EXISTING CONDITIONS

This section discusses the existing conditions of both the physical and biological environments of the streams of Ojai. The physical environment of the Ojai streams includes topography, landscape, altitude, hydrology, substrate, climate, and rainfall of subwatersheds and stream reaches. This section also discusses the land use activities adjacent to the Ojai streams, as well as the barriers causing habitat degradation and limiting factors to the survival, migration, and spawning of Southern Steelhead Trout.

PHYSICAL ENVIRONMENT OF OJAI BASIN STREAMS

The Ventura River basin forms part of the Western Transverse Ranges of southern California (Hickman 1993) and is characterized by steep, coastal, mountainous and narrow canyons, which converge to form a comparatively broad, level central valley. The ratio of mountainous and foothill area to valley area is greater than six to one. The crest of the mountains along the boundary of the watershed commonly rises to over 1,524 meters, and in a few areas, it rises to a height of 1,828 meters. Much of the river basin lies within the Los Padres National Forest. (Moore 1980b.)

Climate and Rainfall

The climate of the Ventura River basin is characterized by two distinct seasons: a cool, wet winter from November through April; and a warm, dry summer from May through October (Bailey 1966). The majority of the precipitation falls as rain during the months of December through March in most years, with annual precipitation varying considerably from year to year. The average annual rainfall for the basin also varies, ranging from 400 milimeters (mm) near the river's mouth at the Pacific Ocean, to approximately 1,020 mm in the Mountainous areas of the basin. The average annual rainfall for the entire basin is approximately 56 centimeters (cm). Snow is common during the winter months in the higher elevations; however, the snow does not normally contribute significantly to the annual stream run-off (U.S. Army Corps of Engineers 1971). (Moore 1980b.)

Photograph 1 *(left). Overflow of Thacher Creek on Ojai Avenue during winter storm event (5 January 2005).*
Photograph 2 *(right) San Antonio Creek during winter storm event (9 January 2005).*

The climate of the South Coast, from Point Conception to Ventura, is generally Mediterranean typified by relatively mild winters, hot dry summers, and coastal fog during the early days of summer. Rain generally occurs only between the months of November to March, and temperatures at lower elevations are almost always above freezing. High-pressure systems, which develop over Utah and Nevada, are strong enough to keep the weather of the South Coast warm and sunny for much of the summer and fall. They also keep rain away and there is little summer precipitation.

The upper watershed may have summer daytime temperatures of 85-100ºF, while the coastal regions will generally be about ten to fifteen degrees cooler. Fall daytime temperatures generally are 70-90ºF in the inland areas, but considerably colder at night. In the fall, Santa Ana winds blow hot and dry from the desert. These warm winds and the prevalent dry conditions often combine to exacerbate natural wild fires, which are a natural part of the ecosystem. Winter is characterized by periodic bouts of heavy rainfall, often several inches in each storm. The upper mountainous regions of watersheds see more rainfall than the lower coastal areas, as Pacific storms are uplifted over the coast range. The foothills, on average, see about 560 to 740 mm (22 to 29 inches) of rain a year, while amounts near the ocean are closer to 380 mm (15 inches). Snow can fall at upper elevations during particularly cold winter storms. (Leydecker and Grabowsky 2004.)

Hydrology

The main stem of the Ventura River is classified as an interrupted stream, made up of perennial reaches with intervening intermittent reaches. The Ventura River generally maintains a perennial surface flow approximately 10 kilometers from its headwaters to the Robles Diversion Dam. The next 12.8 kilometers, from the Robles Diversion Dam to the confluence of San Antonio Creek, is intermittent carrying surface flows for short periods during and following major rainstorms. The 3.2 kilometers from the confluence of San Antonio Creek to Foster Park maintains a perennial surface flow, with some desiccation occurring in the Foster Park area during drought years as a result of municipal groundwater extraction. Surface flow in this reach of the river is made up of flows from San Antonio Creek, Live Oak Acres Creek, several small springs, and rising groundwater.

Of special significance is a geologic discontinuity or natural obstruction in the Ventura River alluvium in the vicinity of Casitas Springs. This feature obstructs the sub-surface flow in the Ventura River above the confluence of San Antonio Creek causing groundwater to rise and flow as a surface stream. This rising groundwater contributes to the perennial surface flow below the confluence of San Antonio Creek (Casitas Municipal Water District and City of San Buenaventura 1978). The lower 9.6 kilometers of the river, from Foster Park to the Pacific Ocean, also normally maintains a perennial surface flow, but is augmented by the discharge from the Ojai Valley Sanitary District's sewage treatment plant. (Moore 1980b.)

Subwatersheds

A total of twenty-five (25) subwatersheds (approximately 2,795 acres) that support the Ojai Basin Watershed have been delineated. The City of Ojai and Ojai Valley primary subwatersheds included in this study are Stewart Canyon Creek, Fox Canyon Barranca, and a portion of Thacher Creek, which are all tributaries to San Antonio Creek. San Antonio Creek originates in Senior Canyon on the southerly slopes of the Topatopa Mountains in the northeast quadrant of the basin. San Antonio Creek joins the Ventura River 13 kilometers upstream from the river's mouth in Casitas Springs.

Within the 25 subwatersheds, a total of 16 creeks flow through the City of Ojai, which totals approximately 86,905 feet (35,179 meters; 16.5 miles) of creek channels. Table 6, Summary of Ojai Basin Streams Hydrology, shows the hydrology for Ojai creeks, within the Ojai Basin Watershed.

Table 6. Summary of Ojai Basin Streams Hydrology[1]

Creek Name	Reach	QBF	Q2	Q50	R Code	Area	VC Node	VCQ50	VC Area	VCcfs/ac	Q2/Q50
Ayers Creek	1	26.1	52.1	400.9	AR1	207	562C	397	205	1.9	0.13
	2	17.7	35.5	295.7	AR2	156	561CD	309	163	1.9	0.12
	3	37.2	74.3	743.3	AY1	376	20AE	680	344	2.0	0.1
	4	33.0	65.9	659.0	AY2	323	18AC	611	299	2.0	0.1
	5	8.6	17.2	214.8	AY3	99	1A	217	100	2.2	0.08
Del Norte Creek	1	32.5	65.1	591.8	DN1	418	646B	538	380	1.4	0.11
	2	22.1	44.1	367.8	DN2	238	644B	408	264	1.5	0.12
	3	14.4	28.8	239.6	DN3	153	640BC	285	182	1.6	0.12
Fox Canyon Creek	1	116.4	232.7	1790.0	FX1	1042	625C	1778	1035	1.7	0.13
	2	82.3	164.5	1370.9	FX2	764	612C	1344	749	1.8	0.12
	3	59.6	119.3	1084.4	FX3	583	601CD	1103	593	1.9	0.11
	4	22.3	44.6	495.4	FX4	266	578CD	555	298	1.9	0.09
	5	18.3	36.6	457.3	FX5	242	576C	480	254	1.9	0.08
Ojai Creek	1	33.5	67.1	447.0	OJ1	224	622DF	465	233	2.0	0.15
	2	24.9	49.8	332.2	OJ2	168	619D	346	175	2.0	0.15
	3	18.8	37.6	250.7	OJ3	119	617DE	198	94	2.1	0.15
San Antonio Creek	1	869.1	1738.2	17382.2	SA1	21555	635AD	16375	20306	0.8	0.1
	2	735.1	1470.2	16335.5	SA2	17133	521A	16570	17379	1.0	0.09
	3	484.2	968.4	10760.2	SA3	9339	463BC	10562	9167	1.2	0.09
	4	408.6	817.3	10216.1	SA4	7630	403B	10283	7680	1.3	0.08
Stewart Canyon Creek	1	259.2	518.5	4320.7	ST1	2858	630B	4230	2798	1.5	0.12
	2	106.0	212.0	2355.1	ST2	1423	563BC	2327	1406	1.7	0.09
	3	88.4	176.8	2209.7	ST3	1203	552B	2206	1201	1.8	0.08
Thacher Creek	1	298.2	596.4	6626.7	TH1	6593	162A	6875	6840	1.0	0.09
Villanova Creek	1	23.4	46.7	389.4	VN1	214	651F	313	172	1.8	0.12
	2	20.3	40.6	270.8	VN2	144	650F	220	117	1.9	0.15
	3	16.7	33.4	208.9	VN3	111	649F	155	82	1.9	0.16

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[1] Hydrology is based on a hydrology study performed by Ventura County Watershed Protection District with appropriate adjustments. Since the reaches identified in this report do not always correspond with the nodes used in the County Hydrology, the above table was developed to make the appropriate adjustments.

Legend:
QBF = Bankfull Discharge
Q2 = Peak flow for the 2-year storm
Q50 = Peak flow for the 50-year storm
R-CODE = Reach Code (2 letter acronym for the creek plus 1 digit starting downstream)
AREA = Watershed area above downstream end of reach in acres
VCNODE = Identifier used in County Hydrology study
VCQ50 = Peak flow for the 50-year storm according to County hydrology
VCAREA = Area used in County Hydrology
VCCFS/AC = Peak flow per unit acre from County Hydrology
Q2/Q50 = Ratio of 2-year to 50-year peak flow based on estimation of percent imperviousness and County "hydrology multipliers"

Table 7, Area of Subwatersheds Upstream from the City of Ojai; Table 8, Area of Subwatersheds in The City of Ojai; and Figure 6, Ojai Basin Subwatershed Areas, provide the acres of subwatersheds in and out of the City. Table 9, Length of Creeks and Their Tributaries Upstream from Ojai City Limits, provides the total distance of all creeks (including tributaries) outside the City limits. Table 10, Summary of Creek Lengths within the City of Ojai, gives total creek lengths, distance of each creek underground and aboveground, and distance of general imperviousness.

Table 7. Area of Subwatersheds Upstream from the City of Ojai

Subwatershed Name	Acres
Ayers	742.6
Black Mountain	328.7
Del Norte	181.1
Dennison Park	29.3
Fox Canyon	125.0
Gridley Canyon	2,832.1
Gridley Canyon (East)	700.3
Ladera Ranch	1,469.9
Upper Ojai (North)	518.2
Reeves	1,831.9
Reeves (West)	345.6
Senior Canyon	3,689.5
Stewart Canyon	1,178.4
Thacher Canyon	310.1
Lower Thacher	1,137.9
Upper Thacher	496.2
Upper Thacher (Northeast)	567.2
Upper Thacher (Northwest)	1,309.4
Total:	**17,965.0**

Table 8. Area of Subwatersheds in the City of Ojai

Name of Creek	Acres
Ayers	451.0
Black Mountain	32.5
Back Mountain (West)	57.2
West Black Mountain	0.4
Camp Comfort (Drains to Ventura River)	0.4
Del Norte	230.5
Fox Canyon Barranca	911.0
Gridley Canyon	16.1
Happy Valley Drain	151.0
Ladera Ranch	38.6
Mira Monte (Drains to Ventura River)	91.6
Lower San Antonio	10.9
Stewart Canyon	608.0
Lower Thacher	47.3
Villanova	148.3
Total:	**2,794.9**

Figure 6. Ojai Basin Subwatershed Areas

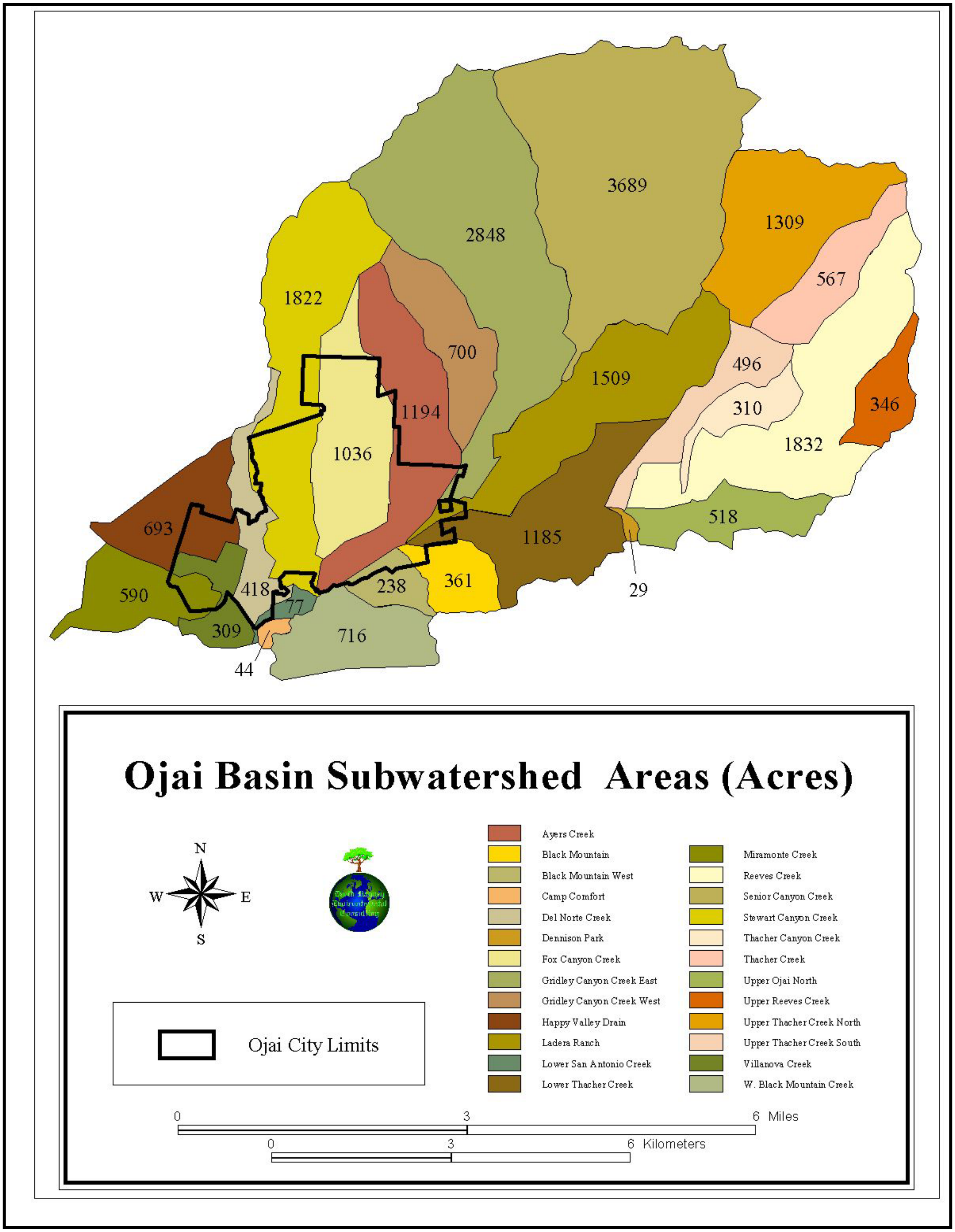


Table 9. Length of Creeks and their Tributaries Upstream from Ojai City Limits

Creek Name	Feet	Miles
Ayers	873	0.4
Del Norte	4162	0.8
Fox Canyon Barranca	3452	0.7
San Antonio	218,881	41.5
Soule Park	4513	0.9
Stewart Canyon	29,116	5.5
Thacher	121,936	23.1
West Soule Park	2,840	0.5
Total:	**386,773**	**73.3**

Table 10. Length of Creeks and their Tributaries within the City of Ojai

Creek Name	Feet	Miles
Arbolada Creek	5,758.6	1.1
Ayers Creek	10,196.5	1.9
Del Norte Creek	7,927.9	1.5
East End Creek	339.1	0.1
Fox Canyon Barranca	17,425.5	3.3
Grandview-Park Drain	4,160.4	0.8
Nordhoff Drainage	837.1	0.2
Oak Creek	1,719.7	0.3
Ojai Creek	8,017.7	1.5
Post Office Creek	1,035.8	0.2
San Antonio Creek	12,095.6	2.3
Soule Park Creek	1,560.7	0.3
West Soule Park Creek	1,304.6	0.2
Stewart Canyon Creek	9,002.9	1.7
Thacher Creek	2,445.1	0.5
Villanova Creek	3,077.9	0.6
Total:	**86,905.3**	**16.5**

Habitat Characterization of Stream Reaches

Of the 16 creeks flowing through the City of Ojai, 51 distinct reaches were delineated within those creeks (Figure 7, Delineation of Ojai City Stream Reaches). This subsection discusses the results of the stream habitat characterization study conducted throughout the streams of Ojai. The findings for each of the primary stream characterization parameters (Appendix A provides an example Stream Characterization and Water Quality Sampling Field Data Sheet), of each stream reach, are presented below. A discussion of these parameters and results and how they ultimately affect Steelhead habitat, as well as other aquatic and terrestrial wildlife in the area, is also provided. Based on the analysis of the stream characterization results, the limiting factors are indicated to aid in identifying restoration projects for implementation as part of the restoration plan presented in the following section. Each stream reach is evaluated for each habitat parameter, and those that fall outside acceptable conditions for Steelhead are identified as a limiting factor.

General Flow Conditions

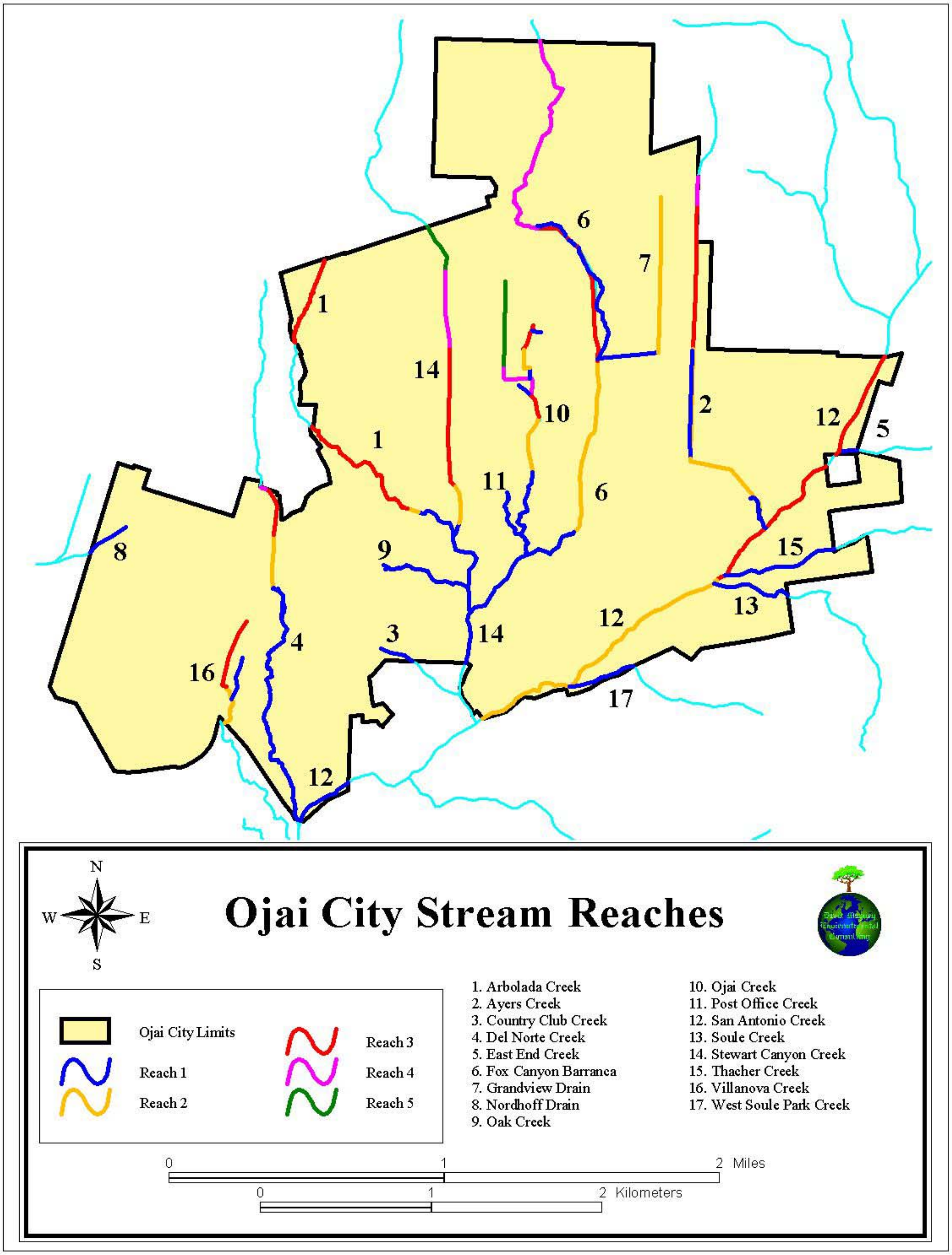
The streams of Ojai can be generally classified as having the following flow conditions: perennial, intermittent, and/or ephemeral. Perennial flow conditions include those channels where the gradient is low, water velocity is slow, and water is usually always flowing year-round. Intermittent flow conditions include channels with flowing water for part of the year (typically through the winter and spring months); however, when water is not flowing, it may remain in isolated pools, or surface flows may be absent. Ephemeral flow conditions are those channels that become inundated with flowing surface water only during periodic/seasonal rain or flood events.

Table 11, Stream Characterization Results for Flow Conditions, Channel Morphology, and Stream Type, presents the flow conditions of specific reaches within the streams of Ojai. In general, Steelhead are most likely expected to migrate and occupy the perennial channels of San Antonio and Stewart Canyon Creeks over the other creeks in the City of Ojai. (Note: A Steelhead approximately 12 inches long was observed in Stewart Canyon Creek on 5 December 2004.) The creek flow conditions is summarized as the following:

- San Antonio and Stewart Canyon Creeks are predominantly perennial with intermittent reaches upstream.
- Fox Canyon Barranca is perennial in the lower reaches, and becomes intermittent/ephemeral upstream.
- Nordhoff Drain and Thacher Creek are both entirely intermittent.
- East End, Grandview-Park, Oak, Post Office, Soule Park, West Soule Park, and Villanova Creeks are all ephemeral drainages.
- Arbolada, Ayers, Del Norte, and Ojai Creeks are intermittent (lower reaches) and ephemeral (upstream).

Flow conditions of streams initiate all other activities as far as Steelhead are concerned. If flows are present within an ephemeral stream, and Steelhead are able to migrate up that stream, then the flow condition of an ephemeral creek is not a limiting factor for migration. However, since (1) spawning occurs only between December and April where water is present year-round, (2) it takes approximately 30 days for the eggs to hatch (estimated in hatcheries at 51°F [Leitritz and Lewis 1980]), (3) fry emerge 4 to 6 weeks after hatching, and (4) rearing generally occurs over 1 to 3 years in freshwater, it can generally be determined that most ephemeral drainages are a limiting factor to the spawning and rearing activities of Steelhead (CDFG 1996). Based on these requirements, Steelhead prefer to spawn only in perennial streams since the duration of generally one to three years is required for offspring to mature enough and to reach the ocean (if ever). However, steelhead can spawn in intermittent streams and the juveniles will survive if they can migrate to perennial reaches to oversummer.

Figure 7. Delineation of Ojai City Stream Reaches



Channel Morphology

Natural channel morphology is the path carved by water flows and this morphology is significantly influenced by the sediment load carried by those flows. Natural channel morphology is maintained by bankfull discharge (Wolman and Leopold 1957). The bankfull discharge typically is considered as discharge that, on the average and over many years, performs the most work on stream systems. The primary geomorphic response to that stream work is sediment transport, and therefore, channel morphology maintenance. Small discharges occur frequently but move small amounts of sediment; large discharges move large amounts of sediment but occur infrequently. The moderate discharges occur moderately frequently and move moderate amounts of sediment. These discharges typically dominate sediment transport and channel morphology maintenance over long periods. (Wolman and Miller 1960.)

***Photograph 3**. San Antonio Creek above Grand Avenue showing natural channel morphology finding its course (4 February 2005).*

Fluvial geomorphologists have long recognized the unique geomorphic responses to episodic flood/high-sediment flux events. Short-term variations in flow can result in a channel morphology that is adjusted to high flows but is not in equilibrium with subsequent low flows (Schumm and Lichty 1963). For example, the channel morphology created during high flows on alluvial fans may be completely reconfigured during low-flow events. The result is that subsequent high flows may not follow the previous paths and kinetic energy may be dissipated in previously unaffected areas (Dawdy 1979).

Table 11 presents the findings for morphology within the primary streams reaches within Ojai that were walked by biologists during the streams habitat characterization assessment. Natural channel morphology is vital for fish passage, spawning, and rearing. The natural creek channels (95 to 100 percent natural) with well-defined bed and banks (in some reaches) include: Arbolada, East End, Nordhoff, Oak, Post Office, San Antonio, Soule Park, West Soule Park, and Thacher Creeks. The predominantly impervious/compacted (unnatural) creek channels (0 to 55 percent natural) limiting fish passage include Ayers, Del Norte, Fox Canyon, Grandview-Park, Ojai, Stewart Canyon, and Villanova Creeks. Although most of Stewart Canyon Creek is impervious, Reaches 1 and 5 have favorable stream morphology characteristic. (See Table 25, Percent Impervious Cover Summary for Creeks within the City of Ojai, for more detailed account of percent impervious cover.)

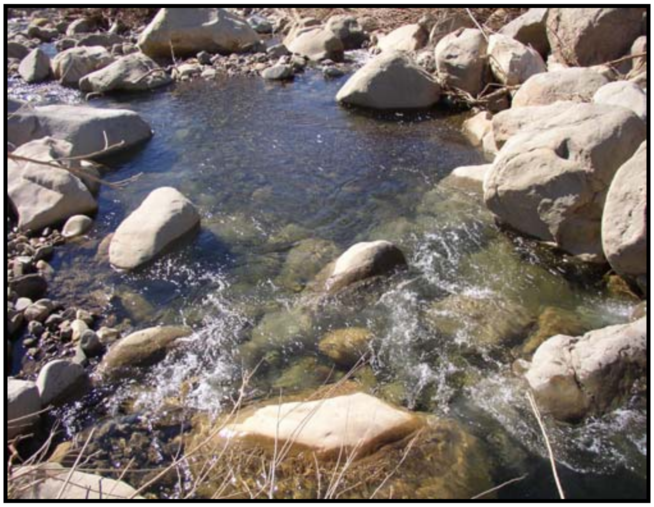
Stream Type

Stream type was recorded for each characterized stream reach. Stream type refers to the natural transitions a creek makes as water flows over various substrates, sediment deposits, and slopes. For this study, a stream was determined to consist of a run, riffle, or pool stream type, or a combination of the three. Most juveniles inhabit riffles but some of the larger ones will inhabit pools or deeper runs (Barnhart 1986)

The general structure of a pool includes large woody debris, large substrate particles such as large cobble, boulders, or some geomorphic feature that would support a pool. The pool usually forms a basin in which a variety of material may enter the pool to provide a range of cover. The velocity of stream flow in a pool may be reduced to near still water. The dominant substrate usually consists of sand and silt particles; however, pools may include gravel, cobble, and boulders depending upon the peak flow rate for that subwatershed. Finally, pools contain a hydraulic control at the tail crest of the pool.

Riffles are generally characterized by shallow reaches with swiftly flowing, turbulent water. Substrate materials may be exposed, and they usually consist of sand, gravel, cobble, and boulder particles; however, riffles may include silt, depending on flow rates.

Flatwater runs include habitat characterized by reduced flows around structures. These are fairly shallow areas and may consist of uniformed and non-uniformed substrate.



Photograph 4 *(left). San Antonio Creek showing a riffle-pool-riffle stream type.*
Photograph 5 *(right). San Antonio Creek showing a run stream type. Photos taken on 4 February 2005.*

Table 11 summarizes the general stream types for the reaches within the Ojai streams. The predominant stream types are riffles and runs; however, it should be noted that in addition to natural runs, the reaches with significant lengths of culverts and channelization were classified as runs also. Again, juvenile Steelhead generally prefer to inhabit riffles and pools; therefore, an example of a limiting factor for rearing juvenile Steelhead is where those streams, shown in Table 11, have channelized reaches that force the water to flow in shallow runs.

Table 11. Stream Characterization Results for Flows, Morphology, and Stream Type

Creek Name	Reach No.	Flow Conditions	Channel Morphology	Stream Type
Arbolada	**1**	Intermittent	Natural bed/banks, sinuous, with human-placed boulders	Run
	2	Ephemeral	Concrete/metal pipe; underground	Run
	3	Ephemeral	Variable, alternating from natural channel to channelized with placed rocks, to lawns; sinuous through yards	Riffle, Run
Ayers	**1**	Intermittent	Natural bottom, highly disturbed, straightened	Riffle, Run
	2	Ephemeral	Underground pipe; underground pipe	Run
	3	Ephemeral	Paved ditch; paved ditch	Run
	4	Ephemeral	Soft bottom ditch; soft bottom ditch	Run
	A-1	Ephemeral	Undergrounded by culvert, ditch draining water from pipe to main channel, undergrounded again opening to filled/cemented drainage	Run
	B-1	Ephemeral	Concrete/asphalt-lined ditch	Run
Del Norte	**1**	Intermittent	Natural bed and banks, defined channel, low sinuosity, undergrounded twice	Pool, Riffle, Run
	2	Ephemeral	Man-laid natural rock (boulder walls/banks), some standing water, back yards, along Del Norte Street	Riffle, Run
	3	Ephemeral	High-density polyethylene pipe; underground (at cemetery)	Run
	4	Ephemeral	Natural bottom, incised, man-laid rock on banks	Pool, Riffle, Run
	A-1	Ephemeral	Natural bed and banks, defined channel, low sinuosity, undergrounded twice	Pool, Riffle, Run
	B-1	Ephemeral	Natural, straight	Run
East End	**1**	Ephemeral	Natural	.
Fox Canyon	**1**	Perennial	Defined, natural channel, sinuous, natural	Pool, Riffle, Run
	2	Intermittent	Undergrounded/channelized by concrete	Run
	3	Ephemeral	Cement channel	Run
	4	Ephemeral	Natural, high-gradient, steep banks	Riffle
	A-1	Ephemeral	Culverts and natural channel stretches, disturbed, through yards	Run
	B-1	Ephemeral	Incised natural channel	Riffle, Run
Grandview-Park	**1**	Ephemeral	Cement	Run
	2	Ephemeral	Asphalted drainage, bed and banks	Run
Nordhoff	**1**	Intermittent	Natural, defined channel, straight, narrow	Run
Oak	**1**	Ephemeral	Natural bed/banks, +/- straight	Riffle, Pool
Ojai	**1**	Intermittent	Variable from culverts and cement/rip rap channelization to natural bed/banks, natural bed/banks, defined channel, sinuous	Pool, Riffle, Run
	2	Intermittent	Cement	Run
	3	Intermittent	Mixed Compacted	Run
	4	Intermittent	Cement, underground	Run
	5	Intermittent	Rock-lined ditch, grouted	Run

Table 11. Stream Characterization Results Flows, Morphology, and Stream Type (continued)

Creek Name	Reach No.	Flow Conditions	Channel Morphology	Stream Type
Ojai (continued)	**A-1**	Ephemeral	Mixed Compacted	Run
	B-1	Ephemeral	Metal pipe, underground	Run
	B-2	Ephemeral	Above ground gutter	Pool, Riffle
	B-3	Ephemeral	Upper portion of reach is lawn/irrigation runoff, lower is dry swale with ill-defined banks	Pool, Riffle
	A of B-1	Ephemeral	Upper portion of reach is lawn/irrigation runoff, lower is dry swale with ill-defined banks	Pool, Riffle
Post Office	**1**	Ephemeral	Variable from natural, defined bed/banks to road culverts, sinuous; filled areas, and channelized with concrete rip rap	Pool, Riffle, Run
San Antonio	**1**	Perennial	Natural ill-defined bed/banks, low sinuosity, braided throughout with cobble bars and some rock riprap	Pool, Riffle
	2	Intermittent	Natural, defined channel, wide floodplain area, low sinuosity, braided (burn area)	Pool, Riffle, Run
	3	Intermittent	Natural bed/banks, defined channel, low sinuosity	Pool, Riffle
Soule Park	**1**	Ephemeral	Natural bed/banks, defined channel	.
West Soule Park	**1**	Ephemeral	Natural bed/banks, defined channel	.
Stewart Canyon	**1**	Perennial	Natural bed/banks, defined channel	Pool, Riffle
	2	Perennial	Channelized, cement rock rip rap on bed/banks	Pool, Riffle
	3	Intermittent	Channelized, concrete channel	Run
	4	Intermittent	Channelized, concrete channel	Run
	5	Intermittent	Natural bed/banks, defined channel	Pool, Riffle, Run
Thacher	**1**	Intermittent	Predominantly natural bed/banks, braided, low sinuosity, braided, good potential ponding (area of channelization, fencing/concrete	Pool, Riffle, Run
Villanova	**2** Note: Reach 1 is outside the City limits	Ephemeral	Natural bed/banks, sinuous	Pool
	3	Ephemeral	Compacted/filled soil	Run
	B-1	Ephemeral	Natural bed/banks, defined channel	Riffle, Pool

Inundation

Inundation is a parameter that indicates whether the stream being sampled or characterized actually has water present within its channel or not (whether water is present/flowing). Refer to Table 12, Stream Characterization Results for Inundation, Water Depth and Width, Velocity, Discharge, and Stream Type, for inundation results for specific reaches within the Ojai streams. Table 12 indicates the months that water was observed flowing, and/or is expected to flow, in each creek.

Stewart Canyon Creek has water flows year round, San Antonio Creek has flows almost year round, and Fox Canyon Barranca has flows almost year round in its first reach. Most remaining creeks have water flows during most of the winter and spring months. As discussed in General Flow Conditions (above) long periods of inundation is required for spawning and rearing activities. Streams that are not inundated year round are a limiting factor to rearing; however, streams inundated for only the winter and spring months are not limiting factors to Steelhead migration as long as portions of the stream are perennial. Streams which support Steelhead, but are intermittent, exist in the Santa Monica Mountains, where Steelhead persist as long as some portion of the stream has water year round.

Water Depth and Width

Water depth and water width were measured at each water quality sampling station during each sampling session. Water quality sampling stations were designated at specific locations in the primary Ojai creeks; therefore, not all creeks were measured for water width and depth.

The following creeks were assigned water sampling stations to monitor water quality as well as water width, depth, velocity, and discharge (see also Table 16, Ojai Stream Reaches with Corresponding Water Quality Sampling Stations, in the Water Quality Section below):

- Arbolada Creek (2 stations)
- Ayers Creek (1 station)
- Del Norte Creek (2 stations)
- Fox Canyon Barranca (2 stations)
- Happy Valley Drain (1 station outside of the City limits)
- Ojai Creek (1 station)
- San Antonio Creek (4 stations)
- Stewart Canyon Creek (4 stations)
- Thacher Creek (1 station)
- Villanova (1 station)

These measurements were monitored at the sampling stations to observe fluctuations of stream depth, width, velocity, and discharge at single points within the creeks over several dates, and to detect changes throughout the four seasons.

The preferred depth for Steelhead spawning is approximately 14 inches and ranges from 6 to 24 inches. Fry prefer water approximately 8 inches in depth and utilize water 2 to 14 inches deep, while parr prefer a water depth of 10 inches, but utilize water 10 to 20 inches deep (Bovee 1978). In natural channels, water depth usually does not hinder adult migration because adult Steelhead normally migrate during high flows. Depth can become a significant barrier or impedance in streams that have been altered for flood control purposes, especially those that do not have a low flow channel. It has been reported that 7 inches is the minimum depth required for successful migration of adult Steelhead (Thompson 1972) although the distance fish must travel through shallow water areas is also a critical factor. Optimum depths for migration of adult Steelhead range from 18-61 cm (Bovee 1978). Excessive water velocity and obstacles, which impede the swimming and jumping ability, are more significant in hindering or blocking migration (Barnhart 1986). (CDFG 1996.)

Table 12 provides the average water depths and widths for specific reaches of the Ojai streams over six separate sampling dates. Appendix B, Ojai Streams Water Quality Sampling Results, provides all water width and depth data collected during each of the six dates on which the water quality sampling portion of this study were conducted. Water widths and depths of the streams were also measured at each water quality sampling station in order to determine the estimated water velocity and discharge of each creek.

Average water *width* was narrowist at Del Norte Creek Reach 1 (2.75 ft., or 33 in.), and was the widest at San Antonio Creek Reach 3 (18 ft., or 216 in.).

San Antonio Creek Reach 3 had the shallowest average *depth* measurement of 0.26 ft. (approximately 3 in.). Ayers Reach 1 (0.34 ft.), Ojai Reach 1 (0.32 ft.), San Antonio Reach 2 (0.35 ft.), Stewart

Canyon Reach 1 (0.33 ft.), and Thacher Reach 1 (0.39 ft.) also had shallow depth measurements of approximately 3.5 inches. Arbolada Reach 3 (2.14 ft., or 26 in.), Del Norte Reach 1 (2 ft., or 24 in.) and Reach 2 (1.92 ft., or 23 in.), Fox Canyon Reach 1 (1.3 feet, or 16 in.), and San Antonio Reach 1 (0.73 ft., or 9 in.) had the deepest measurements.

Based on these measurements, Arbolada, Del Norte, Fox Canyon, and San Antonio Creeks have water depth measurements that could potentially support Steelhead spawning, fry and parr development, and migration, that is if water is present long enough throughout the year, and if all other environmental and biological conditions are also supportive to Steelhead requirements. All other stream reaches have too shallow of flows that potentially limit these vital Steelhead activities.

Velocity and Discharge

Water velocities of 10 to 13 feet per second (fps) begin to hinder the swimming ability of adult Steelhead and may retard migration (Reiser and Bjornn 1979). Steelhead spawn in areas with water velocities ranging from 1 fps to 3.6 fps, but prefer velocities of about 2 fps (Bovee 1978). The ability to spawn in higher velocities is a function of size: larger Steelhead can establish redds and spawn in faster currents than smaller Steelhead (Barnhart 1986). (CDFG 1996.)

As with water depth and width, stream velocity and discharge were also measured at each water quality sampling station (listed above under Water Depth and Width) over six sampling The water quality stations were designated based on their location and orientation to adjacent or upstream variables such as golf courses and horse corrals, influences from the City runoff, and input from tributaries. Habitats varied between stations; however, the stations were selected to be representative of the reach in which each station is located.
Discharge was determined by multiplying average stream depth by stream width, and then by stream velocity. Table 12 shows the average water velocity and discharge measurements for specific reaches within the Ojai streams. Appendix B, Ojai Streams Water Quality Sampling Results, provides all water velocity and discharge data collected during the water quality sampling portion of this study.

In general, average water velocity measurements within the creeks of Ojai are relatively low at around 1 fps. Water velocity averages throughout the streams of Ojai range from 0.21 fps (discharge of 0.35 cfs) at Ayers Creek Reach 1, to 1.66 fps (discharge of 2.32 cfs) at Stewart Canyon Creek Reach 1. All creek reaches are below the 10 fps threshold for hindering Steelhead swimming ability. Approximately 1/4 of the creek reaches within Ojai have favorable average velocity measurements for Steelhead spawning as they are within the 1 to 3 fps threshold.

The creek reaches that were sampled and were determined to have an average water velocity between the favorable 1 and 3 fps include: Del Norte Reach 2 (1.47 fps); Fox Canyon Reach 1 (generally favorable based on two station's averages - 0.1 to1.08 fps), San Antonio Reach 1, 2, and 3 (1.18 to 1.34 fps); and Stewart Canyon Reach 1 (generally favorable based on three station's averages – 0.53 to 1.66 fps). In addition to the sampled creek reaches, the creek reaches expected to have favorable velocity during the winter and spring months include Fox Canyon Reach 2 and 3, and Stewart Reach 2, 3, 4, and 5.

The creeks reaches that were sampled and were determined to have water velocity measurements of less than 1 fps include Ayers Reach 1 (0.21 fps), Thacher Reach 1 (0.5 fps), Fox Canyon Reach 1 (0.6 fps), and Ojai Reach 1 (0.66 fps). These creek reaches may be limiting to Steelhead spawning. No creek reaches are determined to limit Steelhead migration since no stream reaches had velocity measurements above 3.33 fps.

Table 12. Stream Characterization Results for Inundation, Water Depth and Width, Velocity, Discharge, and Stream Type[2]

Creek Name	Reach No.	Months Inundated (water present)	Average Water Depth (feet)	Average Water Width (feet)	Average Velocity (fps)	Average Discharge (cfs)
Arbolada	**1**	Jan, Feb, Mar, Oct, Nov, Dec	.	.	Not favorable	.
	2	Jan, Feb, Mar, Oct, Nov, Dec	.	.	Not favorable	.
	3[3]	Jan, Feb, Mar, Oct, Nov, Dec	0.28	2.45	0.43 Not favorable	0.25
Ayers	**1**	Jan, Feb, Mar, Apr, Oct, Nov, Dec	0.34	4.25	0.21 Not favorable	0.35
	2	Jan, Oct, Dec	.	.	Not favorable	.
	3	Jan, Feb, Mar, Oct, Dec	.	.	Not favorable	.
	4	Jan, Feb, Mar, Oct, Dec	.	.	Not favorable	.
	A-1	Jan, Apr, Oct, Dec	.	.	Not favorable	.
	B-1	Jan, Oct, Dec	.	.	Not favorable	.
Del Norte	**1**	Jan, Feb, Apr, Sep, Oct, Nov, Dec	2	2.75	0.89 +/- Favorable	6.39
	2	Jan, Feb, Oct, Dec	1.92	3.25	1.47 Favorable	39.08 (this number is high due to Jan measurement)
	3	Jan, Feb, Oct, Dec	.	.	Not favorable	.
	4	Jan, Feb, Oct, Dec	.	.	Not favorable	.
	A-1	Jan, Feb, Oct, Dec	.	.	Not favorable	.
	B-1	Jan, Feb, Sep, Oct, Dec	.	.	Not favorable	.
East End	**1**	Jan, Oct, Dec	.	.	Not favorable	.
Fox Canyon	**1**	Jan, Feb, Mar, Apr, May, Jun, Oct, Nov, Dec	1.3	6.39	1.08 at Station 8, 0.1 at Station 14; Generally favorable	3.51
	2	Jan, Feb, Jun, Oct, Nov, Dec	.	.	Favorable	.
	3	Jan, Feb, Oct, Dec	.	.	Favorable	.
	4	Jan, Feb, Oct, Dec	.	.	Not favorable	.
	A-1	Jan, Oct, Nov, Dec	.	.	Not favorable	.
	B-1	Jan, Oct, Dec	.	.	Not favorable	.
Grandview-Park	**1**	Jan, Mar, Oct, Dec	.	.	Not favorable	.
	2	Jan, Mar, Oct, Dec	.	.	Not favorable	.
Nordhoff	**1**	Jan, Feb, Mar, Oct, Nov, Dec	.	.	Not favorable	.
Oak	**1**	Jan, Feb, Oct, Nov, Dec	.	.	Not favorable	.
Ojai	**1**	Jan, Feb, Sep, Oct, Nov, Dec	0.32	4.03	0.66 Not favorable	0.8
	2	Jan, Feb, Oct, Nov, Dec	.	.	Not favorable	.
	3	Jan, Feb, Oct, Dec	.	.	Not favorable	.
	4	Jan, Feb, Oct, Dec	.	.	Not favorable	.
	5	Jan, Feb, Mar, Oct, Dec	.	.	Not favorable	.

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[2] Refer to Table 5 and Figure 5 for station locations, and Table 16 for creek reaches with corresponding stations.

[3] Arbolada Creek Reach 3 contains two water quality sampling stations (Stations 9 and 16). Since Station 16 (1) was only sampled once (dry at all other attempts), (2) had unusually high flows due to flood event in October 2004, and (3) is outside of the City limits, Station 16 was not factored into the velocity and discharge results for Arbolada Creek Reach 3.

Table 12. Stream Characterization Results for Inundation, Water Depth and Width, Velocity, Discharge, and Stream Type (continued) [4]

Creek Name	Reach No.	Months Inundated (water present)	Average Water Depth (ft)	Average Water Width (ft)	Average Velocity (fps)	Average Discharge (cfs)
Ojai (continued)	**A-1**	Jan, Oct, Dec	.	.	Not favorable	.
	B-1	Jan, Oct, Dec	.	.	Not favorable	.
	B-2	Jan, Oct, Dec	.	.	Not favorable	.
	B-3	Jan, Oct, Dec	.	.	Not favorable	.
	A of B-1	Jan, Oct, Dec	.	.	Not favorable	.
Post Office	**1**	Jan, Feb, Oct, Nov, Dec	.	.	Not favorable	.
San Antonio	**1**	Jan, Feb, Mar, Apr, May, Jun, Oct, Nov, Dec	0.72	12.98	1.34 at Station 3, 1.18 at Station 4; Favorable	14.41
	2	Jan, Feb, Mar, Apr, May, Jun, Oct, Nov, Dec	0.35	11.68	1.3 Favorable	5.82
	3	Jan, Feb, Oct, Nov, Dec	0.26	18	1.34 Favorable	6.96
Soule Park	**1**	.	.	.	.	.
West Soule Park	**1**	.	.	.	.	.
Stewart Canyon	**1**	Year Round	0.33	4.83	0.71 at Station 6, 0.53 at Station 15; Generally Favorable	2.32
	2	Jan, Feb, Mar, Apr, May, Oct, Nov, Dec	.	.	Generally Favorable for Reaches 2, 3, & 4[5]	.
	3	Jan, Feb, Mar, Apr, May, Oct, Nov, Dec	.	.		.
	4	Jan, Feb, Mar, Dec	.	.		.
	5	Jan, Feb, Mar, Apr, May, Oct, Nov, Dec	.	.	1.66 at Station 10A, Favorable	.
Thacher	**1**	Jan, Feb	0.39	6	0.5 Not favorable	1.17
Villanova Note: Reach 1 is outside the City limits	**2**	Jan	.	.	Not favorable	.
	3	Jan	.	.	Not favorable	.
	B-1	Jan	.	.	Not favorable	.

Instream Description and Cover Type

Instream cover is composed of elements within a stream channel that provide aquatic vertebrate species protection from predation, reduce water velocities so as to provide resting areas, and reduce intraspecific competition through increased living space within the stream (Hamilton and Bergersen 1984). Instream assessments provide information regarding organisms, organic matter, and inorganic materials occupying aquatic habitats of the Ojai streams. Cover type specifically relates to what type of shelter is available within the immediate water channel, as apposed to cover or shade made by riparian vegetation. Instream cover is recorded as objects under water providing shade and resting areas, including over-hanging vegetation, submerged boulders, logs, root wads, submerged vegetation, and undercut banks.

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[4] Refer to Table 5 and Figure 5 for station locations, and Table 16 for creek reaches with corresponding stations.

[5] Water velocity may be adequate for fish habitat here; however, the imperviousness of the substrate in these creek reaches are not suitable for spawning and rearing, and may create an impediment to fish migration since no resting pools exist throughout these reaches.

Photograph 6. *Stewart Canyon Creek showing root wads and logs as functional instream cover for Steelhead (5 January 2005). A Southern Steelhead was observedat this location in December 2004.*

Table 13, Stream Characterization Results for Instream, Cover Type, Riparian Habitat, and Percent Shading, provides a list of instream descriptions and cover type findings for specific reaches within the Ojai streams. Based on the findings from the streams habitat characterization study, the creek reaches with 5 to 6 instream cover types (optimal conditions) include: Ayers Reach 1, Del Norte Reach 1, Fox Canyon Reach 1, Ojai Reach 1, San Antonio Reach 1 and 2, and Stewart Canyon Reach 1 and 5.

The creek reaches with 4 to 3 instream cover types (satisfactory conditions) include: Arbolada Reach 2 and 3, Del Norte Reach 2 and 4, Post Office Reach 1, San Antonio Reach 3, and Thacher Creek Reach 1. All remaining creek reaches have 2 to 0 instream cover types (unfavorable instream conditions). Inadequate instream cover is a limiting factor specifically to Steelhead rearing and a potential limiting factor for resting migrating Steelhead.

Riparian Habitat

The predominant plant community observed throughout the creeks of Ojai is Coast Live Oak Riparian Woodland. This plant community includes important canopy contributor such as Arroyo Willow (*Salix lasiolepis*), White Alder (*Alnus rhombifolia*), Fremont Cottonwood (*Populus fremontii* ssp. *fremontii*), Valley Oak (*Quercus lobata*), and California Sycamore (*Platanus racemosa*). Predominant shrub and herbaceous plants observed in this plant community include Pacific Blackberry (*Rubus ursinus*), Western Poison Oak (*Toxicodendron diversilobum*), Mugwort (*Artemisia douglasiana*), and Mulefat (*Baccharis salicifolia*). Unfortunately, this habitat type is significantly influenced by escaped ornamental plant species that become highly invasive and create competitive conditions for the less-hearty, more-desirable native riparian species. Refer to the Habitat Descriptions subsection for the classification and detailed description of all the riparian and aquatic habitats and plant communities observed during the stream characterization studies and water quality surveys.

***Photograph** 7 (left). San Antonio Creek showing functional riparian habitat consisting of predominantly native plant species (17 June 2004). **Photograph 8** (right). Fox Canyon Barranca showing poor quality stream habitat dominated by invasive exotics and ornamental plant species, such as Peruvian Peppertree and Mexican Fan Palm (27 November 2004).*

Table 13, provides a summary of the predominant plant communities by creek and stream reach. By far, San Antonio, Fox Canyon, lower Stewart Canyon, and lower Ojai Creeks have the most favorable and functional riparian plant communities of all the Ojai creeks. Other creek reaches inhabited by favorable riparian habitat include all Del Norte Creek reaches, Grandview-Park Reach 2, Stewart Canyon Reach 5, Thacher Reach 1, and Villanova Creek Reach 2. However, these creek reaches are influenced by invasive exotic plant species as well. All other creek reaches are either significantly out-competed by introduced ornamental and naturalized plant species, or are completely channelized.

Percent Shading

Percent shading is recorded as the estimated amount of shade or cover created by the canopy of the surrounding riparian vegetation. Shade is an important component of Steelhead habitat requirements, as specific temperatures are required for survival. Proper shade aids in the cooling of water to provide cooler temperatures for Steelhead migration, spawning, and rearing activities. As temperatures rise, fish have increasing trouble extracting oxygen from water, while at the same time the amount of oxygen in the water decreases. As temperature increases, dissolved oxygen usually decreases, and visa versa. Temperature was measured during water quality sampling; therefore, this parameter is discussed in detail in the following subsection, Water Quality Sampling Results.

Shading of the creeks was variable. Most of the streams' canopies were composed of both broad-leaved, winter-deciduous trees, such as California Sycamore (*Platanus racemosa*), Arroyo Willow (*Salix lasiolepis*), and Fremont Cottonwood (*Populus fremontii*), and evergreen trees, such as Coast Live Oak (*Quercus agrifolia*). Percent shading also includes invasive exotic plant species. Table 13 provides the general estimated percent shading results for specific reaches within the Ojai streams.

The creek reaches with abundant shading between 76% and 90% include the following:

- Arbolada Reach 1
- Del Norte Reach 4
- Fox Canyon Reach 1 and B-1
- Oak Reach 1
- Ojai Reach 1 and 3
- Post Office Reach 1
- San Antonio Reach 1, 2, and 3
- Stewart Canyon Reach 1 and 5
- Villanova Reach 2

The creek reaches with shading between 40% and 75% include the following:

- Arbolada Reach 3
- Ayers Reach 1, 3, 4, and A-1
- Del Norte Reach 1, 2, A-1, and B-1
- East End Reach 1
- Fox Canyon Reach 2, 4 and A-1
- Grandview Reach 2
- Ojai Reach A-1
- Thacher Reach 1
- Villanova Reach 3

Creek reaches with little to no shading by riparian vegetation may be a limiting factor to Steelhead in general (including all life histories), as shading aids in controlling temperatures from increasing beyond threshold levels. Therefore, the Ojai stream reaches that have less than 40% shading create a limiting factor for migrating, spawning, and rearing Steelhead.

Table 13. Stream Characterization Results for Instream, Habitat, and Shading

Creek Name	Reach No.	Instream Description	Instream Cover[6]	Riparian Habitat	% Shade
Arbolada	**1**	.	OV	Coast Live Oak Riparian Woodland with significant ornamentals	90
	2	Concrete/Metal Pipe	OV, SB, RW	.	100
	3	Leaf Litter, lawn, herbaceous vegetation	OV, L, RW	Disturbed Coast Live Oak Riparian Woodland, backyards, ornamentals	55
Ayers	**1**	Leaf litter, herbaceous vegetation	OV, SB, L, RW, SV, UB	Arroyo Willow Riparian Woodland, Toyon, Prunus, Palm	70
	2	Underground pipe	.	None	100
	3	Paved ditch	OV	None	50
	4	Soft bottom ditch	OV	None	50
	A-1	Cement, herbaceous vegetation	Cement, OV	Palustrine Emergent (Umbrella Sedge, Watercress, Willow-herb) with scattered Oak, Eucalyptus, Acacia, Walnut, Toyon	75
	B-1	Cement	None	None	0
Del Norte	**1**	Water striders and other aquatic insects, pollywogs, Mint, algae, Watercress, Cattail	OV, SB, L, RW, SV, UB	Arroyo Willow Riparian Woodland, Eucalyptus, Coast Live Oak Riparian Woodland, Cattail, ornamentals, Pacific Blackberry, Western Poison Oak, Giant Reed, Periwinkle, Smilo Grass	70
	2	Leaf litter, herbaceous vegetation	OV, RW, Eucalyptus stump	Coast Live Oak-Valley Oak Riparian Woodland	60
	3	High-density polyethylene pipe	None	Underground	100
	4	Leaf litter, herbaceous vegetation	OV, RW, UB	Coast Live Oak Riparian Woodland, Pacific Blackberry, ornamentals	80
	A-1	Aquatic insects, pollywogs, algae	None	Arroyo Willow Riparian Woodland, Eucalyptus, Coast Live Oak Riparian Woodland, Cattail, ornamentals, Pacific Blackberry, Western Poison Oak, Giant Reed, Periwinkle, Smilo Grass	70
	B-1	Periwinkle, Umbrella Sedge	OV	Coast Live Oak Riparian Woodland	70
East End	**1**	Leaf litter, herbaceous vegetation	OV	Riparian patches (Mulefat, Arroyo Willow) through orchards	40
Fox Canyon	**1**	Algae, fish, insects, pollywogs	OV, SB, L, RW, SV, UB	Coast Live Oak Riparian Woodland, Willow, Alder, Toyon, Western Poison Oak, Walnut, Mulefat, Pacific Blackberry	90
	2	Algae, trash	OV	Ornamentals	40

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[6] Instream Cover Types: OV = Over-hanging Vegetation; SB = Submerged Boulders; L = Logs; RW = Root Wads; SV = Submerged Vegetation; UB = Undercut Banks

Table 13. Stream Characterization Results for Instream, Habitat, and Shading (continued)

Creek Name	Reach No.	Instream Description	Instream Cover[7]	Riparian Habitat	% Shade
Fox Canyon (continued)	**3**	Cement	None	None	0
	4	Leaf litter, herbaceous vegetation	OV, SB	Sycamore Riparian Woodland, Willow, Mulefat, California Rose, Pacific Blackberry	60
	A-1	Leaf litter, Periwinkle, trash	Culverts, OV	Coast Live Oak Riparian Woodland, ornamentals, Ceanothus, Sumac, Man-root	70
	B-1	Leaf litter, herbaceous vegetation	OV	Coast Live Oak Riparian Woodland	90
Grandview-Park	**1**	Cement	None	None	0
	2	Leaf Litter	OV	Coast Live Oak Riparian Woodland	50
Nordhoff	**1**	Leaf litter, herbaceous vegetation	OV, RW	Freshwater Marsh, Eucalyptus Grove, Mulefat, Annual Grassland	40
Oak	**1**	Annual grasses	OV	Coast Live Oak-Willow Riparian Woodland, ornamentals, Annual Grassland	90
Ojai	**1**	Algae, moss, leaf litter, insects, Goldfish, Mosquitofish,	OV, SB, RW, SV, UB	Coast Live Oak-Sycamore-Willow Riparian Woodland, Walnut, Western Poison Oak, Pacific Blackberry, ornamentals	80
	2	Cement	None	Underground	100
	3	Mixed Compacted	OV	None	80
	4	Cement, underground	None	None	100
	5	Rock-lined ditch, grouted	None	None	0
	A-1	Mixed Compacted	OV	None	45
	B-1	Metal pipe, underground	None	None	100
	B-2	Annual grasses	None	Annual Grassland	0
	B-3	Annual grasses	None	Annual Grassland	0
	A of B-1	Annual grasses	None	Annual Grassland	0
Post Office	**1**	Leaf litter, cement, Raccoon prints	OV, SB, RW, Culverts	Coast Live Oak-Valley Oak-Sycamore Riparian Woodland with Pacific Blackberry dominant below, Eucalyptus, Western Poison Oak, Hollyleaf Cherry	90
San Antonio	**1**	Algae, insects	OV, SB, RW, UB, L	Willow-Sycamore Riparian Woodland, Pacific Blackberry, Western Poison Oak, Giant Reed	80
	2	Algae, insects, fish	OV, SB, RW, SV, UB	Willow-Walnut-Alder-Sycamore Riparian Woodland, Pacific Blackberry, Mulefat, Western Poison Oak, Giant Reed, Scalebroom Scrub	80
	3	Algae, insects, fish	OV, RW, SB	Willow-Sycamore-Alder Riparian Woodland, Mulefat, Scalebroom	80
Soule Park	**1**	.	.	.	.
West Soule Park	**1**	.	.	.	.
Stewart Canyon	**1**	Algae, insects, Duck Weed, Treefrog	OV, SB, RW, SV, L	Coast Live Oak-Walnut Riparian Woodland, ornamentals	85
	2	Trash, Lemna, herb veg, algae, insects, pollywogs	SV	None (Channelized/Rock rip-rap)	0
	3	Cement	None	Underground	100
	4	Cement	None	None	0
	5	Algae, insects, pollywogs	OV, SB, RW, SV, L	Willow-Sycamore Riparian Woodland	80
Thacher	**1**	Cement slabs, herbaceous vegetation, leaf litter	OV, RW, UB	Willow-Alder Woodland, Coast Live Oak Riparian Woodland, Walnut, Mulefat Scrub, Backyard Coast Live Oak trees, ornamentals	60
Villanova Note: Reach 1 is outside the City limits	**2**	Leaf litter, algae, insects	OV, RW	Coast Live Oak-Willow Riparian Woodland, Mulefat, Western Poison Oak	90
	3	Compacted soil	OV	None	60
	B-1	.	OV	Ornamentals	30

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[7] Instream Cover Types: OV = Over-hanging Vegetation; SB = Submerged Boulders; L = Logs; RW = Root Wads; SV = Submerged Vegetation; UB = Undercut Banks

Substrate Composition and Particle Size

Approximately 85% of the Ventura River basin is composed of relatively impervious deposits (not to be confused with huma-induced impervious surfaces) (Turner 1971, U.S. Army Corps of Engineers 1940). The exposed rock material is sedimentary in origin and is generally easily eroded. The primary geologic formations include well-cemented and interbedded sandstones, shales, and conglomerates, which produce little water except along joints and fractures. The streambed of the lower 2/3 of the Ventura River widens to a relatively broad plain composed of pervious materials that are subject to high percolation. These materials consist of alluvial deposits of silt, sand, gravel, cobbles, and boulders common to southern California coastal streams. (Moore 1980b.)

The study area lies within the Western Transverse Ranges of California, which are mountain ranges notable for their easily eroded sedimentary rocks. These ranges have been produced by clockwise crustal rotations between the Pacific and North American tectonic plates. The same plate movements that produce the infamous San Andreas Fault and California's largest earthquakes have rotated and uplifted our coastal mountains. These plates are still uplifting, at rates of 1 to 3 cm per year. Regional tectonics have produced numerous faults and folds and some of the youngest sedimentary rocks have been deformed until they stand nearly vertical. The rocks near the surface are usually recent sedimentary layers of marine origin (Cenozoic, younger than 65 million years old) including hard sandstones alternating with weak shales and mudstones. The surrounding geology is responsible for much of the character of our local streams, as steep mountains with easily eroded rocks yield "flashy" creeks with huge sediment loads (per unit area, some of the highest in the world). Fragile marine sediments create hard water, or cause high background conductivities and total dissolved solids (high in sulfate, calcium, magnesium and chloride). (Leydecker and Grabowsky 2004.)

Adult Steelhead have been reported to spawn in substrates from 0.2 to 4.0 inches in diameter (Reiser and Bjornn 1979). Based on the Bovee (1978) classification, Steelhead utilize mostly gravel-sized material for spawning; however, they will also use mixtures of sand-gravel and gravel-cobble. Fry and juvenile Steelhead prefer approximately the same size of substrate material (cobbles), which is slightly larger than that preferred by adults for spawning (gravel) (Bovee 1978). The gravel must be highly permeable to keep the incubating eggs well oxygenated, and should contain less than 5% sand and silt. (CDFG 1996.)

Photograph 9 *(left), Boulders in San Antonio Creek (17 June 2004).* ***Photograph 10*** *(middle), Cobbles in Fox Canyon Barranca (27 May 2004).* ***Photograph 11*** *(right), Gravels in Arbolada Creek (1 February 2005).*

Table 14, Stream Characterization Results for Substrate Composition and Particle Size, gives the substrate (rock, soil, cement, and/or lawn) and provides the visually estimated particle size class (boulder, cobble, gravel, sand, and/or silt) for specific reaches within the Ojai streams.

A summary of the substrate composition classes are listed below with the Ojai stream reaches that consist of that particular substrate or mix of substrates:

- **Cement, Culvert, or Pipe:** Arbolada Reach 1 and 2; Del Norte Reach 3; Grandview-Park Reach 2; Ayers Reach 2, 3, A-1, and B-1; Fox Canyon Reach 2 and 3; Ojai Reach 2, 4, 5, A-1, and B-1; and Stewart Canyon Reach 2, 3, and 4.
- **Mixed Rock, Soil, Lawn, Cement, and/or Compacted:** Arbolada Reach 3; Del Norte Reach 1, 4, and A-1; Ojai Reach 1 and 3; and Villanova Reach 3.
- **Rock:** Ayers Reach 1; Del Norte Reach 2; Fox Canyon Reach 1, 4, and B-1; San Antonio Reach 1, 2, and 3; Stewart Canyon Reach 1; Thacher Reach 1; and Villanova Reach 2.
- **Rock, Soil:** Arbolada Reach 1; Del Norte Reach B-1; East End Reach 1; Fox Canyon Reach A-1; Nordhoff Reach 1; Oak Reach 1; Post Office Reach 1; Soule Park Reach 1; West Soule Park Reach 1; Stewart Canyon Reach 5; and Villanova Reach B-1.
- **Soil/Fines:** Ayers Reach 4 and Ojai Reach B-2, B-3, and A of B-1.

The stream reaches, listed under Cement, Culvert, or Pipe, have severely limiting substrate (fish barriers and modifications) for Steelhead migration, spawning, and rearing.

For the creek reaches generally containing natural sediment deposits, particle size is summarized below by three primary classes:

1. **Mix of Boulder, Cobble, Gravel, Sand, and Silt:** Arbolada Reach 1 and 3; Del Norte Reach 1, 4, and A-1; Fox Canyon Reach 1, 4, and B-1; Ojai Reach 1; San Antonio Reach 1, 2, and 3; Thacher Reach 1; and Stewart Canyon Reach 1 and 5.
2. **Predominantly Cobble, Gravel, and Sand (no Boulder):** Del Norte Reach B-1; East End Reach 1; Nordhoff Reach 1; Oak Reach 1; and Villanova Reach 2.
3. **Predominantly Boulder, Cobble, and Sand (no Gravel):** Ayers Reach 1; Del Norte Reach 2; Fox Canyon Reach A-1; and Post Office Reach 1.

Based on the above natural particle size summary, the creek reaches listed under Number 1 contain sediment particles that have potential to support Steelhead spawning and/or rearing activities. The creek reaches listed under Number 2 also contain sediment particles that could potentially support Steelhead spawning; however, minimal amounts of boulders are present in these creeks, which limit the amount of instream cover for Steelhead rearing. The creek reaches listed under Number 3 contain sediment particles that would likely support Steelhead rearing activities. Since minimal amounts of gravel are present in the creeks of Number 3, the potential for Steelhead spawning is low.

Table 14. Stream Characterization Results for Substrate Composition and Particle Size

Creek Name	Reach No.	Substrate Composition	Particle Size
Arbolada	1	Rock, Soil	Boulder, Cobble, Gravel
	2	Concrete/Metal Pipe	N/A
	3	Rock, Soil, Lawn	Boulder, Cobble, Gravel, Sand
Ayers	1	Rock	Boulder, Cobble, Sand
	2	Underground pipe	N/A
	3	Paved ditch	N/A
	4	Soft bottom ditch	N/A
	A-1	Cement	N/A

Table 14. Stream Characterization Results Substrate Composition & Particle Size (continued)

Creek Name	Reach No.	Substrate Composition	Particle Size
Ayers (continued)	**B-1**	Cement	N/A
Del Norte	**1**	Rock, Soil, Cement	Boulder, Cobble, Gravel, Sand, Silt
	2	Rock	Boulder, Cobble, Silt
	3	High-density polyethylene pipe, underground	N/A
	4	Rock (some cement)	Boulder, Cobble, Gravel
	A-1	Rock, Soil, Cement	Boulder, Cobble, Gravel, Sand, Silt
	B-1	Rock, Soil	Cobble, Sand
East End	**1**	Rock, Soil	Cobble, Gravel, Sand
Fox Canyon	**1**	Rock	Boulder, Cobble, Gravel, Sand
	2	Cement	N/A
	3	Cement	N/A
	4	Rock	Boulder, Cobble, Gravel, Sand
	A-1	Rock, Soil	Boulder, Cobble
	B-1	Rock	Boulder, Cobble, Gravel, Sand, Silt
Grandview-Park	**1**	Cement	N/A
	2	Asphalt	N/A
Nordhoff	**1**	Rock, Soil	Cobble, Gravel, Sand, Silt
Oak	**1**	Rock, Soil	Cobble
Ojai	**1**	Rock, Cement, Soil	Boulder, Cobble, Gravel, Sand
	2	Cement	N/A
	3	Mixed Compacted	N/A
	4	Cement, underground	N/A
	5	Rock-lined ditch, grouted	N/A
	A-1	Mixed Compacted	N/A
	B-1	Metal pipe, underground	N/A
	B-2	Soil/Fines	Silt
	B-3	Soil/Fines	Silt
	A of B-1	Soil/Fines	Silt
Post Office	**1**	Rock, Soil	Boulder, Cobble, Sand
San Antonio	**1**	Rock	Boulder, Cobble, Gravel
	2	Rock	Boulder, Cobble, Gravel, Sand
	3	Rock	Boulder, Cobble, Gravel
Soule Park	**1**	Rock, Soil	.
West Soule Park	**1**	Rock, Soil	.
Stewart Canyon	**1**	Rock	Boulder, Cobble, Gravel, Silt
	2	Cement	Boulder, Silt
	3	Cement	N/A
	4	Cement	N/A
	5	Rock, Soil	Boulder, Cobble, Gravel, Sand
Thacher	**1**	Rock	Boulder, Cobble, Gravel, Sand
Villanova Note: Reach 1 is outside the City limits	**2**	Rock	Cobble, Gravel, Sand
	3	Compacted soil	N/A
	B-1	Rock, Soil	Sand, Silt

Potential for Spawning and Rearing

Each creek reach has been designated as either having the potential, or not having the potential, to provide suitable spawning and rearing habitat for Steelhead. These findings are based on all parameters measured and all data collected during the water quality sampling sessions and the streams characterization study.

In addition to having favorable results for the measured parameters, water flows must be present more or less year round for successful completion of significant life histories, including adult migration, redd development, spawning activities, egg incubation, fry emergence, and rearing activities. For example, spawning typically occurs only during the months of December through April, eggs take approximately 30 days to hatch (depending on temperature [Leitritz and Lewis 1980]), the emergence of Steelhead fry occurs approximately 45 to 75 days following egg fertilization (Raleigh et al. 1984), and rearing generally takes one to three years before moving to the ocean water (CDFG 1996).

As part of the Steelhead habitat characterization study, inundated areas along the Ojai stream course that had adequate riffles and pools, as well as instream cover, were assumed to provide suitable for Steelhead juveniles and fry. Therefore, if a stream reach contains suitable spawning and rearing substrate (in addition to favorable shade, instream cover, and riparian habitat), and if that stream reach would likely be inundated for a prolonged period (at the very least, throughout the winter and spring seasons of any given year), it is considered to have potentially suitable spawning and/or summer rearing habitat for Steelhead.

Table 15, Stream Characterization Results for Spawning and Rearing Potential, lists whether or not the potential for spawning and/or rearing is present for specific Ojai stream reaches. Eight (8) out of the 51 stream reaches, that were delineated within the City of Ojai, are determined to be potentially suitable Steelhead habitat, and they include:

- Fox Canyon Reach 1;
- Ojai Reach 1;
- Post Office Reach 1;
- San Antonio Reach 1, 2, and 3; and
- Stewart Canyon Reach 1 and 5,

Water Quality

Stormwater pollution occurs when rainwater washes over city streets, parking lots, rooftops, and lawns and transports toxic chemicals, disease-causing organisms, and trash into waterways and onto beaches. This soup of oil, grease, and various other pollutants can pour into rivers, streams and oceans either via storm drains or directly (such as from roads next to streams or water bodies). This is an increasing problem in California, leading to beach closures, human health impacts associated with drinking water quality and skin exposure, and the fouling of aquatic ecosystems.

Table 15. Stream Characterization Results for Spawning and Rearing Potential

(Refer to map on page 32 for stream reach locations.)

Creek Name	Reach No.	Spawning and Rearing Potential Present?	Creek Name	Reach No.	Spawning and Rearing Potential Present?
Arbolada	**1**	No	***Ojai***	**1**	**Yes**
	2	No		**2**	No
	3	No		**3**	No
Ayers	**1**	No		**4**	No
	2	No		**5**	No
	3	No		**A-1**	No
	4	No		**B-1**	No
	A-1	No		**B-2**	No
	B-1	No		**B-3**	No
Del Norte	**1**	No		**A of B-1**	No
	2	No	***Post Office***	**1**	**Yes**
	3	No	***San Antonio***	**1**	**Yes**
	4	No		**2**	**Yes**
	A-1	No		**3**	**Yes**
	B-1	No	***Soule Park***	**1**	No
East End	**1**	No	***West Soule Park***	**1**	No
Fox Canyon	**1**	**Yes**	***Stewart Canyon***	**1**	**Yes**
	2	No		**2**	No
	3	No		**3**	No
	4	No		**4**	No
	A-1	No		**5**	**Yes**
	B-1	No	***Thacher***	**1**	No
Grandview-Park	**1**	No	***Villanova*** Note: Reach 1 is outside the City limits	**2**	No
	2	No		**3**	No
Nordhoff	**1**	No		**B-1**	No
Oak	**1**	No			

Vegetation removal also has been correlated with increases in dissolved ion concentrations in stream water. For example, the conversion of chaparral to grassland, a typical response to extensive grazing and fuel (fire) hazard brush clearance, can increase nitrate concentrations in stream water (Davis 1984). Deforestation has been linked to increases in the concentrations of most major ions (Likens et al. 1970). Phosphorus typically enters aquatic ecosystems attached to suspended sediments so phosphorus concentrations can increase concomitant with increased sediment input. Finally, irrigation return flow typically contains high concentrations of organic and inorganic chemical constituents.

The key ecosystem responses to poor water quality are increased primary productivity where the concentrations of nutrients, such as nitrate and phosphorus are elevated, and reduced primary productivity where the concentrations of many other organic and inorganic chemical constituents are elevated (Welch 1980). Increased primary productivity in the water column, most notably through algal blooms, can rapidly deplete dissolved oxygen and cause shifts in aquatic species compositions and, in extreme cases, can result in the complete elimination of aquatic macroinvertebrates and vertebrates. Decreased primary productivity clearly represents a reduction in the energy harvested from solar radiation and input into local food webs (Welch 1980). Functioning riparian ecosystems can moderate the effects of poor water quality through direct uptake by vegetation and/or by chemical transformations that render chemical constituents insoluble (Peterjohn and Correl 1984).

Water quality sampling was conducted at nineteen (19) stations along several Ojai streams. Table 16, Ojai Stream Reaches with Corresponding Water Quality Sampling Stations, indicates the stream reaches in which the water quality sampling stations occur. Not all reaches were sampled for water quality; however, the water quality stations were determined and designated based on their location in relation to tributary confluences and downstream of significant inlets that may modify the quality of the stream water.

The water quality sampling data were collected at the 19 stations to determine water chemistry and the condition of the streams and drainages that may influence habitat function for Southern Steelhead and other aquatic wildlife. Tables 17A & 17B, Summary of the Ojai Basin Streams Water Quality Sampling Results (Stations 1-9 & Stations 10-18, respectively), provide the averages from the data collected at all 19 sampling stations for all days that data were collected on. The addition of Station 10A makes the total number of stations 19 instead of 18. Appendix B, Ojai Streams Water Quality Sampling Results, provides all specific data collected at each of the 19 sampling stations for each separate date on which water sampling was conducted.

Photograph 12. *Freshly painted "Don't Dump" sign on a Daly Road curb.*

The following subsections present (1) a discussion and definition of the water quality parameters sampled in the field; (2) significant Steelhead requirements and thresholds that are compared to our findings; (3) the results and conclusions of the water quality sampling conducted throughout the streams of Ojai, and (4) the limiting factors based upon the water quality sampling results. Each stream reach is evaluated for each habitat parameter, and those that fall outside acceptable conditions for Steelhead are identified as a limiting factor. Definitions and thresholds for the parameters presented below are summarized from the ChannelKeeper Ventura Stream-Team's Annual Report: *The State of the Ventura River* (Leydecker and Grabowsky 2004). (Note: All water sampling findings are presented in Appendix B, Ojai Streams Water Quality Sampling Results).

Table 16. Ojai Stream Reaches with Corresponding Water Quality Sampling Stations

Creek Name	Reach No.	Water Quality Station
Arbolada Creek	3	9
		16-not in the City
Ayers Creek	1	11
Del Norte Creek	1	18
	2	17
East End Creek	-	No station established
Fox Canyon Barranca	1	8
		14
Grandview-Park Drain	-	No station established
Happy Valley Drain	1	1-not in the City
Nordhoff Drainage	-	No station established
Oak Creek	-	No station established
Ojai Creek	1	7
Post Office Creek	-	No station established
San Antonio Creek	1	3
		4-not in the City
	2	5-not in the City
	3	12
Soule Park Creek	-	No station established
West Soule Park Creek	-	No station established
Stewart Canyon Creek	1	6-not in the City
		15
	5	10
		10A-not in the City
Thacher Creek	1	13
Villanova Creek	1	2-not in the City

Several parameters were studied during the water quality assessment. Tables 17A & 17B show specific parameters (including velocity, *p*H, dissolved oxygen as mg/L, temperature, conductivity, salinity, and turbidity) with measurement ranges and averages in red-, green-, and blue-colored fonts indicating low, favorable, and high measurements (respectively). These specific parameters are the more vital parameters for Steelhead survival, and they are the parameters discussed in the following subsections. Dissolved oxygen as percent saturation, dissolved oxygen as parts per million, specific conductance (conductivity measured at 25°C), carbon dioxide (directly adversely related to dissolved oxygen levels), and coliform bacteria are supplemental parameters studied to provide additional information regarding the condition of the creeks and aquatic environments of Ojai. However, reference is made to specific conductance and carbon dioxide in the following discussions. Although coliform bacteria was tested for the presence or absence of it within the Ojai streams, this parameter was not tested in a way that determines specific levels of the bacteria in each creek of Ojai. Therefore, no threshold for fish survival is discussed in terms of coliform, and it is not highlighted in the table(s) below; however, coliform bacteria is generally discussed in the results subsections below.

Table 17A. Summary of the Ojai Basin Streams Water Quality Sampling Results (Stations 1 through 9)[8]

Site ID Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Drainage/Creek Name	**Happy Valley**	**Villanova**	**San Antonio**	**San Antonio**	**San Antonio**	**Stewart**	**Ojai**	**Fox Canyon**	**Arbolada**
Average (and Range) for Each Parameter									
Average Depth (ft)	0.42 (0.31-0.63)	0.69 (o.5-1.75)	0.97 (0.31-2)	0.49 (0.31-0.67)	0.35 (0.22-0.5)	0.92 (0.36-2.67)	0.32 (0.14-0.5)	0.25 (0.14-0.33)	0.28 (0.19-0.42)
Water Width (ft)	2.45 (2-2.75)	10.64 (4-14.75)	10.67 (5-16)	15.3 (6.5-17.33)	11.68 (6-15)	10.08 (8-12)	4.03 (2-5.17)	4.85 (2.5-5.17)	2.45 (1.5-3.75)
Stream Velocity (ft/sec)	**0.77** **(0.38-1.67)**	**1.24** **(0.42-2)**	**1.83** **(0.5-3.33)**	**1.18** **(0.33-2)**	**1.3** **(0.83-1.67)**	**0.71** **(0.56-1.11)**	**0.66** **(0.5-1.25)**	**1.08** **(0.77-1.43)**	**0.43** **(0.1-1.11)**
Discharge (cfs)	0.68 (.29-1.29)	14.12 (0.89-59.5)	22.64 (1.44-68.8)	8.55 (1.78-15.5)	5.82 (1.98-12.5)	6.5 (1.91-16.1)	0.8 (0.04-3.13)	1.41 (0.32-2.36))	0.25 (0.11-0.63)
***p*H (0-14)**	**7.2** **(6.77-7.63)**	**7.85** **(7.65-8.24)**	**7.83** **(7.65-8.03)**	**7.82** **(7.71-7.97)**	**7.88** **(7.53-8.11)**	**7.84** **(7.55-8.02)**	**7.52** **(7.24-7.67)**	**7.6** **(7.35-7.83)**	**7.59** **(7.33-7.89)**
Dissolved Oxygen (mg/L)	**5.34** **(1.26-8.08)**	**8.34** **(3.81-12.78)**	**8.69** **(5.94-10.68)**	**7.9** **(5.44-10.57)**	**8.52** **(6.35-11.02)**	**8.83** **(6.3-11.08)**	**7.62** **(4.03-10.7)**	**6.79** **(3.7-11.65)**	**5.2** **(0.43-11.01)**
Dissolved Oxygen (%)	45.42 (10.2-74)	52.7 (1.8-123.6)	87.4 (79.4-95.6)	70.52 (53.4-95.3)	81.55 (60-101.4)	82.52 (57.5-108)	71.02 (38.9-101)	76.72 (34.3-110.6)	47.57 (3.8-99.3)
Dissolved Oxygen (ppm)	8.2 (8.2)	9.6 (9.6)	6 (6)	5.6 (5.6)	9.6 (9.6)	8.88 (8.88)	10 (10)	7.6 (7.6)	4.4 (4.4)
Temperature (°C)	**11.2** **(6.9-15.5)**	**12.68** **(10.6-15.7)**	**12.98** **(10.5-15.9)**	**13.2** **(10.6-15.9)**	**12.07** **(9.7-14.4)**	**12.35** **(9.8-15.3)**	**14.28** **(13-16.1)**	**13.38** **(11.6-15.8)**	**12.3** **(9.1-16.1)**
Conductivity (µS)	**295.3** **(82.9-495)**	**875.67** **(499-1492)**	**748.3** **(99.8-1505)**	**904.83** **(553-1487)**	**975** **(638-1426)**	**964.83** **(675-1447)**	**871** **(407-1525)**	**853.9** **(190.5-1319)**	**1370.75** **(915-1633)**
Specific Conductance (µS)	398 (250-543)	1099 (756-1360)	734.67 (762-1327)	1042.75 (767-1214)	1115.25 (632-1464)	1299.75 (910-1475)	1190.25 (585-1474)	1322 (1117-1529)	1906 (1261-2319)
Salinity (ppt)	**0.17** **(0.1-0.2)**	**0.4** **(0.2-0.7)**	**0.62** **(0.4-0.8)**	**0.38** **(0.1-0.6)**	**0.38** **(0.2-0.7)**	**0.52** **(0.1-0.7)**	**0.44** **(0.2-0.7)**	**0.26** **(0.1-0.5)**	**0.57** **(0.2-1.2)**
Carbon Dioxide (ppm)	14.6 (5-21)	10.17 (6-15)	10.58 (8-14)	9.08 (6-11)	9.33 (6-12)	10.17 (7-13)	15.08 (9-21)	13.83 (11-20)	14.2 (9-21)
Turbidity (NTU)	**30.74** **(11.1-59.8)**	**2.39** **(0.2-5)**	**2.77** **(0.1-4)**	**2.13** **(0.1-3.3)**	**8.08** **(1.2-28.8)**	**9** **(0.6-35.5)**	**4.29** **(2-10.3)**	**12.92** **(3-56.4)**	**3.92** **(2.4-5.4)**
Coliform Bacteria	Positive	Positive	Positive	Positive	Positive	Positive	Positive	Positive	Positive

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[8] **Red** = low measurements; **Green** = favorable measurements; **Blue** = high measurements (as compared to the thresholds discussed in the following results subsections). The red, green, and blue fonts indicate the specific parameters that are vital for Steelhead survival, and they are the parameters discussed in detail in the following subsections. The remaining parameters are supplemental studies conducted to provide additional information regarding the condition of the creeks and aquatic environments of Ojai.

Table 17B. Summary of the Ojai Basin Streams Water Quality Sampling Results (Stations 10 through 18)[9]

Site ID Number	**10**	**10A**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Drainage/Creek Name	**Stewart**	**Stewart**	**Ayers**	**San Antonio**	**Thacher**	**Fox Canyon**	**Stewart**	**Arbolada**	**Del Norte**	**Del Norte**
Average (and Range) for Each Parameter										
Average Depth (ft)	0	0.25 (0.11-0.39)	0.34 (0.19-0.42)	0.26 (0.19-0.33)	0.39 (0.39)	2.73 (0.94-4)	0.41 (0.19-0.67)	4 (4)	1.92 (0.33-5)	2 (0.33-3.67)
Water Width (ft)	0	5 (2-8)	4.25 (3-5)	18 (13-23)	6 (6)	14.25 (6-19)	4.67 (3-7)	7 (7)	3.25 (0.5-7)	2.75 (2.5-3)
Stream Velocity (ft/sec)	0	**1.66** **(1.33-2)**	**0.21** **(0.16-0.25)**	**1.34** **(1.25-1.43)**	**0.5** **(0.5)**	**0.1** **(0.1)**	**0.53** **(0.33-0.71)**	**3.33** **(3.33)**	**1.47** **(0.4-3.33)**	**0.89** **(0.67-1.11)**
Discharge (cfs)	0	3.26 (0.29-6.24)	0.35 (0.09-0.53)	6.96 (3.09-10.84)	1.17 (1.17)	2.63 (2.63)	1.39 (0.25-3.33)	93.33 (93.33)	39.08 (0.07-116.55)	6.39 (0.55-12.23)
p**H (0-14)**	0	**7.35** **(7.2-7.5)**	**7.91** **(7.82-8.03)**	**8.4** **(8.23-8.57)**	**8.34** **(8.34)**	**8.15** **(8.08-8.26)**	**8.1** **(8.05-8.15)**	**7.73** **(7.73)**	**7.8** **(7.7-7.9)**	**7.76** **(7.76)**
Dissolved Oxygen (mg/L)	0	**4.99** **(4.99)**	**8.34** **(6.16-9.61)**	**11.48** **(11.48)**	**11.62** **(11.62)**	**8.04** **(5.66-9.68)**	**10.65** **(10.01-11.3)**	0	**6.33** **(6.33)**	**8.46** **(6.49-10.44)**
Dissolved Oxygen (%)	0	50.4 (50.4)	77.05 (62.5-91.6)	101.8 (101.8)	93.9 (93.9)	75.27 (55.4-89.4)	98.5 (98.5)	0	0	93.7 (93.7)
Dissolved Oxygen (ppm)	0	12.1 (12.1)	10 (10)	9.1 (9.1)	0	5.5 (5.5)	11.9 (11.9)	0	6.9 (6.9)	0
Temperature (°C)	0	**16.45** **(14.4-18.5)**	**14.57** **(13.5-16.8)**	**14.4** **(10.3-18.5)**	**7.7** **(7.7)**	**14.57** **(11.3-18.5)**	**14.57** **(12-17.3)**	**14.5** **(14.5)**	**13.77** **(10.7-16.1)**	**9.95** **(9.8-10.1)**
Conductivity (µS)	0	**776.5** **(578-975)**	**921.5** **(560-1335)**	**766** **(478-1054)**	**475** **(475)**	**1151.5** **(931-1433)**	**1232** **(613-1738)**	0	**953.5** **(622-1285)**	**735.5** **(314-1157)**
Specific Conductance (µS)	0	705 (705)	1812.5 (1693-1932)	664 (664)	710 (710)	1482.5 (1202-1763)	768 (768)	0	0	1630 (1630)
Salinity (ppt)	0	**0.3** **(0.3)**	**0.63** **(0.1-0.9)**	**0.3** **(0.3)**	**0.3** **(0.3)**	**0.53** **(0.2-0.9)**	**0.35** **(0.3-0.4)**	0	**0.3** **(0.3)**	**0.55** **(0.3-0.8)**
Carbon Dioxide (ppm)	0	75 (14-136)	10.12 (6-17)	6.5 (6-7)	8 (8)	7.87 (5-10)	6.33 (6-13)	6 (6)	13.83 (5-18.5)	15 (14-16)
Turbidity (NTU)	0	**2.67** **(2-3.35)**	**28.47** **(3-83.6)**	**6.32** **(5-7.64)**	**9** **(9)**	**7.22** **(2-15.2)**	**6.97** **(2-16.7)**	**246** **(246)**	**67.18** **(1.9-194)**	**2.55** **(2.1-3)**
Coliform Bacteria	0	Positive	Positive	Positive	Positive	Positive	Positive	Positive	Positive	Positive

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[9] **Red** = low measurements; **Green** = favorable measurements; **Blue** = high measurements (as compared to thresholds discussed below). See the footnote above for Table 17A.

Conductivity and Specific Conductance

Water is one of the most efficient solvents in the natural world and has the ability to dissolve many solids. Many of these solids carry an electrical charge when put into solution. For example, chloride, nitrate, and sulfate carry negative charges, while sodium, magnesium, and calcium have a positive charge. These dissolved substances increase water's *conductivity* – its ability to conduct electricity. Therefore, measuring conductivity of water indirectly indicates the amount total dissolved solids (TDS). It is not a perfect measure as some substances - particularly organic compounds like oil, alcohol, or sugar - are poor conductors. Each stream tends to have a relatively consistent range of conductivity that, once established, can be used as a baseline for future comparisons. Conductivity tends to decrease in the winter when heavy rainfall and runoff increase the amount of fresh, lower conductivity, water flow. With more water, mineral concentrations are more dilute. On the other hand, in late summer and fall, especially during periods of drought, dissolved solids become more concentrated, raising conductivity.

Conductivity is affected by temperature: the warmer the water, the higher the conductivity. Conductivity readings are based on the current temperature at which the reading is taken. A Specific Conductance reading is reported as conductivity at 25 degrees Celsius (25°C). The basic unit of measurement is the siemen. Conductivity is measured in micro-siemens per centimeter (µS/cm) or milli-siemens per centimeter (mS/cm).

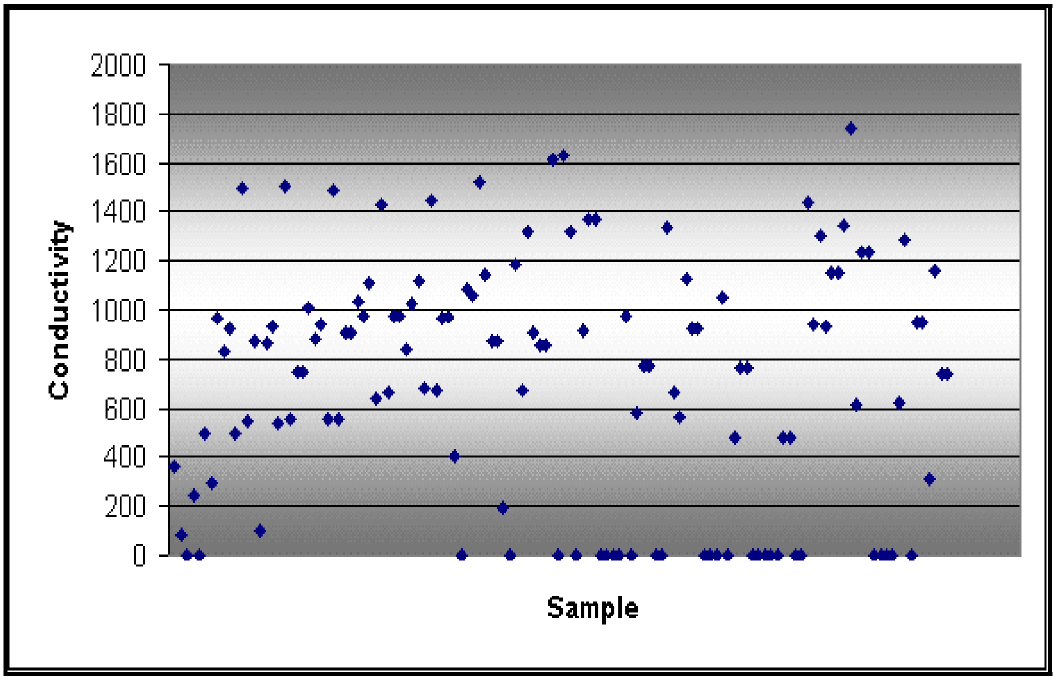
THRESHOLDS

Distilled water has conductivity in the range of 0.5 to 3 µS/cm. The conductivity of rivers in the United States generally ranges from 50 to 1,500 µS/cm. Drinking water usually has to meet a standard of 1,000 mg/L TDS and a maximum conductivity of 1,600 µS/cm. Conductivity in the Ventura River is usually above 1,000 µS/cm because of high mineral content in the easily eroded marine sediments that form coastal mountains. In spite of the 1,600-µS/cm limit, high conductivity waters are not necessarily bad for wildlife and human health. As long as acceptable reasons exist for higher values, as they are in this case, higher mineral content may even be beneficial. Increased values of conductivity in the Ventura River are generally caused by (1) increasingly depleted groundwater inflows, (2) enhanced uptake by growing riparian vegetation, and (3) a relative increase in evaporation as dry-season river flows diminish. Measurements **above 1,000 µS/cm as a lower limit and 1,600 µS/cm will be used as an upper limit for conductivity thresholds** since these are the normal conductivity standards for the Ventura River and drinking water.

RESULTS

The range of conductivity throughout the 19 stations sampled (excluding zero values from dry creeks) over several days is between 82.9 µS/cm at Station 1 (Happy Valley Reach 1) and 1,738 µS/cm at Station 15 (Stewart Canyon Reach 1). The stations with average conductivity values that fall into the favorable conductivity range include only Station 9 (Arbolada Reach 3), Station 14 (Fox Canyon Reach 1), and Staion 15 (Stewart Canyon Reach 1). All other stations have average conductivity values that fall below or rise above the favorable threshold range for conductivity. Refer to Tables 17A & 17B (above), and Appendix B, Ojai Streams Water Quality Sampling Results, for all survey data results. Figure 8, Scatter Plot of Conductivity Results for the Ojai Streams, shows the conductivity pattern of all samples taken at all stations over several dates from the creeks of Ojai. (Note: samples with a measurement of "0 µS/cm" are readings from dry creeks.)

Figure 8. Scatter Plot of Conductivity Results for the Ojai Streams



Temperature

Temperature is the simplest parameter to measure, yet one of the most important. The expected annual pattern is that the temperature rises from winter lows to summer highs, and then decreases in early fall. Temperatures often increase above 24°C in summer and rarely drop below 11°C in winter.

THRESHOLDS

Important threshold temperatures for Steelhead include the following:

- Above 24°C leads to death;
- 20-24°C is the upper limit of tolerance (juveniles show stress, adults inactive and will not spawn, problems extracting oxygen from water [above 21°C] (Hooper 1973);
- Below 16°C (10-15°C is optimum) indicates good dry season (summer) conditions; and
- Below 11°C in winter is excellent for spawning and incubation.

The temperature milestones used here are for Trout and Steelhead, as warm-water fish have greater tolerance for higher temperatures. As temperatures rise, fish have increasing trouble extracting oxygen from water, while at the same time the amount of oxygen in the water decreases. However, Southern Steelhead have evolved in what are essentially warm-water rivers and streams, and probably have greater tolerance for higher temperatures than their more northern cousins. Fish are not passive participants, but free to seek out conditions that are more favorable. Deeper water is usually cooler water; however, higher flows of the lower streams also keep temperatures low even though the water is at a lower elevation and more exposed to sunlight.

Other optimal water temperatures for various life stages of Steelhead are (Bovee 1978, Reiser and Bjorn 1979, Bell 1986):

- Adult migration = 8ºC to 11ºC
- Spawning = 4ºC to 11ºC
- Incubation and emergence = 9ºC to 11ºC
- Fry and juvenile rearing = 13ºC to 16ºC
- Smoltification = <14ºC

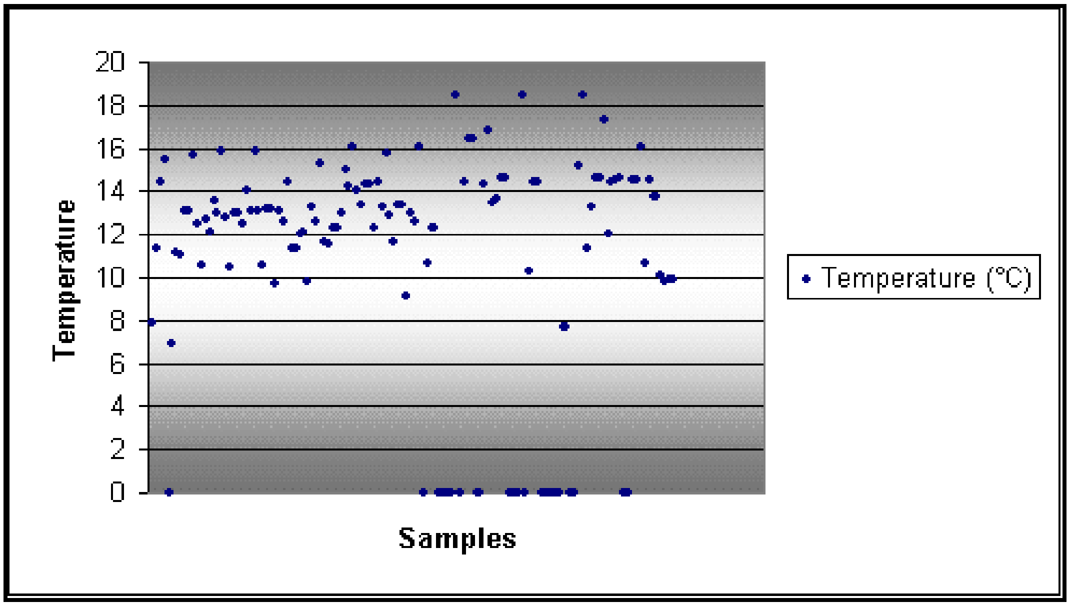
Optimal temperature requirements of Steelhead may vary depending on season, life stage, and stock characteristics. In California, low temperatures are not as much of a concern as high temperatures, especially the high temperatures that occur during adult migration, egg incubation, and juvenile rearing. However, Steelhead of southern coastal streams are known to exist in relatively high temperature regimes, some of which exceed preferred temperatures for considerable lengths of time.

Based on the important and optimal thresholds listed above, a **range between 4ºC and 16ºC will be used as the threshold for favorable temperatures** throughout the creeks of Ojai.

RESULTS

The range in temperature throughout the 19 stations sampled (excluding zero values from dry creeks) is between 6.9ºC at Station 1 (Happy Valley Reach 1) and 18.5ºC (Fox Canyon Reach 1 and San Antonio Reach 3). The stations with average temperatures between 6ºC and 16ºC include all stations except Station 10A (Stewart Canyon Reach 5) (Tables 17A & 17B; Appendix B). The individual temperature measurements collected throughout the creeks of Ojai over several dates are generally favorable for Steelhead, except for some high (over 16ºC) temperatures collected at Station 10A (Stewart Canyon Reach 5), 11 (Ayers Reach 1), 12 (San Antonio Reach 3), 14 (Fox Canyon Reach 1), and 15 (Stewart Canyon Reach 1). Figure 9, Scatter Plot of Temperature Results for the Ojai Streams, shows the temperature pattern of all samples taken at all stations over several dates in the creeks of Ojai. Note: samples that fall at "0ºC" are readings from creeks that were dry.

Figure 9. Scatter Plot of Temperature Results for the Ojai Streams



Dissolved Oxygen and Carbon Dioxide

Aquatic organisms rely on the presence of oxygen in streams. If oxygen is insufficient for those organisms, they will move, weaken, or die. In air, oxygen is 20% of the atmosphere; in water, oxygen is a dissolved gas with a maximum concentration of only approximately 16 parts per million (0.0016%). Water temperature, altitude, time of day, and season can all affect the amount of oxygen in water. Water holds less oxygen at warmer temperatures and high altitudes. Dissolved oxygen was primarily measured either in milligrams per liter (mg/L) or "percent saturation". Percent saturation is the amount of oxygen in a liter of water relative to the total amount of oxygen that water can naturally hold at that temperature.

Oxygen is both produced and consumed in a stream. Due to constant churning, running water dissolves more oxygen than still water found in pools. As flows drop, streams become more sluggish, and there is both less opportunity for water to pick up more oxygen through re-aeration and more time for wildlife and other biochemical processes to extract oxygen. Oxygen also has a greater solubility in cold water. As temperature increases, dissolved oxygen should decrease, and visa versa.

Ironically, very high dissolved oxygen concentrations can indicate trouble as well. In daylight, algae and aquatic vegetation photosynthesize, removing carbon dioxide from air and water and replacing it with oxygen. Unfortunately, this process is reversed at night: oxygen is removed and carbon dioxide added. Thus, very high daytime oxygen concentrations can indicate an overabundance of algae. Under these conditions, oxygen reaches a minimum just before sunrise. Therefore, it is the concentrations found during this critical period that determine the actual threat to fish, a threat usually not evaluated, but that probably should be.

THRESHOLDS

As dissolved oxygen levels in water drop below 5 mg/L, aquatic life is put under stress. Steelhead require oxygen levels above 6 mg/L. **Important dissolved oxygen thresholds for Steelhead** include the following:

- Below 4 mg/L results in severe damage and death;
- At 6 mg/L hypoxia begins and fish start to feel stress (significant decrease in swimming performance and activity between 6.5 to 7.0 mg/L [Reiser and Bjorn 1979]); and
- **Above 8 mg/L represents near ideal conditions** and may be required for spawning (and 80% saturation is essential to meet the needs of spawning fish [Reiser and Bjorn 1979]).

Warm-water fish can probably tolerate levels as low as 4 mg/L. The lower the concentration of oxygen, the greater the stress on Steelhead. Oxygen levels that remain below 1-2 mg/L for a few hours can result in large fish kills.

RESULTS

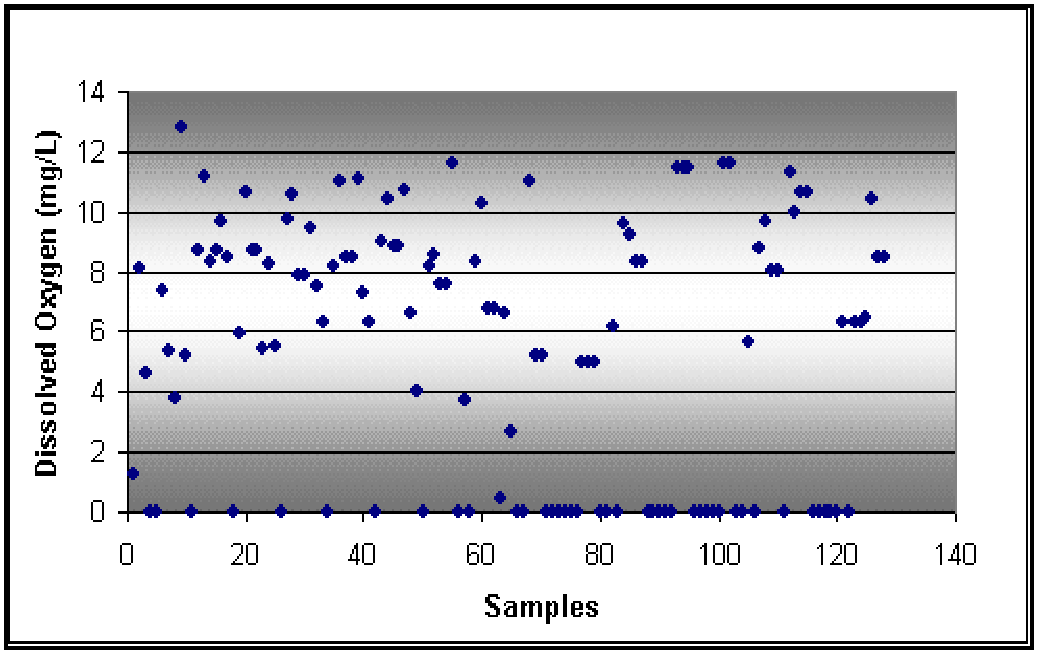
The range in dissolved oxygen for the 19 stations sampled (excluding zero values from dry creeks) is between 0.43 mg/L at Station 9 (Arbolada Reach 3) and 12.78 mg/L at Station 2 (Villanova Reach 1) (Tables 17A & 17B, Appendix B).

The following Stations represent the creek reaches that have favorable average dissolved oxygen measurements (above 8 mg/L):

- Station 2 (Villanova Reach 1)
- Stations 3, 4 (~7.9 mg/L), 5, 12 (San Antonio Reach 1, 2, and 3)
- Station 14 (Fox Canyon Reach 1)
- Station 11 (Ayers Reach 1)
- Station 13 (Thacher Reach 1)
- Stations 6 and 15 (Stewart Canyon Reach 1)
- Station 18 (Del Norte Reach 2)

Figure 10, Scatter Plot of Dissolved Oxygen Results for the Ojai Streams, illustrates the dissolved oxygen pattern of all samples taken at all stations over several dates in the creeks of Ojai. Note: samples with a "0 mg/L" value are readings from dry creeks.

Figure 10. Scatter Plot of Dissolved Oxygen Results for the Ojai Streams



Turbidity

Turbidity is a measure of the amount of sediment in the water column, and sediment has both long- and short-term effects on steelhead and other fish. Over the long term, sediment settles on the bottom and fills the interstices (spaces and cracks) between streambed gravels and rocks decreasing the amount of desirable habitat required for spawning as well as habitat required by smaller organisms (insects) which are a vital source of food for fish. Over the short term, turbidity reduces the ability of fish to see and feed.

Photograph 13. *Thacher Creek at Boardman Road during winter storm creating elevated levels of turbidity (9 January 2005).*

THRESHOLDS

Water quality begins to degrade by suspended sediment between turbidities of 3 and 5 NTU, and impacts on Steelhead begin to be noticeable above 25 NTU. These limits apply to the dry-season and periods between storms. During storms, these limits become meaningless as suspended sediment concentrations rise to tens of thousands of milligrams per liter, which would equal turbidity readings in the hundreds of thousands. During storms, fish hide until turbidities return to background levels within three days of a rainfall event. Normally, readings are below 5 NTU; however, if sampling is conducted during or soon after a storm, they reach levels above the ability of turbidity meters to record a value. **The EPA has suggested a turbidity limit of 1.9 NTU for streams in this region.**

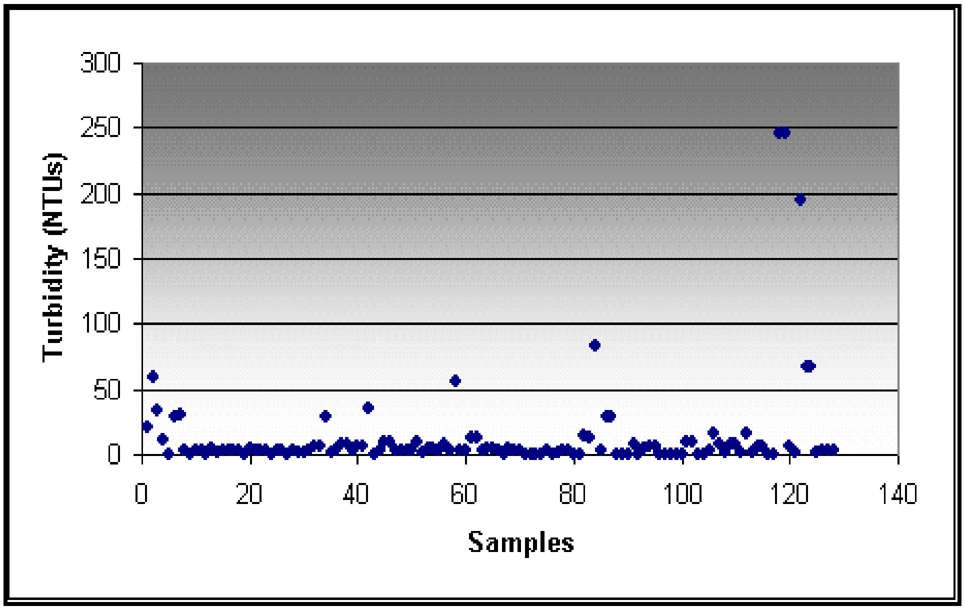
RESULTS

The range in turbidity for all measurements from all 19 stations (excluding zero values from dry creeks) over several dates is recorded between 0.1 NTU at Station 3 and 4 (San Antonio Reach 1) and 246 NTU at Station 16 (Arbolada Creek Reach 3). None of the 19 stations have an average turbidity level that is 1.9 NTU or below. The lowest average turbidity measurement is 2.13 NTU at Station 4 (San Antonio Reach 1) (Tables 17A & 17B). However, the results from individual dates for each station (according to the results table in Appendix B) show that of the dates sampled, December 8th and 9th 2004 yield the lowest turbidity levels. Favorable turbidity levels (below 1.9 NTU) were observed only at the following stations on the following dates:

- Station 2 (Villanova Reach 1) = 0.2 NTU (on 8 Dec 04)
- Station 3 (San Antonio Reach 1) = 0.1 NTU (on 8 Dec 04)
- Station 4 (San Antonio Reach 1) = 0.3 NTU (on 23 Feb 05) and 0.1 NTU (on 9 Dec 04)
- Station 5 (San Antonio Reach 2) = 1.2 NTU (on 9 Dec 04)
- Station 6 (Stewart Canyon Reach 1) = 0.6 (on 20 Oct 04 and 9 Dec 04)
- Station 17 (Del Norte Reach 2) = 1.9 NTU (on 8 Dec 04)

Figure 11, Scatter Plot of Turbidity Results for the Ojai Streams, shows the turbidity level pattern of all samples taken at all stations over several dates in the creeks of Ojai. Note: samples that fall to "0 NTU" are readings from dry creeks. The significantly high readings are a result of sampling conducted during the storms of the 2004/2005 winter season.

Figure 11. Scatter Plot of Turbidity Results for the Ojai Streams



*p*H

*p*H is a relative measure of alkalinity and acidity, or an expression of the number of free hydrogen atoms present. It is measured on a scale of 1 to 14, with 7 indicating neutral (neither acid nor base). The lower numbers (<7) indicate increasing acidity, whereas the higher numbers (>7) indicate increasing alkalinity. Blood (*p*H of 7.5), seawater (*p*H of 9.3), and household ammonia (*p*H of 11.4) are all alkaline or basic. Urine (*p*H of 6.0), oranges (*p*H of 4.5), Coca Cola Classic (*p*H of 2.5), and the contents of your stomach (*p*H of 2.0) are acidic. *p*H numbers represent a logarithmic scale, therefore, small differences in numbers can be significant: a *p*H of 4 is one thousand times more acidic than a *p*H of 6. All plants and animals live within a specific *p*H range, where altering *p*H beyond this range causes injury or death. Pollutants can push *p*H toward extremes, and low *p*H allows toxic elements and compounds to "mobilize" (go into solution) and be taken in by aquatic plants and animals. A change of more than two points on the scale can kill many species of fish. The EPA and Los Angeles Regional Water Quality Control Board (LARWQCB) regard a change of more than 0.5 as harmful.

THRESHOLDS

Several different standards exist for determining thresholds of *p*H. Fish can tolerate a range of 5 to 9; however, the best fishing waters are between 6.5 to 8.2. The Central Coast Regional Board uses a standard of 7.0 to 8.5 for surface water and 6.5 to 8.3 for potable water and swimming; the Los Angeles Board uses 6.5 to 8.5; and the EPA recommends 6.5 to 8.0 as being the best for aquatic animals. **We will use a *p*H of 6.5 as a lower limit** since this seems to be the consensus, and **8.5 will be used as an upper limit** since the LARWQCB establishes the legal standard for the Ventura.

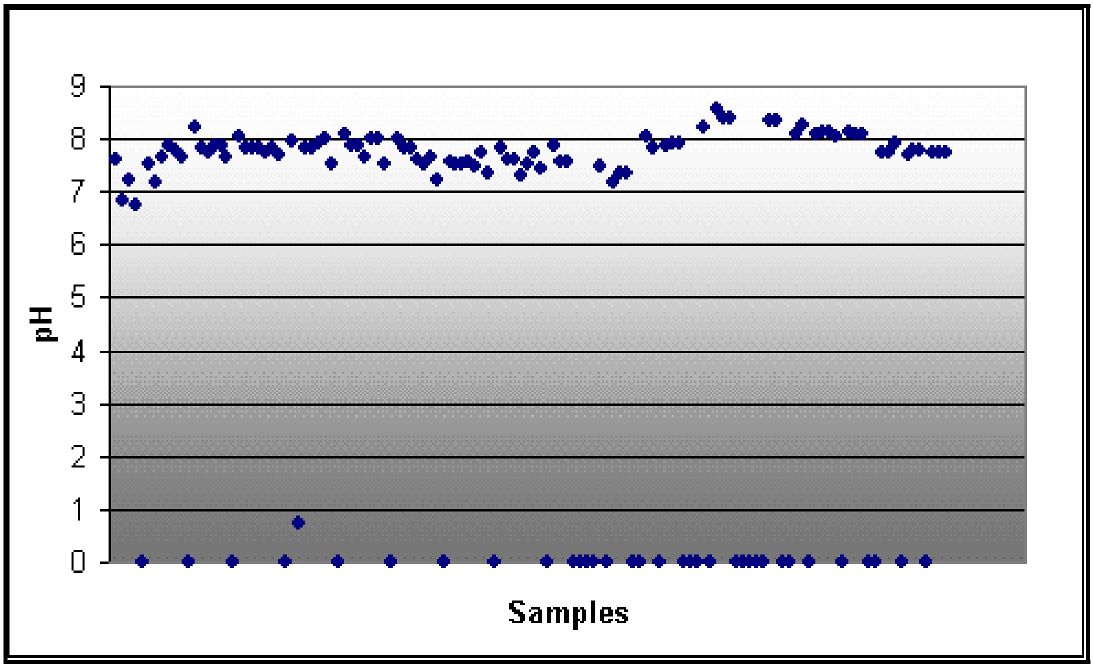
RESULTS

Lower reaches of the Ventura River are reported to have lower *p*H values occurring with the start of winter rains, while the highest occur in spring or early summer. Rain has a lower *p*H (usually slightly acidic) than baseflow in the Ventura River and its tributaries, and the first few storms usually lower river values. The spring/summer increase is caused by the same algal and plant growth responsible for increasing daylight dissolved oxygen. Photosynthesis withdraws carbon dioxide from the water at the same time as it releases oxygen. Removing carbon dioxide is the same as removing acidity, thus it increases in *p*H. Normally, little change in *p*H occurs, as the dissolved minerals that give us high conductivity usually are the same dissolved minerals that "buffer" the river against large variations; however, changes in dissolved carbon dioxide is a major exception.

The photosynthetic effect is responsible for almost all high *p*H values of the Ventura River. If sampling were conducted around the clock, similar variations in both *p*H and dissolved oxygen would occur over a 24-hour period. The variation would be appreciable at stations with algal problems, relatively muted in locations with normal conditions. This kind of testing would be one of the better ways of estimating the extent of over-fertilization and algal growth on the river.

The range of *p*H for all measurements from all 19 stations (excluding zero values from dry creeks) over several dates is recorded between 6.77 at Station 1 (Happy Valley Reach 1) and 8.57 at Station 12 (San Antonio Reach 3). This Station 12 is the only station (and has only one date) that has a *p*H over the recommended 8.5. However, all stations have an average *p*H that is within the 6.5 to 8.5 threshold (Tables 17A & 17B; Appendix B). Figure 12, Scatter Plot of *p*H Results for the Ojai Streams, shows the *p*H level pattern of all samples taken at all stations over several dates in the creeks of Ojai. Note: samples that fall to "0" are readings from dry creeks.

Figure 12. Scatter Plot of *p*H Results for the Ojai Streams



Salinity

Salinity is a measure of the amount of ocean-derived salts dissolved in water. Since this study focuses on freshwater river and stream systems, the level of salinity is expected to be very low. Although Steelhead are Southern Steelhead, and are adapted to both fresh and saline waters, salinity was measured as an additional environmental parameter to be discussed along with the more vital Steelhead parameters in this section. This parameter is measured primarily to determine the freshwater organism environment in terms of salinity rather than the requirements or limitations of salinity for Steelhead. Freshwater organisms can tolerate only small amounts of salinity, and measurements are expected to be low for freshwater environments.

THRESHOLDS

The freshwater streams sampled for this study are classified within the Riverine system according to the *Classification of Wetlands and Deepwater habitats of the United States* (Cowardin et al. 1979), which has been adopted by the U.S. Fish and Wildlife Service. The Riverine system includes all wetlands and deepwater habitats contained within a channel (or a conduit periodically or continuously containing moving water, or forming a connecting link between two bodies of water), with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens; and (2) habitats with water containing ocean-derived salts in excess of 0.5‰. Water is usually, but not always, flowing in this system.

Therefore, the Riverine system includes all water habitats with ocean-derived salt concentrations of less than 0.5‰ (‰ = parts per thousand = ppt). Since the U.S. Fish and Wildlife Service has adopted the Cowardin (1979) classification of wetlands, salinity values of **less than 0.5 ppt will be used as the threshold for salinity** for measurements taken in the streams of Ojai.

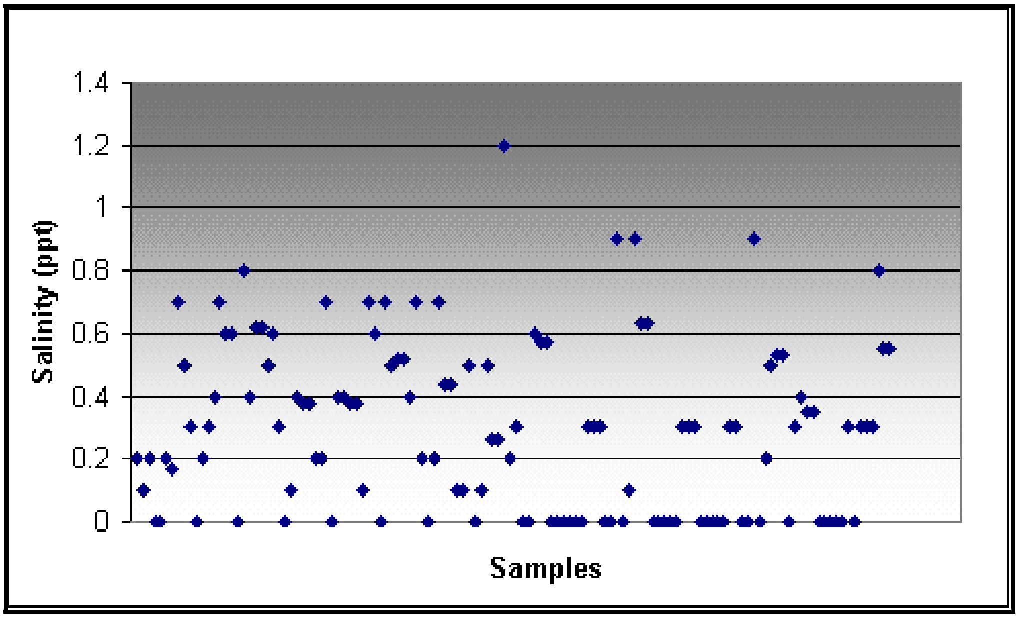
RESULTS

The range in salinity for all 19 stations sampled (excluding zero values from dry creeks) over several dates was between *0.1 ppt* - at Stations 4 (San Antonio Reach 1), 6 (Stewart Canyon Reach 1), 8 (Fox Canyon Reach 1), and 11 (Ayers Reach 1) - and *1.2 ppt* at Station 9 (Arbolada Reach 3). The stations with average salinity measurements (Tables 17A & 17B, Appendix B) that are less than 0.5 ppt (favorable for freshwater aquatic wildlife) include the following:

- Station 1 (Happy Valley Reach 1)
- Station 2 (Villanova Reach 1)
- Stations 4, 5, and 12 (San Antonio Reach 1, 2, 3)
- Station 7 (Ojai Reach 1)
- Station 8 (Fox Canyon Reach 1 [~0.5ppt])
- Station 9 (Arbolada Reach 3)
- Stations 10A and 15 (Stewart Canyon Reach 1 and 5)
- Station 13 (Thacher Reach 1)
- Station 18 (Del Norte Reach 1)

Figure 13, Scatter Plot of Salinity Results for the Ojai Streams, shows the salinity level pattern of all samples taken at all stations over several dates in the creeks of Ojai. Note: samples that fall to "0 ppt" are readings from creeks that were dry.

Figure 13. Scatter Plot of Salinity Results for the Ojai Streams



Total Coliform Bacteria

Members of three bacteria groups: coliforms, enterococci, and fecal streptococci, are used as indicators of possible sewage contamination because they are commonly found in human and animal feces. Although they are not necessarily harmful themselves, they indicate the presence of pathogenic (disease causing) bacteria, viruses, and protozoans that also live in human and animal digestive systems. Therefore, their presence in streams, lakes, and rivers suggests that pathogenic microorganisms might also be present and that swimming, drinking, or eating shellfish from those waters might be a health risk[10].

Due to the great expense and time required for testing every pathogen, scientists instead measure one of the indicator groups of bacteria to assess the sanitary quality of a water body. The most commonly tested fecal bacteria indicators are total coliforms, fecal coliforms, *Escherichia* coliforms (*E. coli*), fecal streptococci, and enterococci. All but *E. coli* are composed of a number of species of bacteria that share common traits such as shape, habitat, or behavior. *E. coli* is a single species in the fecal coliform group[11]. Total coliforms are a large and widespread group of bacteria. Coliforms can occur in human feces, but are also found in animal manure, soil, vegetation, submerged wood, and in other places outside the human body. Thus, the usefulness of total coliforms, as an indicator of fecal contamination, depends on the extent the bacteria found are fecal and human in origin.

For recreational waters, total coliforms are no longer recommended by the EPA as an indicator, but they are still the standard test for drinking water because their presence indicates contamination of a water supply by some outside source. California still requires a total coliform test for recreational waters because the *ratio* of fecal to total coliforms (number of fecal coliforms divided by the total number of coliforms) remains a good indicator of swimming related illness. (Leydecker and Grabowsky 2004.)

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[10] Obtained from: http://kingfish.coastal.edu/marine/risingtide/waterquality/background.html
[11] Ibid.

Photograph 14. *"Don't Litter" sign on fence of Fox Canyon Barranca at Ojai Avenue.*

Members of two bacteria groups, the coliforms and fecal streptococci, are typically used as indicators of possible sewage contamination because they are commonly found in human and animal feces. Although they are generally not harmful themselves, they indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoa that live in human and animal digestive systems. Their presence in streams suggests that pathogenic microorganisms might also be present and that swimming and eating shellfish might be a health risk. Since it is difficult, time-consuming, and expensive to test directly for the presence of a large variety of pathogens, water is usually tested for coliforms and fecal streptococci instead.

Photograph 15. *Showing close proximity of horse corral to the active creek channel creating a significant input of horse manure and urine (8 January 2005).*

WATER QUALITY STANDARDS AND THRESHOLDS

The South Carolina Department of Health and Environmental Control (SC DHEC) has issued water classification and standards for all bodies of water in South Carolina. In South Carolina's coastal region, the majority of drinking water comes from surface waters including regional rivers and lakes. Each water body has been given a classification, which establishes which activities - such as boating, swimming, or drinking - must be protected. A set of water quality criteria were established for each classification. The classifications and water quality criteria are described in "Water Classifications and Standards" (R.61-68). For example, the Waccamaw River has been assigned to the classification Freshwaters (FW), which is defined as "freshwaters suitable for primary and secondary contact recreation and as a source for drinking water supply after conventional treatment in accordance with the requirements of the Department (DHEC)." These waters are suitable for fishing, swimming, and the survival and propagation of a balanced indigenous flora and fauna. The water quality criteria, which assure that these uses are protected, are listed below in Table 18, Classes of Fresh Water Quality Standards (http://kingfish.coastal.edu/marine/risingtide/waterquality/ background.html). Table 18 provides a useful list of pollutants and water quality criteria for this study.

Table 18. Classes of Fresh Water Quality Standards

Pollutant	Water Quality Criteria
a. Garbage, cinders, ashes, oils, sludge, or other refuse	None allowed
b. Treated wastes, toxic wastes, deleterious substances, colored or other wastes except those given in "a" above.	None alone or in combination with other substances or wastes in sufficient to make the waters unsafe or unsuitable for primary contact recreation or to impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
c. Toxic Pollutants	As prescribed in a separate regulation. (Section E of this regulation which uses US EPA's criteria for human and aquatic health)
d. Color	Not to exceed a rise above background of 30 color units measured as true color.
e. Dissolved Oxygen	Daily average not less that 5.0 mg/L with a low of 4.0 mg/L.
f. Fecal Coliform	Not to exceed a geometric mean of 200 CFU per 100 mL, based on five consecutive samples during any 30-day period; nor shall more than 10% of the total samples during any 30-day period exceed 400 CFU per 100 mL.
g. *p*H	Between 6.0 and 8.5
h. Temperature	For free-flowing water, the temperature may not be increased more than 5°F above natural temperature conditions and shall not exceed a maximum of 90°F as a result of discharge.
i. Turbidity (Lakes only: Not to exceed 25 NTUs provided existing uses are maintained.)	Not to exceed 50 NTUs providing existing uses are maintained.

Table 19, Federal Standards for Indicator Bacteria, provides federal water quality standards promulgated by the U.S. Environmental Protection Agency (US EPA) for indicator bacteria. These standards can be found in the US EPA's publication "Ambient Water Quality Criteria for Bacteria" (1986). (http://kingfish.coastal.edu/marine/risingtide/waterquality/background.html.)

Table 19. Federal Standards for Indicator Bacteria

Indicator Bacteria	Acceptable Swimming Associated Gastroenteritis Rate Per 1000 Swimmers	Steady State Geometric Mean Indicator Density	Single Sample Maximum Allowable Density			
			Designated Beach Area	Moderate Full Body Contact Recreation	Lightly Used Full Body Contact Recreation	Infrequently Used Full Body Contact Recreation
Freshwater						
Enterococci	8	33	61	89	108	151
E. coli	8	126	235	298	406	576
Marine Water						
Enterococci	19	35	104	124	276	500

At this time, *E. coli* is recommended by the US EPA for freshwater testing and *Enteroccocus* for marine waters because these bacteria provide a better correlation with body-contact related illnesses than fecal or total coliforms. For historical reasons, many state standards (see above for South Carolina) still employ fecal coliform levels. Although the US EPA has not set standards for total coliforms, some states have promulgated their own. For example, the state of California has a set for its marine waters as shown below. South Carolina does not have standards for total coliforms. (http://kingfish.coastal.edu/marine/risingtide/waterquality/background.html.)

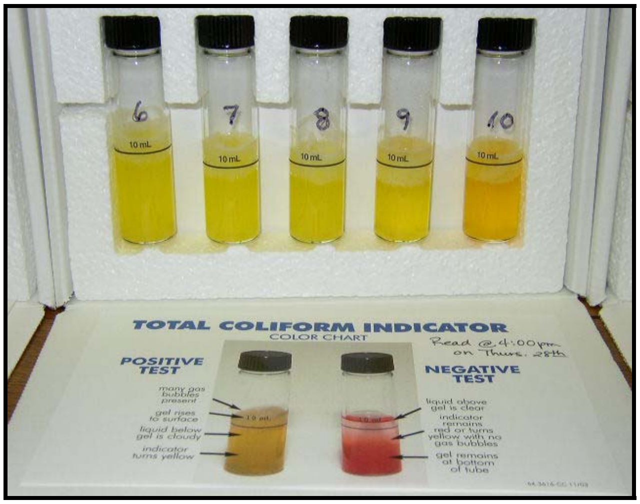
The total coliforms as per California Code for Ocean Water Quality include the following:

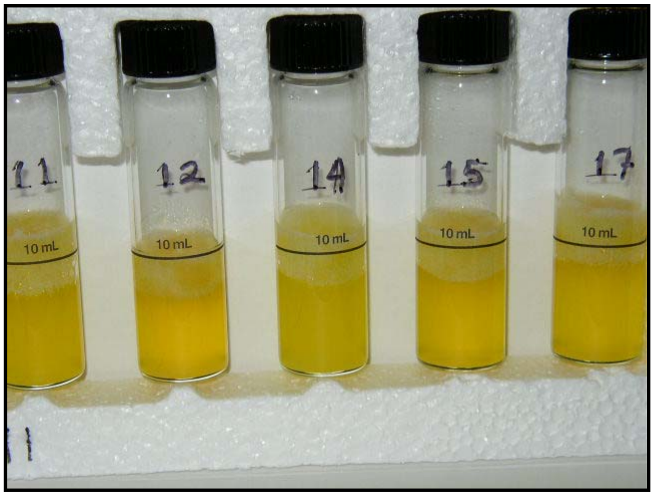
- Single Sample Maximum Allowable Density:
  - 1,000 total coliforms bacteria per 100 mL, if ratio of fecal/total coliforms exceeds 0.1; or
  - 10,0000 total coliform bacteria per 100 mL; or
  - 400 fecal coliform bacteria per 100 mL; or
  - 104 enteroccocus coliform bacteria per 100 mL.
- Geometric mean of at least five weekly samples during any 30-day period:
  - 1,000 total coliform bacteria per 100 mL;
  - 200 fecal coliform bacteria per 100 mL;
  - 35 enteroccocus coliform bacteria per 100 mL.

RESULTS

The LaMotte Model TC-5 Coliform Indicator Test Kit was used for determining the presence of coliform bacteria. This coliform test kit provides a test tube method to indicate the presence of Total Coliform Bacteria in a drinking water supply via a coliform-indicating test tablet, a gelling substance, and a *p*H indicator. The tablet neutralizes water samples containing chlorine that tends to suppress coliform bacteria growth, and provides growth-supporting nutrients for coliform bacteria. If coliform organisms are present in the sample, the bacteria metabolizing the nutrients in the tablet will generate gases. The gases will be trapped in the gelling substance causing the gel to rise in the tube. The *p*H indicator may change color from red to yellow, also indicating coliform bacteria activity. For this study, a sample was collected from each water quality sampling station, brought back to the lab, and analyzed for the **presence (a positive test result) or absence (a negative test result)** of total coliform bacteria.

Every sample of creek water that was tested produced a positive result for the presence of coliform. Therefore, all of the water quality sampling stations that had water present were positive for coliform bacteria at least once (see Appendix B for the dates on which the stations were sampled for coliform). It should be noted that the test used does not analyze the amount of bacteria present in each sample tested; therefore, the actual amount of coliform was not determined in this study, which would detect dangerous levels within specific creek reaches. The tests show that, after the high flows produced by the January 2005 storms, all water quality stations that were sampled produced positive coliform results. It can be assumed that in higher water flows, such as after a significant flood event, the presence of coliform will be higher, due to significant surface runoff into the streams, than during periods of low flows.





Photograph 16 *(top left). Positive coliform indicator results for Water Quality Sampling Stations 1 through 5.* ***Photograph 17*** *(top right). Positive coliform indicator results for Water Quality Sampling Stations 6 through 10, and showing the color chart for reading positive and negative results.* ***Photograph 18*** *(lower left). Positive coliform indicator results for Water Quality Sampling Stations 11, 12, 14, 15, and 17 (no water was present at Station 13 and 16; therefore, no sample was collected). Photos taken 28 October 2004.*