAS	1,607	15	
Low NF Matilija	LNF extra	64	LGR	1,619	12	
Low NF Matilija	LNF extra	65	MCP	1,668	49	
Low NF Matilija	LNF extra	66	MCP	1,707	39	flag 6020 @ top
Low NF Matilija	LNF extra	67	CAS	1,729	22	
Low NF Matilija	LNF extra	68	RUN	1,781	52	
Low NF Matilija	LNF extra	69	CAS	1,818	37	
Low NF Matilija	LNF extra	70	LGR	1,860	42	
Low NF Matilija	LNF extra	71	MCP	1,913	53	
Low NF Matilija	LNF extra	72	MCP	1,945	32	end
Low NF Matilija	LNF low	1	GLD	100	100	
Low NF Matilija	LNF low	2	MCP	129	29	
Low NF Matilija	LNF low	3	HGR	151	22	
Low NF Matilija	LNF low	4	RUN	192	41	
Low NF Matilija	LNF low	5	LGR	200	8	
Low NF Matilija	LNF low	6	RUN	222	22	
Low NF Matilija	LNF low	7	MCP	235	13	
Low NF Matilija	LNF low	8	SRN	284	49	
Low NF Matilija	LNF low	9	LGR	323	39	
Low NF Matilija	LNF low	10	SRN	374	51	
Low NF Matilija	LNF low	11	MCP	406	32	
Low NF Matilija	LNF low	12	POW	418	12	
Low NF Matilija	LNF low	13	RUN	458	40	
Low NF Matilija	LNF low	14	LGR	470	12	
Low NF Matilija	LNF low	15	POW	500	30	
Low NF Matilija	LNF low	16	SRN	530	30	
Low NF Matilija	LNF low	17	LGR	546	16	
Low NF Matilija	LNF low	18	LSBk	570	24	
Low NF Matilija	LNF low	19	HGR	626	56	
Low NF Matilija	LNF low	20	LGR	652	26	almost entire unit gravel
Low NF Matilija	LNF low	21	MCP	694	42	good gravel in tail
Low NF Matilija	LNF low	22	LGR	708	14	large substrate
Low NF Matilija	LNF low	23	MCP	733	25	
Low NF Matilija	LNF low	24	RUN	768	35	
Low NF Matilija	LNF low	25	POW	817	49	cemented Rip-Rap LB
Low NF Matilija	LNF low	26	LGR	834	17	cemented Rip-Rap LB
Low NF Matilija	LNF low	27	MCP	889	55	cemented Rip-Rap LB
Low NF Matilija	LNF low	28	RUN	915	26	cemented Rip-Rap LB
Low NF Matilija	LNF low	29	LSBk	939	24	cemented Rip-Rap LB
Low NF Matilija	LNF low	30	RUN	956	17	cemented Rip-Rap LB
Low NF Matilija	LNF low	31	CAS	972	16	cemented Rip-Rap LB
Low NF Matilija	LNF low	32	LGR	1,003	31	cemented Rip-Rap LB
Low NF Matilija	LNF low	33	SRN	1,028	25	cemented Rip-Rap LB
Low NF Matilija	LNF low	34	LGR	1,043	15	cemented Rip-Rap LB; Large substrate
Low NF Matilija	LNF low	35	LSCo	1,094	51	LB is concrete wall ~ 20' tall
Low NF Matilija	LNF low	36	LGR	1,126	32	end concrete wall @ top
Low NF Matilija	LNF low	37	MCP	1,159	33	Bdrk LB
Low NF Matilija	LNF low	38	HGR	1,167	8	gorge-like
Low NF Matilija	LNF low	39	RUN	1,206	39	
Low NF Matilija	LNF low	40	LGR	1,231	25	transverse
Low NF Matilija	LNF low	41	GLD	1,270	39	pool tail good gravel most of unit
Low NF Matilija	LNF low	42	MCP	1,289	19	
Low NF Matilija	LNF low	43	POW	1,324	35	
Low NF Matilija	LNF low	44	HGR	1,335	11	gorge
Low NF Matilija	LNF low	45	MCP	1,368	33	
Low NF Matilija	LNF low	46	LGR	1,384	16	Large substrate
Low NF Matilija	LNF low	47	RUN	1,399	15	
Low NF Matilija	LNF low	48	LSBk	1,436	37	
Low NF Matilija	LNF low	49	RUN	1,458	22	

Appendix D. (continued)

Stream	HSI Study Site	Habitat Unit #	Habitat Type	Distance Upstream	Unit Length	Comments
Low NF Matilija	LNF low	50	MCP	1,479	21	
Low NF Matilija	LNF low	51	LGR	1,503	24	
Low NF Matilija	LNF low	52	GLD	1,538	35	Bdrk RB, pool tail
Low NF Matilija	LNF low	53	MCP	1,567	29	
Low NF Matilija	LNF low	54	RUN	1,597	30	
Low NF Matilija	LNF low	55	MCP	1,616	19	
Low NF Matilija	LNF low	56	CAS	1,635	19	
Low NF Matilija	LNF low	57	RUN	1,661	26	
Low NF Matilija	LNF low	58	MCP	1,677	16	
Low NF Matilija	LNF low	59	HGR	1,698	21	
Low NF Matilija	LNF low	60	RUN	1,718	20	
Low NF Matilija	LNF low	61	MCP	1,784	66	
Low NF Matilija	LNF low	62	LGR	1,825	41	
Low NF Matilija	LNF low	63	CAS	1,835	10	Tunnel LB
Low NF Matilija	LNF low	64	SRN	1,896	61	Rock wall LB
Low NF Matilija	LNF low	65	GLD	1,919	23	
Low NF Matilija	LNF low	66	POW	1,939	20	
Low NF Matilija	LNF low	67	CAS	2,001	62	
Low NF Matilija	LNF low	68	LGR	2,023	22	
Low NF Matilija	LNF low	69	MCP	2,067	44	Good gravel in tail; Trib/ spring @ top RB
Low NF Matilija	LNF up	1	SRN	18	18	w/ some BRS; split
Low NF Matilija	LNF up	2	CAS	24	6	
Low NF Matilija	LNF up	3	RUN	37	13	
Low NF Matilija	LNF up	4	MCP	56	19	
Low NF Matilija	LNF up	5	RUN	81	25	
Low NF Matilija	LNF up	6	LGR	94	13	
Low NF Matilija	LNF up	7	PLP	110	16	
Low NF Matilija	LNF up	8	LSBo	131	21	
Low NF Matilija	LNF up	9	CAS	141	10	
Low NF Matilija	LNF up	10	LGR	154	13	
Low NF Matilija	LNF up	11	RUN	164	10	
Low NF Matilija	LNF up	12	MCP	174	10	
Low NF Matilija	LNF up	13	BRS	186	12	
Low NF Matilija	LNF up	14	MCP	199	13	
Low NF Matilija	LNF up	15	CAS	216	17	bdrk
Low NF Matilija	LNF up	16	LGR	233	17	
Low NF Matilija	LNF up	17	POW	249	16	
Low NF Matilija	LNF up	18	MCP	270	21	deep pool
Low NF Matilija	LNF up	19	RUN	286	16	
Low NF Matilija	LNF up	20	LGR	298	12	Large substrate
Low NF Matilija	LNF up	21	MCP	311	13	
Low NF Matilija	LNF up	22	RUN	323	12	
Low NF Matilija	LNF up	23	HGR	333	10	
Low NF Matilija	LNF up	24	POW	357	24	14018@top
Low NF Matilija	LNF up	25	MCP	400	43	deep pool
Low NF Matilija	LNF up	26	CAS	413	13	
Low NF Matilija	LNF up	27	RUN	428	15	
Low NF Matilija	LNF up	28	GLD	447	19	
Low NF Matilija	LNF up	29	MCP	463	16	
Low NF Matilija	LNF up	30	SRN	479	16	
Low NF Matilija	LNF up	31	CAS	489	10	
Low NF Matilija	LNF up	32	POW	503	14	
Low NF Matilija	LNF up	33	HGR	523	20	
Low NF Matilija	LNF up	34	POW	543	20	
Low NF Matilija	LNF up	35	RUN	563	20	
Low NF Matilija	LNF up	36	LGR	573	10	
Low NF Matilija	LNF up	37	LSBo	586	13	
Low NF Matilija	LNF up	38	LGR	596	10	
Low NF Matilija	LNF up	39	GLD	608	12	
Low NF Matilija	LNF up	40	MCP	625	17	
Low NF Matilija	LNF up	41	RUN	635	10	
Low NF Matilija	LNF up	42	CAS	640	5	
Low NF Matilija	LNF up	43	SRN	657	17	
Low NF Matilija	LNF up	44	HGR	668	11	split @ top
Low NF Matilija	LNF up	45	MCP	683	15	take R ch.
Low NF Matilija	LNF up	46	LGR	695	12	

Appendix D. (continued)

Stream	HSI Study Site	Habitat Unit #	Habitat Type	Distance Upstream	Unit Length	Comments
Low NF Matilija	LNF up	47	MCP	719	24	
Low NF Matilija	LNF up	48	LGR	727	8	
Low NF Matilija	LNF up	49	RUN	742	15	
Low NF Matilija	LNF up	50	LGR	748	6	
Low NF Matilija	LNF up	51	RUN	762	14	
Low NF Matilija	LNF up	52	HGR	769	7	
Low NF Matilija	LNF up	53	RUN	780	11	
Low NF Matilija	LNF up	54	LGR	792	12	
Low NF Matilija	LNF up	55	SRN	817	25	
Low NF Matilija	LNF up	56	RUN	838	21	
Low NF Matilija	LNF up	57	POW	865	27	
Low NF Matilija	LNF up	58	SRN	881	16	
Low NF Matilija	LNF up	59	LGR	896	15	
Low NF Matilija	LNF up	60	POW	906	10	
Low NF Matilija	LNF up	61	LGR	915	9	
Low NF Matilija	LNF up	62	MCP	933	18	Dense ovh brush
Low NF Matilija	LNF up	63	LGR	954	21	
Low NF Matilija	LNF up	64	RUN	966	12	
Low NF Matilija	LNF up	65	POW	981	15	
Low NF Matilija	LNF up	66	LGR	993	12	
Low NF Matilija	LNF up	67	LSR	1,018	25	
Low NF Matilija	LNF up	68	LGR	1,035	17	
Low NF Matilija	LNF up	69	RUN	1,052	17	
Low NF Matilija	LNF up	70	POW	1,067	15	
Low NF Matilija	LNF up	71	GLD	1,090	23	
Low NF Matilija	LNF up	72	MCP	1,131	41	
Low NF Matilija	LNF up	73	HGR	1,144	13	
Low NF Matilija	LNF up	74	POW	1,153	9	
Low NF Matilija	LNF up	75	LGR	1,159	6	
Low NF Matilija	LNF up	76	RUN	1,173	14	
Low NF Matilija	LNF up	77	MCP	1,189	16	
Low NF Matilija	LNF up	78	SRN	1,228	39	
Low NF Matilija	LNF up	79	LGR	1,244	16	
Low NF Matilija	LNF up	80	RUN	1,258	14	
Low NF Matilija	LNF up	81	LGR	1,282	24	
Low NF Matilija	LNF up	82	RUN	1,307	25	
Low NF Matilija	LNF up	83	LSR	1,321	14	
Low NF Matilija	LNF up	84	POW	1,330	9	
Low NF Matilija	LNF up	85	MCP	1,351	21	
Low NF Matilija	LNF up	86	RUN	1,368	17	
Low NF Matilija	LNF up	87	POW	1,385	17	
Low NF Matilija	LNF up	88	RUN	1,407	22	
Low NF Matilija	LNF up	89	POW	1,423	16	
Low NF Matilija	LNF up	90	RUN	1,434	11	
Low NF Matilija	LNF up	91	HGR	1,445	11	
Low NF Matilija	LNF up	92	POW	1,454	9	split - L ch.
Low NF Matilija	LNF up	93	LGR	1,465	11	
Low NF Matilija	LNF up	94	MCP	1,478	13	
Low NF Matilija	LNF up	95	LGR	1,497	19	
Low NF Matilija	LNF up	96	RUN	1,511	14	
Low NF Matilija	LNF up	97	LGR	1,537	26	end split @ top
Low NF Matilija	LNF up	98	POW	1,552	15	pool tail
Low NF Matilija	LNF up	99	MCP	1,573	21	
Low NF Matilija	LNF up	100	HGR	1,590	17	
Low NF Matilija	LNF up	101	LSBo	1,599	9	
Low NF Matilija	LNF up	102	RUN	1,607	8	
Low NF Matilija	LNF up	103	MCP	1,623	16	
Low NF Matilija	LNF up	104	RUN	1,638	15	
Low NF Matilija	LNF up	105	LGR	1,646	8	
Low NF Matilija	LNF up	106	RUN	1,662	16	
Low NF Matilija	LNF up	107	POW	1,681	19	
Low NF Matilija	LNF up	108	RUN	1,700	19	
Low NF Matilija	LNF up	109	GLD	1,722	22	pool tail
Low NF Matilija	LNF up	110	MCP	1,750	28	
Low NF Matilija	LNF up	111	RUN	1,766	16	
Low NF Matilija	LNF up	112	HGR	1,778	12	

Appendix D. (continued)

Stream	HSI Study Site	Habitat Unit #	Habitat Type	Distance Upstream	Unit Length	Comments
Low NF Matilija	LNF up	113	RUN	1,795	17	trib? Enters RB; pool like @ top
Low NF Matilija	LNF up	114	MCP	1,810	15	
Low NF Matilija	LNF up	115	HGR	1,817	7	
Low NF Matilija	LNF up	116	MCP	1,832	15	
Low NF Matilija	LNF up	117	POW	1,843	11	
Low NF Matilija	LNF up	118	RUN	1,860	17	
Low NF Matilija	LNF up	119	HGR	1,879	19	
Low NF Matilija	LNF up	120	MCP	1,888	9	
Matilija	MAT 3	1	MCP	47	47	top run-like
Matilija	MAT 3	2	RUN	75	28	
Matilija	MAT 3	3	HGR	106	31	
Matilija	MAT 3	4	SRN	145	39	
Matilija	MAT 3	5	GLD	218	73	
Matilija	MAT 3	6	MCP	253	35	Rip-Rap start RB
Matilija	MAT 3	7	POW	307	54	289 split rif LB
Matilija	MAT 3	8	RUN	334	27	
Matilija	MAT 3	9	POW	359	25	
Matilija	MAT 3	10	RUN	402	43	
Matilija	MAT 3	11	LGR	464	62	Transverse bottom; end split
Matilija	MAT 3	12	POW	583	119	
Matilija	MAT 3	13	RUN	617	34	
Matilija	MAT 3	14	POW	655	38	
Matilija	MAT 3	15	RUN	686	31	
Matilija	MAT 3	16	POW	723	37	
Matilija	MAT 3	17	LGR	750	27	
Matilija	MAT 3	18	RUN	800	50	
Matilija	MAT 3	19	SRN	870	70	Bldrs
Matilija	MAT 3	20	POW	894	24	Bldrs
Matilija	MAT 3	21	RUN	930	36	Bldrs
Matilija	MAT 3	22	POW	1,050	120	Bldrs
Matilija	MAT 3	23	GLD	1,154	104	2 pockets LB
Matilija	MAT 3	24	LGR	1,174	20	
Matilija	MAT 3	25	RUN	1,263	89	
Matilija	MAT 3	26	LGR	1,300	37	
Matilija	MAT 3	27	POW	1,326	26	
Matilija	MAT 3	28	GLD	1,363	37	
Matilija	MAT 3	29	POW	1,424	61	
Matilija	MAT 3	30	RUN	1,525	101	end lower segment
Matilija	MAT 3	31	RUN	1,634	109	begin upper segment; left channel of split
Matilija	MAT 3	32	LGR	1,717	83	end split
Matilija	MAT 3	33	GLD	1,805	88	pool tail
Matilija	MAT 3	34	MCP	1,943	138	split @ top; H20 enters RB
Matilija	MAT 3	35	POW	1,973	30	split
Matilija	MAT 3	36	RUN	1,991	18	split
Matilija	MAT 3	37	SRN	2,020	29	split
Matilija	MAT 3	38	RUN	2,047	27	split
Matilija	MAT 3	39	LGR	2,070	23	split
Matilija	MAT 3	40	SRN	2,126	56	split
Matilija	MAT 3	41	RUN	2,175	49	split
Matilija	MAT 3	42	POW	2,204	29	split
Matilija	MAT 3	43	RUN	2,271	67	end spllit @ top
Matilija	MAT 3	44	LGR	2,351	80	
Matilija	MAT 3	45	GLD	2,451	100	left side run-like
Matilija	MAT 3	46	POW	2,475	24	
Matilija	MAT 3	47	RUN	2,523	48	
Matilija	MAT 3	48	LGR	2,551	28	
Matilija	MAT 3	49	POW	2,620	69	
Matilija	MAT 3	50	RUN	2,674	54	
Matilija	MAT 3	51	POW	2,766	92	
Matilija	MAT 3	52	RUN	2,791	25	transverse top
Matilija	MAT 3	53	LGR	2,839	48	transverse
Matilija	MAT 3	54	SRN	2,866	27	
Matilija	MAT 3	55	POW	2,906	40	
Matilija	MAT 3	56	MCP	2,953	47	
Matilija	MAT 3	57	RUN	2,984	31	

Appendix D. (continued)

Stream	HSI Study Site	Habitat Unit #	Habitat Type	Distance Upstream	Unit Length	Comments
Matilija	MAT 5	1	SRN	88	88	
Matilija	MAT 5	2	POW	130	42	
Matilija	MAT 5	3	GLD	174	44	pool tail
Matilija	MAT 5	4	MCP	375	201	
Matilija	MAT 5	5	GLD	413	38	pool top
Matilija	MAT 5	6	RUN	445	32	BPB left side
Matilija	MAT 5	7	POW	493	48	
Matilija	MAT 5	8	RUN	516	23	
Matilija	MAT 5	9	HGR	562	46	
Matilija	MAT 5	10	LGR	578	16	
Matilija	MAT 5	11	MCP	605	27	
Matilija	MAT 5	12	RUN	659	54	
Matilija	MAT 5	13	SRN	719	60	channel very wide/braided
Matilija	MAT 5	14	LGR	759	40	
Matilija	MAT 5	15	RUN	796	37	
Matilija	MAT 5	16	POW	943	147	channel begins to narrow at top
Matilija	MAT 5	17	RUN	967	24	
Matilija	MAT 5	18	POW	1,029	62	
Matilija	MAT 5	19	LGR	1,067	38	
Matilija	MAT 5	20	MCP	1,090	23	
Matilija	MAT 5	21	POW	1,129	39	
Matilija	MAT 5	22	LGR	1,156	27	
Matilija	MAT 5	23	RUN	1,186	30	
Matilija	MAT 5	24	LGR	1,199	13	
Matilija	MAT 5	25	DPL	1,230	31	Main feature seems to be bldr dam
Matilija	MAT 5	26	RUN	1,252	22	
Matilija	MAT 5	27	POW	1,285	33	
Matilija	MAT 5	28	RUN	1,360	75	1309 fence x-ing
Matilija	MAT 5	29	LGR	1,373	13	
Matilija	MAT 5	30	RUN	1,396	23	
Matilija	MAT 5	31	POW	1,424	28	out of string re-zero
Matilija	MAT 5	32	RUN	1,444	20	
Matilija	MAT 5	33	LGR	1,476	32	
Matilija	MAT 5	34	SRN	1,493	17	
Matilija	MAT 5	35	MCP	1,528	35	
Matilija	MAT 5	36	SRN	1,545	17	
Matilija	MAT 5	37	POW	1,584	39	
Matilija	MAT 5	38	SRN	1,612	28	
Matilija	MAT 5	39	LGR	1,666	54	wide/braided
Matilija	MAT 5	40	POW	1,719	53	
Matilija	MAT 5	41	MCP	1,761	42	
Matilija	MAT 5	42	RUN	1,781	20	
Matilija	MAT 5	43	MCP	1,826	45	some good gravel
Matilija	MAT 5	44	POW	1,893	67	house RB
Matilija	MAT 5	45	LGR	1,913	20	
Matilija	MAT 5	46	SRN	2,018	105	
Matilija	MAT 5	47	MCP	2,060	42	
Matilija	MAT 5	48	RUN	2,082	22	
Matilija	MAT 5	49	LGR	2,093	11	
Matilija	MAT 5	50	RUN	2,108	15	
Matilija	MAT 5	51	LGR	2,123	15	
Matilija	MAT 5	52	MCP	2,136	13	
Matilija	MAT 5	53	POW	2,146	10	
Matilija	MAT 5	54	LGR	2,158	12	
Matilija	MAT 5	55	RUN	2,187	29	
Matilija	MAT 5	56	POW	2,225	38	
Matilija	MAT 5	57	SRN	2,316	91	
Matilija	MAT 5	58	MCP	2,346	30	
Matilija	MAT 5	59	RUN	2,413	67	
Matilija	MAT 6	1	RUN	12	12	
Matilija	MAT 6	2	MCP	28	16	
Matilija	MAT 6	3	HGR	50	22	
Matilija	MAT 6	4	MCP	68	18	
Matilija	MAT 6	5	POW	93	25	
Matilija	MAT 6	6	RUN	115	22	
Matilija	MAT 6	7	POW	168	53	

Appendix D. (continued)

Stream	HSI Study Site	Habitat Unit #	Habitat Type	Distance Upstream	Unit Length	Comments
Matilija	MAT 6	8	MCP	218	50	~ 4' deep
Matilija	MAT 6	9	SRN	258	40	
Matilija	MAT 6	10	RUN	292	34	BPB RB ~15' long
Matilija	MAT 6	11	CAS	300	8	
Matilija	MAT 6	12	RUN	320	20	
Matilija	MAT 6	13	CAS	334	14	
Matilija	MAT 6	14	RUN	349	15	
Matilija	MAT 6	15	POW	386	37	Lrg bldr mc
Matilija	MAT 6	16	MCP	439	53	
Matilija	MAT 6	17	LGR	450	11	
Matilija	MAT 6	18	POW	474	24	
Matilija	MAT 6	19	MCP	497	23	
Matilija	MAT 6	20	SRN	529	32	
Matilija	MAT 6	21	POW	574	45	
Matilija	MAT 6	22	RUN	591	17	
Matilija	MAT 6	23	MCP	601	10	
Matilija	MAT 6	24	SRN	652	51	
Matilija	MAT 6	25	POW	683	31	
Matilija	MAT 6	26	MCP	705	22	
Matilija	MAT 6	27	HGR	725	20	
Matilija	MAT 6	28	RUN	743	18	pocket LB
Matilija	MAT 6	29	MCP	771	28	
Matilija	MAT 6	30	CAS	783	12	
Matilija	MAT 6	31	POW	828	45	
Matilija	MAT 6	32	MCP	846	18	
Matilija	MAT 6	33	LGR	861	15	
Matilija	MAT 6	34	RUN	885	24	
Matilija	MAT 6	35	MCP	917	32	SCT 00 @ 900
Matilija	MAT 6	36	CAS	931	14	
Matilija	MAT 6	37	POW	944	13	
Matilija	MAT 6	38	MCP	964	20	
Matilija	MAT 6	39	LGR	980	16	
Matilija	MAT 6	40	POW	997	17	
Matilija	MAT 6	41	PLP	1,013	16	
Matilija	MAT 6	42	CAS	1,024	11	
Matilija	MAT 6	43	POW	1,063	39	
Matilija	MAT 6	44	MCP	1,083	20	
Matilija	MAT 6	45	LGR	1,100	17	
Matilija	MAT 6	46	POW	1,139	39	
Matilija	MAT 6	47	RUN	1,173	34	Backwater RB
Matilija	MAT 6	48	LGR	1,191	18	
Matilija	MAT 6	49	POW	1,223	32	
Matilija	MAT 6	50	RUN	1,252	29	
Matilija	MAT 6	51	LGR	1,268	16	
Matilija	MAT 6	52	RUN	1,289	21	
Matilija	MAT 6	53	LGR	1,306	17	
Matilija	MAT 6	54	POW	1,345	39	
Matilija	MAT 6	55	LGR	1,362	17	
Matilija	MAT 6	56	RUN	1,394	32	
Matilija	MAT 6	57	POW	1,421	27	
Matilija	MAT 6	58	MCP	1,431	10	
Matilija	MAT 6	59	POW	1,457	26	
Matilija	MAT 6	60	LGR	1,470	13	
Matilija	MAT 6	61	POW	1,496	26	
Matilija	MAT 6	62	SRN	1,545	49	
Matilija	MAT 6	63	CAS	1,570	25	
Matilija	MAT 6	64	MCP	1,611	41	
Matilija	MAT 6	65	SRN	1,638	27	
Matilija	MAT 6	66	MCP	1,654	16	
Matilija	MAT 6	67	LGR	1,676	22	
Matilija	MAT 6	68	POW	1,716	40	
Matilija	MAT 6	69	LGR	1,729	13	
Matilija	MAT 6	70	MCP	1,814	85	
Matilija	MAT 6	71	RUN	1,841	27	pool head
Matilija	MAT 6	72	CAS	1,857	16	
Matilija	MAT 6	73	HGR	1,879	22	split; R shallow pool

Appendix D. (continued)

Stream	HSI Study Site	Habitat Unit #	Habitat Type	Distance Upstream	Unit Length	Comments
Matilija	MAT 6	74	POW	1,903	24	
Matilija	MAT 6	75	RUN	1,927	24	SCT 1004 @1924
Matilija	MAT 6	76	MCP	1,976	49	
Matilija	MAT 6	77	RUN	2,012	36	end
Matilija	MAT 7	1	MCP	40	40	
Matilija	MAT 7	2	RUN	56	16	
Matilija	MAT 7	3	CAS	104	48	V-shaped. 1/2 upper section is BRS
Matilija	MAT 7	4	RUN	138	34	
Matilija	MAT 7	5	MCP	156	18	shallow
Matilija	MAT 7	6	RUN	182	26	
Matilija	MAT 7	7	MCP	215	33	w/ BPB; substrate Bedrock
Matilija	MAT 7	8	SRN	268	53	Bedrock
Matilija	MAT 7	9	MCP	289	21	Bedrock
Matilija	MAT 7	10	CAS	305	16	Bedrock
Matilija	MAT 7	11	MCP	368	63	
Matilija	MAT 7	12	LSBk	418	50	LWD @ top, Alder
Matilija	MAT 7	13	LGR	430	12	split, take R ch.
Matilija	MAT 7	14	PLP	451	21	3' falls @ top
Matilija	MAT 7	15	RUN	464	13	
Matilija	MAT 7	16	HGR	477	13	
Matilija	MAT 7	17	RUN	497	20	
Matilija	MAT 7	18	HGR	523	26	end split
Matilija	MAT 7	19	MCP	549	26	Bedrock
Matilija	MAT 7	20	RUN	568	19	
Matilija	MAT 7	21	LSBo	626	58	2 RBT, ~8"; very lrg Bldrs
Matilija	MAT 7	22	RUN	650	24	
Matilija	MAT 7	23	MCP	700	50	
Matilija	MAT 7	24	CAS	720	20	Bedrock falls ~ 3.5' tall; SCT 6043
Matilija	MAT 7	25	MCP	784	64	2 possible redds in pool tail; 10' deep
Matilija	MAT 7	26	RUN	800	16	Bedrock
Matilija	MAT 7	27	MCP	820	20	shallow
Matilija	MAT 7	28	RUN	842	22	
Matilija	MAT 7	29	CAS	849	7	3' falls
Matilija	MAT 7	30	RUN	859	10	pool tail
Matilija	MAT 7	31	MCP	885	26	
Matilija	MAT 7	32	BRS	933	48	
Matilija	MAT 7	33	RUN	982	49	
Matilija	MAT 7	34	MCP	1,004	22	
Matilija	MAT 7	35	LGR	1,020	16	
Matilija	MAT 7	36	MCP	1,056	36	
Matilija	MAT 7	37	HGR	1,079	23	
Matilija	MAT 7	38	POW	1,113	34	
Matilija	MAT 7	39	MCP	1,150	37	
Matilija	MAT 7	40	BRS	1,217	67	
Matilija	MAT 7	41	CAS	1,241	24	
Matilija	MAT 7	42	POW	1,260	19	
Matilija	MAT 7	43	RUN	1,323	63	W/ BPB, deep
Matilija	MAT 7	44	MCP	1,382	59	
Matilija	MAT 7	45	RUN	1,419	37	
Matilija	MAT 7	46	MCP	1,447	28	roots LB
Matilija	MAT 7	47	MCP	1,467	20	roots LB
Matilija	MAT 7	48	SRN	1,510	43	
Matilija	MAT 7	49	HGR	1,526	16	
Matilija	MAT 7	50	SRN	1,579	53	
Matilija	MAT 7	51	CAS	1,604	25	Bedrock
Matilija	MAT 7	52	RUN	1,670	66	
Matilija	MAT 7	53	CAS	1,693	23	Brk & Bldrs
Matilija	MAT 7	54	MCP	1,718	25	cemented gravels
Matilija	MAT 7	55	HGR	1,740	22	
Matilija	MAT 7	56	RUN	1,780	40	
Matilija	MAT 7	57	HGR	1,824	44	split, take L ch.
Matilija	MAT 7	58	MCP	1,850	26	
Matilija	MAT 7	59	POW	1,896	46	LWD
Matilija	MAT 7	60	SRN	1,966	70	end split
Matilija	MAT 7	61	MCP	2,011	45	WPT in unit
Matilija	MAT 7	62	MCP	2,034	23	

Appendix D. (continued)

Stream	HSI Study Site	Habitat Unit #	Habitat Type	Distance Upstream	Unit Length	Comments
Matilija	MAT 7	63	HGR	2,071	37	
Matilija	MAT 7	64	SRN	2,112	41	1 fish, RBT?
Matilija	MAT 7	65	MCP	2,245	133	long, deepest near head
Matilija	MAT 7	66	CAS	2,269	24	Bedrock
Murietta	MUR 3	1	LGR	9	9	
Murietta	MUR 3	2	RUN	33	24	
Murietta	MUR 3	3	LGR	54	21	
Murietta	MUR 3	4	MCP	86	32	
Murietta	MUR 3	5	CAS	92	6	
Murietta	MUR 3	6	SRN	127	35	
Murietta	MUR 3	7	HGR	151	24	
Murietta	MUR 3	8	RUN	183	32	
Murietta	MUR 3	9	POW	197	14	7x5 gravel
Murietta	MUR 3	10	LSBo	216	19	
Murietta	MUR 3	11	SRN	251	35	~4' rif separating
Murietta	MUR 3	12	MCP	270	19	w/ side pool
Murietta	MUR 3	13	LGR	295	25	
Murietta	MUR 3	14	RUN	315	20	
Murietta	MUR 3	15	POW	354	39	Channel wide and braided
Murietta	MUR 3	16	RUN	375	21	Channel wide and braided
Murietta	MUR 3	17	HGR	401	26	some pockets; side ch.
Murietta	MUR 3	18	MCP	439	38	1 RBT
Murietta	MUR 3	19	RUN	453	14	
Murietta	MUR 3	20	HGR	476	23	
Murietta	MUR 3	21	POW	487	11	
Murietta	MUR 3	22	LGR	498	11	
Murietta	MUR 3	23	STP	531	33	2 small pools w/ 3' CAS
Murietta	MUR 3	24	CAS	541	10	
Murietta	MUR 3	25	MCP	555	14	
Murietta	MUR 3	26	SRN	574	19	
Murietta	MUR 3	27	MCP	602	28	Lrg Bldrs @ top
Murietta	MUR 3	28	RUN	613	11	narrow
Murietta	MUR 3	29	CAS	637	24	
Murietta	MUR 3	30	MCP	660	23	
Murietta	MUR 3	31	RUN	669	9	fast chute
Murietta	MUR 3	32	POW	691	22	some rif @ top
Murietta	MUR 3	33	MCP	716	25	5x6 gravel patch
Murietta	MUR 3	34	SRN	771	55	
Murietta	MUR 3	35	MCP	806	35	
Murietta	MUR 3	36	RUN	820	14	
Murietta	MUR 3	37	CAS	838	18	
Murietta	MUR 3	38	SRN	881	43	1' rif
Murietta	MUR 3	39	HGR	894	13	
Murietta	MUR 3	40	SRN	941	47	
Murietta	MUR 3	41	HGR	949	8	
Murietta	MUR 3	42	STP	982	33	2' falls; braided
Murietta	MUR 3	43	MCP	1,007	25	
Murietta	MUR 3	44	SRN	1,028	21	flag 4653 SA @ top
Murietta	MUR 3	45	POW	1,064	36	
Murietta	MUR 3	46	CAS	1,084	20	flag 4694
Murietta	MUR 3	47	LGR	1,105	21	
Murietta	MUR 3	48	MCP	1,123	18	wide
Murietta	MUR 3	49	RUN	1,139	16	
Murietta	MUR 3	50	CAS	1,164	25	
Murietta	MUR 3	51	MCP	1,211	47	
Murietta	MUR 3	52	LGR	1,229	18	
Murietta	MUR 3	53	RUN	1,245	16	
Murietta	MUR 3	54	MCP	1,293	48	
Murietta	MUR 3	55	MCP	1,322	29	2' small break
Murietta	MUR 3	56	LGR	1,359	37	
Murietta	MUR 3	57	RUN	1,373	14	flag 4967
Murietta	MUR 3	58	CAS	1,391	18	
Murietta	MUR 3	59	POW	1,436	45	wide/braided; some steps
Murietta	MUR 3	60	MCP	1,484	48	lrg Bldr @ top
Murietta	MUR 3	61	SRN	1,555	71	
Murietta	MUR 3	62	LGR	1,586	31	

Appendix D. (continued)

Stream	HSI Study Site	Habitat Unit #	Habitat Type	Distance Upstream	Unit Length	Comments
Murietta	MUR 3	63	POW	1,610	24	
Murietta	MUR 3	64	RUN	1,635	25	
Murietta	MUR 3	65	LSBo	1,656	21	
Murietta	MUR 3	66	RUN	1,683	27	
Murietta	MUR 3	67	MCP	1,739	56	pool depth = 5.1'; flag 5332 @ 1726
Murietta	MUR 3	68	CAS	1,749	10	falls; some cementing
Murietta	MUR 3	69	MCP	1,765	16	
Murietta	MUR 3	70	CAS	1,776	11	
Murietta	MUR 3	71	RUN	1,794	18	
Murietta	MUR 3	72	LGR	1,839	45	3' HGR in middle, some run
Murietta	MUR 3	73	MCP	1,882	43	
Murietta	MUR 3	74	CAS	1,908	26	
Murietta	MUR 3	75	LGR	1,941	33	
Murietta	MUR 3	76	MCP	1,958	17	
Murietta	MUR 3	77	SRN	1,992	34	
Murietta	MUR 3	78	HGR	2,014	22	
Murietta	MUR 3	79	RUN	2,034	20	
Murietta	MUR 3	80	LGR	2,064	30	
Murietta	MUR 3	81	POW	2,088	24	
Murietta	MUR 3	82	MCP	2,116	28	
Murietta	MUR 3	83	SRN	2,147	31	
Murietta	MUR 3	84	HGR	2,163	16	end
Old Man	OLD 2	1	MCP	28	28	
Old Man	OLD 2	2	CAS	33	5	
Old Man	OLD 2	3	RUN	51	18	
Old Man	OLD 2	4	HGR	69	18	
Old Man	OLD 2	5	RUN	80	11	
Old Man	OLD 2	6	MCP	94	14	
Old Man	OLD 2	7	RUN	111	17	
Old Man	OLD 2	8	CAS	125	14	
Old Man	OLD 2	9	RUN	139	14	
Old Man	OLD 2	10	LGR	154	15	
Old Man	OLD 2	11	MCP	167	13	
Old Man	OLD 2	12	LGR	204	37	
Old Man	OLD 2	13	SRN	233	29	
Old Man	OLD 2	14	MCP	248	15	
Old Man	OLD 2	15	SRN	268	20	
Old Man	OLD 2	16	LGR	294	26	
Old Man	OLD 2	17	MCP	316	22	
Old Man	OLD 2	18	HGR	335	19	
Old Man	OLD 2	19	RUN	351	16	
Old Man	OLD 2	20	LGR	375	24	
Old Man	OLD 2	21	MCP	410	35	1 RBT ~6"
Old Man	OLD 2	22	CAS	427	17	SR 4438 @ 417
Old Man	OLD 2	23	SRN	448	21	
Old Man	OLD 2	24	MCP	460	12	
Old Man	OLD 2	25	CAS	471	11	
Old Man	OLD 2	26	MCP	487	16	
Old Man	OLD 2	27	SRN	507	20	
Old Man	OLD 2	28	CAS	518	11	
Old Man	OLD 2	29	SRN	535	17	
Old Man	OLD 2	30	MCP	547	12	
Old Man	OLD 2	31	CAS	566	19	
Old Man	OLD 2	32	STP	589	23	
Old Man	OLD 2	33	RUN	613	24	
Old Man	OLD 2	34	CAS	639	26	
Old Man	OLD 2	35	STP	675	36	
Old Man	OLD 2	36	CAS	684	9	
Old Man	OLD 2	37	MCP	727	43	
Old Man	OLD 2	38	CAS	749	22	
Old Man	OLD 2	39	MCP	772	23	w/ BPB Right
Old Man	OLD 2	40	CAS	786	14	
Old Man	OLD 2	41	RUN	799	13	
Old Man	OLD 2	42	MCP	812	13	
Old Man	OLD 2	43	CAS	823	11	
Old Man	OLD 2	44	RUN	848	25	

Appendix D. (continued)

Stream	HSI Study Site	Habitat Unit #	Habitat Type	Distance Upstream	Unit Length	Comments
Old Man	OLD 2	45	STP	878	30	
Old Man	OLD 2	46	CAS	890	12	
Old Man	OLD 2	47	MCP	904	14	
Old Man	OLD 2	48	CAS	918	14	
Old Man	OLD 2	49	RUN	947	29	
Old Man	OLD 2	50	MCP	964	17	
Old Man	OLD 2	51	SRN	995	31	
Old Man	OLD 2	52	LGR	1,007	12	
Old Man	OLD 2	53	SRN	1,043	36	
Old Man	OLD 2	54	HGR	1,063	20	
Old Man	OLD 2	55	MCP	1,073	10	
Old Man	OLD 2	56	CAS	1,089	16	
Old Man	OLD 2	57	RUN	1,102	13	
Old Man	OLD 2	58	HGR	1,114	12	
Old Man	OLD 2	59	MCP	1,126	12	
Old Man	OLD 2	60	LGR	1,145	19	
Old Man	OLD 2	61	STP	1,178	33	some CAS
Old Man	OLD 2	62	SRN	1,201	23	
Old Man	OLD 2	63	LSR	1,221	20	flag 5202 @ 1211
Old Man	OLD 2	64	SRN	1,271	50	1 fish darting yoy; seep RB; good gravel
Old Man	OLD 2	65	CAS	1,283	12	
Old Man	OLD 2	66	SRN	1,314	31	
Old Man	OLD 2	67	MCP	1,331	17	small patch of good gravel
Old Man	OLD 2	68	CAS	1,342	11	cementing not as bad
Old Man	OLD 2	69	LSBo	1,364	22	
Old Man	OLD 2	70	RUN	1,378	14	
Old Man	OLD 2	71	CAS	1,391	13	
Old Man	OLD 2	72	LSBo	1,413	22	
Old Man	OLD 2	73	LSBo	1,430	17	
Old Man	OLD 2	74	CAS	1,438	8	
Old Man	OLD 2	75	MCP	1,457	19	
Old Man	OLD 2	76	LGR	1,471	14	
Old Man	OLD 2	77	MCP	1,487	16	
Old Man	OLD 2	78	CAS	1,501	14	
Old Man	OLD 2	79	MCP	1,511	10	LWD, logs
Old Man	OLD 2	80	CAS	1,523	12	
Old Man	OLD 2	81	RUN	1,539	16	
Old Man	OLD 2	82	MCP	1,552	13	
Old Man	OLD 2	83	LGR	1,585	33	
Old Man	OLD 2	84	MCP	1,596	11	
Old Man	OLD 2	85	RUN	1,605	9	
Old Man	OLD 2	86	LSBk	1,645	40	
Old Man	OLD 2	87	CAS	1,666	21	some pockets
Old Man	OLD 2	88	SRN	1,700	34	split
Old Man	OLD 2	89	PLP	1,709	9	
Old Man	OLD 2	90	LGR	1,723	14	
Old Man	OLD 2	91	MCP	1,739	16	
Old Man	OLD 2	92	CAS	1,748	9	~5' high, very steep
Old Man	OLD 2	93	RUN	1,772	24	
Old Man	OLD 2	94	MCP	1,787	15	
Old Man	OLD 2	95	SRN	1,817	30	
Old Man	OLD 2	96	LSR	1,836	19	
Old Man	OLD 2	97	HGR	1,845	9	cementing gone
Old Man	OLD 2	98	MCP	1,858	13	
Old Man	OLD 2	99	CAS	1,873	15	
Old Man	OLD 2	100	PLP	1,892	19	riff @ tail, good gravel pile
Old Man	OLD 2	101	SRN	1,949	57	some pockets
Old Man	OLD 2	102	LGR	1,965	16	
Old Man	OLD 2	103	STP	1,987	22	
Old Man	OLD 2	104	RUN	2,023	36	
Old Man	OLD 2	105	PLP	2,038	15	end
Up NF Matilija	UNF low	1	MCP	48	48	
Up NF Matilija	UNF low	2	POW	71	23	1' drop @ top
Up NF Matilija	UNF low	3	SRN	115	44	
Up NF Matilija	UNF low	4	POW	136	21	
Up NF Matilija	UNF low	5	RUN	157	21	

Appendix D. (continued)

Stream	HSI Study Site	Habitat Unit #	Habitat Type	Distance Upstream	Unit Length	Comments
Up NF Matilija	UNF low	6	LGR	187	30	
Up NF Matilija	UNF low	7	RUN	217	30	
Up NF Matilija	UNF low	8	LGR	250	33	
Up NF Matilija	UNF low	9	POW	282	32	
Up NF Matilija	UNF low	10	MCP	330	48	Transverse @ top; trail x-ing; good gravel
Up NF Matilija	UNF low	11	LGR	347	17	
Up NF Matilija	UNF low	12	POW	388	41	w/ some run/riff
Up NF Matilija	UNF low	13	GLD	413	25	pool tail; 2RBT ~4", 2 NGF
Up NF Matilija	UNF low	14	MCP	480	67	
Up NF Matilija	UNF low	15	LGR	490	10	
Up NF Matilija	UNF low	16	RUN	504	14	
Up NF Matilija	UNF low	17	LGR	514	10	
Up NF Matilija	UNF low	18	RUN	530	16	
Up NF Matilija	UNF low	19	POW	544	14	
Up NF Matilija	UNF low	20	RUN	569	25	
Up NF Matilija	UNF low	21	LGR	574	5	
Up NF Matilija	UNF low	22	SRN	614	40	trail x-ing
Up NF Matilija	UNF low	23	POW	639	25	
Up NF Matilija	UNF low	24	RUN	659	20	
Up NF Matilija	UNF low	25	MCP	680	21	transverse top
Up NF Matilija	UNF low	26	LGR	702	22	
Up NF Matilija	UNF low	27	POW	748	46	
Up NF Matilija	UNF low	28	MCP	793	45	
Up NF Matilija	UNF low	29	RUN	804	11	
Up NF Matilija	UNF low	30	POW	830	26	
Up NF Matilija	UNF low	31	GLD	845	15	
Up NF Matilija	UNF low	32	MCP	866	21	
Up NF Matilija	UNF low	33	RUN	877	11	
Up NF Matilija	UNF low	34	LGR	888	11	
Up NF Matilija	UNF low	35	POW	921	33	
Up NF Matilija	UNF low	36	SRN	970	49	
Up NF Matilija	UNF low	37	POW	996	26	
Up NF Matilija	UNF low	38	RUN	1,022	26	
Up NF Matilija	UNF low	39	LGR	1,050	28	
Up NF Matilija	UNF low	40	MCP	1,088	38	
Up NF Matilija	UNF low	41	POW	1,105	17	
Up NF Matilija	UNF low	42	HGR	1,114	9	
Up NF Matilija	UNF low	43	POW	1,134	20	
Up NF Matilija	UNF low	44	HGR	1,146	12	
Up NF Matilija	UNF low	45	STP	1,164	18	
Up NF Matilija	UNF low	46	LGR	1,174	10	
Up NF Matilija	UNF low	47	POW	1,200	26	1 deep ~2.5' pocket @ top
Up NF Matilija	UNF low	48	MCP	1,235	35	possible redds, very small; flag 5301
Up NF Matilija	UNF low	49	SRN	1,260	25	
Up NF Matilija	UNF low	50	LGR	1,275	15	
Up NF Matilija	UNF low	51	POW	1,297	22	
Up NF Matilija	UNF low	52	LGR	1,314	17	
Up NF Matilija	UNF low	53	RUN	1,346	32	
Up NF Matilija	UNF low	54	LGR	1,364	18	
Up NF Matilija	UNF low	55	RUN	1,388	24	
Up NF Matilija	UNF low	56	GLD	1,409	21	
Up NF Matilija	UNF low	57	LGR	1,425	16	
Up NF Matilija	UNF low	58	RUN	1,448	23	
Up NF Matilija	UNF low	59	POW	1,491	43	2 yoy
Up NF Matilija	UNF low	60	RUN	1,518	27	
Up NF Matilija	UNF low	61	POW	1,541	23	
Up NF Matilija	UNF low	62	LGR	1,576	35	some run
Up NF Matilija	UNF low	63	GLD	1,621	45	
Up NF Matilija	UNF low	64	SRN	1,659	38	
Up NF Matilija	UNF low	65	POW	1,702	43	
Up NF Matilija	UNF low	66	SRN	1,735	33	1 yoy? Darting fish
Up NF Matilija	UNF low	67	GLD	1,752	17	1 yoy? Darting fish
Up NF Matilija	UNF low	68	MCP	1,783	31	2 RBT ~4-5", 10 yoy; silt
Up NF Matilija	UNF low	69	RUN	1,812	29	
Up NF Matilija	UNF low	70	SRN	1,834	22	
Up NF Matilija	UNF low	71	POW	1,879	45	

Appendix D. (continued)

Stream	HSI Study Site	Habitat Unit #	Habitat Type	Distance Upstream	Unit Length	Comments
Up NF Matilija	UNF low	72	RUN	1,919	40	
Up NF Matilija	UNF low	73	POW	1,968	49	
Up NF Matilija	UNF low	74	LGR	2,005	37	
Up NF Matilija	UNF low	75	GLD	2,041	36	
Up NF Matilija	UNF low	76	RUN	2,062	21	
Up NF Matilija	UNF low	77	LGR	2,085	23	split ch.
Up NF Matilija	UNF low	78	SRN	2,127	42	
Up NF Matilija	UNF low	79	HGR	2,136	9	end split @ top
Up NF Matilija	UNF low	80	SRN	2,173	37	
Up NF Matilija	UNF 2	1	HGR	24	24	
Up NF Matilija	UNF 2	2	POW	38	14	
Up NF Matilija	UNF 2	3	RUN	57	19	
Up NF Matilija	UNF 2	4	MCP	82	25	
Up NF Matilija	UNF 2	5	SRN	108	26	
Up NF Matilija	UNF 2	6	POW	124	16	
Up NF Matilija	UNF 2	7	MCP	150	26	
Up NF Matilija	UNF 2	8	SRN	180	30	
Up NF Matilija	UNF 2	9	POW	204	24	
Up NF Matilija	UNF 2	10	RUN	232	28	
Up NF Matilija	UNF 2	11	LGR	253	21	transverse
Up NF Matilija	UNF 2	12	RUN	270	17	
Up NF Matilija	UNF 2	13	MCP	290	20	
Up NF Matilija	UNF 2	14	LGR	298	8	
Up NF Matilija	UNF 2	15	MCP	339	41	
Up NF Matilija	UNF 2	16	RUN	368	29	
Up NF Matilija	UNF 2	17	POW	382	14	
Up NF Matilija	UNF 2	18	RUN	402	20	
Up NF Matilija	UNF 2	19	MCP	423	21	
Up NF Matilija	UNF 2	20	LGR	431	8	
Up NF Matilija	UNF 2	21	MCP	457	26	
Up NF Matilija	UNF 2	22	POW	468	11	
Up NF Matilija	UNF 2	23	SRN	501	33	
Up NF Matilija	UNF 2	24	POW	554	53	
Up NF Matilija	UNF 2	25	RUN	575	21	
Up NF Matilija	UNF 2	26	LGR	593	18	
Up NF Matilija	UNF 2	27	POW	618	25	
Up NF Matilija	UNF 2	28	RUN	643	25	w/ BPB
Up NF Matilija	UNF 2	29	MCP	667	24	
Up NF Matilija	UNF 2	30	SRN	695	28	
Up NF Matilija	UNF 2	31	LGR	705	10	
Up NF Matilija	UNF 2	32	MCP	723	18	
Up NF Matilija	UNF 2	33	MCP	743	20	very short break between pools
Up NF Matilija	UNF 2	34	CAS	753	10	
Up NF Matilija	UNF 2	35	SRN	787	34	
Up NF Matilija	UNF 2	36	LGR	795	8	
Up NF Matilija	UNF 2	37	RUN	808	13	
Up NF Matilija	UNF 2	38	LGR	829	21	
Up NF Matilija	UNF 2	39	GLD	844	15	
Up NF Matilija	UNF 2	40	POW	861	17	
Up NF Matilija	UNF 2	41	CAS	876	15	
Up NF Matilija	UNF 2	42	HGR	898	22	
Up NF Matilija	UNF 2	43	DPL	922	24	woody debris; split
Up NF Matilija	UNF 2	44	POW	937	15	end split
Up NF Matilija	UNF 2	45	SRN	965	28	
Up NF Matilija	UNF 2	46	RUN	996	31	
Up NF Matilija	UNF 2	47	MCP	1,014	18	
Up NF Matilija	UNF 2	48	LGR	1,025	11	
Up NF Matilija	UNF 2	49	RUN	1,036	11	
Up NF Matilija	UNF 2	50	POW	1,066	30	
Up NF Matilija	UNF 2	51	RUN	1,080	14	
Up NF Matilija	UNF 2	52	HGR	1,096	16	
Up NF Matilija	UNF 2	53	GLD	1,110	14	pool tail
Up NF Matilija	UNF 2	54	MCP	1,161	51	
Up NF Matilija	UNF 2	55	LGR	1,192	31	
Up NF Matilija	UNF 2	56	SRN	1,216	24	
Up NF Matilija	UNF 2	57	MCP	1,228	12	

Appendix D. (continued)

Stream	HSI Study Site	Habitat Unit #	Habitat Type	Distance Upstream	Unit Length	Comments
Up NF Matilija	UNF 2	58	RUN	1,238	10	
Up NF Matilija	UNF 2	59	POW	1,259	21	
Up NF Matilija	UNF 2	60	HGR	1,272	13	
Up NF Matilija	UNF 2	61	MCP	1,301	29	
Up NF Matilija	UNF 2	62	HGR	1,310	9	
Up NF Matilija	UNF 2	63	SRN	1,323	13	
Up NF Matilija	UNF 2	64	POW	1,341	18	
Up NF Matilija	UNF 2	65	RUN	1,351	10	
Up NF Matilija	UNF 2	66	MCP	1,373	22	
Up NF Matilija	UNF 2	67	SRN	1,411	38	
Up NF Matilija	UNF 2	68	HGR	1,433	22	
Up NF Matilija	UNF 2	69	RUN	1,449	16	
Up NF Matilija	UNF 2	70	POW	1,483	34	wide, mult. Channels
Up NF Matilija	UNF 2	71	MCP	1,509	26	
Up NF Matilija	UNF 2	72	GLD	1,538	29	run-like @ btm. Pool tail
Up NF Matilija	UNF 2	73	MCP	1,565	27	
Up NF Matilija	UNF 2	74	RUN	1,582	17	pool head
Up NF Matilija	UNF 2	75	LGR	1,596	14	
Up NF Matilija	UNF 2	76	POW	1,613	17	
Up NF Matilija	UNF 2	77	SRN	1,635	22	
Up NF Matilija	UNF 2	78	MCP	1,667	32	
Up NF Matilija	UNF 2	79	HGR	1,685	18	
Up NF Matilija	UNF 2	80	SRN	1,709	24	end
Up NF Matilija	UNF up	1	GLD	14	14	
Up NF Matilija	UNF up	2	MCP	34	20	
Up NF Matilija	UNF up	3	HGR	57	23	
Up NF Matilija	UNF up	4	POW	82	25	
Up NF Matilija	UNF up	5	SRN	102	20	
Up NF Matilija	UNF up	6	POW	116	14	bdrk
Up NF Matilija	UNF up	7	RUN	130	14	
Up NF Matilija	UNF up	8	CAS	151	21	bdrk fast chute
Up NF Matilija	UNF up	9	MCP	169	18	
Up NF Matilija	UNF up	10	RUN	190	21	
Up NF Matilija	UNF up	11	CAS	200	10	
Up NF Matilija	UNF up	12	SRN	241	41	
Up NF Matilija	UNF up	13	CAS	248	7	
Up NF Matilija	UNF up	14	RUN	259	11	
Up NF Matilija	UNF up	15	HGR	267	8	
Up NF Matilija	UNF up	16	MCP	287	20	
Up NF Matilija	UNF up	17	HGR	298	11	
Up NF Matilija	UNF up	18	SRN	319	21	
Up NF Matilija	UNF up	19	MCP	332	13	
Up NF Matilija	UNF up	20	HGR	347	15	
Up NF Matilija	UNF up	21	SRN	367	20	1 fish darting
Up NF Matilija	UNF up	22	LGR	392	25	
Up NF Matilija	UNF up	23	LSBo	413	21	
Up NF Matilija	UNF up	24	POW	438	25	1 RBT ~6"
Up NF Matilija	UNF up	25	MCP	454	16	flag 3019 @ btm
Up NF Matilija	UNF up	26	SRN	486	32	
Up NF Matilija	UNF up	27	LSBo	517	31	RB undercut
Up NF Matilija	UNF up	28	SRN	537	20	
Up NF Matilija	UNF up	29	POW	563	26	mult. WSEL's
Up NF Matilija	UNF up	30	LSBo	596	33	
Up NF Matilija	UNF up	31	MCP	608	12	
Up NF Matilija	UNF up	32	SRN	621	13	
Up NF Matilija	UNF up	33	HGR	629	8	
Up NF Matilija	UNF up	34	RUN	650	21	
Up NF Matilija	UNF up	35	LGR	659	9	
Up NF Matilija	UNF up	36	MCP	684	25	
Up NF Matilija	UNF up	37	BRS	720	36	w/ 3' falls @ btm
Up NF Matilija	UNF up	38	MCP	744	24	
Up NF Matilija	UNF up	39	SRN	769	25	
Up NF Matilija	UNF up	40	MCP	789	20	
Up NF Matilija	UNF up	41	RUN	803	14	
Up NF Matilija	UNF up	42	CAS	833	30	falls, barrier# 49
Up NF Matilija	UNF up	43	PLP	848	15	split

Appendix D. (continued)

Stream	HSI Study Site	Habitat Unit #	Habitat Type	Distance Upstream	Unit Length	Comments
Up NF Matilija	UNF up	44	LSR	883	35	end split
Up NF Matilija	UNF up	45	BRS	898	15	
Up NF Matilija	UNF up	46	GLD	918	20	bdrk
Up NF Matilija	UNF up	47	HGR	950	32	split, L ch.
Up NF Matilija	UNF up	48	RUN	969	19	tree limbs down
Up NF Matilija	UNF up	49	POW	994	25	end split @ btm
Up NF Matilija	UNF up	50	RUN	1,031	37	bdrk 90% of substrate
Up NF Matilija	UNF up	51	HGR	1,057	26	
Up NF Matilija	UNF up	52	MCP	1,083	26	
Up NF Matilija	UNF up	53	SRN	1,102	19	
Up NF Matilija	UNF up	54	LGR	1,116	14	
Up NF Matilija	UNF up	55	MCP	1,130	14	
Up NF Matilija	UNF up	56	SRN	1,154	24	steep, almost cascade
Up NF Matilija	UNF up	57	LSBk	1,197	43	
Up NF Matilija	UNF up	58	RUN	1,226	29	
Up NF Matilija	UNF up	59	LGR	1,237	11	
Up NF Matilija	UNF up	60	RUN	1,249	12	
Up NF Matilija	UNF up	61	LGR	1,267	18	
Up NF Matilija	UNF up	62	RUN	1,313	46	w/BP; lots of fines
Up NF Matilija	UNF up	63	SRN	1,337	24	
Up NF Matilija	UNF up	64	HGR	1,358	21	
Up NF Matilija	UNF up	65	LSBo	1,380	22	
Up NF Matilija	UNF up	66	MCP	1,412	32	
Up NF Matilija	UNF up	67	CAS	1,440	28	bdrk falls, flag 4021; barrier #51
Up NF Matilija	UNF up	68	LSBo	1,456	16	end UNF
Up NF Matilija	UNF up	69	HGR	1,485	29	start trib.
Up NF Matilija	UNF up	70	RUN	1,500	15	
Up NF Matilija	UNF up	71	POW	1,520	20	
Up NF Matilija	UNF up	72	RUN	1,541	21	
Up NF Matilija	UNF up	73	LGR	1,551	10	
Up NF Matilija	UNF up	74	MCP	1,566	15	
Up NF Matilija	UNF up	75	SRN	1,584	18	
Up NF Matilija	UNF up	76	HGR	1,601	17	
Up NF Matilija	UNF up	77	SRN	1,627	26	
Up NF Matilija	UNF up	78	LGR	1,664	37	some pockets
Up NF Matilija	UNF up	79	MCP	1,691	27	
Up NF Matilija	UNF up	80	POW	1,722	31	
Up NF Matilija	UNF up	81	CAS	1,735	13	
Up NF Matilija	UNF up	82	MCP	1,758	23	
Up NF Matilija	UNF up	83	HGR	1,777	19	
Up NF Matilija	UNF up	84	SRN	1,804	27	

Appendix E. Individual variable and component variable HSI scores according to HSI study site.

Model Variable	Label	Vent 1		Vent 2		Vent 3		Vent 5		Vent 6		LNF extra		LNF low		LNF up	
		Est	HSI	Est	HSI	Est	HSI	Est	HSI	Est	HSI	Est	HSI	Est	HSI	Est	HSI
max rearing temp	V1r	25.5	0.05	25.5	0.05	25	0.17	25.5	0.05	25.5	0.05	22	0.50	22	0.50	22	0.50
max adlt migr temp (Jan-Mar)	V1a	20	0.50	20	0.50	20	0.50	20	0.50	20	0.50	15	1.00	15	1.00	15	1.00
max smolt migr temp (Mar-Jun)	V2s	21	0.25	21	0.25	21	0.25	21	0.25	21	0.25	18	0.50	18	0.50	18	0.50
max inc temp (Jan-Mar)	V2e	20	0.20	20	0.20	20	0.20	20	0.20	20	0.20	15	0.75	15	0.75	15	0.75
min DO during rearing	V3b-o	7.7	0.85	11	1.00	12	1.00	7.9	0.88	6.8	0.65	8.5	0.97	9	1.00	9	1.00
min DO during inc	V3a-e	9	1.00	11	1.00	12	1.00	9	1.00	8	0.90	9.19	1.00	10.09	1.00	9.56	1.00
avg thalweg depth	V4	45.1	1.00	64.0	1.00	57.4	1.00	43.6	1.00	72.4	1.00	40.9	1.00	51.8	1.00	33.0	1.00
avg spawning area vel	V5	117.0	0.00	68.0	1.00	78.9	1.00	13.4	0.00	N/A		49.8	1.00	58.0	1.00	21.3	0.55
% instream cover-juv	V6j	18.8	1.00	41.0	1.00	14.5	1.00	26.6	1.00	31.4	1.00	12.6	0.98	21.9	1.00	20.9	1.00
% cover-adlt	V6a	4.4	0.43	14.9	0.85	4.8	0.46	4.8	0.47	16.6	0.89	1.6	0.32	4.8	0.45	2.0	0.32
spawning substr size	V7b	3.7	1.00	2.1	1.00	2.5	1.00	1.4	0.99	N/A		4.0	1.00	1.9	0.96	1.7	1.00
% large substrate	V8	11.7	1.00	32.5	1.00	26.6	1.00	41.3	1.00	70.0	1.00	23.0	1.00	31.3	1.00	30.2	1.00
avg riffle substr type	V9	A	1.00	A	1.00	B	0.60	B	0.60	C	0.30	B	0.60	C	0.30	B	0.60
% pools	V10	36.1	1.00	26.7	0.89	32.5	0.97	30.2	0.95	37.1	1.00	28.0	0.91	29.6	0.95	26.6	0.86
% vegetation	V11	172.0	1.00	115.4	0.85	135.3	0.95	108.0	0.80	100.9	0.76	171.7	1.00	139.9	0.98	193.4	1.00
% stable banks	V12	87.2	1.00	95.3	1.00	95.4	1.00	85.6	1.00	94.6	1.00	91.7	1.00	92.4	1.00	91.7	1.00
ann max/min pH	V13	8.7	0.40	8.8	0.30	8.3	0.88	8.3	0.88	8.4	0.78	8.47	0.70	8.46	0.72	8.3	0.83
ratio low Q/avg Q	V14	0.05	0.10	0.05	0.10	0.05	0.10	0.14	0.28	0.14	0.28	0.1	0.26	0.13	0.26	0.1	0.26
pool class rating	V15	B	0.60	A	1.00	B	0.60	C	0.30	C	0.30	B	0.60	B	0.60	B	0.60
%fines in spawn areas	V16a	8.4	1.00	21.7	0.39	25.8	0.24	41.5	0.15	N/A		23.6	0.29	9.6	0.95	18.6	0.55
%fines in riffles	V16b	33.4	0.66	12.6	0.98	22.2	0.89	27.2	0.80	10.2	1.00	10.3	1.00	14.3	0.98	11.0	0.99
% shade	V17	22.5	0.62	10.8	0.47	7.2	0.40	22.4	0.60	22.2	0.60	55.0	1.00	33.4	0.75	45.0	0.94
ratio migr Q/avg Q	V18	3.03	1.00	3.03	1.00	3.03	1.00	2.59	1.00	2.59	1.00	2.49	1.00	2.64	1.00	2.49	1.00
Adult		C_{AS}=	**0.77**	C_{AS}=	**0.79**	C_{AS}=	**0.77**	C_{AS}=	**0.74**	C_{AS}=	**0.74**	C_{AS}=	**0.95**	C_{AS}=	**0.95**	C_{AS}=	**0.95**
Juvenile		C_{JS}=	**0.47**	C_{JS}=	**0.49**	C_{JS}=	**0.46**	C_{JS}=	**0.43**	C_{JS}=	**0.44**	C_{JS}=	**0.64**	C_{JS}=	**0.65**	C_{JS}=	**0.64**
Fry		C_F=	**0.90**	C_F=	**0.94**	C_F=	**0.96**	C_F=	**0.92**	C_F=	**1.00**	C_F=	**0.95**	C_F=	**0.97**	C_F=	**0.93**
Embryo		C_E=	**0.04**	C_E=	**0.20**	C_E=	**0.20**	C_E=	**0.20**	C_E=	**0.20**	C_E=	**0.63**	C_E=	**0.75**	C_E=	**0.68**
Other		C_O=	**0.54**	C_O=	**0.52**	C_O=	**0.60**	C_O=	**0.57**	C_O=	**0.51**	C_O=	**0.77**	C_O=	**0.70**	C_O=	**0.78**
Overall			**0.36**		**0.52**		**0.53**		**0.51**		**0.51**		**0.78**		**0.79**		**0.78**

Appendix E. (continued)

		MAT 3		MAT 5		MAT 6		MAT 7		MUR 3		OLD 2		UNF low		UNF 2		UNF up	
Model Variable	Label	Est	HSI	Est	HSI	Est	HSI	Est	HSI	Est	HSI	Est	HSI	Est	HSI	Est	HSI	Est	HSI
max rearing temp	V1r	25	0.13	24	0.25	22	0.50	20	0.75	18	1.00	20	0.75	20	0.75	20	0.75	20	0.75
max adlt migr temp (Jan-Mar)	V1a	18.9	0.63	18.3	0.75	18.3	0.75	14.4	1.00	13.9	1.00	16.7	0.88	14.4	1.00	14.4	1.00	14.4	1.00
max smolt migr temp (Mar-Jun)	V2s	21	0.25	21	0.25	20	0.33	17	0.58	16	0.67	18	0.50	16	0.67	16	0.67	16	0.67
max inc temp (Jan-Mar)	V2e	18.9	0.32	18.3	0.43	18.3	0.43	14.4	0.85	13.9	0.85	16.7	0.54	14.4	0.85	14.4	0.85	14.4	0.85
min DO during rearing	V3b-o	8.0	0.90	8	0.90	8	0.90	8.5	0.97	8	0.90	8.5	0.97	8.5	0.97	9	1.00	9	1.00
min DO during inc	V3a-e	9.20	1.00	8.77	0.99	9.47	1.00	9.42	1.00	8.76	1.00	9.24	1.00	9.08	1.00	10.62	1.00	9.92	1.00
avg thalweg depth	V4	41.7	0.96	44.0	0.99	44.2	0.99	56.7	1.00	45.3	1.00	40.2	1.00	42.0	1.00	44.3	1.00	38.7	1.00
avg spawning area vel	V5	60.7	1.00	30.8	1.00	N/A		13.2	0.15	10.0	0.00	8.7	0.00	22.2	0.60	70.3	1.00	28.7	0.95
% instream cover-juv	V6j	70.1	1.00	59.5	1.00	38.5	1.00	33.2	1.00	34.3	1.00	19.4	1.00	29.3	1.00	18.0	1.00	17.4	1.00
% cover-adlt	V6a	6.2	0.51	5.5	0.47	4.9	0.47	6.6	0.55	5.3	0.45	3.2	0.37	1.8	0.32	3.1	0.37	2.1	0.32
spawning substr size	V7b	1.5	1.00	1.27	0.86	N/A		2.7	1.00	2.4	1.00	4.0	1.00	1.9	1.00	3.1	1.00	1.9	1.00
% large substrate	V8	63.7	1.00	70.0434	1.00	31.8	1.00	32.6	1.00	48.8	1.00	29.2	1.00	44.6	1.00	36.3	1.00	30.7	1.00
avg riffle substr type	V9	A	1.00	A	1.00	A	1.00	C	0.30	C	0.30	C	0.30	C	0.30	C	0.30	C	0.30
% pools	V10	9	0.50	20	0.73	26	0.86	41.6	1.00	32.1	0.98	37.6	1.00	17.1	0.67	27.0	0.88	25.7	0.86
% vegetation	V11	104.1	0.76	76.3	0.51	35.2	0.15	85.5	0.61	145.4	0.98	99.0	0.74	210.9	1.00	158.7	1.00	112.0	0.83
% stable banks	V12	96.7	1.00	95.0	1.00	96.9	1.00	97.2	1.00	98.9	1.00	93.3	1.00	93.6	1.00	76.0	1.00	95.1	1.00
ann max/min pH	V13	8.07	0.97	N/A	0.80	8.40	0.76	8.34	0.80	8.07	0.97	8.34	0.80	8.13	0.94	8.47	0.70	8.37	0.78
ratio low Q/avg Q	V14	0.1	0.20	0.1	0.20	0.13	0.26	0.13	0.26	0.13	0.26	0.13	0.26	0.13	0.26	0.13	0.26	0.13	0.26
pool class rating	V15	C	0.30	B	0.60	B	0.60	B	0.60	B	0.60	B	0.60	B	0.60	B	0.60	B	0.60
%fines in spawn areas	V16a	6.86	0.98	37.5	0.17	N/A		9.2	0.96	10.9	0.91	6.3	0.99	23.7	0.30	22.0	0.40	16.0	0.70
%fines in riffles	V16b	8.94	1.00	5.6	1.00	6.6	1.00	3.3	1.00	8.8	1.00	5.0	1.00	11.7	0.99	5.2	1.00	8.1	1.00
% shade	V17	1.40	0.31	5.8	0.36	1.1	0.31	23.9	0.64	59.5	1.00	79.6	0.93	80.9	0.94	14.5	0.50	90.6	0.99
ratio migr Q/avg Q	V18	2.49	1.00	2.49	1.00	2.64	1.00	2.64	1.00	2.64	1.00	2.64	1.00	2.64	1.00	2.64	1.00	2.64	1.00
Adult		C_{AS}=	**0.72**	C_{AS}=	**0.85**	C_{AS}=	**0.86**	C_{AS}=	**0.96**	C_{AS}=	**0.96**	C_{AS}=	**0.92**	C_{AS}=	**0.93**	C_{AS}=	**0.95**	C_{AS}=	**0.95**
Juvenile		C_{JS}=	**0.39**	C_{JS}=	**0.44**	C_{JS}=	**0.52**	C_{JS}=	**0.71**	C_{JS}=	**0.76**	C_{JS}=	**0.66**	C_{JS}=	**0.71**	C_{JS}=	**0.74**	C_{JS}=	**0.74**
Fry		C_F=	**0.71**	C_F=	**0.85**	C_F=	**0.93**	C_F=	**1.00**	C_F=	**0.99**	C_F=	**1.00**	C_F=	**0.82**	C_F=	**0.94**	C_F=	**0.93**
Embryo		C_E=	**0.32**	C_E=	**0.43**	C_E=	**0.43**	C_E=	**0.51**	C_E=	**0.27**	C_E=	**0.27**	C_E=	**0.52**	C_E=	**0.49**	C_E=	**0.85**
Other		C_O=	**0.62**	C_O=	**0.60**	C_O=	**0.56**	C_O=	**0.63**	C_O=	**0.77**	C_O=	**0.68**	C_O=	**0.76**	C_O=	**0.70**	C_O=	**0.71**
Overall			**0.52**		**0.61**		**0.63**		**0.74**		**0.68**		**0.64**	**HSI**	**0.73**	**HSI**	**0.74**	**HSI**	**0.83**