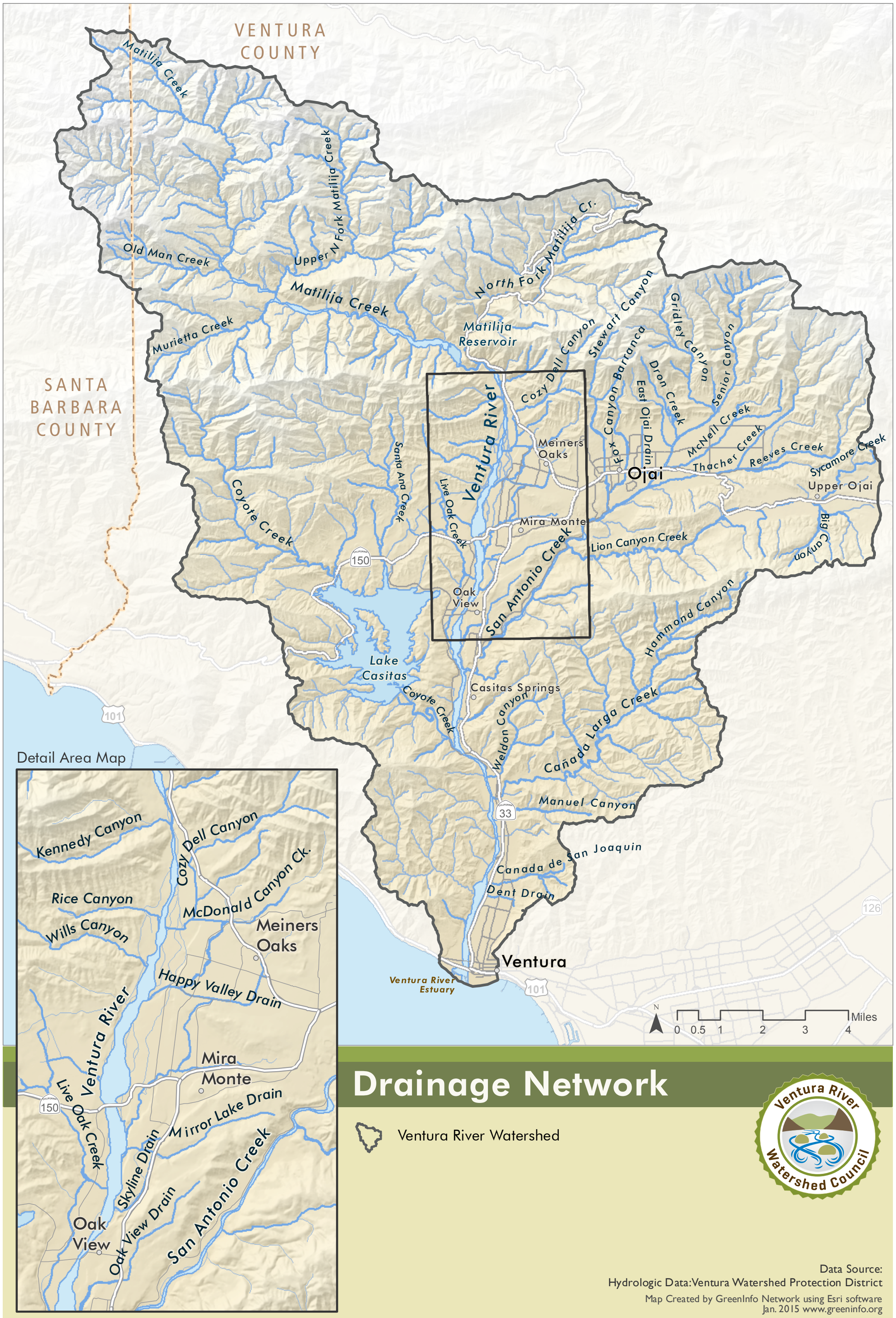


Figure 3.3.1.1.1 Drainage Network Map

Above the Robles Diversion

The Ventura River begins at the confluence of Matilija Creek and North Fork Matilija Creek, just south of Matilija Hot Springs Road. The river's beginning marks the transition from the steep canyons associated with these two creeks to flatter land and the exit of these creeks from the Los Padres National Forest. Still constrained by mountains, the river remains narrow for about a mile as it flows past orchards and the community of Ojala off of Camino Cielo Road.

Aerial View of Ventura River's Beginnings, Looking Downstream
Photo courtesy of Google Earth.

Ventura River's Beginnings. Upstream of Camino Cielo Bridge, June 2008
Photo courtesy of Santa Barbara Channelkeeper

Ventura River at Camino Cielo Bridge

Ventura River Exits the Mountains

Below the Robles Diversion – The Dry Reach

About 1.5 miles downstream from the river's formation, the landscape opens up and becomes much flatter. The river responds by becoming "depositional," dropping its largest sediments (very large boulders and cobbles) as the force of the flow from the steep canyons dissipates onto the gentler gradients.

Robles Diversion Facility

The Robles Diversion Facility—the structure that diverts Ventura River flow to Lake Casitas—is located on the west bank of the Ventura River channel, opposite and just below where Cozy Dell Canyon Creek enters.

Past the Robles Diversion, the riverbed widens considerably and splits into multiple braided channels. The river flows past the community of Meiners Oaks and through the Ventura River Preserve, picking up Kennedy, Rice, and Wills Canyon creeks from the west and McDonald Canyon Creek and Happy Valley Drain from the east before flowing under the Highway 150 Bridge.

Ventura River below Robles Diversion at Ventura River Preserve

Photo courtesy of Rick Wilborn

Happy Valley Drain, Meiners Oaks

The stretch of the Ventura River from below the Robles Diversion to just above the river's confluence with San Antonio Creek (just below Oak View) is the river's "dry reach." (The exact boundaries of the dry reach depend on the time of year, magnitude of the previous rainy season, and the level of groundwater storage.) This stretch of the river to just above the Santa Ana Boulevard Bridge is also referred to as the "Robles Reach" (CMWD 2010). Except during very wet rainfall years, surface water in this part of the river quickly disappears underground once storm flows have passed—even when the river is still flowing above and below this reach. About 80% of the time there is no significant surface flow in the Ventura River in this reach (Cardno-Entrix 2012).

The stretch of the Ventura River from below the Robles Diversion to just above the river's confluence with San Antonio Creek is the river's "dry reach." Except during very wet rainfall years, surface water in this part of the river quickly disappears underground once storm flows have passed—even when the river is still flowing above and below the reach.

> Flow duration curves were developed by the BOR [Bureau of Reclamation] for various stream gauges along the river. Over 60 percent of the time, the flow is less than ten cfs in the Ventura River at Foster Park, and approximately 80 percent of the time the flow is less than ten cfs in the Ventura River at Meiners Oaks. The river has no flow at least 30 percent of the time at Meiners Oaks.
>
> —*Draft Environmental Impact Statement/Environmental Impact Report for the Matilija Dam Ecosystem Restoration Project* (USACE 2004)

The San Francisco Estuary Institute documented numerous historical records going back to the 19th and early 20th century indicating that this reach of river has regularly gone dry, or exhibited intermittent flow (Beller et al. 2011).

Ventura River above Highway 150 Bridge

Past the community of Mira Monte, the Ventura River picks up two channelized drainages from the east: Mirror Lake Drain and Skyline Drain. It then flows past the Live Oak Acres development on the west, where the Live Oak Levee constricts the river down to a small fraction of its width and guides it under the Santa Ana Bridge on Santa Ana Road.

Definitions: Perennial, Intermittent, and Ephemeral

Ephemeral Stream: A stream that flows in direct response to and only during and shortly after precipitation events. Ephemeral streams may or may not have a well-defined channel. Their beds are always above the elevation of the water table, and stormwater runoff is their primary source of water. Ephemeral streams include normally dry arid or semi-arid region desert washes.

Intermittent Stream: A stream that flows only at certain times of the year when it receives water from springs, groundwater, rainfall, or surface sources such as melting snow. Includes intermittently dry desert washes in arid or semi-arid regions.

Perennial Stream: A stream that flows continuously during a year of normal rainfall (Vyverberg 2010).

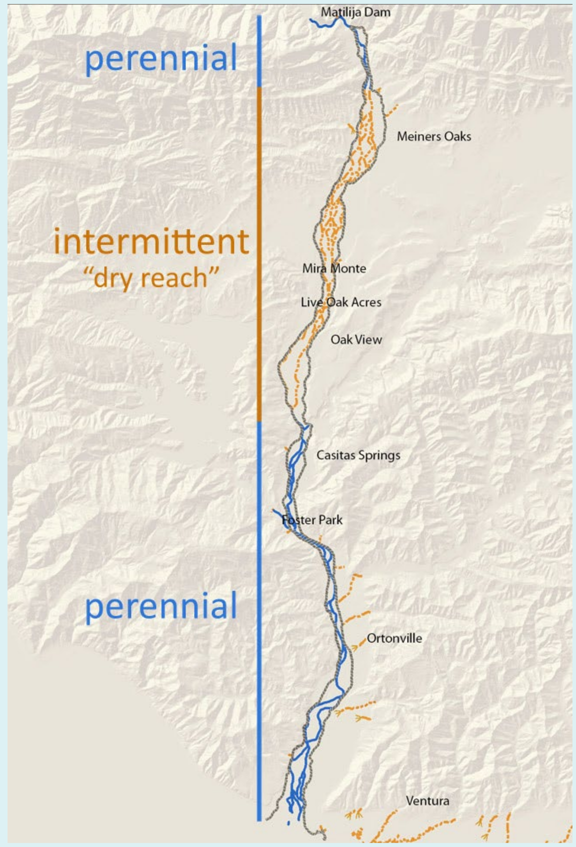
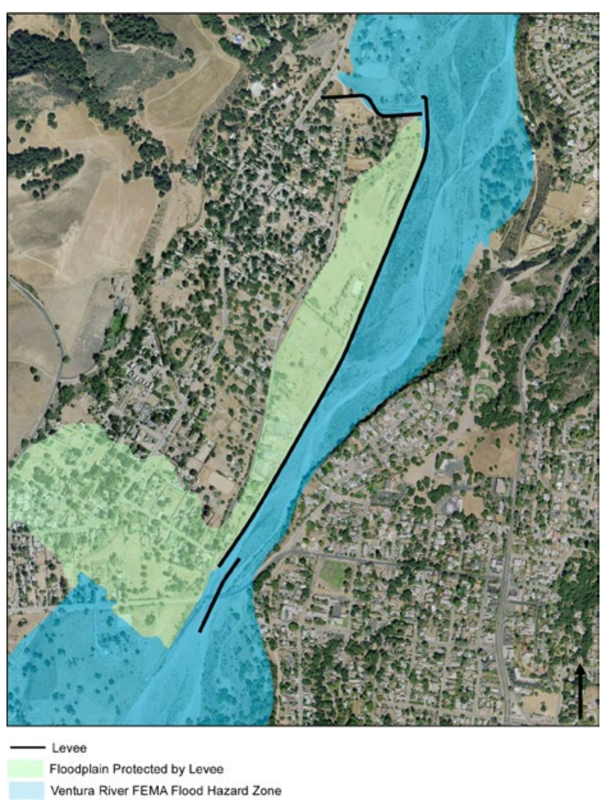


Figure 3.3.1.1.2 Ventura River Dry Reach. Since the 19th and early 20th century, the dry reach of the Ventura River has had intermittent flows, in contrast to the reaches above and below it. In many years, the dry reach could even be called "ephemeral," because flows disappear so quickly after storms. The transitions between intermittent and perennial reaches are approximate boundaries, which shift from year to year. Image courtesy of San Francisco Estuary Institute (Beller et al. 2011)

Live Oak Levee Protects Live Oak Acres Community. Live Oak Acres, to the left, is protected by the Live Oak Levee. Oak View is to the right.



Past the Santa Ana Bridge, the river widens again and flows by the community of Oak View, receiving the Oak View Drain before reaching the confluence with San Antonio Creek.

San Antonio Creek Confluence to Foster Park – The Live Reach

Just above the San Antonio Creek confluence, the Ventura River's wide depositional channel begins to narrow. The river then picks up water and momentum from San Antonio Creek for the last half of its journey to the ocean. During wetter years or winter rainy periods, rising groundwater springs in the river cause the Ventura River's flow to begin increasing above the San Antonio Creek confluence.

Ventura River Looking Upstream From San Antonio Creek Confluence
Photo courtesy of Santa Barbara Channelkeeper

A large pool forms at the confluence of the Ventura River and San Antonio Creek, providing important habitat for fish and other animals.

Confluence Pool, Ventura River at San Antonio Creek. San Antonio Creek can be seen flowing into the Ventura River at the confluence pool.
Photo courtesy of Santa Barbara Channelkeeper

Casitas Springs Levee and Pool

In-river groundwater springs are also found in the river as it passes through the aptly named "Casitas Springs" area below the San Antonio Creek confluence (EDAW 1978). The community of Casitas Springs is protected here by the Casitas Springs Levee.

Farther downstream at Foster Park, underground geologic structures also force subsurface flow to the surface (USACE 2004). At Foster Park, Coyote Creek enters from the west; however, this drainage contributes very little water to the river since the construction of Casitas Dam in 1959. Highway 33, which closely parallels the river, turns into a freeway at this point.

Ventura River at Foster Park Bridge

Because of the significant contributions of water from San Antonio Creek and naturally rising groundwater, the stretch of the Ventura River between the San Antonio Creek confluence and Foster Park is referred to as "the live reach." This reach typically flows year round except in multi-year dry periods.

Because of the significant contributions of water from San Antonio Creek and naturally rising groundwater, the stretch of the Ventura River between the San Antonio Creek confluence and Foster Park is referred to as "the live reach." This reach typically flows year round except in multi-year dry periods.

The City of Ventura draws subsurface water from the river and groundwater in the Foster Park area. The City also has a surface water diversion in the river at Foster Park, but this location has been dry since 2000 because the main channel of the river has meandered.

Below Foster Park to the Estuary

In the mile between Foster Park and the Ojai Valley Sanitary District's wastewater treatment plant, there are several good-sized pools surrounded by the denser vegetation typical of this area.

Pool Below Foster Park

Downstream from this location, the river receives treated effluent from the wastewater treatment plant. The effluent constitutes a significant input and, in many years, accounts for the perennial flow in the remaining stretch of the Ventura River.

Aerial View of Wastewater Treatment Plant. The Ojai Valley Sanitary District's wastewater treatment plant contributes treated wastewater to the flow of the river. Located to the east of the wastewater plant is the City of Ventura's plant for treating water pulled from the river upstream at Foster Park.

Just past the wastewater treatment plant, Cañada Larga Creek enters the Ventura River from the east; the river then flows through an area of active oil production wells. Several minor drainages (Manuel Canyon Creek, Cañada de San Joaquin, and Dent Drain) flow into the river from the east in this reach. The last 2.6 miles of the river are constrained by the Ventura River Levee on the east, which protects the City of Ventura from flooding.

Ventura River Flowing Through Active Oil Fields

Photo courtesy of Brian Hall, Santa Barbara Channelkeeper and LightHawk

Ventura River Levee

Photo courtesy of Rick Wilborn

Ventura River Estuary

In its final stretch, the Ventura River flows through the Ventura River estuary, which extends from around the 101 Freeway bridge to the ocean. The estuary is a shallow body of water that receives both freshwater from the river and salt water from the ocean. A sandbar typically separates the estuary from the ocean during the dry season; when storms breach the sandbar, however, the flow of the river can proceed directly to the ocean. A smaller estuary at the "second mouth" of the Ventura River also exists to the west of the main estuary, but is only open to the ocean during very large floods (RWQCB-LA 2002).

Ventura River Estuary
Photo courtesy of Rick Wilborn

Ventura River Estuary, Sandbar Breached, March 2014

Matilija Creek

Matilija Creek, considered the primary headwaters of the Ventura River, originates in the rugged mountains in the northwest corner of the watershed.

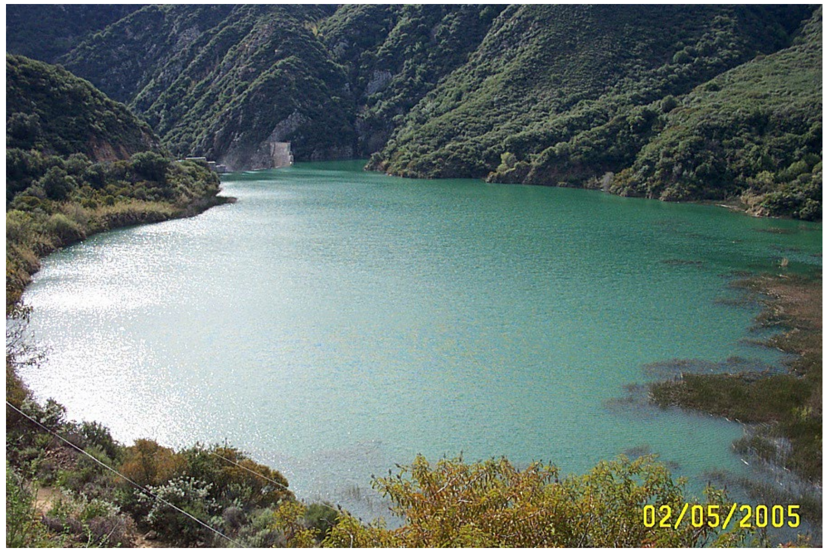
Matilija Falls, Near the Headwaters of the Watershed
Photo courtesy of Michael McFadden

Matilija Creek flows southeast, and is fed along the way by a number of smaller tributaries including Upper North Fork Matilija Creek from the north (not to be confused with North Fork Matilija Creek, described later in this section), and Old Man and Murrieta creeks draining the Santa Ynez Mountains from the south. Matilija Creek and its tributaries originate at elevations between 4,000 and 6,000 feet in the watershed's tallest and steepest mountains.

Matilija Creek

Matilija Reservoir

Photo courtesy of Paul Jenkin



Matilija Dam Spilling, March 2014

Photo courtesy of Mike Sullivan

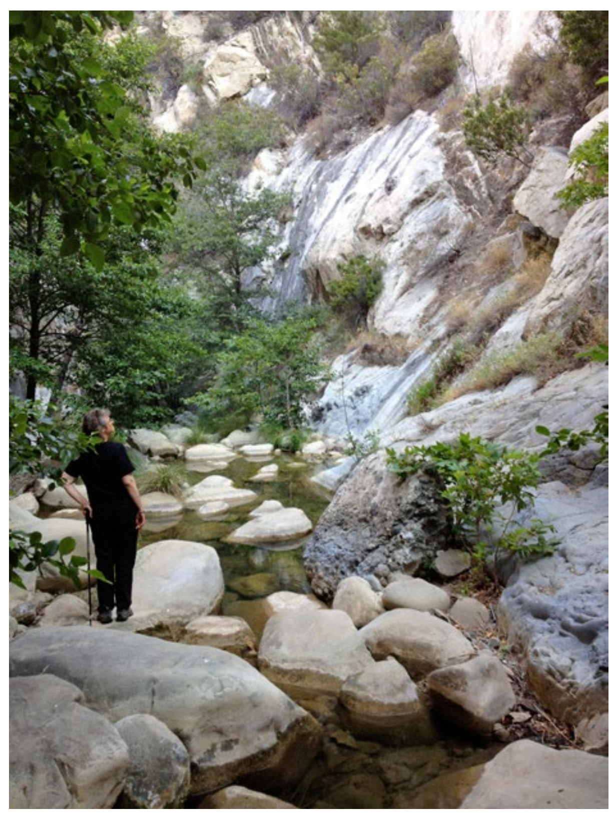
Matilija Creek flows for about 15 miles until it meets Matilija Reservoir behind Matilija Dam, and for an additional half mile after the reservoir until it joins with North Fork Matilija Creek. In the past, water was released from the reservoir a few times during the winter to enhance diversions to Lake Casitas via the Robles Canal; however this practice was discontinued in 2011 because of regulatory concerns related to instream water quality (Evans 2013). Even during low flow periods, water flowing into Matilija Reservoir commonly flows over the top of Matilija Dam.

Almost all, 93% (32,391 acres), of Matilija Creek's drainage area is in the Los Padres National Forest, and 67% (23,477 acres) is in a federal wilderness area.

Almost all, 93% (32,391 acres), of Matilija Creek's drainage area is in the Los Padres National Forest, and 67% (23,477 acres) is in a federal wilderness area. Several hot springs and a few cold springs are located along the creek's course. With the exception of Matilija Dam, Matilija Creek is unchannelized.

North Fork Matilija Creek

From its origins at the top of the watershed near the Rose Valley turnoff, North Fork Matilija Creek parallels Highway 33 down about 8 miles to where it joins Matilija Creek below Matilija Dam. The course of North Fork Matilija Creek winds southwest out of the mountains through a steep and rugged canyon, which in places becomes a narrow, confined gorge bordered by vertical walls of bare, folded, and tilted rock. North Fork Matilija Creek is relatively unmodified.



Wheeler Gorge, North Fork Matilija Creek

Swimming Hole, North Fork Matilija Creek

Many seeps and springs flow out of the rocks along this canyon. Until 2006, Bellyache Springs, a perennial spring located next to Highway 33, had an easy access spigot that allowed people to fill water bottles with spring water. Wheeler Hot Springs, located along the creek, was a popular tourist destination in the area from 1891 to 1997.

Except for a few properties along the highway, all of North Fork Matilija Creek's drainage area (94% or 9,673 acres) is in the Los Padres National Forest.

San Antonio Creek

In terms of water volume, San Antonio Creek is the Ventura River's most significant tributary after Matilija Creek.

In terms of water volume, San Antonio Creek is the Ventura River's most significant tributary after Matilija Creek. San Antonio Creek originates in the northeast part of the watershed on the eastern end of the Ojai Valley floor, and serves as the main drainage for the greater Ojai Valley. Lion Canyon Creek, a major tributary to San Antonio Creek, contributes a significant amount of flow from the Upper Ojai Valley at the extreme eastern end of the Ventura River watershed.

A number of East End creeks, all draining the steep Topatopa Mountains, feed into upper San Antonio Creek. The creek's beginning is marked by the convergence of Gridley and Senior Canyon creeks; it then flows southwest through orchards on the valley floor and picks up Dron Creek and Crooked Creek from the north, then McNell Creek (near Highway 150) from the east. In Soule Park Golf Course, Thacher Creek adds its considerable flow. Reeves Creek, a tributary to Thacher, also adds substantial flow.

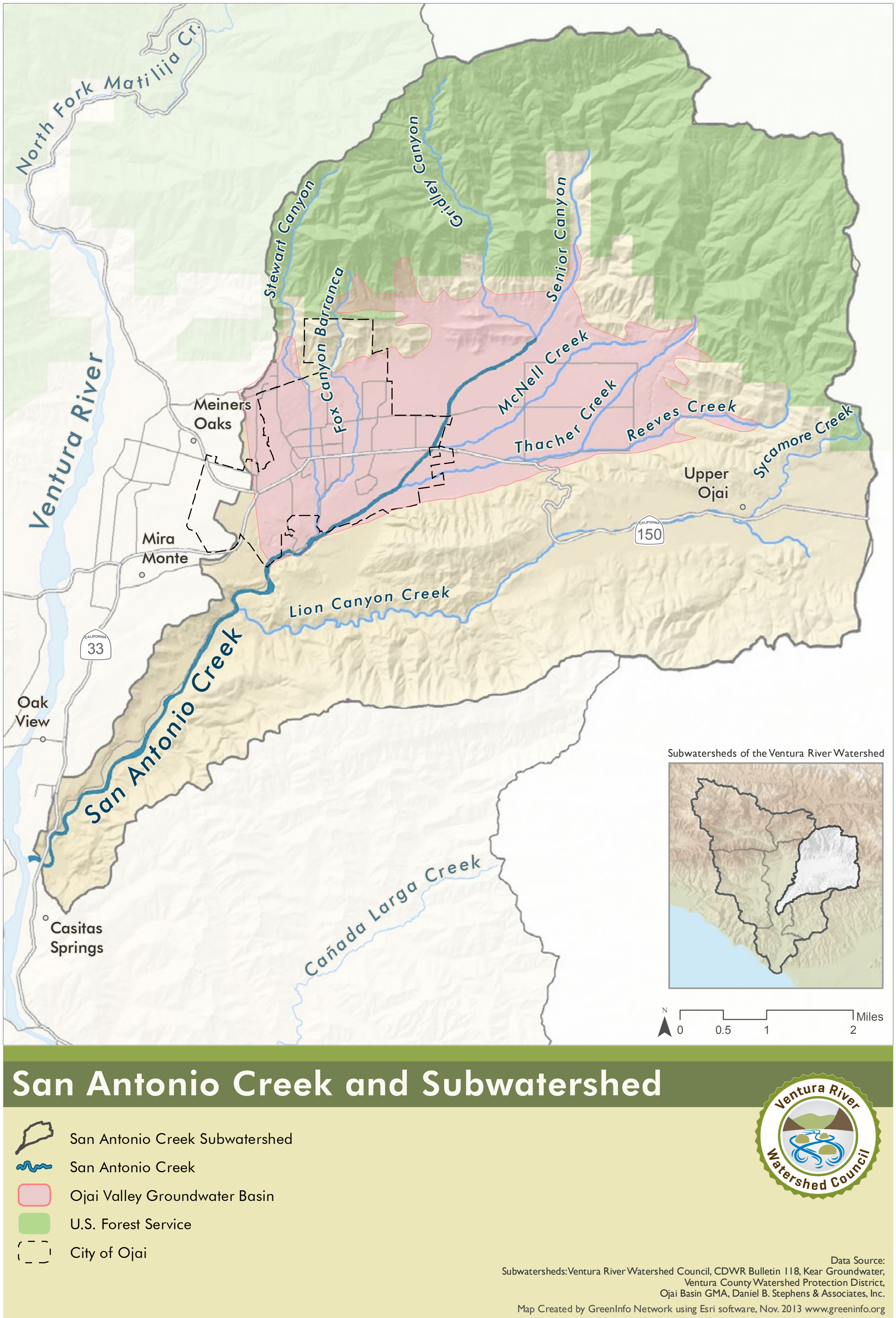


Figure 3.3.1.1.3 San Antonio Creek Subwatershed Map

Upper San Antonio Creek at Grand Avenue

Thacher Creek at Highway 150

Reeves Creek at McNell Road, March 2014

The headwater drainages of San Antonio Creek are also responsible for forming the alluvial fans of the East End and the underlying alluvial Ojai Valley groundwater basin.

Continuing southwest along the edge of the City of Ojai, San Antonio Creek receives flow from Stewart Canyon Creek at the beginning of Creek Road. Stewart Canyon Creek is an important drainage that flows south from the Topatopa Mountains through the City of Ojai. Much of it is underground or channelized through the City, but the lower reach, which receives flow from Fox Canyon Barranca, is primarily unchannelized and often has perennial flow (Magney 2005).

Fox Canyon Barranca, Downtown Ojai

Stewart Canyon Creek Going Underground Above Ojai

Stewart Canyon Creek Flowing into San Antonio Creek Below Ojai. Stewart Canyon Creek converges with San Antonio Creek just below Creek Road

"Typical" in the Ventura River Watershed

Given the extreme variability of rainfall and other factors in the Ventura River watershed, describing what streamflow conditions are like in a "typical" year is highly suspect. The reader must keep in mind that, by necessity, fairly gross generalizations have been made in the descriptions of "typical" conditions.

Below its junction with Stewart Canyon Creek, San Antonio Creek winds along Creek Road, picking up Lion Creek—which drains the Upper Ojai Valley—just past Camp Comfort, and finally converges with the Ventura River after passing under Highway 33 above Casitas Springs.

Upstream of the Thacher Creek confluence in Soule Park Golf Course, San Antonio Creek is ephemeral—typically drying quickly after storm flows have passed. After the confluence with Thacher Creek, San Antonio Creek typically exhibits perennial flow downstream to about a half mile past the Lion Canyon Creek confluence. From that point to the Ventura River confluence, San Antonio Creek's flow characteristics typically alternate between perennial (~65% of this length of creeek), intermittent (~10%), and ephemeral (~25%) (Lewis 2014).

Lion Canyon Creek. Lion Canyon Creek drains Upper Ojai and is a significant tributary to San Antonio Creek.

Lower San Antonio Creek, Camp Comfort. San Antonio Creek during storm flows, March 2014.

San Antonio Creek is 9.66 miles long and is, except for revetments at bridges, primarily unchannelized.

Coyote Creek

Coyote Creek originates in the Santa Ynez Mountains on the western rim of the watershed. From its origins at an elevation of 4,200 feet, the creek flows southeast. Before Lake Casitas was built, Coyote Creek picked up Santa Ana Creek as a tributary from the north before converging with the Ventura River at Foster Park. The Lake Casitas Dam was built across Coyote Creek and has transformed much of the creek into a reservoir. Now Santa Ana Creek and most of Coyote Creek flow directly into the lake.

Coyote Creek Flowing into Lake Casitas

Coyote Creek is 14.62 miles long (including the stretch now under the reservoir). Because of Casitas Dam, the lower 2.5 miles of the creek below Lake Casitas is now disconnected from its original hydrology and only receives water from surrounding small drainages. With the exception of Casitas Dam, Coyote Creek is unchannelized. Forty-seven percent (12,384 acres) of its drainage area lies within the Los Padres National Forest.

Cañada Larga Creek

Cañada Larga Creek originates on the lower eastern edge of the watershed at 1,400 feet. It is the last major tributary to add water to the Ventura River, and the least steep. It flows southwest through a wide, largely undeveloped valley of low foothills used primarily for cattle grazing.

There is at least one major spring as well as numerous smaller springs and seeps throughout the Cañada Larga Creek drainage area. These are more common during wetter years. Oil is found in some of the springs (Williams 2014). Cañada Larga Creek is joined by Hammond Canyon Creek from the north in its upper reaches and a handful of smaller tributaries farther downstream as it winds along Cañada Larga Road.

Cañada Larga Creek Drainage Area

Channelized Cañada Larga Creek
Photo courtesy of Santa Barbara Channelkeeper

To expedite freeway construction, Cañada Larga Creek was diverted so that the streambed now makes a sharp bend where it meets Highway 33 and flows south along the east side of the highway for a stretch. A concrete channel conducts Cañada Larga Creek under Highway 33 and North Ventura Avenue and subsequently through an undeveloped field before converging with the Ventura River just above the abandoned Petrochem gasoline refinery site. Cañada Larga Creek is 7.85 miles long.

3.3.1.2 Streamflow

In the often dry and ever-variable Ventura River watershed, flowing water is a precious resource. Streamflow is vital for habitat and wildlife, both aquatic and terrestrial, on all levels in the food chain. Streamflow determines how much Lake Casitas refills each year, and plays a big role in groundwater recharge. Flow affects pollutant concentrations and water quality. It affects whether or not there will be water in the swimming holes, and whether fish can swim to spawning grounds. Flow can also flood property, damage infrastructure, and scour the riverbed clean of vegetation. Streamflow is also the major contributor to sediment transport, scour, and erosion within the watershed.

Sources of water for streamflow in the watershed include rainwater, groundwater (baseflow and springs), treated wastewater, and urban runoff.

Inputs and Outputs

Sources of water for streamflow in the watershed include rainwater, groundwater (baseflow and springs), treated wastewater, and urban runoff. Snowmelt is typically an insignificant contributor to streamflow in the watershed.

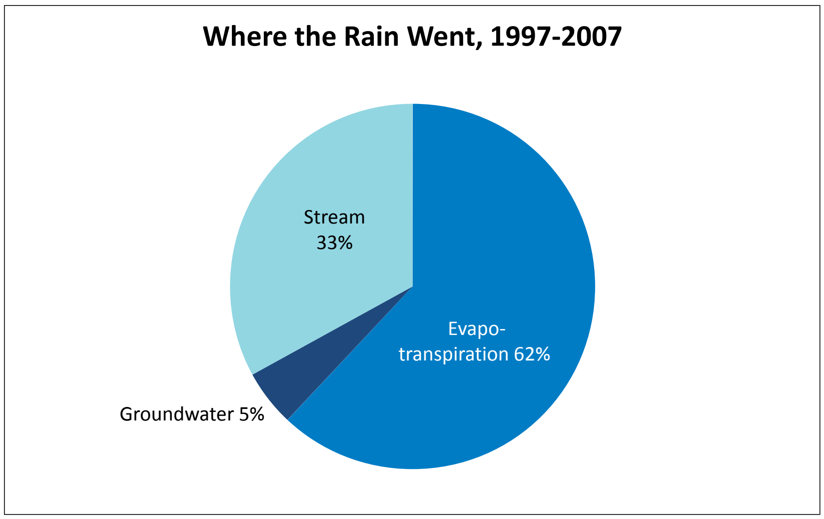
Rainwater

A watershed hydrology model, called the HSPF model (Hydrological Simulation Program – Fortran), was developed for the watershed in 2009 based on data from water years 1997 to 2007. The average Ventura River streamflow during these 11 years was 87.69 cubic feet per second (cfs) (at Foster Park), 30% greater than the long-term average of 65.38 cfs. However, the average rainfall during these years (22.41 inches in downtown Ojai), was very similar to the long-term average of 21.31 inches. Based on the data from these 11 years, the model estimated that about 322,008 acre-feet (AF) of rain falls on the watershed in a typical year and that 33% of that rainfall (113,275 AF) makes its way directly into streams and rivers (Tetra Tech 2009a, Table 6-6).

(See “4.4 Appendices” for a table of monthly average and annual average streamflow at Foster Park between 1930 and 2013.)

Figure 3.3.1.2.1 Where the Rain Went, 1997–2007

Source: Baseline Model Calibration and Validation Report (Tetra Tech 2009a, Table 6-6)



Exchanges between surface water and groundwater have an important effect on the total amount of streamflow in the watershed. Changes in either the surface water or groundwater system can affect the other in both positive and negative ways.

Surface Water/Groundwater Interaction

Exchanges between surface water and groundwater have an important effect on the total amount of streamflow in the watershed. The Ventura River and San Antonio Creek are known to have “gaining reaches” and “losing reaches”—stretches of the river where the stream “gains” water from groundwater and stretches where it “loses” water to groundwater (Entrix 2001a). This surface water/groundwater relationship is dynamic and influenced by many variables. Changes in either the surface water or groundwater system can affect the other in both positive and negative ways.

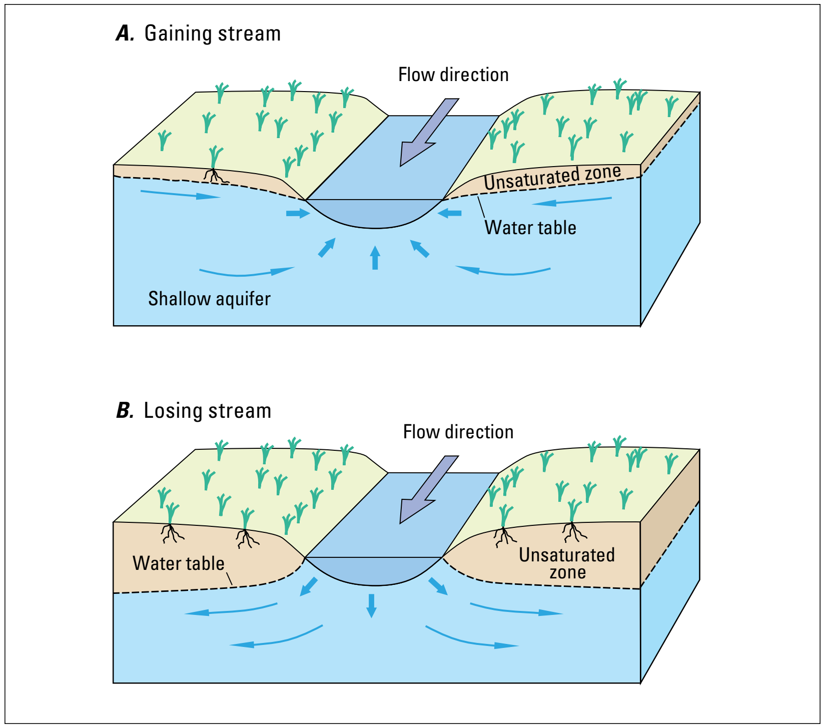


Figure 3.3.1.2.2 Gaining and Losing Streams. These images illustrate the concept of gaining and losing streams. In some places the stream recharges the groundwater below, and in other areas it receives groundwater from the aquifer—depending on the relationship between the water level in the stream and the elevation of the water table in the nearby aquifer.

Source: Streamflow Depletion by Wells (Barlow & Leake 2012). Reprinted with permission.

Because many animals and riparian habitats depend on the availability of surface flow, the condition of the groundwater basins can have important consequences for both terrestrial and aquatic species. The availability of surface water for recreation, aesthetic value, or water supply diversions can also be impacted.

> One of the primary concerns related to the development of groundwater resources is the effect of groundwater pumping on streamflow. Groundwater and surface-water systems are connected, and groundwater discharge is often a substantial component of the total flow of a stream. Groundwater pumping reduces the amount of groundwater that flows to streams and, in some cases, can draw streamflow into the underlying groundwater system. Streamflow reductions (or depletions) caused by pumping have become an important water-resource management issue because of the negative impacts that reduced flows can have on aquatic ecosystems, the availability of surface water, and the quality and aesthetic value of streams and rivers.
>
> —*Streamflow Depletion by Wells—Understanding and Managing the Effects of Groundwater Pumping on Streamflow* (Barlow & Leake 2012)

The surface water/groundwater interconnection is an important water management issue in the Ventura River watershed for a number of reasons, including the need to provide habitat for the endangered southern California steelhead.

The surface water/groundwater interconnection is an important water management issue in the Ventura River watershed for a number of reasons, including the need to provide habitat for the endangered southern California steelhead. Ventura River Reaches 3 and 4 (from Camino Cielo

Road below Matilija Dam to the confluence with Weldon Canyon, just north of Cañada Larga Creek) are on the Section 303(d) list of impaired waterbodies for diversion and pumping. In adding these reaches to the 303(d) list, the Regional Water Quality Control Board associated groundwater pumping and surface water diversion with impacts to the cold freshwater habitat needed by the steelhead (USEPA 2012).

The link between groundwater pumping and streamflow in the Ventura River watershed is poorly understood at this time because neither the collection of sufficient field measurements nor the development of a groundwater model have been undertaken.

Changes in surface flows can also affect groundwater recharge. For example, the requirement that the Robles Diversion must allow a minimum of 20 cfs of Ventura River water to flow downstream is in place to prevent unreasonable interference with prior rights to the use of underground water.

The link between groundwater pumping and streamflow in the Ventura River watershed is poorly understood at this time because neither the collection of sufficient field measurements nor the development of a groundwater model have been undertaken. The HSPF model developed in 2009 to understand surface water hydrology in the watershed lacked critical information about these surface water/groundwater relationships, and thus does not constitute a comprehensive model of the watershed's overall hydrology.

An improved understanding of this surface water/groundwater relationship—how the magnitude, timing, and location of groundwater pumping affects the flow in the river and creeks— is critical for better management of water supplies among multiple competing needs.

Ventura River Dry Reach Going Dry
This photo was taken in December 2011 on the Ventura River Preserve (Meiners Oaks area), just a few hundred feet downstream of "the swimming hole" where children were jumping off rocks into a large pool. This marks the point where the river disappeared underground.

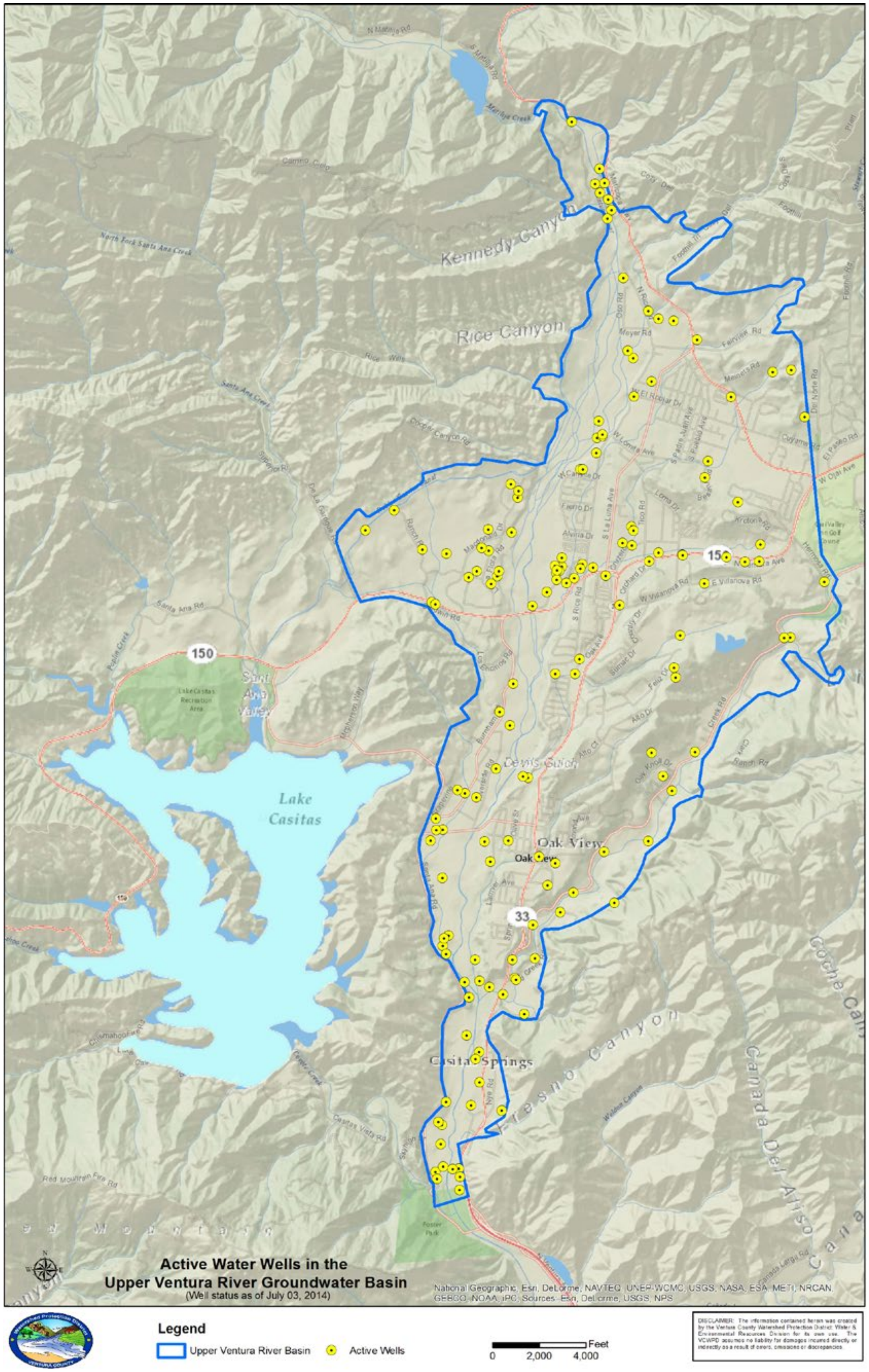


Figure 3.3.1.2.3 Map of Wells in Upper Ventura River Basin. The link between groundwater pumping and streamflow in the Ventura River watershed is not well understood at this time.

Various studies have estimated the amount of water flowing between surface water and groundwater, but without more sophisticated measurements and analyses, the findings of these studies are understood to be preliminary and based on insufficient data. The key studies focused on this interaction and some of their findings are described below:

Drying Ventura River above Highway 150 Bridge

Photo courtesy of Paul Jenkin

> The *Draft Environmental Impact Report for the Ventura River Conjunctive Use Agreement,* prepared by EDAW [consultants] in 1978, described a very close correspondence between the groundwater level in a well located on the floodplain adjacent to the Ventura River just above Highway 150 bridge and the surface flow 250 feet below the mouth of the San Antonio Creek (in the live reach). When the water level in the well falls below approximately 495 feet msl (mean sea level), surface flow in much of the live reach stops (though some pools remain). A flow of 1 cfs or more in the live reach corresponds with a water level in this well of greater than 507 feet msl. When the groundwater in the Upper Ventura River Basin is depleted or nearly depleted, flows due to rising groundwater springs in the area of San Antonio Creek will cease (EDAW 1978).

> The *Surface Water-Groundwater Interaction Report,* a comprehensive study prepared by Entrix in 2001 to inform a Habitat Conservation Plan for the Ventura River, estimated that annual groundwater contributions from the Upper Ventura River basin to surface water flow at Foster Park range from approximately 3,000 to 10,000 AF per year (Entrix 2001). To put this into perspective, the annual median flow at Foster Park between 1930 and 2013 was approximately 6,226 AF (USGS 2014b).

When the groundwater in the Upper Ventura River Basin is depleted or nearly depleted, flows due to rising groundwater springs in the area of San Antonio Creek will cease.

> The HSPF model of the Ventura River watershed estimated that 7,375 AF of water from streams in the watershed infiltrates into groundwater basins annually, and that 4,252 AF of groundwater is contributed back to surface waterbodies annually (Tetra Tech 2009a, Table 6-6).

> A groundwater budget study for the Upper and Lower Ventura River Basins, prepared by Daniel B. Stephens & Associates in 2010, estimated a *net* of 2,290 AF of surface water from the river infiltrates into the Upper Ventura River Basin; and that in the Lower Ventura River Basin a *net* of 1,254 AF of groundwater discharges to surface water (DBS&A 2010, Tables 13 & 14).

> A surface water/groundwater interaction study focused on the City of Ventura's groundwater extractions in the Foster Park area concluded that, for this area, "As long as there is surface flow in the river, the alluvial aquifer is completely refilled in less than a week (2 to 4 days) after cessation of city pumping." (Hopkins 2010)

The Ojai Basin Groundwater Model estimated that an average of 2,282 AF per year is discharged to San Antonio Creek from the Ojai Valley Basin (DBS&A 2011).

A Ventura River Water District analysis of groundwater pumping in the dry reach of the Upper Ventura River Groundwater Basin during the 2010 steelhead migration season found that pumping by the two water districts using that part of the basin was equivalent to a continuous flow of 3.5 cfs and private pumping in the reach was estimated to be equivalent to a flow of 1.1 cfs (VRWD 2014).

Natural springs found throughout the watershed also contribute to streamflow (Entrix & URS 2004).

Ventura River at Casitas Springs, Very Wet and Very Dry. Both of the photos above were taken on August 14, 2013, in the Ventura River at Casitas Springs. The lake-like pool was next to the levee immediately adjacent to the Casitas Springs Mobile Home Park (top); about 400 feet downstream, the main channel of the river disappeared underground (bottom).

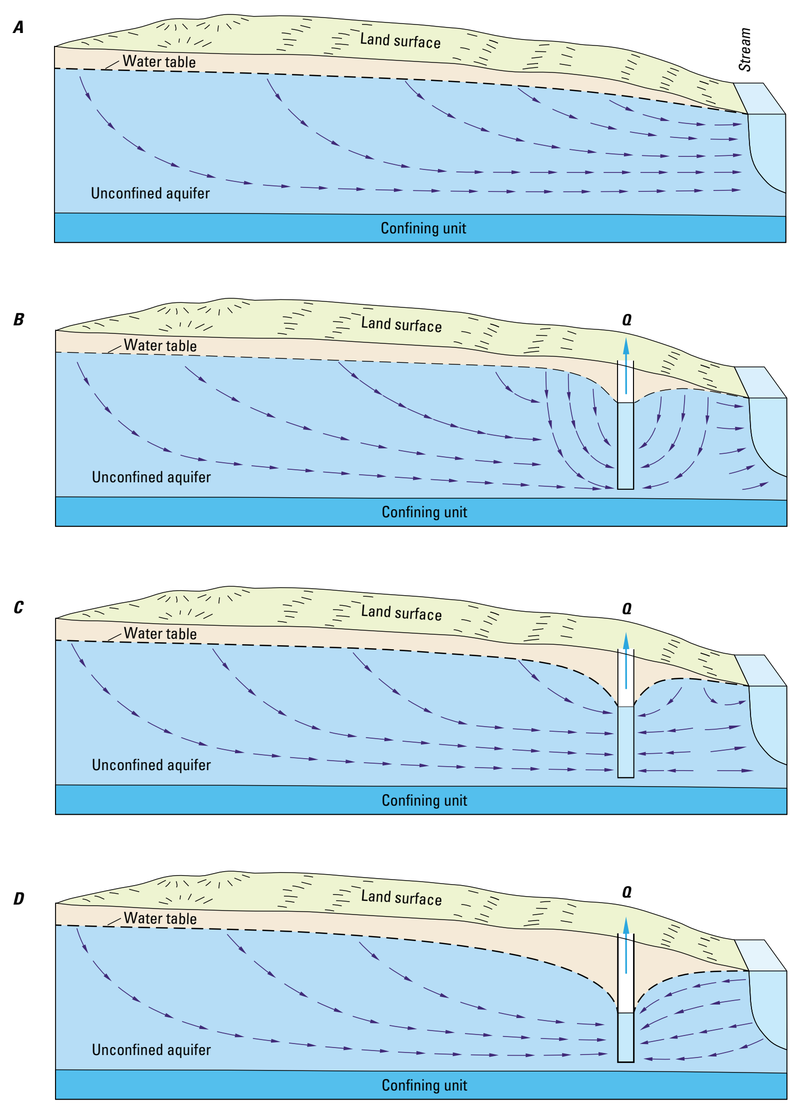


Figure 3.3.1.2.4 Effects of Pumping on an Unconfined Aquifer that Discharges to a Stream. Effects of pumping from a hypothetical water table aquifer that discharges to a stream. A, Under natural conditions, recharge at the water table is equal to discharge at the stream. B, Soon after pumping begins, all of the water pumped by the well is derived from water released from groundwater storage. C, As the cone of depression [a depression of the water level that occurs when groundwater is pumped from a well] expands outward from the well, the well begins to capture groundwater that would otherwise have discharged to the stream. D, In some circumstances, the pumping rate of the well may be large enough to cause water to flow from the stream to the aquifer, a process called induced infiltration of streamflow. [Q, represents the pumping rate at the well]

Note: this example is a generalization and may not apply to all situations.
Source: Streamflow Depletion by Wells (Barlow & Leake 2012). Reprinted with permission.

The contribution to the Ventura River of treated effluent from the wastewater treatment plant averages 2.1 million gallons per day, which is equivalent to an average year-round streamflow of approximately 3.3 cubic feet per second.

Wastewater

The watershed's primary wastewater treatment plant is located next to the Ventura River just below Foster Park, about five miles from the ocean. Managed by the Ojai Valley Sanitary District (OVSD), it produces highly treated water, called effluent, which is discharged to the Ventura River. The contribution from the treatment plant averages 2.1 million gallons, or 6.44 AF, per day, which is equivalent to an average year-round streamflow of approximately 3.3 cfs. During the rainy season, this contribution of effluent to streamflow is a relatively small portion of the total volume of water. During the dry season, however, the effluent can constitute more than 50% of the streamflow below the treatment plant (Entrix & Woodward Clyde1997).

Urban and Agricultural Runoff

Some storm drains in urban areas of the watershed continue to have a minor trickle of flow even in the driest times of summer. This water can come from a variety of urban sources, including irrigation runoff, car washing, other types of cleaning, leaking pipes, etc. This water can make its way to streams.

Urban Runoff in Fox Canyon Barranca, Summer 2013 After Two Dry Winters

Urban development—specifically impervious surfaces such as roads, parking lots, and rooftops—prevents natural infiltration of rain water, thus decreasing recharge to groundwater and increasing the amount of water entering the drainage network. Because water runs off pavement and rooftops so quickly, these impervious surfaces also increase peak flows during storms. Increased urban development can thus put a strain on existing channels lacking sufficient width and depth to carry additional storm flows, as well as levees built to protect developed areas.

Urban development—specifically impervious surfaces such as roads, parking lots, and rooftops—prevents natural infiltration of rain water, thus decreasing recharge to groundwater and increasing the amount of water entering the drainage network.

Excess agricultural irrigation water may also contribute to streamflows.

Outputs

Once in the drainage network, streamflow is discharged to the ocean, diverted for use, used by riparian plants, evaporated, or infiltrated into soil and groundwater basins. The HSPF model estimated, based on data from water years 1997 to 2007, that approximately 71% of the water entering the stream network travels fairly quickly to the ocean by way of the Ventura River, 16% is diverted for consumption, 6% recharges groundwater basins, and 7% is lost to stream and reservoir evaporation (Tetra Tech 2009a).

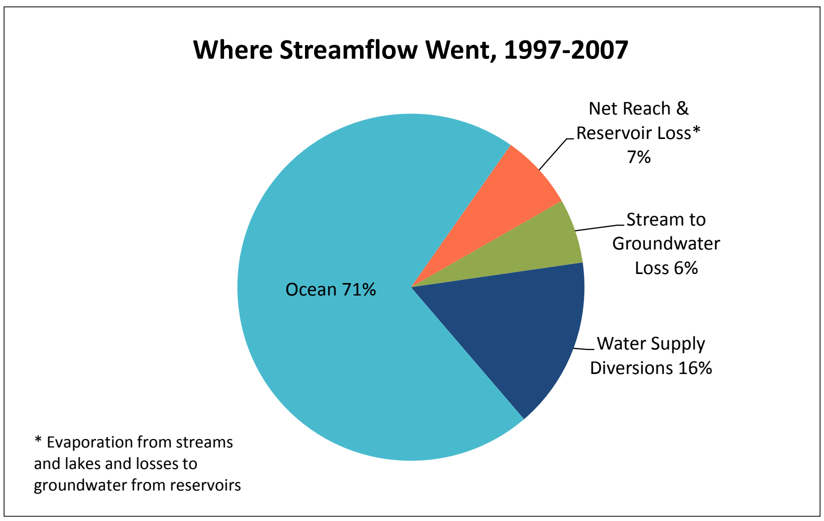


Figure 3.3.1.2.5 Where Streamflow Went, 1997–2007

Data source: Baseline Model Calibration and Validation Report (Tetra Tech 2009a, Table 6-6)

Table 3.3.1.2.1 Factors Affecting Streamflow

Climate	Rainfall is the primary factor affecting streamflow in the watershed. Because groundwater basins are readily recharged by big rain events, and groundwater discharges water to the stream network, rainfall ultimately determines the amount of water contributed to the stream network from groundwater. (See "3.2.1 Climate" for more information.) Temperature, which affects plant water demand as well as evaporation, also affects streamflow.
Groundwater and Springs	The greatest total volume of water comes from rainwater. However, once the rains and associated runoff have passed, the primary source of water in local streams for the rest of the year is groundwater. Natural springs are also found throughout the watershed, and can contribute to streamflow.
Geology and Soils	The watershed's steep mountains cause runoff water to flow very quickly, resulting in "flashy" streamflow after rain events. Steep mountains also increase the amount of rain received because of "orographic lift"—air coming in from the ocean hits the mountains, rises up quickly, cools, condenses, and forms rain. The cobbly, alluvial nature of the watershed's streambeds and groundwater basins plays a key role in the dynamic relationship between surface water and groundwater. (See "3.2.2 Geology and Soils" for more information.)
Water Withdrawals	The amount of water withdrawn from streams for consumption affects streamflow. Because groundwater is an important source of streamflow, groundwater withdrawals may also affect streamflow.
Water Additions	The addition of treated wastewater to the lower Ventura River is a significant contribution to streamflow, especially in the dry season.
Dams, Channel Modifications, and In-Channel Structures	Streamflow is reduced by the watershed's two dams, is increased during rain events by cement-lined drainage channels, and is modified by other in-channel structures such as debris basins, levees, and groundwater recharge basins.
Urban Development	Impervious surfaces reduce infiltration and increase storm flow volumes and rate of flow. Irrigation water can also contribute to streamflow.
Fires and Vegetative Cover	Recently burned hill slopes in steep, semi-arid lands can respond to winter rains with increased runoff. The removal of natural vegetation, such as floodplain riparian plants, can increase the flashy response of rivers during flood events (Stillwater Sciences 2011).
Native & Invasive Riparian Plants	The growth of all riparian vegetation follows cycles of flood scour and regrowth. Denser vegetation consumes more water. The nonnative, invasive plant *Arundo donax*, which occupies many parts of the watershed, is significantly thirstier than native streamside plants.

Besides the obvious contribution from rainfall, there are many other factors that influence the amount and duration of flow in the watershed's streams.

Arundo in Ventura River

Photo courtesy of Santa Barbara Channelkeeper

Definition: Base Flow

Base flow is the flow of water in streams that remains well after storms have passed.

Streamflow Characteristics

Storms contribute the greatest volume of water to streamflow, so seasonal flows mimic rainfall seasonality. However, the watershed typically experiences only a few major storms a year. Outside of the direct runoff of these infrequent wet periods, it is groundwater that provides base flow, if it exists, to the Ventura River and its tributaries (RWQCB-LA 2012).

Streamflows fall into the “major flood” category on the Ventura River when flows hit 40,000 cfs or more as measured at Foster Park. This has occurred about once every 14 years since 1933. Between 1933 and 2011, the highest peak flow measurement obtained for the Ventura River at Foster Park was 63,600 cfs, measured on February 11, 1978 (VCWPD 2013).

Of the watershed’s major tributaries, Matilija Creek and San Antonio Creek are the biggest contributors of water. Table 3.3.1.2.3 shows the relative amount of peak flow in the watershed’s various drainages.

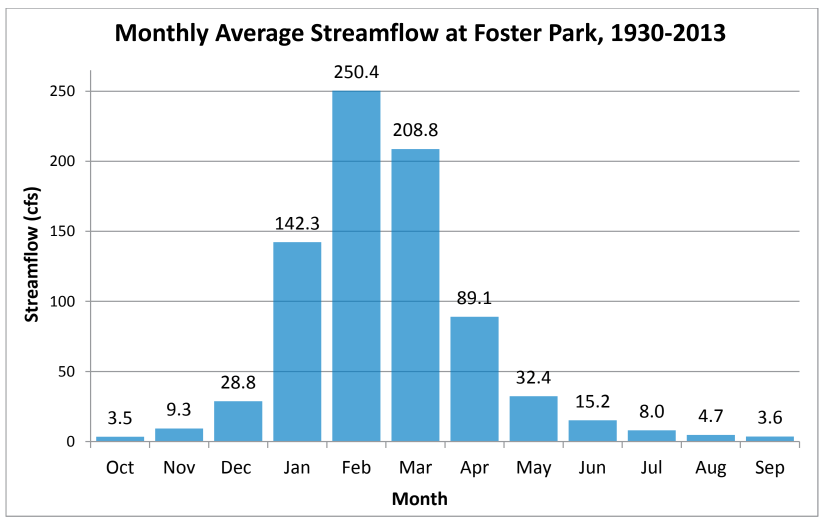


Figure 3.3.1.2.6 Monthly Average Streamflow at Foster Park, Water Years 1930–2013

Data Source: USGS National Water Information System Website (USGS 2014b)

Table 3.3.1.2.2 Monthly Average Streamflow (cfs) at Foster Park, Water Years 1930–2013

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Average	3.5	9.4	29.2	142.3	250.4	208.8	89.1	32.4	15.2	8.0	4.7	3.6
Median	0.6	1.4	5.0	12.6	34.1	30.7	18.3	9.2	5.1	2.9	1.5	0.5
Highest	41	278	234	1,880	2,919	1,954	1,351	408	158	64	36	29
Water Year	1984	1966	1966	1969	1998	1938	1958	1998	1998	1998	1941	1998
Lowest	0	0	0	0	0	0	0	0	0	0	0	0
Water Year	Multiple Years											

Monthly average streamflow is the average of all daily streamflows for the month.
Data Source: USGS National Water Information System Website (USGS 2014b)

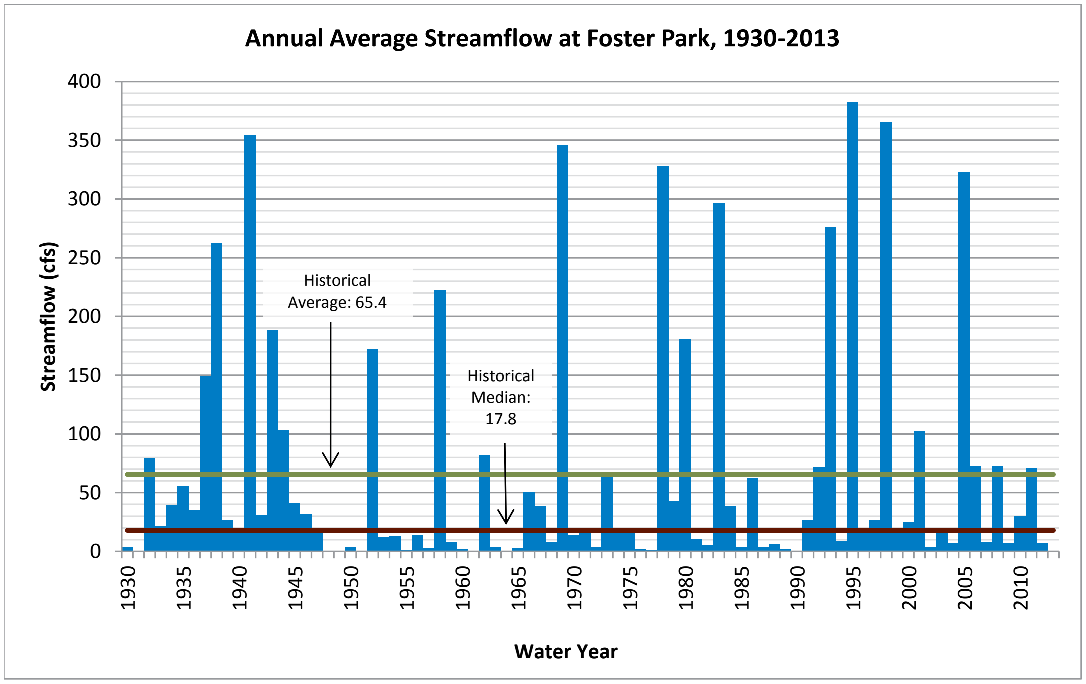


Figure 3.3.1.2.7 Annual Average Streamflow at Foster Park, Water Years 1930–2013. As this chart indicates, the historical annual average streamflow in the watershed rarely occurs in actuality. This is because occasional extreme flows skew the average. Historical annual median streamflow is much more common. The "median" represents the midpoint of the set of data, such that half of the years had an average rate of flow less than the median and half had an average rate of flow greater than the median.

Annual average streamflow is the average of all daily streamflows for the year.

Data Source: USGS National Water Information System Website (USGS 2014b)

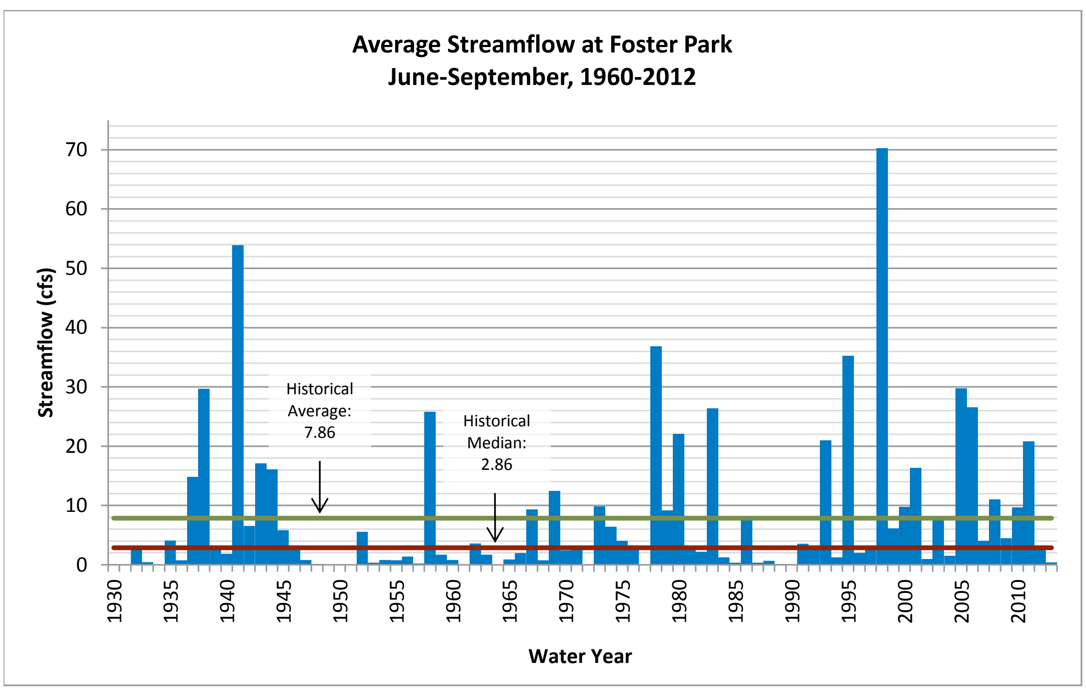


Figure 3.3.1.2.8 Average Streamflow at Foster Park, June–September, Water Years 1960–2012

Data Source: USGS National Water Information System Website (USGS 2014b)

Table 3.3.1.2.3 Storm Peak Flow Estimates Based on Modeling

	Peak Flow (cfs)	
Stream Name	**10-Yr**	**50-Yr**
Ventura River and Smaller Tributaries		
Below Matilija Creek/N. Fork Matilija Creek Confluence	15,000	24,000
Ventura River Baldwin Rd	16,000	24,800
Ventura River Casitas Springs	35,200	56,600
Ventura River Gauge at Foster Park	36,400	59,700
Ventura River at Shell	41,300	67,900
Matilija Creek		
Matilija Creek below dam and above N. Fork Matilija Creek	12,500	18,800
North Fork Matilija Creek		
N. Fork Matilija (upper part)	3,830	10,380
N. Fork Matilija (lower part)	3,960	10,740
San Antonio Creek and Tributaries		
Senior and Gridley	4,590	12,440
San Antonio Creek below McNell Creek	5,760	15,630
Reeves Creek above Thacher Creek	1,530	4,150
Thacher Creek above San Antonio Creek	2,860	7,750
San Antonio Creek below Thacher Confluence	7,490	20,330
San Antonio Creek above Stewart Creek	7,620	20,690
Stewart Canyon above San Antonio Creek with Fox	1,070	2,920
San Antonio after Stewart Confluence	8,590	23,320
San Antonio Creek above Lion Confluence	7,760	21,050
Big Canyon (Upper Ojai)	690	1,880
Lower Lion Canyon Creek	3,430	9,310
San Antonio after Lion Canyon Confluence	10,430	28,300
San Antonio Creek above Ventura River Confluence	9,960	27,020
Coyote Creek		
Coyote Creek above Ventura River	680	1,980
Cañada Larga Creek		
Cañada Larga Creek above Ventura River	5,370	14,580

This table shows model-generated estimates of peak flows of various streams and stream reaches in the watershed. These 10-year and 50-year peak flows are expected to occur once every 10 or 50 years, respectively. The largest peak flows ever measured in the watershed (63,600 cfs) were at the Foster Park gauge and were the equivalent of a 65-year peak flow.

Source: Ventura River Watershed Design Storm Modeling Final Report (VCWPD 2010)

Extremely Variable

Streamflow patterns in the Ventura River watershed reflect the same extreme variation found in rainfall patterns.

As in other watersheds in the region, streamflow patterns in the Ventura River watershed reflect the same extreme variation found in rainfall patterns. As shown in Table 3.3.1.2.4, between 1930 and 2013, the average annual rate of flow of the Ventura River at Foster Park was 65.4 cfs, but this period saw an annual low of 0 cfs and a high of 382.8 cfs. Table 3.3.1.2.4 also indicates the equivalent volume of water from these flow rate amounts. The annual runoff volume of the wettest water year was 227,096 AF—almost five times greater than the annual average and over 18 times greater than the annual median. These numbers help illustrate the extremely variable nature of streamflow in the watershed.

Table 3.3.1.2.4 Annual Average Streamflow at Foster Park, Water Years 1930–2013

	Avg.	Median	Low (1951)	High (1995)
Cubic feet/second (cfs)	65.4	17.8	0.0	382.8
Acre feet/year (AF/yr)	47,329	12,349	0.0	227,096

For comparison purposes, the rate of flow (cfs) was converted into the equivalent acre-feet for the year (AF/yr).

Annual average streamflow is the average of all daily streamflows for the year. 2012–2013 data is provisional.

Data Source: USGS National Water Information System Website (USGS 2014b)

Table 3.3.1.2.5 Annual Peak Flows at Foster Park, Water Years 1933–2013

	Avg.	Median	Low (1951)	High (1978)
Cubic feet/second	10,410	3,330	0.0	63,600
Acre-feet/minute	14.34	4.59	0.0	87.60

For comparison purposes, the peak rate of flow (cfs) was converted into acre-feet per minute.

Data Source: Ventura County Watershed Protection District Hydrologic Data Server (VCWPD 2013)

An average flow that is almost four times the median flow indicates high streamflow variability.

The median rate of flow is also provided in Table 3.3.1.2.4. The median represents the midpoint of the set of data, such that half of the years had an average rate of flow less than the median and half had an average rate of flow greater than the median. When data sets have an extreme range of variability, a few extreme numbers, such as a few extreme flood years, can skew the average. In such instances the median represents a much truer picture of "typical"—in this case, what flow is like in a typical year. Median flows, those closer to 17.8 cfs, are experienced much more often than average flows of 65.4 cfs. An average flow that is almost four times the median flow indicates high streamflow variability. Table 3.3.1.2.5 shows similar data for *peak* flows at Foster Park between the years 1933 and 2013.

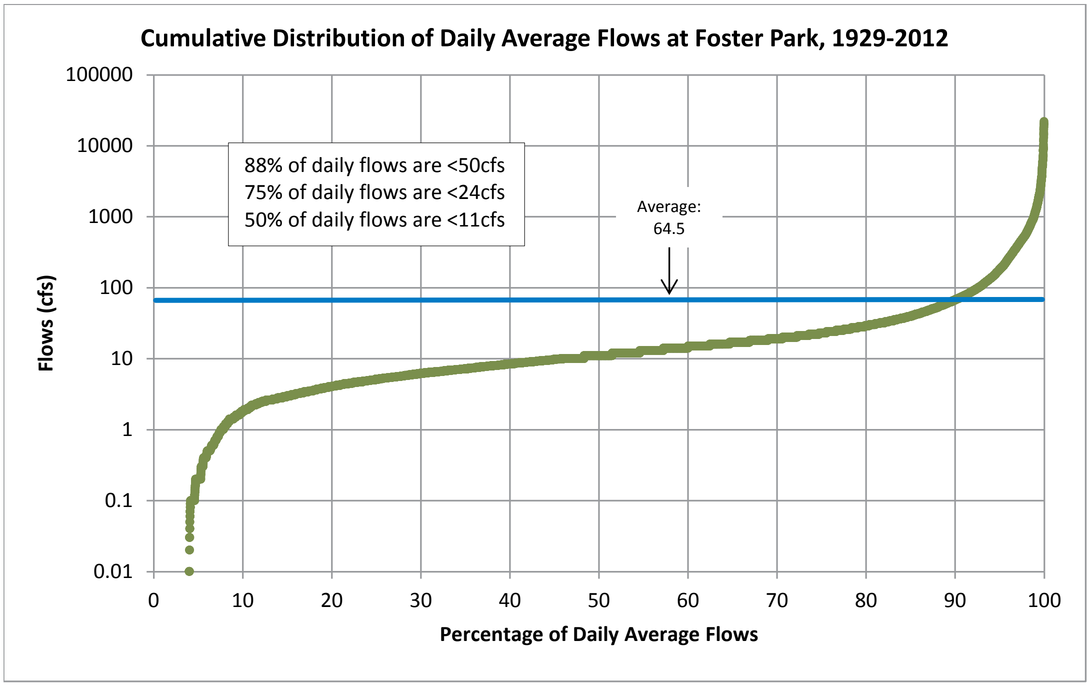


Figure 3.3.1.2.9 Cumulative Distribution of Daily Average Flows at Foster Park, Sept. 1926–Oct. 2012.
This chart illustrates that typical flows in the river are relatively low: 88% of the time average daily flows at the Foster Park gauge are less than 50 cfs, 75% of the time flows are less than 24 cfs, and 50% of the time flows are less than 11 cfs.
Data Source: USGS National Water Information System Website (USGS 2014b)

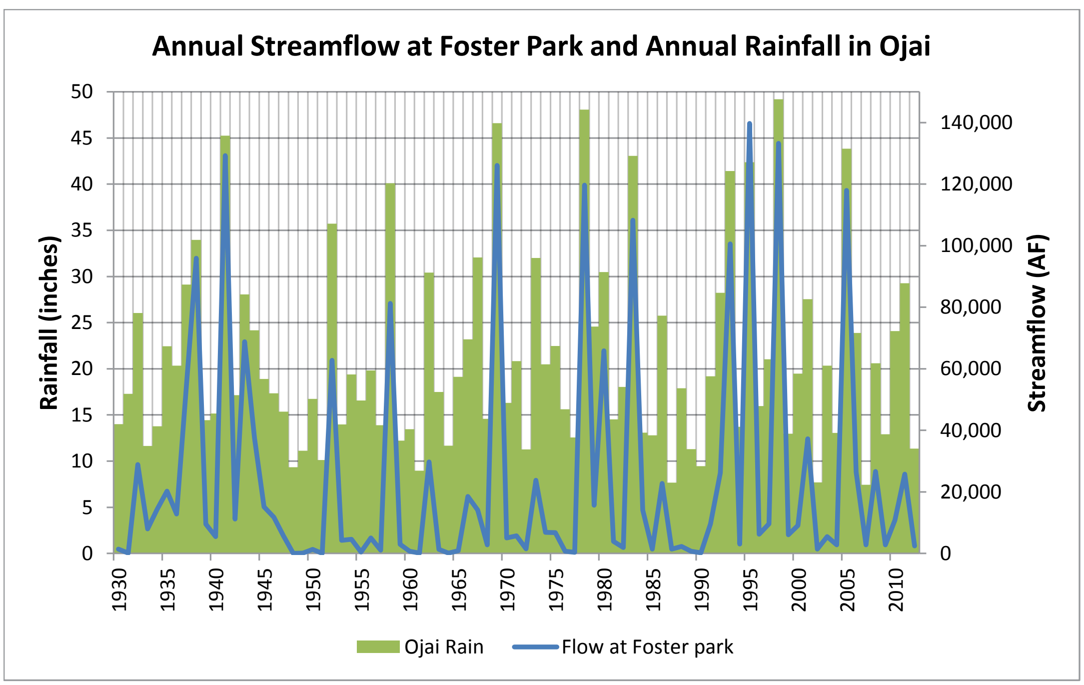


Figure 3.3.1.2.10 Total Annual Streamflow Volume and Ojai Rainfall, Water Years 1930–2012
Data Sources: Streamflow: USGS National Water Information System Website (USGS 2013); Rainfall: VCWPD Hydrologic Data Server (VCWPD 2013)

Cubic Feet Per Second and Acre-Feet

Water in motion—streamflow—is usually measured in "cubic feet per second" or "cfs," which is equal to the volume of water one-foot wide and one-foot high, flowing a distance of one foot in one second. A cubic foot equals 7.48 gallons flowing each second, or 449 gallons flowing each minute. One cfs will produce 646,272 gallons per day, or 724 AF of water per year.

Water that is in storage or impounded is typically measured in "acre-feet" or "AF," which is equal to the volume of water that would cover an acre of land (43,560 square feet) to a depth of one foot. An AF equals 325,851 gallons of water. One AF is equal to 0.504 cfs/day, meaning that that if water was flowing at 0.504 cfs for the duration of one day, the volume discharged during that day would be one AF (USGS 2014).

Below are photos that illustrate what different streamflows look like on the Ventura River.

35 and 200+ CFS of Streamflow, Ventura River, Below Robles Diversion.

These photos are intended to show what different rates of flow (cubic feet per second, or cfs) look like. The top photo shows a flow of about 35 cfs and the bottom photo, a flow 200+ cfs.

Photo courtesy of Casitas Municipal Water District

Streamflow of 30,000 cfs, Ventura River at Casitas Springs, 1998

Photo courtesy of Ventura County Watershed Protection District

Flashy and Intermittent

Streamflow in the Ventura River watershed responds very quickly to rainfall. During the rainy season, streamflows in the watershed are typically "flashy"—they increase, peak, and subside rapidly in response to storms. The rainy season is between October 15 and April 1, and rainfall tends to occur in just a few significant storms during this time. Streamflows generally peak in January through March and are lowest from August through October. See also "3.3.2 Flooding" for a look at streamflow and flood events.

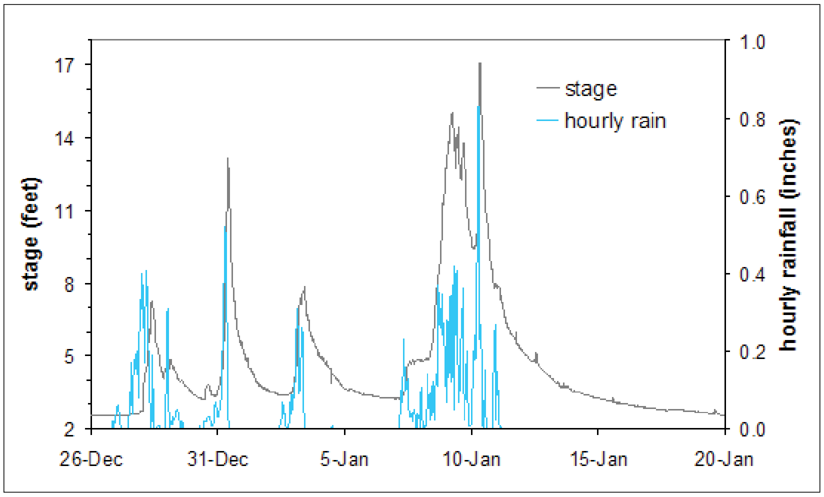


Figure 3.3.1.2.11 Flood Hydrograph at Foster Park, December 2004 to January 2005. Hydrographs illustrate how long it takes for streamflows (or "discharge") to build up in response to rain. This example compares the intensity of rainfall (in blue) with the flood stage (in grey) in the Ventura River at Foster Park during the December 2004 to January 2005 flood events. The term "stage" refers to how high water levels rose at the streamflow gauge; when the gauge reads 2.5 feet, the river is flowing at a trickle. The hydrograph shows that streamflow had a delayed response to rainfall at the beginning of the storm, because the watershed's dry and porous soils absorbed the initial rain. Twenty-three inches of rain fell during the period shown on the graph, but only about 6 inches of this rain flowed down the river, most of it during the second storm pulse.

Data source: Ventura Stream Team 2001–2005 (Leydecker & Grabowsky 2006)

The amount of streamflow that persists outside the rainy season, called "base flow," depends upon how much rain fell the previous winter and consequently how much recharge the groundwater basins received and how saturated the soil became. Typically, after the rains have passed, the amount of water flowing in streams in the watershed diminishes fairly rapidly. For the "ephemeral" streams, this marks the end of flow altogether; for the "intermittent" streams or stream reaches, flow will continue on for some time; and for the "perennial" stream reaches, flow will continue all year except in extended drought periods.

Direct Runoff vs. Base Flow

Direct runoff is the surface flow that contributes to a stream during and immediately after a storm. Base flow is the flow of water in streams that remains well after storms have passed. The source of base flow is groundwater that has made its way into the stream channel (Williamson & Klamut 2001). Base flow is a critical factor in the life cycle of some species, such as the endangered southern California steelhead, and is highly impacted by sustained drought or water withdrawals for human use. Because streamflow in the Ventura River watershed comes primarily from rain and not snowmelt, and because a few big storms often bring the bulk of the rain, the majority of total annual flow occurs as storm flow, or direct surface runoff, rather than as base flow.

Of the six major streams in the watershed, only Matilija Creek and North Fork Matilija Creek are typically perennial for their entire lengths, although sections of Matilija Creek occasionally dry up. Some of the tributaries of San Antonio Creek that are spring fed, such as Gridley Canyon and Senior Canyon Creeks, are also known to be perennial in their upper reaches. All other major streams are typically intermittent for either their entire length or parts of it. In rare, very wet years, the Ventura River may have continuous flow to the ocean; however, in most years, flow is intermittent, with the river drying up in the dry reach between the Robles Diversion Facility and the confluence with San Antonio Creek. Many of the watershed's smaller streams are ephemeral, existing only briefly after storms.

Although the increased consumption of water by people in recent times has certainly influenced streamflow in the watershed, an extensive study of historical records by the San Francisco Estuary Institute demonstrated that the intermittent nature of the Ventura River mainstem has been a condition of the river for over one hundred years. As observed today, surface flows commonly became intermittent when the river dropped out of the mountains and entered flatter terrain. At the confluence with San Antonio Creek, and from Foster Park to the mouth of the river, flows were perennial (Beller et al. 2011).

The intermittent nature of the Ventura River mainstem has been a condition of the river for over one hundred years.

> "…we found ourselves at the mouth of…the Matilija Cañon…A rapid brook runs down the anon, shrinking into the deserted bed of what must once have been a broad river, and here and there the gravel spreads far over the desolate bottom. But soon after entering the ravine, the eye is relieved by patches of wood and verdure which at short intervals break in upon the sand" (Hassard 1887).
>
> Documentation of flow conditions on the Ventura River consistently depicts three reaches with distinct summer flow regimes within the study area. These reaches are depicted on the historical topographic quad for the river (USGS 1903c; fig. 4.9). The first perennial reach extends from beyond the northern edge of the study area (Matilija Hot Springs) downstream to around the Cozy Dell Canyon (Matilija reach). Below this, the Ventura River valley begins to open up into the head of the Ojai Valley, and the river is intermittent until below Oak View and the river's confluence with San Antonio Creek (Oak View reach). Last, perennial flow is shown from just above the San Antonio Creek confluence downstream to the ocean (Avenue/Casitas reach).
>
> —*Historical Ecology of the Lower Santa Clara River, Ventura River, and Oxnard Plain* (Beller et al. 2011)

3.3.1.3 Surface Water Diversions, Dams and Reservoirs

The natural flow of water through the stream network has been altered by diversions of water for human use. These include dams and surface water diversions, which are discussed below, but also the extraction of groundwater. See "3.3.3 Groundwater Hydrology" and "3.4 Water Supplies and Demands" for information on groundwater withdrawals.

There are two major dams within the Ventura River watershed: Casitas Dam, which forms Lake Casitas, and Matilija Dam, which forms the Matilija Reservoir. There are two minor dams: Senior Canyon Dam, which forms Senior Canyon Reservoir, and the Stewart Canyon Debris Basin Dam, which exists to slow storm flows and capture storm debris. There is also one subsurface dam in the Ventura River at Foster Park and two significant surface water diversions, the Robles Diversion and the Foster Park Diversion (although the Foster Park surface diversion has not been used since the mid 1990's because the river has been dry in that location). Many others in the watershed, including individuals, farms and ranches, and small water companies, hold and use rights to divert smaller amounts of surface water (SWRCB 2013). As of March 2014, 21 different entities were registered in the state's eWRIMS (Electronic Water Rights Information Management System) database as having rights to withdraw surface water or water from subterranean streams in the watershed (SWRCB 2014b).

Lake Casitas and Robles Diversion

When winter rains result in sufficient surface flows at the Robles Diversion, the amount of water diverted to the lake versus that required to be released downstream is dictated by a regulatory document called the Robles Fish Passage Facility Biological Opinion.

Lake Casitas is the watershed's principal water supply reservoir, providing water to users throughout the watershed and to the small adjoining coastal watersheds (including the Rincon area and the City of Ventura). Lake Casitas gets its water from Coyote and Santa Ana Creeks (~55%), which flow directly into the lake; and from Ventura River diversions (~45%), transported to the lake via the 5.4-mile Robles Canal from the Robles Diversion and Fish Passage Facility (Robles Diversion) located on the river. The relative amounts from these sources depend upon a variety of factors that change from year to year (Wickstrum 2014). The lake has a maximum storage capacity of 254,000 AF.

The Robles Diversion is located on the western bank of the Ventura River about 1.5 miles downstream of the junction of Matilija and North Fork Matilija Creeks, and it includes a fish ladder to facilitate passage of migrating fish. In low rainfall years, there is typically little or no surface flow in the river at the diversion. When winter rains result in sufficient surface flows at the diversion, the amount of water diverted to the lake versus that required to be released downstream is dictated by a regulatory

Lake Casitas Dam and Reservoir

Photo courtesy of Rick Wilborn

Santa Ana Creek Entering Lake Casitas Recreation Area

document called the *Robles Fish Passage Facility Biological Opinion* (NMFS 2003). The Biological Opinion was prepared by the National Marine Fisheries Service as a required part of construction of a fish passage facility (which became operational in 2006) at the Robles Diversion. It outlines complex operational and flow guidelines to provide for the migration and passage of the endangered southern California steelhead up and down the main stem of the Ventura River and through the diversion during the steelhead migration season, which is between January 1 and June 30. Outside of the migration season, the flow guideline is simpler: a minimum flow of 20 cfs must be released downstream to protect rights of downstream groundwater users.

Robles Diversion Aerial
Photo courtesy of Google Earth

Robles Diversion. The Robles Diversion structure is located 1.5 miles downstream of the confluence of Matilija and North Fork Matilija Creeks, the beginning of the Ventura River. The concrete structure is located on the western bank of the river, and has diversion gates, bypass gates, and a fish ladder. A 350-foot-long by 9.5-foot-high earthen dam is located across the river to divert flows to the diversion structure (Entrix & Woodward Clyde 1997). Both photos were taken during the dry season when no water diversions were occurring.

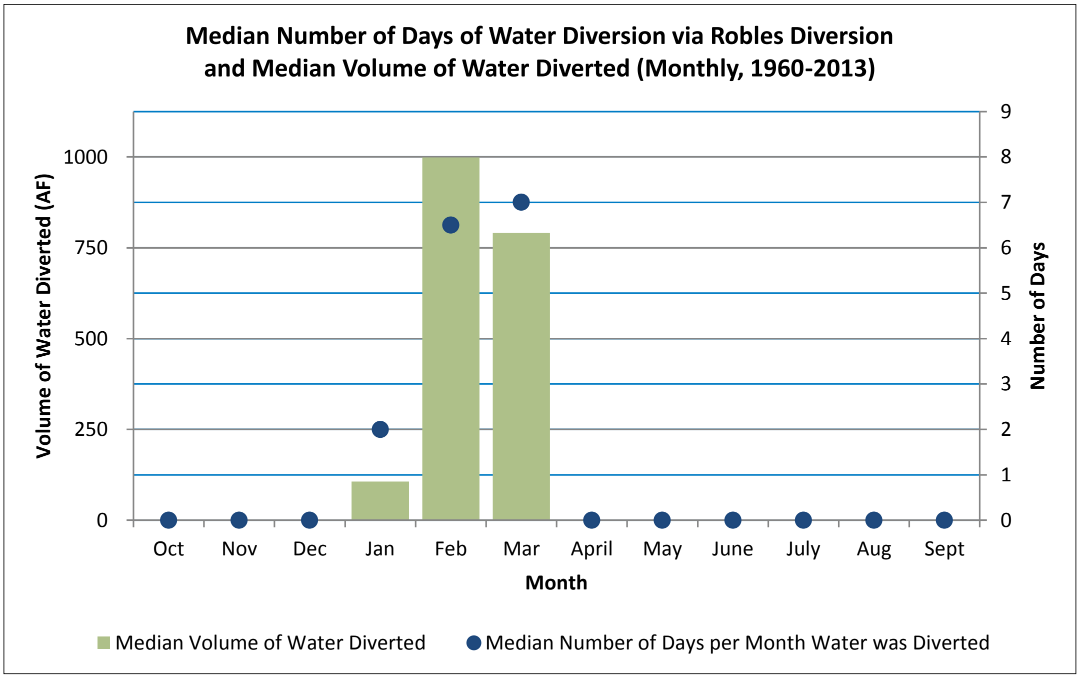


Figure 3.3.1.3.1 Median Number of Days of Water Diversion via Robles Diversion & Median Volume of Water Diverted, Monthly: Water Years 1960–2013

Source: Casitas Municipal Water District (CMWD 2014)

Table 3.3.1.3.2 Diversion via Robles Diversion, Water Years: 1960–2013

Number of Days of Diversion				Volume Diverted (acre-feet per year)			
Annual Average				Annual Average			
Avg.	Median	High (1967)	Low (1990, 1999, 2002, 2007, 2013)	Avg.	Median	High (1969)	Low (1990, 1999, 2002, 2007, 2013)
52	38	198	0	11,376	6,007	50,080	0

Source: Casitas Municipal Water District (CMWD 2014)

Matilija Reservoir and Dam

Matilija Reservoir is an older, smaller reservoir built on Matilija Creek. It was originally built to hold 7,000 AF of water, but is now nearly full of sediment and holds less than 500 AF (USACE 2004b). During the 1950s and 1960s, irrigation water from Matilija Reservoir was delivered by gravity flow to the western Ojai Valley via a pipeline system, called the Matilija Conduit, originating at the face of the dam. In the past, reservoir water was also sometimes released in the winter through a gate valve in the dam to enhance diversions to Lake Casitas via the Robles Diversion; however, this practice was discontinued in 2011 because of regulatory concerns over instream water quality (Evans 2013).

Matilija Dam and Reservoir

A concerted, multi-stakeholder effort to remove Matilija Dam has been underway since 1998 because the reservoir no longer provides a water supply function, blocks the migration of the endangered southern California steelhead and restricts the natural transport of sediment to the Ventura River and coastal beaches. See "3.6.3 Matilija Dam" for a more detailed discussion about the dam.

Foster Park Subsurface Dam and Diversion

In 1906, a subsurface diversion dam was built across the river to enhance the amount of water available for diversion to the City of Ventura.

A small dam also exists in the Ventura River at Foster Park. This is an area of the river that naturally has regular flow, in part because underground geologic structures force subsurface flow to the surface. In 1906, this natural geologic feature was enhanced by construction of a subsurface diversion dam across the river to enhance the amount of water available for diversion to the City of Ventura. The dam crosses the Ventura River as well as the mouth of Coyote Creek (Entrix & Woodward Clyde 1997), and works in combination with subsurface collector pipes.

Foster Park Subsurface Dam and Diversion, August 2013. This photo was taken in August after two dry winters.

The City of Ventura also has a surface diversion in the Ventura River in this area; however, the intake for the surface diversion is located in a part of the river that has been dry since 2000. In addition, the City has four wells, referred to as the Nye well field, located between 1,000 and 2,890 feet north of the subsurface dam (Entrix & Woodward Clyde 1997).

3.3.1.4 Streamflow Monitoring

Streamflow data are regularly monitored in the watershed by the Ventura County Watershed Protection District (VCWPD), the United States Geological Survey (USGS), Casitas Municipal Water District (CMWD), and Santa Barbara Channelkeeper (SBCK). The City of Ventura has also conducted intermittent streamflow monitoring.

The VCWPD and USGS have websites that make these data available to the public.

Streamflow Data Limitations

Streamflow monitoring is subject to a number of data quality challenges and limitations, as described in this excerpt:

Data quality is an important issue for stream gauge records. Many of the streams in the watershed flow through unstable channels that shift dimensions over time and become choked with debris, causing the relationship between measured stage and discharge to change over time. In addition, flood peaks that exceed the range for which velocities have been measured (or those that disable the stage recorder) are often estimated with considerable uncertainty.

—*Data Summary Report, Ventura River Watershed Hydrology Model* (Tetra Tech 2008)

Table 3.3.1.4.1 Streamflow Gauges in the Ventura River Watershed, 2013

VCWPD #	USGS #[1]	Location	Agency[2]	Monitored
603	11114495	Matilija Creek above Matilija Reservoir	USGS (with $ from VCWPD)	Continuous flow
		Matilija Creek at Matilija Hot Springs	CMWD	Continuous flow
602	(11115500)	Matilija Creek at Matilija Hot Springs	VCWPD	Continuous flow
604	(11116000)	North Fork Matilija Creek	VCWPD	Continuous flow
	(11116550)	Ventura River below Robles Diversion (Meiners Oaks)	CMWD	Continuous flow
605	(11117500)	San Antonio Creek at Hwy 33	VCWPD	Continuous flow
		Santa Ana Creek above lake	CMWD	Continuous flow
	(11117600)	Coyote Creek above lake	CMWD	Continuous flow
608	11118500	Ventura River at Foster Park	USGS (with $ from VCWPD & CMWD)	Continuous flow
630		Cañada Larga Creek at Ventura Ave	VCWPD	Storm peak and event data only
631		Fox Canyon Drain below Hwy 150	VCWPD	Continuous flow
633		Happy Valley Drain at Rice Rd	VCWPD	Storm peak and event data only
669		Thacher Creek at Boardman	VCWPD	Event peak and flood warning only
		Robles Diversion Canal, 1 near Diversion; 1 inside park before lake	CMWD	Continuous flow

1: Gauge numbers in parentheses indicate gauges that were historically, but are no longer, monitored by USGS.

Data Source: VCWPD (VCWPD 2014)

2: USGS-United States Geological Survey; CMWD-Casitas Municipal Water District; VCWPD-Ventura County Watershed Protection District

VCWPD Historic Streamflow Data. Data from eight active streamflow monitoring stations (#s 602, 603, 604, 605, 608, 630, 633, and 669) are collected by VCWPD and can be found at www.vcwatershed.net/hydrodata/php/getstations.php?dataset=stream_day. Some VCWPD stream gauges are operated or co-operated by the USGS.

VCWPD Current Streamflow Data. VCWPD also provides current (almost real-time) observed and forecasted streamflow data at a website that is updated every 10 minutes. Website: www.vcwatershed.net/fws/VCAHPS/#.

USGS Historic and Current Streamflow Data: The USGS currently operates two streamflow gauges (#s 11114495 and 11118500) in the watershed. They have also operated gauges at other locations in the watershed in the past. Streamflow data are available in real-time (updated every 15 minutes) or as a daily average of streamflow dating back to the beginning of the period of record. The USGS data can be found at: http://waterdata.usgs.gov/ca/nwis/sw.

CMWD Streamflow Data: CMWD operates five streamflow gauges and helps fund a sixth gauge, as indicated in Table 3.3.1.4.1. Data from the gauges are compiled in the district's annual hydrology report.

Santa Barbara Channelkeeper Streamflow Data: Santa Barbara Channelkeeper's Stream Team has collected estimated streamflow measurements since 2001. From 2001 to November 2006, estimated measurements were made utilizing a "float" method. In December 2006, Stream Team began collecting measurements using electronic current velocity meters. In accordance with an adapted USGS streamflow measurement protocol, flow is estimated based on measurements of the cross-sectional width, velocity, and depth of the stream at several equally spaced intervals along the cross section. Streamflow measurements have been irregularly collected at various Stream Team sites throughout the duration of the program. Channelkeeper maintains its streamflow dataset and makes it available by request to educators, agencies, and the public.

City of Ventura Data: Since 2009 the City of Ventura has conducted intermittent monitoring of groundwater levels and streamflow in the vicinity of the City's wellfield at Foster Park. This monitoring is a part of a Surface/Groundwater Interaction Study that looks at the effect of the City's pumping on flows in the Foster Park Area. In addition, the City has monitored the pools and riffles (shallow areas of a stream where water moves fast enough that it ripples) within the Foster Park reach of the river on several occasions in an attempt to compare changes in flow rates with changes in fish habitat using a Habitat Suitability Index based on 18 variables (indicators) including water temperature, flow velocity, substrate, and shading. These studies are intermittent for the purpose of developing data for CEQA documentation for the installation of additional wells.

3.3.1.5 Key Data and Information Sources/ Further Reading

Below are some of key documents that address surface water hydrology in the watershed. See "4.3 References" for complete reference citations.

HSPF Model

In 2008, under contract from the VCWPD, Tetra Tech completed a hydrologic model for the Ventura River Watershed using the USEPA's Hydrological Simulation Program-Fortran (HSPF). Data integrated into this model include precipitation, evapotranspiration, land use and land cover, soils, slopes and elevations, watershed segmentation, planning and zoning, fire regime, hydrography, channel characteristics, flood elevation modeling (HEC-RAS), reservoir management for Casitas and Matilija, diversion structures, debris and detention basins, groundwater recharge, discharge, and surface water interactions, irrigation, point sources, and stream gauging. While the HSPF model has the ability to account for some aspects of groundwater, groundwater-surface water interactions are a potential source of uncertainty because limited groundwater information was included in the majority of the model runs, and the model has limited capability for groundwater simulation and dynamic exchanges with surface water features. The HSPF model was validated against data from water years 1997–2007. Following the validation, the model was used to perform a natural conditions simulation to determine what the state of water resources in the Ventura River Watershed would be without human influence. The input data and the results of the model runs are listed in several reports:

> Data Summary Report, Ventura River Watershed Hydrology Model (Tetra Tech 2008),
>
> Natural Condition Report, Ventura River Watershed Hydrology Model (Tetra Tech 2009),
>
> Baseline Model Calibration and Validation Report, Ventura River Watershed Hydrology Model (Tetra Tech 2009a).

A Review of the Findings of Santa Barbara Channelkeeper's Ventura Stream Team January 2001–January 2005 (Leydecker & Grabowsky 2006)

Casitas Municipal Water District Hydrology Report, Water Year 2008–2009 (CMWD 2009)

Channel Geomorphology and Stream Processes (Entrix 2001a)

Acronyms

AF—acre-feet

AF/yr—acre-feet per year

BOR—Bureau of Reclamation

cfs—cubic feet per second

CMWD—Casitas Municipal Water District

eWRIMS—Electronic Water Rights Information Management System

HSPF—Hydrological Simulation Program – Fortran

msl—mean sea level

OVSD—Ojai Valley Sanitary District

SBCK—Santa Barbara Channelkeeper

USGS—United States Geological Survey

VCWPD—Ventura County Watershed Protection District

City of Ojai Urban Watershed Assessment and Restoration Plan (Magney 2005)

Design Hydrology Manual (VCWPD 2010a)

Draft Ventura River Habitat Conservation Plan (Entrix & URS 2004)

Historical Ecology of the lower Santa Clara River, Ventura River, and Oxnard Plain: an analysis of terrestrial, riverine, and coastal habitats. (Beller et al. 2011)

Groundwater Budget and Approach to a Groundwater Management Plan Upper and Lower Ventura River Basin (DBS&A 2010)

Hydrologic Assessment San Antonio Creek Sub-Watershed, Ventura County, California (DBS&A 2006)

Hydrology, Hydraulics and Sediment Studies of Alternatives for the Matilija Dam Ecosystem Restoration Project (USBR 2007)

Preliminary Hydrogeological Study, Surface Water/Groundwater Interaction Study, Foster Park (Hopkins 2010)

Report on the Environmental Impacts of the Proposed Agreement Between Casitas Municipal Water District and the City of San Buenaventura for Conjunctive Use of the Ventura River–Casitas Reservoir System (EDAW 1978)

Surface Water-Groundwater Interaction Report for the Ventura River Habitat Conservation Plan (Entrix 2001)

Ventura River Steelhead Restoration and Recovery Plan (Entrix & Woodward Clyde 1997)

Ventura River Watershed Design Storm Modeling Final Report (VCWPD 2010)

3.3.2 Flooding

This section describes the recurring pattern of floods in the Ventura River watershed. The major flood types—riverine, alluvial, coastal, and urban—are defined, and the nature of these floods is described, including the role that the watershed's steep mountains play in the flashy nature of local floods. Coastal floods and erosion, which stem not from fresh water but from saltwater, are also examined. Finally, existing infrastructure and systems that are in place to protect lives and the built environment are reviewed.

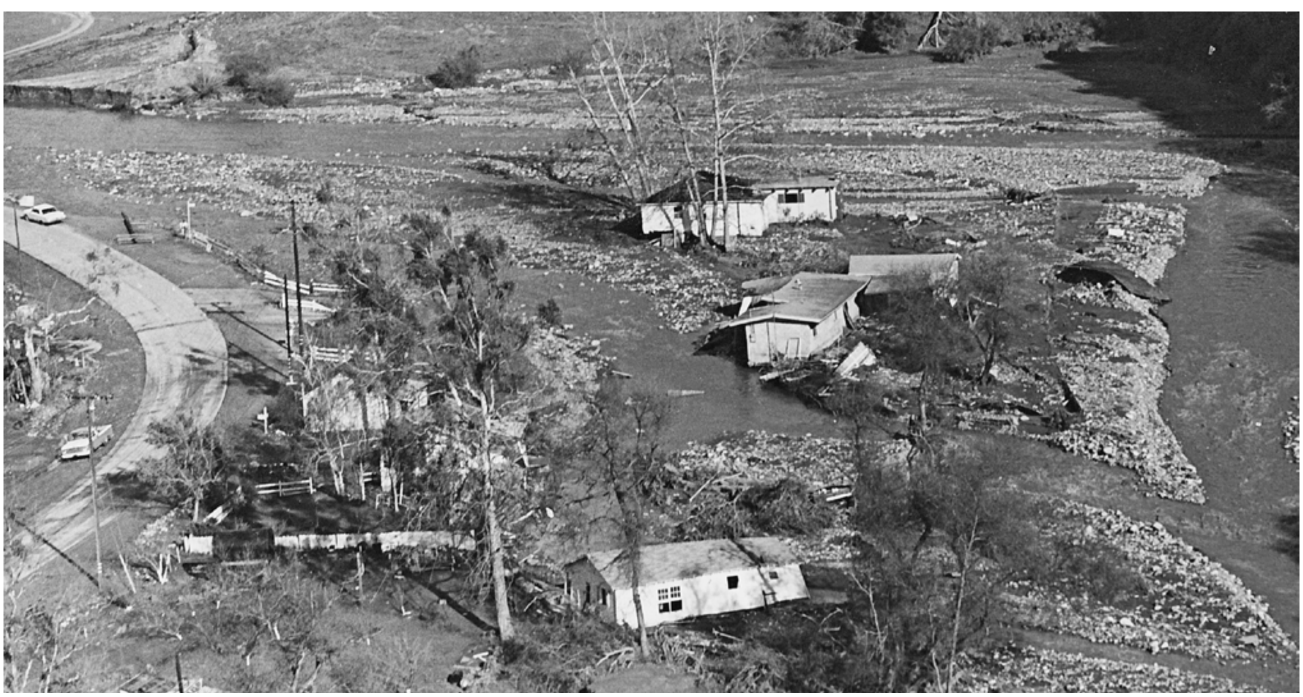
Floodplain Management

Floods are, of course, natural events; it is only human-created infrastructure—either put in the pathway of flood flows or altering flooding conditions—that presents the need to "manage" them. Fortunately, those charged with managing floods are moving beyond simple "flood control" approaches focused strictly on moving water quickly in order to protect human life and property, to a "floodplain management" approach that acknowledges the functions and values of floodplains, such as water infiltration and groundwater recharge, providing critical riverine and aquatic habitats, and naturally attenuating flood flows.

Some flood-related topics are covered in other sections of this report: precipitation in "3.2.1 Climate," topography and well as the flood-related hazards of landslides, debris flows, and liquefaction in "3.2.2 Geology and Soils," and surface water flows in"3.3.1 Surface Water Hydrology."

San Antonio Creek Ranch, 1969 Flood

Photo courtesy of Ventura County Star



3.3.2.1 Flood Frequency and Intensity

Ventura River watershed residents are no strangers to floods. Damaging floods, like droughts, are an unpredictable yet relatively frequent occurrence. What local officials consider "major" floods—peak flows of 40,000 cubic feet per second (cfs) or more (as measured at Foster Park)—have occurred once every 14 years on average since 1933. Some of the watershed's bigger floods are in the "moderate" category, those with peak flows of 20,000 cfs to 39,999 cfs (at Foster Park). Major or moderate flood flows on the Ventura River have occurred once every 5 years on average since 1933. Sometimes multiple peak flow events are seen in the course of one rainy season. Two of the watershed's six major peak flows on record occurred during one wet season: the flood of 1969; of the 18 major and moderate flows on record, three occurred during the winter of 2005.

Major or moderate flood flows on the Ventura River have occurred once every 5 years on average since 1933.

Since 1962, there have been eight Presidentially declared major flood disasters in Ventura County (see Table 3.3.2.1.2). "A Presidential major disaster declaration puts into motion long-term federal recovery programs, some of which are matched by state programs and designed to help disaster victims, businesses and public entities." (FEMA 2014)

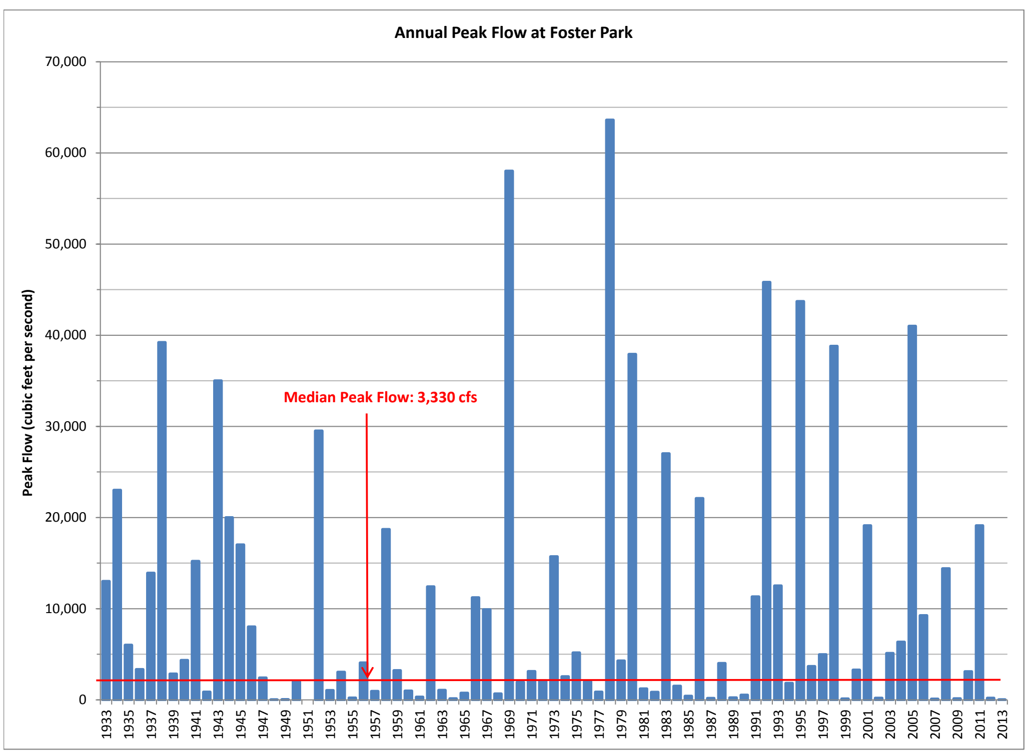


Figure 3.3.2.1.1 Annual Peak Flow at Foster Park, 1933–2013. This graph shows the largest peak flow event for each of the years from 1933 to 2013.

Table 3.3.2.1.1 summarizes significant flood flows since streamflow monitoring began in 1933.

Table 3.3.2.1.1 Ventura River Flood Flows Greater than 15,000 cfs, 1933–2011

Date	Water Year	Peak Flow (cfs)[1]	% Annual Exceedance Probability[2]	Flood Category[3]
1978, February	1978	63,600	1.5%	Major
1969, January	1969	58,000	2.2%	Major
1992, February	1992	45,800	5.2%	Major
1995, January	1995	43,700	6.0%	Major
2005, January	2005	41,000	7.3%	Major
1969, February	1969	40,000	7.8%	Major
1938, March	1938	39,200	8.2%	Moderate
1998, February	1998	38,800	8.5%	Moderate
1980, February	1980	37,900	9.0%	Moderate
1943, January	1943	35,000	11.0%	Moderate
1952, January	1952	29,500	16.1%	Moderate
2005, January	2005	29,400	16.2%	Moderate
1983, March	1983	27,000	19.1%	Moderate
1952, March	1952	24,600	22.5%	Moderate
1934, January	1934	23,000	25.2%	Moderate
1986, February	1986	22,100	26.8%	Moderate
2004, December	2005	20,600	29.7%	Moderate
1944, February	1944	20,000	30.9%	Moderate
2011, March	2011	19,100	32.9%	Flood
2001, March	2001	19,100	32.9%	Flood
2005, February	2005	18,800	33.6%	Flood
1958, April	1958	18,700	33.8%	Flood
1945, February	1945	17,000	38.1%	Action
1969, January	1969	16,600	39.1%	Action
1973, February	1973	15,700	41.6%	Action
1941, March	1941	15,200	43.1%	Action

1: Peak flows are as measured, in cubic feet per second (cfs), at the Foster Park gauging station.

2: The Annual Exceedance Probability (AEP) values indicate the chance that specific flood flows will occur in any one year. A 1% AEP means there is a 1 in 100 chance that a flood will occur in any one year. AEP values are most accurate for the highest flows, but estimates are provided for the lower flows to indicate the general trend. See sidebar definition of 100-year flood and AEP.

3: Flood Category thresholds are different in different parts of the watershed, as determined by Ventura County Watershed Protection District.

Data Sources: Hydrologic Data Server (VCWPD 2013); (VCWPD 2014)

Definitions

100-Year Flood (also called Base Flood)—A misleading term that does NOT mean a flood that will occur once every 100 years. It is a flood whose flow has a 1% chance of being *exceeded* in any given year. A 50-year flood (which has smaller peak flows) has a greater chance, 2%, of being exceeded in any given year; and a 500-year flood (which has greater peak flows) has a lesser chance, 0.2%, of being exceeded in any given year.

1% Annual Exceedance Probability Flood—"Annual Exceedance Probability (AEP) Flood" is the current preferred term, because it describes the probability of specific flood flows occurring, rather suggesting the length of time (years) between floods of specific flows. A 100-year flood could occur more than once in a short period of time.

According to the Federal Emergency Management Agency's (FEMA) statistics, a 100-year flood has a 26% chance of occurring during a 30-year period, which happens to be the length of many mortgages. People living inside of the 100-year, or 1% AEP, flood hazard zone are subject to flood insurance requirements if their mortgage is backed by the federal government through the National Flood Insurance Program (VCWPD 2014; CRS 2013).

The Ventura River's greatest recorded peak flood flow, 63,600 cfs (in February 1978), was the equivalent of a 65-year flood or 1.5% AEP flood (VCWPD 2014). Since streamflow measuring began in 1929, the Ventura River has never experienced a 100-year (1% AEP) flood.

Most of the watershed's major and moderate floods have occurred in January or February, well into the rainy season when soils may have already been saturated and "primed" for runoff.

As described in more detail in "3.3.1 Surface Water Hydrology," streamflows in the watershed are closely correlated with rainfall, and thus flood events are almost exclusively associated with rainfall events. As indicated in Table 3.3.2.1.1, most of the watershed's major and moderate floods have occurred in January or February, well into the rainy season when soils may have already been saturated and "primed" for runoff.

The total amount of rainfall, however, is not the only factor involved; the timing and intensity of the rainfall, the timing and quantity of previous rainfall, soil saturation levels, and the condition of the stream channels, among other factors, also matter. Snowmelt is not a significant contributor to flooding in the Ventura River watershed. The snow that sometimes does fall on the mountains of the watershed generally melts gradually and fairly quickly—not lasting long enough for a warmer storm to cause the fast melting that boosts flood flows.

Table 3.3.2.1.2 Presidentially Declared Major Flood Disasters in Ventura County[1]

1962, February (Kennedy)
1965, November–December (Johnson)
1967, November–December (Johnson)
1969, January (Nixon)
1983, February–March (Reagan)
1992, February (Bush)
1995, January–March (Clinton)
2005, January (Bush)

1: The Presidents declaring the disaster are shown in parenthesis.

Data Source: Flood Histories of the Counties in the Alluvial Fan Task Force Study Area (Earp 2007)

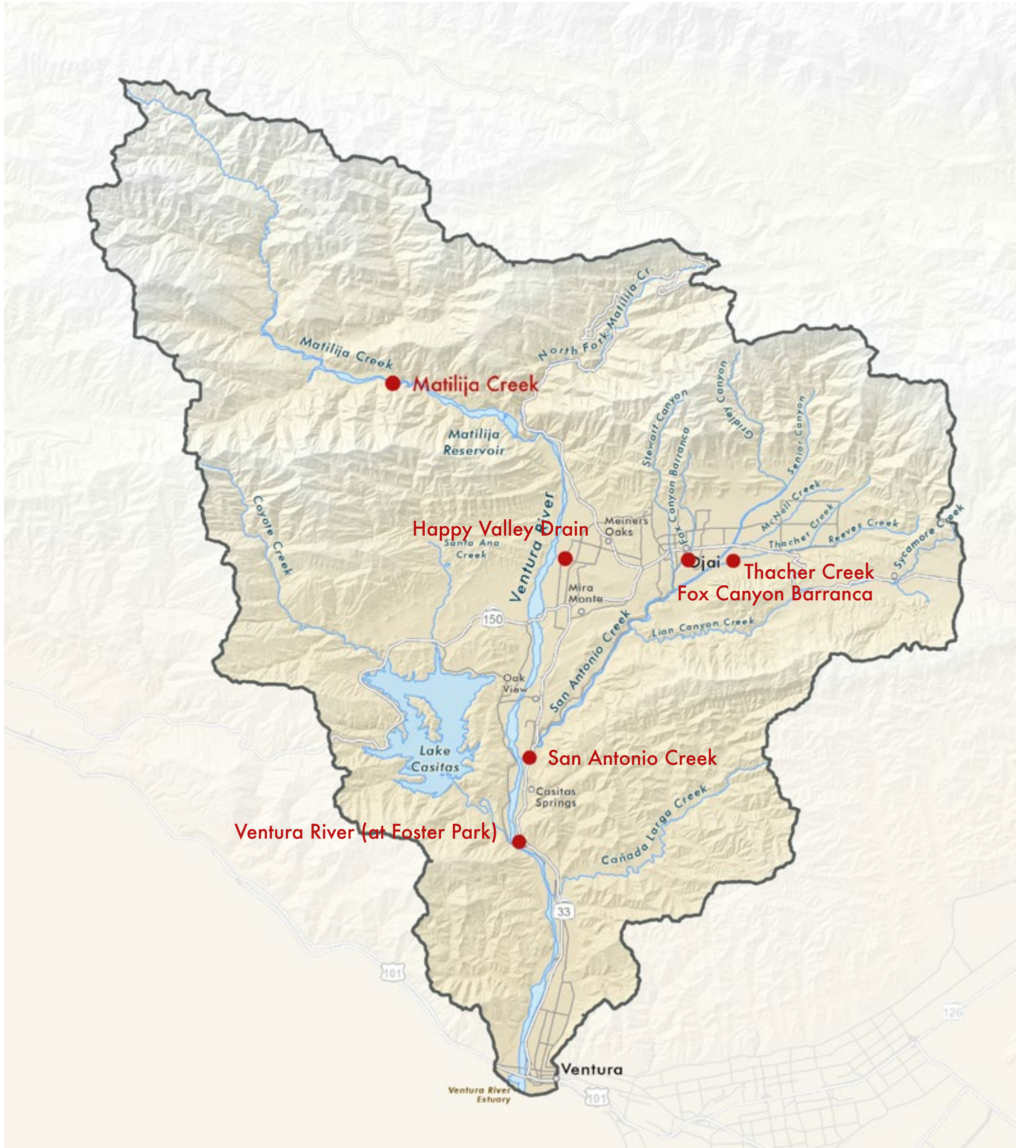


Figure 3.3.2.1.2 Select Flow Monitoring Locations Map. This map of select streamflow monitoring locations accompanies Table 3.3.2.1.3.

Table 3.3.2.1.3 Flood Flows (cfs) by Flood Category on Various Drainages

Drainage Location[1]	Major	Moderate	Flood	Action
Matilija Creek (above Matilija Dam)	9,000	8,000	7,000	6,000
Ventura River (at Foster Park)	40,000	20,000	18,000	15,000
Thacher Creek (at Boardman)	5,500	5,000	4,000	3,000
Fox Canyon Barranca (at Athletic Club)	2,050	1,950	1,900	1,700
Happy Valley Drain (at Rice Rd.)	2,000	1,900	1,700	1,500
San Antonio Creek (near confluence with Ventura River)	10,000	9,000	8,000	6,000

1: See Figure 3.3.2.1.2 for a map of these locations.

The flow, in cubic feet per second (cfs), that is considered "major," "moderate," or "minor" is different for different streams and different sections of the river. On San Antonio Creek, for example, a flow of 10,000 cfs or higher at the creek's confluence with the Ventura River indicates a major flood, whereas on the Ventura River, a flow of 40,000 cfs or higher (at Foster Park) is considered a major flood.

Data Source: VCWPD Google Maps Interface for rainfall, stream, and evaporation stations (www.vcwatershed.net/fws/VCAHPS/#)

San Antonio Creek Flood Flows

Major floods along San Antonio Creek are described as having a peak discharge greater than 10,000 cfs. The most severe flood on record on San Antonio Creek occurred in 2005, with a peak flow of 24,000 cfs recorded at the gauging station on San Antonio Creek at Casitas Springs (VCWPD 2013c).

As discussed later in this section, coastal flooding, caused by ocean water tide and wave inundation, often occurs when riverine flooding occurs, but can also occur independently of inland flooding. Table 3.3.2.1.4 summarizes past coastal floods in the watershed.

Table 3.3.2.1.4 Significant Coastal Floods in the Watershed

1907, December
1939, September
1969, December
1977–78, Winter
1982–83, Winter
1988, January
1997–98, Winter
2010, January

Data Source: Ventura County Open Pacific Coast Study (FEMA 2011)

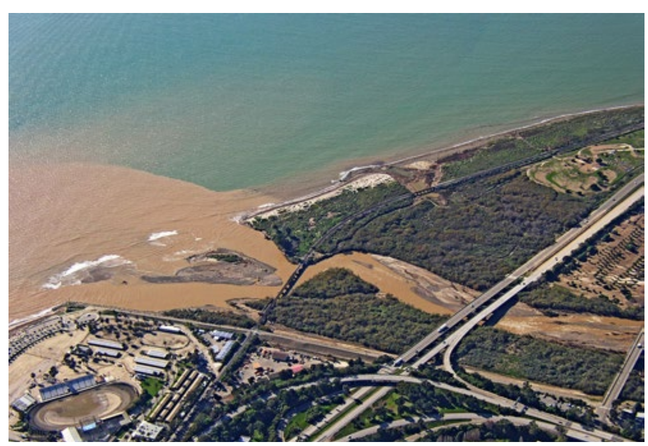
Of Water and Sediment

Flooding in the Ventura River watershed is as much about sediment and boulders as it is about water. The erosive rocks of the Transverse Ranges supply a steady stream of boulders and sediment, easily eroded in the intense downpours that occur in the watershed's upper elevations. When a flood is rolling down the river valley, the chocolate brown flow is thick with rocks, sediment, and other debris, and residents report the sound of thunder as boulders crash downstream.

Debris from the river's flood flows is carried out to sea or gets deposited along the way, typically in wider and flatter areas of the river channel. Piled-up debris can also create islands in the river or change the path of the river altogether. This topic is discussed further in "3.2.3 Geomorphology and Sediment Transport."

Thacher Creek in Siete Robles Neighborhood, 2005 Flood

Photo courtesy of Ventura County Watershed Protection District



Sediment Flowing Out to Sea, 2005 Flood

Photo copyright David L. Magney

3.3.2.2 Flood Hazard Zones

The Federal Emergency Management Agency (FEMA) manages the National Flood Insurance Program. As part of that program FEMA creates and updates flood hazard maps, called Flood Insurance Rate Maps (or FIRM), for communities across the country. These maps indicate areas where there is a 1% or greater probability of inundation by flood flows in any year, now called a "1% annual exceedance probability (AEP) flood" (formerly referred to as the 100-year flood).

Homes and buildings in areas mapped as having a 1% AEP are considered at high risk for floods and are required to have flood insurance if they have mortgages from federally regulated or insured lenders. These areas have a 1% or greater chance of flooding in any given year, which is equivalent to a 26% chance of flooding during a 30-year mortgage period (FEMA 2013).

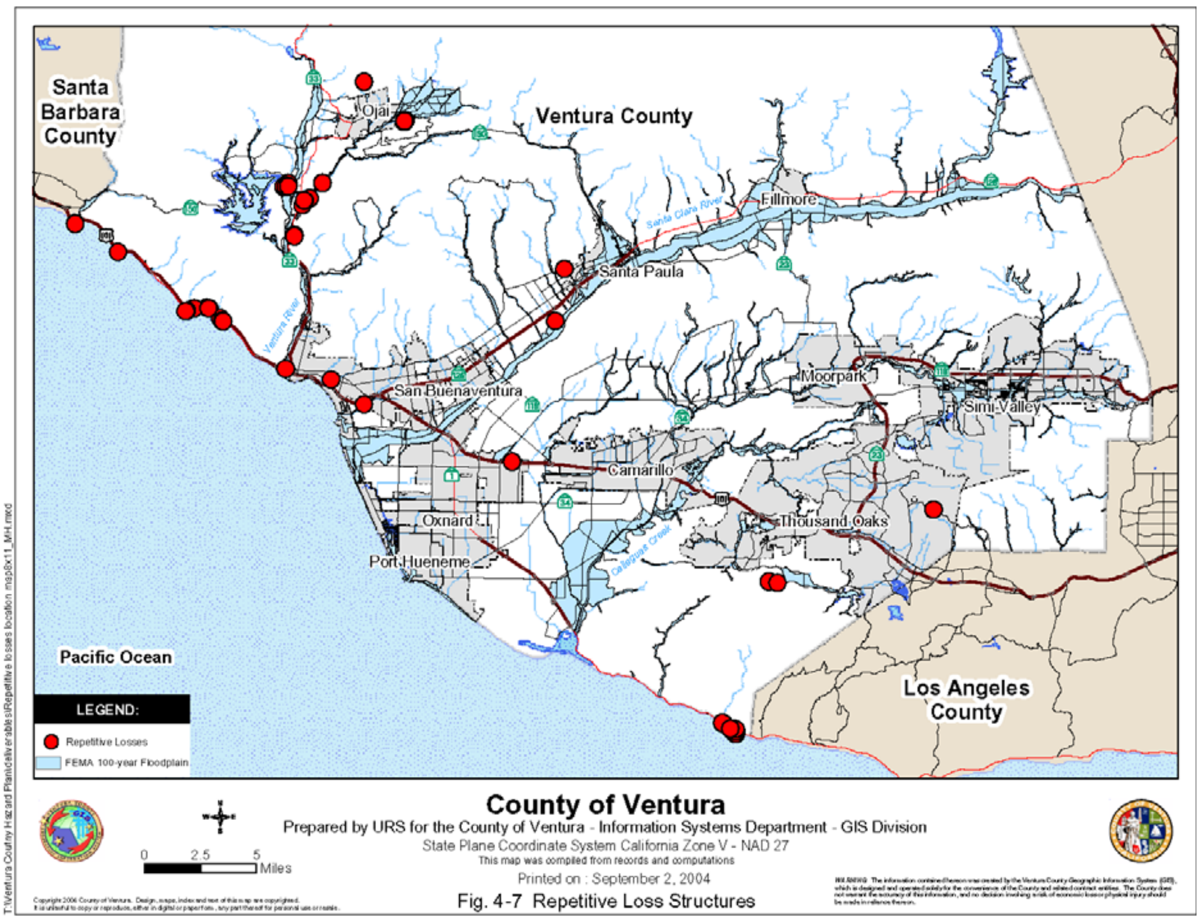


Figure 3.3.2.2.1 Repetitive Loss Structures Map. Repetitive loss structures are buildings identified by FEMA that, since 1978 and regardless of any change(s) of ownership during that period, have experienced one of the following: 1) four or more paid flood losses of more than $1,000 each; 2) two paid flood losses within a 10-year period that, in the aggregate, equal or exceed the current value of the insured property; and 3) three or more paid losses that, in the aggregate, equal or exceed the current value of the insured property (URS 2005). Of the 49 repetitive loss structures in Ventura County (as of 2004), 19 (39%) are located in the Ventura River watershed. Because of the high incidence of repetitive loss claims, FEMA has been working to reduce the losses experienced by repetitively flooded properties.

Source: VCWPD 2014e