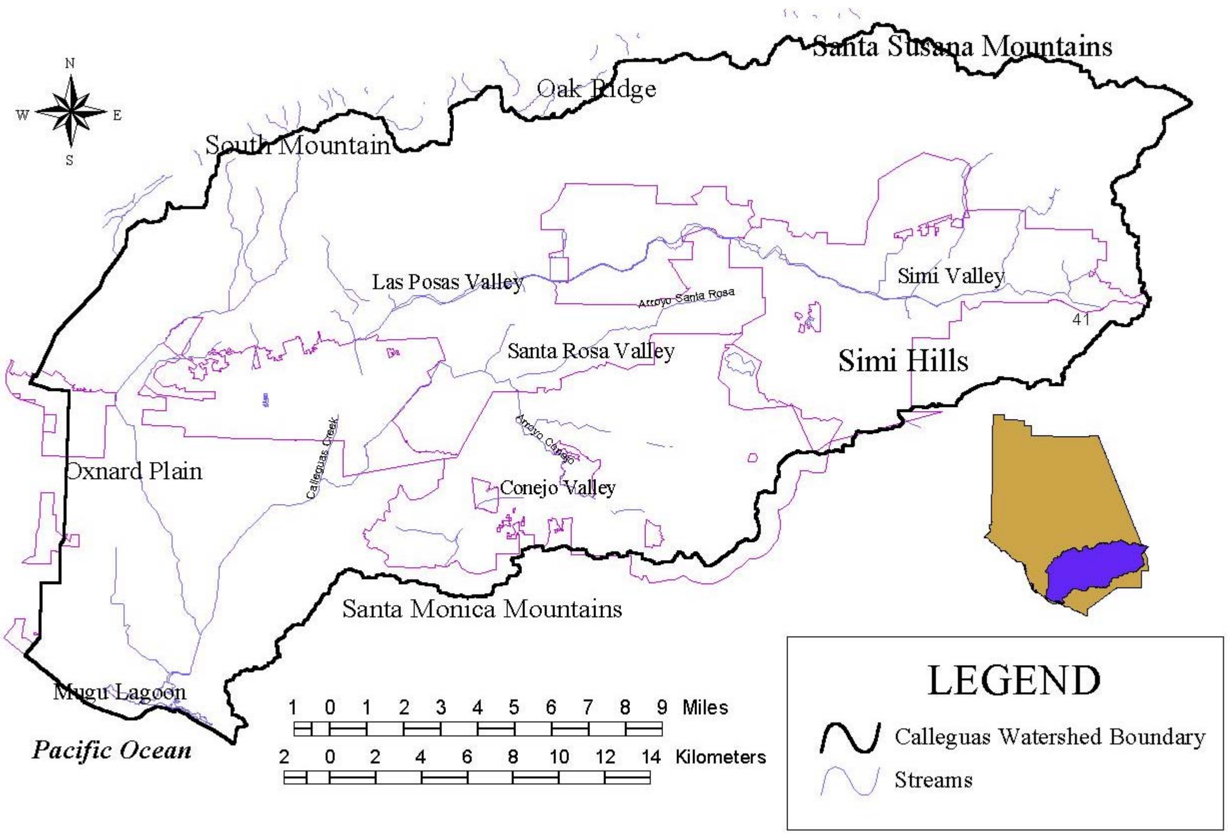
David Magney Environmental Consulting

CALLEGUAS CREEK WATERSHED WETLAND RESTORATION PLAN



Prepared for:

CALIFORNIA STATE COASTAL CONSERVANCY

AND

U.S. ENVIRONMENTAL PROTECTION AGENCY

October 2000

Calleguas Creek Watershed Wetland Restoration Plan

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INTRODUCTION

This report was prepared pursuant to a wetlands restoration grant issued by the United States (U.S.) Environmental Protection Agency (EPA) to the California State Coastal Conservancy (Coastal Conservancy) for watershed restoration planning. The Coastal Conservancy hired David Magney Environmental Consulting (DMEC) through a competitive bidding process to prepare a wetlands restoration plan for the Calleguas Creek Watershed.

BACKGROUND

The Calleguas Creek Watershed historically contained an extensive riverine wetland system, culminating in a highly productive and regionally important estuary at Mugu Lagoon. Since European settlement of the region, the wetlands have been largely confined to narrow and incised channels, with adjacent wetlands eliminated and replaced with croplands and development.

Resources agencies, including the U.S. EPA, U.S. Army Corps of Engineers (Corps), U.S. Fish and Wildlife Service (USFWS), California Department of Fish and Game (CDFG), California Coastal Commission, Coastal Conservancy, National Park Service, Los Angeles Regional Water Quality Control Board, and regional and local governments, and nonprofit conservation organizations (California Native Plant Society [CNPS], Surfrider Foundation, Environmental Defense Center, League of Woman Voters, and others) have all expressed concerns about a large number of wetland-related problems associated with the loss and degradation of the region's wetlands. The Coastal Conservancy is particularly concerned with sedimentation and degradation of the Mugu Lagoon and the loss of riparian plant and wildlife habitat throughout the watershed.

Primarily concerned with water quality degradation and regulatory constrains, as well as a general degradation of the human and natural environment, a large number of interested parties formed an informal group, known as the Calleguas Creek Watershed Management Plan Committee, to develop a strategic management plan for the Calleguas Creek watershed. This committee, made up of many different stakeholders, is committed to develop a comprehensive management plan addressing many of the environmental and development issues of concern in the watershed.

Sedimentation, erosion, flood control, water quality, and habitat are several of the biggest issue areas for which the Committee wishes to resolve, which directly relates to many functions wetlands provide, or can provide. The relationship between sedimentation, erosion, and flood control was addressed in a 1994 report, funded by the Coastal Conservancy and conducted by Natural Resources Conservation Service (NRCS) in Somis, which focused on erosion and sedimentation.

The EPA, as part of its wetlands program, is interested in characterizing and restoring wetlands in a watershed perspective, and issues grants to state and local agencies to assess and implement wetland restoration projects.

PROBLEM STATEMENT

Comparable to elsewhere in California, over 90 percent of the wetlands in the Calleguas Creek watershed have been destroyed or significantly impacted since colonization by European settlement (1780s-1980s) (Dahl and Johnson 1989, Dahl 1990). Most of the losses of wetland habitats within the watershed have occurred during the last 50 years.

Current city general plans for the watershed call for approximately two times as much urban land use in the next ten years. Future development activities will result in further direct wetland losses and erosion downstream unless development is set back far enough from streams and arroyos, carefully sited, and specifically designed to retain or appropriately direct and control runoff. The Ventura County general plan (for the unincorporated portions of the County) contains policies that recognize the importance and significance of riparian wetland habitats, with restrictions on activities within 30 m (100 ft.) from riparian areas for discretionary projects; however, ministerial projects have no such protection policies, except what may be regulated by other agencies.

Along with the loss of wetlands, many of the functions provided by wetlands have also been lost, leading to an overall degradation of the environment, including adjacent upland habitats. The drastic changes and reduction in wetlands in the watershed have resulted significant increases in erosion, sedimentation, and flooding problems, and significantly reduced wildlife and native plant habitats, water supply, and water quality.

Effects of Wetland Losses

Wetlands provide many functions to the natural and human landscape (EPA 1995, USFWS 1991, Brinson et al. 1995). Modifying or impacting wetlands and floodplains result in direct and indirect reductions of wetland functions, which often adversely affect the human environment (EPA 1995, Brinson et al. 1995). Effects of wetland losses include:

- Reducing biodiversity, resulting in lower species richness and decreased wildlife habitat function;
- Increasing erosion of remnant habitats that are not completely established prior to any disturbance;
- Flooding and erosion of farmland;
- Flooding and destruction of roads, bridges, and building;
- Lowering water quality generally, via decreased pollutant attenuation; and
- Reducing water supply.

Each of these affects have economic consequences that could be cumulatively significant to Ventura County, from agricultural losses and public works costs, to reduced tourism. For example, as flood peaks increase in frequency and height, adjacent lands are more frequently flooded. Some of these lands contain high-value crops. Other lands adjacent to Calleguas Creek and its tributaries contain residences and commercial or industrial facilities. Significant amounts of farmland is damaged or lost as a result of flooding, sedimentation, or erosion in the Calleguas Creek watershed. Because more and more of the watershed is being paved over to accommodate development, flood control facilities are often incapable of carrying an ever-increasing amount of runoff. Constructing larger flood control facilities, and maintaining them, is extremely expensive and a never-ending battle (McPhee 1989). The end result is a loss of wetland habitats and functions, as well as expensive infrastructure and maintenance costs born by the taxpayer.

OBJECTIVES

The overall goal of the EPA and Coastal Conservancy for the Calleguas Creek Watershed Wetlands Restoration project is to preserve, maintain, restore, and improve wetland functions. The primary objectives to achieve this goal are to:

- characterize and understand the state of the wetland functions in the watershed;
- identify suitable and specific restoration sites, which will generally, and locally, have the greatest benefit to wetland functions for an overall improvement in wetland habitats throughout the watershed.

A secondary objective is to provide a basis for a regional wetland functions model, which could be developed in a subsequent phase. This report proposes specific restoration activities at several sites within the watershed, each of which would improve wetland functions over existing conditions if implemented.

WATERSHED CHARACTERIZATION

This section provides a characterization of the conditions of the physical and biotic environmental conditions, as it relates to wetland restoration, of the Calleguas Creek watershed.

GENERAL WATERSHED DESCRIPTION

Physiography

The Calleguas Creek Watershed is located in coastal southern California, primarily in Ventura County, with the easternmost end of the watershed in western Los Angeles County. The watershed is surrounded by rugged mountainous terrain that reaches a maximum elevation of 1,128 meters [m] (3,700 feet [ft]) in the northeast in the Santa Susana Mountains. The watershed is part of the Transverse Range geomorphic province in which major geologic structures trend east-west. Thus, major drainages and associated alluvial valleys trend east-west, except on the delta plain where major drainages trend north-south prior to discharging to Mugu Lagoon.

The east-west trending Transverse Ranges is atypical of nearly all mountain ranges (and intervening valleys) in the United States, hence the name "Transverse Ranges". The orientation of the mountains and valleys, relative to the prevailing winds, has a significant affect on the local climate.

The watershed is approximately 48 kilometers [km] (30 miles) long and 22.4 km (14 miles) wide with a drainage area of approximately 550 square (sq.) km (344 sq. miles) (Figure 1, General Location and Physiography of the Calleguas Creek Watershed). Currently, surface water flow is discharged to Mugu Lagoon through Calleguas Creek, which drains approximately 422 sq. km (264 sq. miles), Revolon Slough, which drains approximately 94 sq. km (59 sq. miles), and the southwestern Oxnard Plain, which drains approximately 34 sq. km (21 sq. miles).

Geology

The mountainous terrain comprises various hard and soft sedimentary deposits primarily of marine origin along with some igneous deposits (Figure 2, Geologic Map of the Calleguas Creek Watershed) (Fall 1981). Sedimentary formations exposed at the surface dominate the watershed, most of which are relatively young from the Tertiary Era.

The oldest sedimentary formation in the watershed is the Chatsworth Formation, consisting predominantly of marine sandstones of the Cretaceous Era. The Chatsworth Formation is the primary formation of the Simi Hills, extending into the Santa Susana Mountains, with a few outcrops in the Santa Monica Mountains. Other sedimentary rock formations in the watershed include the Pico, Pio, Mugu, San Pedro, and Santa Barbara Formations, and Quarternary alluvial deposits and landslides.

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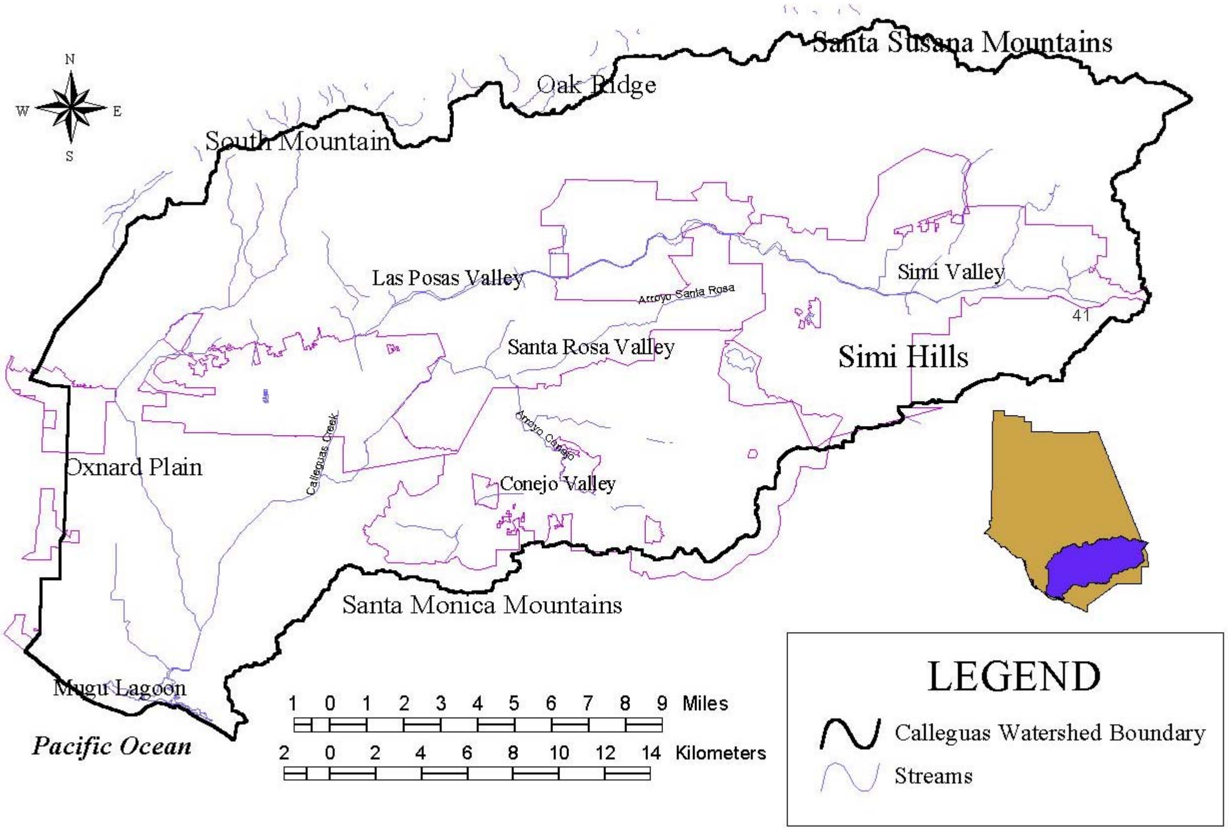
Figure 1. General Location and Physiography of the Calleguas Creek Watershed



Tectonic activity has uplifted the terrain by as much as 76 centimeters [cm] (2.5 ft) per century, while erosion has denuded the terrain by as much as 23 cm (0.75 ft) per century (Scott and Williams 1978). The Calleguas Creek Watershed has one of the lowest sediment yields of the Transverse Range watersheds (Table 1, Sediment Yields of Selected California Watersheds) (Brown and Thorpe 1947, Scott and Williams 1978, Larson and Sidle 1980, Taylor 1983).

Nevertheless, the topographic rejuvenation through tectonic uplift and the prevalence of highly erodable sedimentary deposits have maintained conditions conducive to reasonably high rates of erosion and sediment yield. This is evident when sediment yields of Calleguas Creek are compared to sediment yields of selected rivers in California (Table 1). The Calleguas Creek Watershed sediments are found throughout the alluvial valleys, the delta plain, and the near shore system (Scott and Williams 1978, USDA-NRCS 1995).

Figure 2. Geologic Map of the Calleguas Creek Watershed

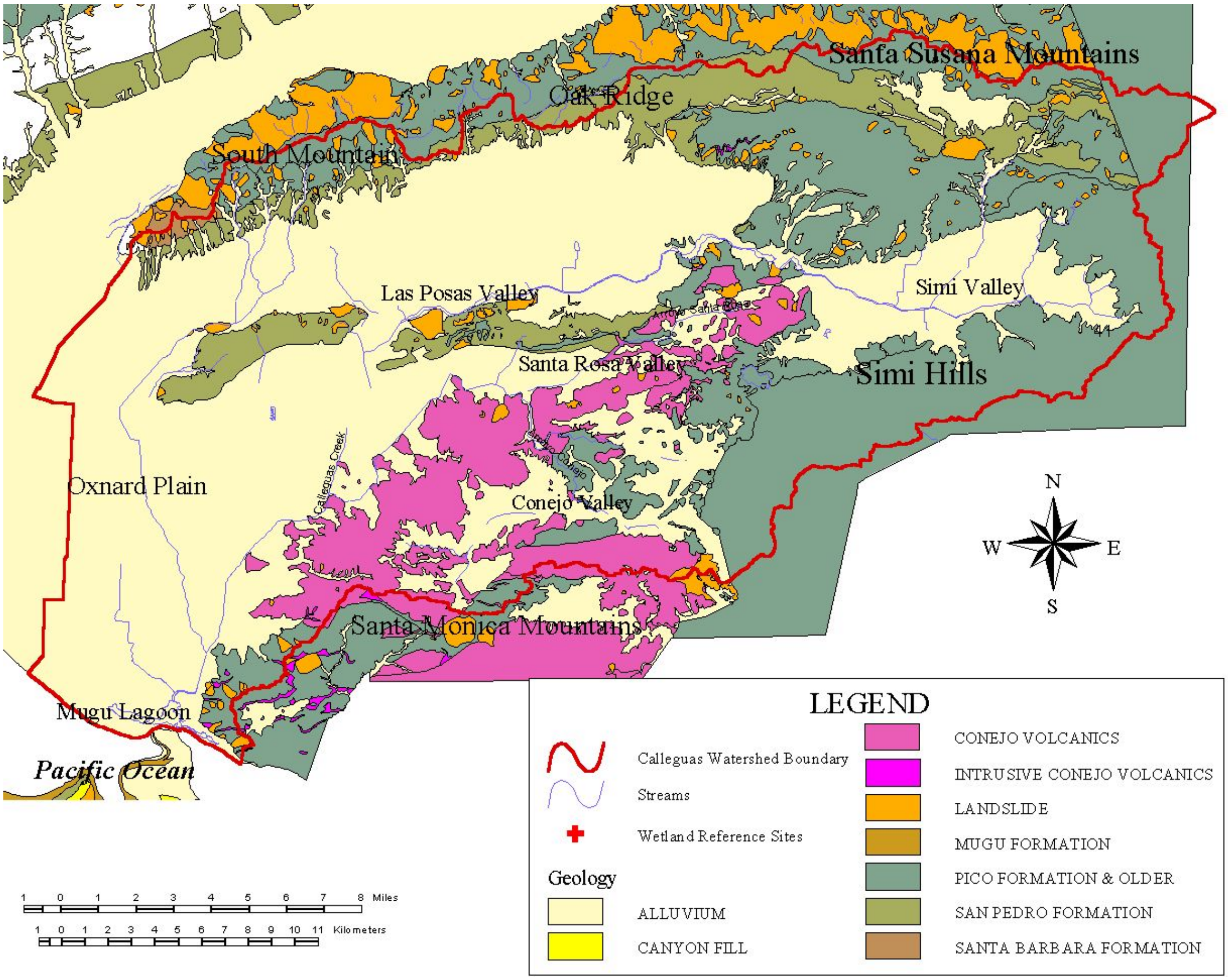


Table 1. Sediment Yields of Selected California Watersheds

Watershed	Total Annual Sediment Yield (tons y⁻)	Annual Sediment Yield per Square Mile (tons mi^{-2} y^{-})
Ventura River near the Pacific Ocean[1]	925,600	4100
Santa Clara River near the Pacific Ocean[1]	3,712,800	2300
Calleguas Creek near the Pacific Ocean[1]	259,000	800
Eel River near the Pacific Ocean[2]	31,248,300	10,000
Little Stony Creek at East Park Reservoir[3]	22,800	250

Watershed	Total Annual Sediment Yield (tons y^{-})	Annual Sediment Yield per Square Mile (tons mi^{-2} y^{-})
Stony Creek at Stony Gorge Reservoir[3]	45,600	250
Tuolumne at Don Pedro Reservoir[4]	281,600	300

[1] South Flank Transverse Ranges
[2] West Flank North Coast Ranges
[3] East Flank North Coast Ranges
[4] West Flank Sierra Nevada

The delta plain and the alluvial valleys have gone through periods of cutting and filling with rates of filling reaching 1.8 m (6 ft.) per century on the delta plain (USDA-NRCS 1995). The most recent sea level lowstand occurred during the late Pleistocene, approximately 18,000 years before present. During this period, streams were incised in valleys on the delta plain and it is likely that Calleguas Creek was connected to the Mugu Submarine Canyon. Sea level has risen steadily for the last 18,000 years, and incised stream valleys were filled and sediments deposited on the delta plain surface (Muto 1987, Muto and Blum 1989).

By the late 19th Century, streams were distributary in nature and, quite possibly, did not flow to the ocean except during extreme events. Instead, surface water recharged aquifers underlying the delta plain and sediment was deposited throughout the delta plain. The depths of the delta plain deposits have been increased through fore arc basin subsidence. As the hinterland was uplifted, the fore arc basin (e.g. the delta plain and continental shelf) subsided. A hinge point is likely somewhere around U.S. 101, where the hinterlands above uplifted and the fore arc basin below subsided.

It is not known to what extent this sea level-tectonic control model of downcutting and filling applies to the alluvial valleys in the upper watershed. It is probable that periods of downcutting and filling were translated far into the upper watershed as stream base profiles adjusted to increasingly lower or higher sea levels (Miall 1996, Quirk 1996). However, streams can accommodate subtle or slow changes in sea level by adjusting channel morphology, particularly sinuosity and slope (Schumm 1993, Ethridge et al. 1998). Additionally, variations in the discharge:sediment supply ratio become increasingly important in stream downcutting and filling sequences with distance from the sea shore, so climate changes and tectonism may have played more prominent roles in alluvial valley down cutting and filling sequences in the hinterlands (see review of Lane 1954 in Bull 1991). Regardless, the stratigraphic architectures of the alluvial valleys of the upper watershed are characterized by complex down cutting and filling sequence deposits.

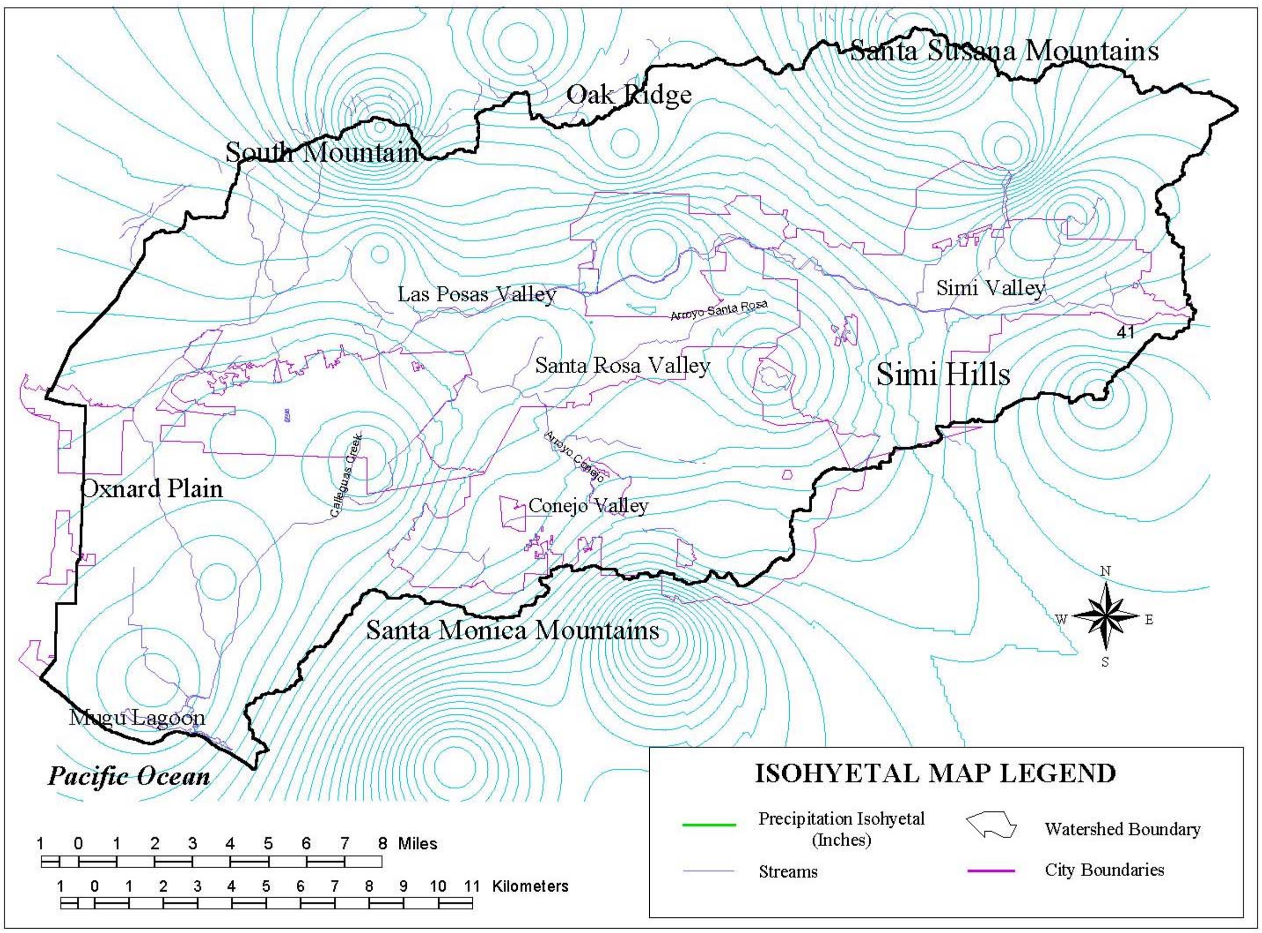
Climate

The climate is Mediterranean, with warm, dry summers and mild, wet winters. Mean annual precipitation ranges from approximately 305 mm (12 inches) on the lower delta plain to approximately 533 mm (21 inches) in the mountainous terrain. Precipitation patterns in the Calleguas Creek Watershed follow those elsewhere in the Transverse Ranges, with a general trend of increased precipitation along and elevational and eastward gradient, with bulbs of lower precipitation extending into the lowland areas of the valleys (Figure 3, Isohytel Map of Calleguas

Creek Watershed). In most years, precipitation is entirely rainfall. Approximately 85 percent of the precipitation falls from November to March.

Temperatures and temperature ranges are moderate. Thus, the growing season, as defined for agricultural crops, is approximately 350 days at the lower elevations and 300 days at the higher elevations in the watershed (Edwards et al. 1970). However, this method for determining growing season is not accurate for determining the growing season in wetlands, which requires that the lower soil temperature limit, at 20 inches, be at or below biologic zero (40°F). Since the soils in the Calleguas Creek watershed never drop below biologic zero, the growing season should be considered to be year-round (365 days) (Magney 1993).

Figure 3. Isohyetal Map of Calleguas Creek Watershed



Hydrology

SURFACE WATER

The Natural Resources Conservation Service (NRCS) has stratified the Calleguas Creek Watershed into 37 subwatersheds (USDA-NRCS 1995) which can be grouped into four primary subwatersheds that vary in physiography, land use, and discharge characteristics (Table 2, Primary Subwatersheds in the Calleguas Creek Watershed).

Table 2. Primary Subwatersheds in the Calleguas Creek Watershed

Subwatershed	Area (sq. mi.)	Primary Drainages
Calleguas Creek	218.0	Arroyo Simi, Arroyo Las Posas, Arroyo Santa Rosa, Arroyo Conejo, Calleguas Creek
Arroyo Conejo	45.7	Arroyo Conejo
Revolon Slough	59.4	Beardsley Wash, Revolon Slough
SW Oxnard Plain	20.6	Surface and shallow subsurface drainage to Mugu Lagoon and the Pacific Ocean

The Calleguas Creek Subwatershed is approximately 348.8 sq. km (218.0 sq. miles), draining the Simi Valley, Moorpark, Somis, eastern Camarillo, and eastern Oxnard Plain areas. The Arroyo Conejo Subwatershed is substantially smaller, comprising approximately 73.1 sq. km (45.7 sq. miles) and draining the Thousand Oaks area. However, gage records indicate that most of the Calleguas Creek flood flows, as measured at Lewis Road, come from the Arroyo Conejo Subwatershed. The gage on Calleguas Creek at CSU Channel Islands measures discharge for a watershed area of 396.8 sq. km (248 sq. miles) and includes the 102.7 sq. km (64.2 sq miles) measured by the gage on Arroyo Conejo above U.S. 101.

Note that much of the discharge, measured by the gage on Calleguas Creek at CSU Channel Islands, can be accounted for by discharge measured by the gage on Arroyo Conejo above U.S. 101 (Figure 4, Flood Frequency from the Annual Maximum Series at Four Locations in the Calleguas Creek Watershed; Figure 5, Flood Frequency from the Annual Maximum Series at Calleguas Creek at California State University [CSU] Channel Islands [1969-1982]; Figure 6, Flood Frequency from the Annual Maximum Series at Arroyo Conejo above U.S. 101 [1973-1983]; Figure 7, Flood Frequency from the Annual Maximum Series at Arroyo Simi near Simi Valley [1933-1983]; Figure 8, Flood Frequency from the Annual Maximum Series at Calleguas Creek at Camarillo [1955-1958]; and Figure 9, Flow Duration Curve from Average Daily Discharge at Calleguas Creek at CSU Channel Islands [1969-1982] and Arroyo Conejo above U.S. 101 [1973-1983]).

The Calleguas Creek Subwatershed has large areas of undeveloped upper watershed and large groundwater recharge zones in broad, alluvial valleys (Izbicki and Martin 1997). The Arroyo

Conejo Subwatershed is largely developed and lacks the broad, alluvial valleys that provide for flood plain storage and groundwater recharge. These characteristics may contribute to the observed discharge patterns.

The flow duration curve for Arroyo Simi (1933-1983) indicates that discharge is less than 0.02832 cubic meters per second [cms] (1 cubic feet per second [cfs]) for approximately 80 percent of the year. However, the flow duration curve for Arroyo Simi under recent development conditions (1970-1983) shows that discharge is less than 1 cfs for approximately 35 percent of the year (Figure 10, Flow Duration Curve from Average Daily Discharge at Arroyo Simi near Simi Valley [1970-1983 and 1933-1983]). The precise sources of these increased base flows (i.e. nuisance flows) are unclear, but water treatment discharge, reservoir discharge, irrigation return flow, and general urban water discharge (e.g. lawn and garden irrigation return flow) all likely contribute to nuisance flows in the Calleguas Creek Watershed. The net result is that many streams currently flow for longer durations than under historical conditions, particularly in the lower reaches of the watershed.

Although the Arroyo Conejo Subwatershed provides a disproportionate amount of the flood flows, it is the Calleguas Creek and Revolon Slough Subwatersheds that provide disproportionate amounts of the sediment. The USDA-NRCS (1995) designated 11 of the 37 subwatersheds as priority subwatersheds for sediment control treatment. Ten of these subwatersheds are located in the Calleguas Creek Subwatershed, and the other is located in the Revolon Slough Subwatershed.

Figure 4. Flood Frequency from the Annual Maximum Series at Four Locations in the Calleguas Creek Watershed

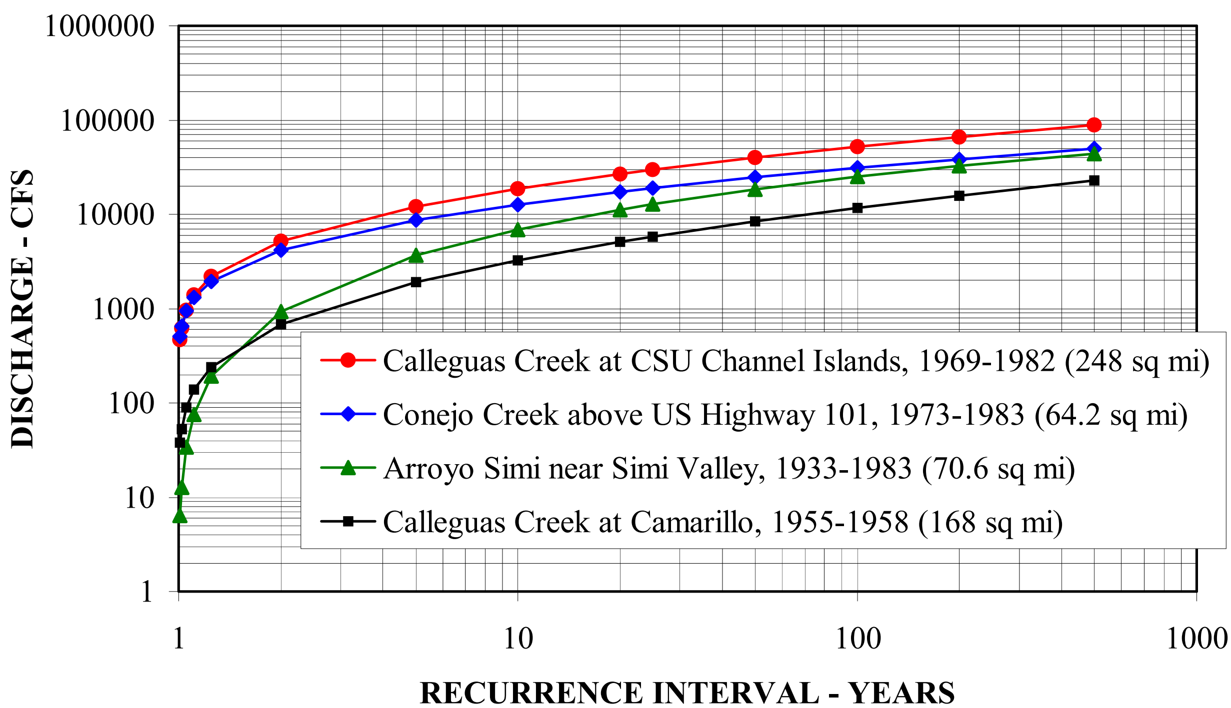


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Figure 5. Flood Frequency from the Annual Maximum Series at Calleguas Creek at California State University (CSU) Channel Islands (1969-1982)

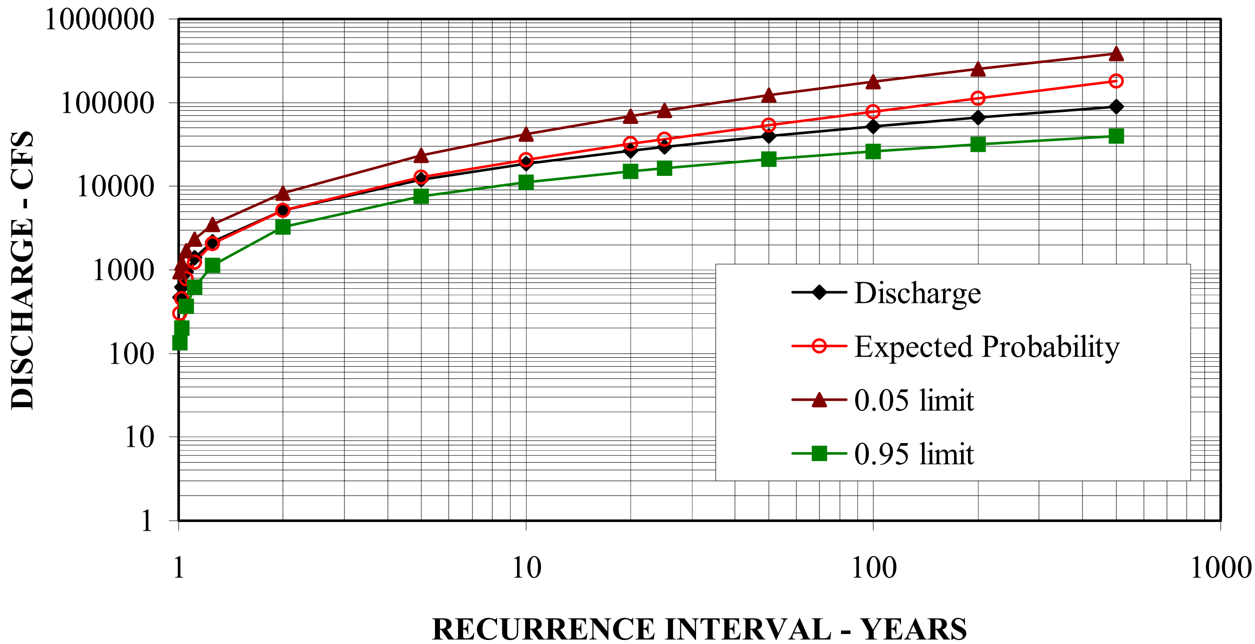


Figure 6. Flood Frequency from the Annual Maximum Series at Arroyo Conejo above U.S. 101 (1973-1983)

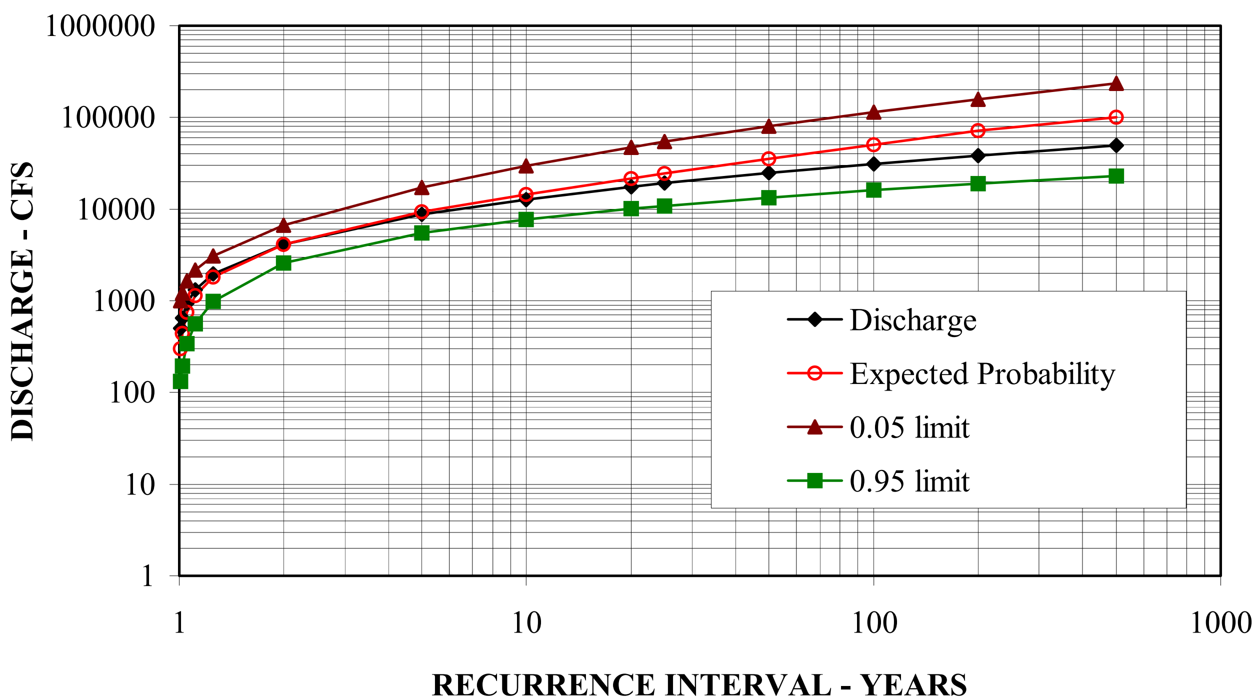


Figure 7. Flood Frequency from the Annual Maximum Series at Arroyo Simi near Simi Valley (1933-1983)

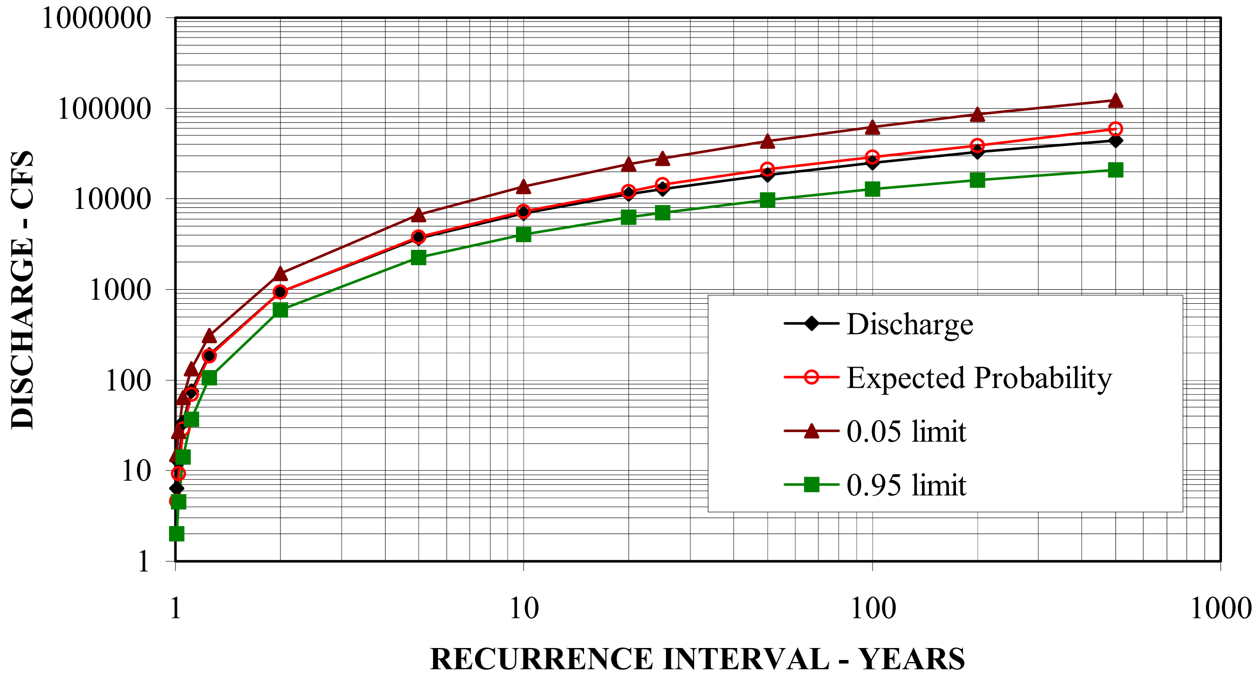


Figure 8. Flood Frequency from the Annual Maximum Series at Calleguas Creek at Camarillo (1955-1958)

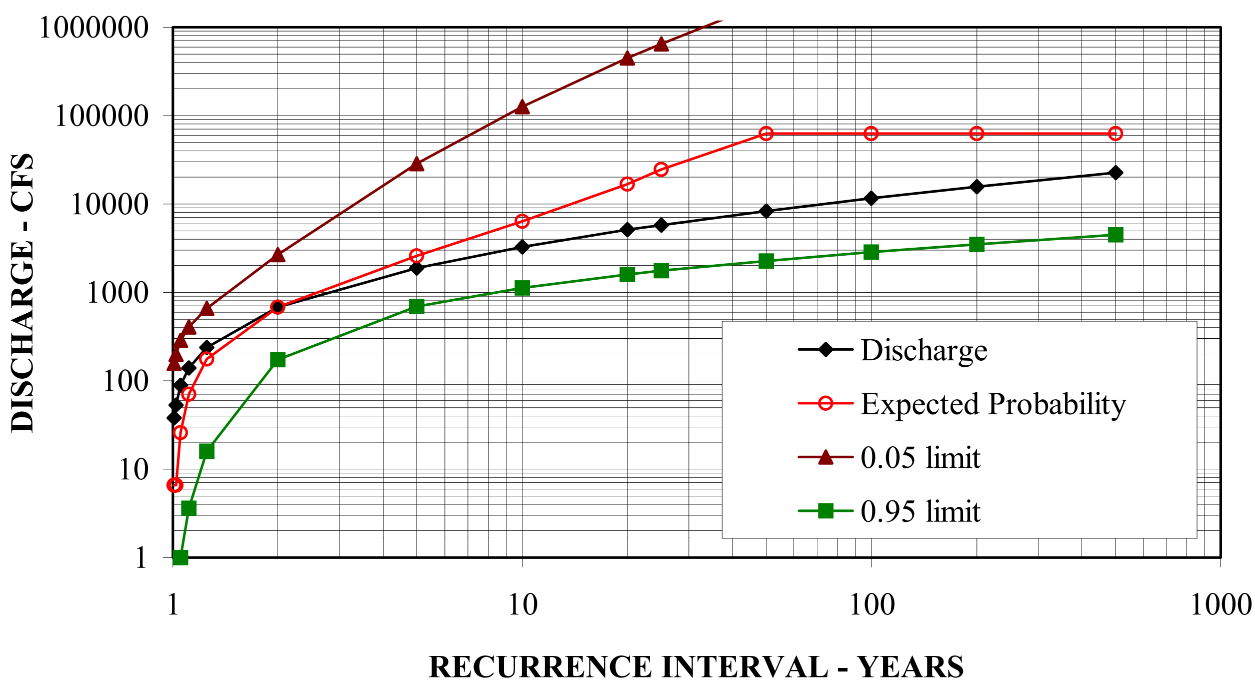


Figure 9. Flow Duration Curve from Average Daily Discharge at Calleguas Creek at CSU Channel Islands (1969-1982) and Arroyo Conejo above U.S. 101 (1973-1983)

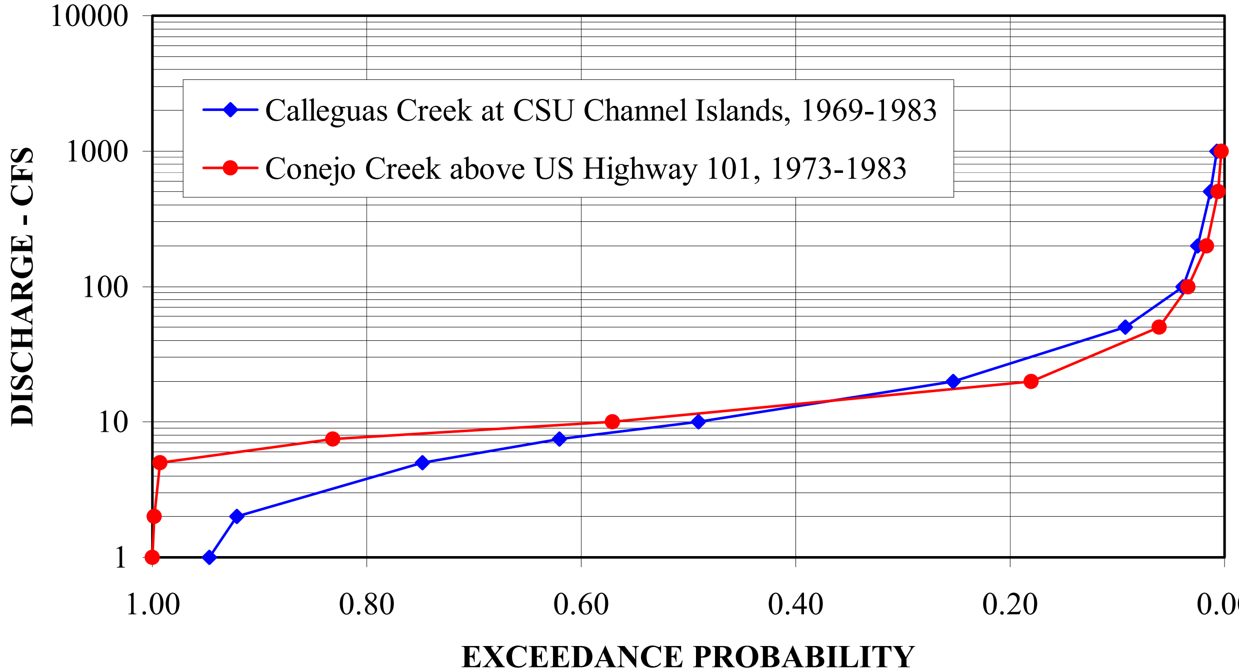
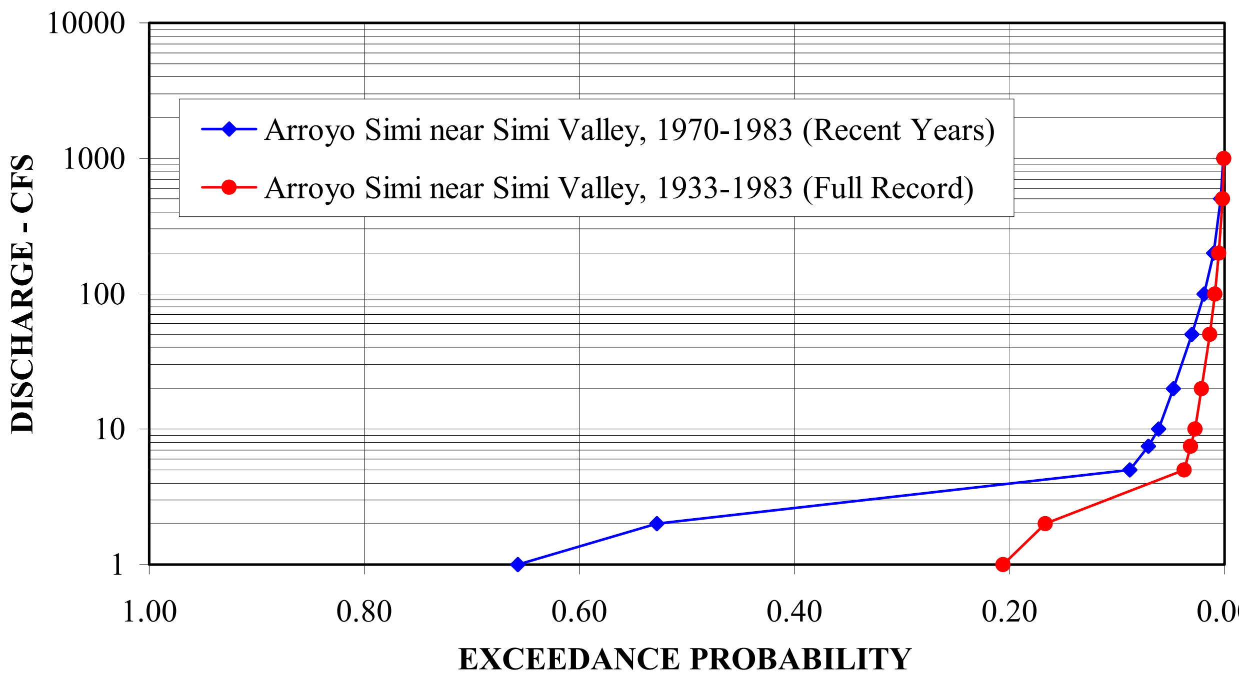


Figure 10. Flow Duration Curve from Average Daily Discharge at Arroyo Simi near Simi Valley (1970-1983 and 1933-1983)



GROUNDWATER

Bookman-Edmonston Engineering, Inc. (1998) divided the Calleguas Creek Watershed into 11 groundwater basins, six of which were included in a groundwater basin characterization study (Table 3, Primary Ground Water Basins and Associated Aquifers in the Calleguas Creek Watershed [Bookman-Edmonston Engineering, Inc. 1998]). These six primary groundwater basins are comprised of 11 aquifers (Table 4, Characteristics of the Aquifers in the Calleguas Creek Watershed [Bookman-Edmonston Engineering, Inc. 1998]).

Table 3. Primary Groundwater Basins and Associated Aquifers in the Calleguas Creek Watershed[1]

Groundwater Basin	Area (sq. km [sq. mi.])	Aquifers
Eastern Oxnard Pressure Plain	116.2 [72.6]	Semiperched, Oxnard, Mugu, Hueneme, Fox Canyon, Grimes Canyon
Pleasant Valley	75.2 [47.0]	Recent Alluvium, Fox Canyon, Grimes Canyon, Conejo Volcanics
North Las Posas	86.1 [53.8]	Recent Alluvium, Fox Canyon, Grimes Canyon.
South Las Posas	23.7 [14.8]	Recent Alluvium, San Pedro Formation, Fox Canyon, Grimes Canyon
Santa Rosa	14.4 [9.0]	Recent Alluvium, San Pedro Formation, Santa Margarita Formation, Conejo Volcanics
Tierra Rejada	11.0 [6.9]	Topanga Formation Sandstone, Conejo Volcanics

Table 4. Characteristics of the Aquifers in the Calleguas Creek Watershed[2]

Aquifer	Characteristics
Conejo Volcanics	Confined except in outcrops (e.g. at alluvial fans); faulted in Santa Rosa Basin
Fox Canyon	Confined except in outcrops (e.g. at alluvial fans); considerable groundwater development
Grimes Canyon	Confined except in outcrops (e.g. at alluvial fans); considerable groundwater development
Hueneme	Confined; not laterally extensive in the Calleguas Creek Watershed
Mugu	Confined
Oxnard	Confined; considerable groundwater development; sea water intrusion due to overdraft in the Oxnard Pressure Plain Basin
Recent Alluvium	Shallow and unconfined; poor water quality; little groundwater development

[1] Adapted from Bookman-Edmonston Engineering, Inc. (1998)
[2] Ibid.

Aquifer	Characteristics
San Pedro Formation	Confined and unconfined; faulted in the Santa Rosa Basin
Santa Margarita Formation	Confined; faulted in the Santa Rosa Basin
Semiperched	Shallow and unconfined; poor water quality; little groundwater development
Topanga Sandstone Formation	Unconfined; variable water quality

The semiperched and recent alluvial aquifers are reportedly shallow and unconfined. They likely are tightly linked to stream flows, particularly in the near channel areas. These aquifers are reportedly recharged by precipitation, stream runoff, irrigation return flows, and urban water runoff. Water quality is reportedly poor and there is little groundwater development.

The Fox Canyon, Grimes Canyon, Topanga Formation Sandstone, and Conejo Volcanics aquifers are reportedly unconfined at outcrops such as those occurring at alluvial fans. These aquifers also are recharged by precipitation, stream runoff, irrigation return flows, and urban water runoff at the outcrops. The remaining aquifers are confined and deep and receive little to no direct recharge from the stream network (Izbicki and Martin 1997, Bookman-Edmonston Engineering, Inc. 1998). The Fox Canyon and Grimes Canyon aquifers are reportedly extensively developed for groundwater extraction, so groundwater recharge from the stream network could represent an important source of future groundwater resources.

The semiperched and recent alluvial aquifers, although not directly developed, clearly could be drawn down as a consequence of deeper aquifer development and depletion. No reference is required to support this statement. It is a statement of elementary hydrologic principles that groundwater moves down a potentiometric head gradient. Therefore, reductions in potentiometric head in underlying aquifers – through groundwater pumping, for example – clearly can result in reductions in potentiometric head in hydrologically-connected overlying aquifers. When this occurs, riparian vegetation can die, resulting in a loss of habitat and locally high rates of bank erosion (Kondolf and Curry 1986). However, agricultural and/or municipal return flows typically recharge shallow groundwater resources and can, therefore, result in locally higher potentiometric heads in overlying aquifers (reviewed in Postel 1999).

A detailed analysis of the interactions between surface water, shallow groundwater, and deep groundwater in the Calleguas Creek Watershed is beyond the scope of this study and, to the authors knowledge, has not been studied to date. Thus, the degree to which pumping and return flows affect shallow groundwater resources in the Calleguas Creek Watershed is unknown. This is unfortunate since understanding these interactions is a critical element of sustainable ecosystem management (Job and Simmons 1996).

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Soils

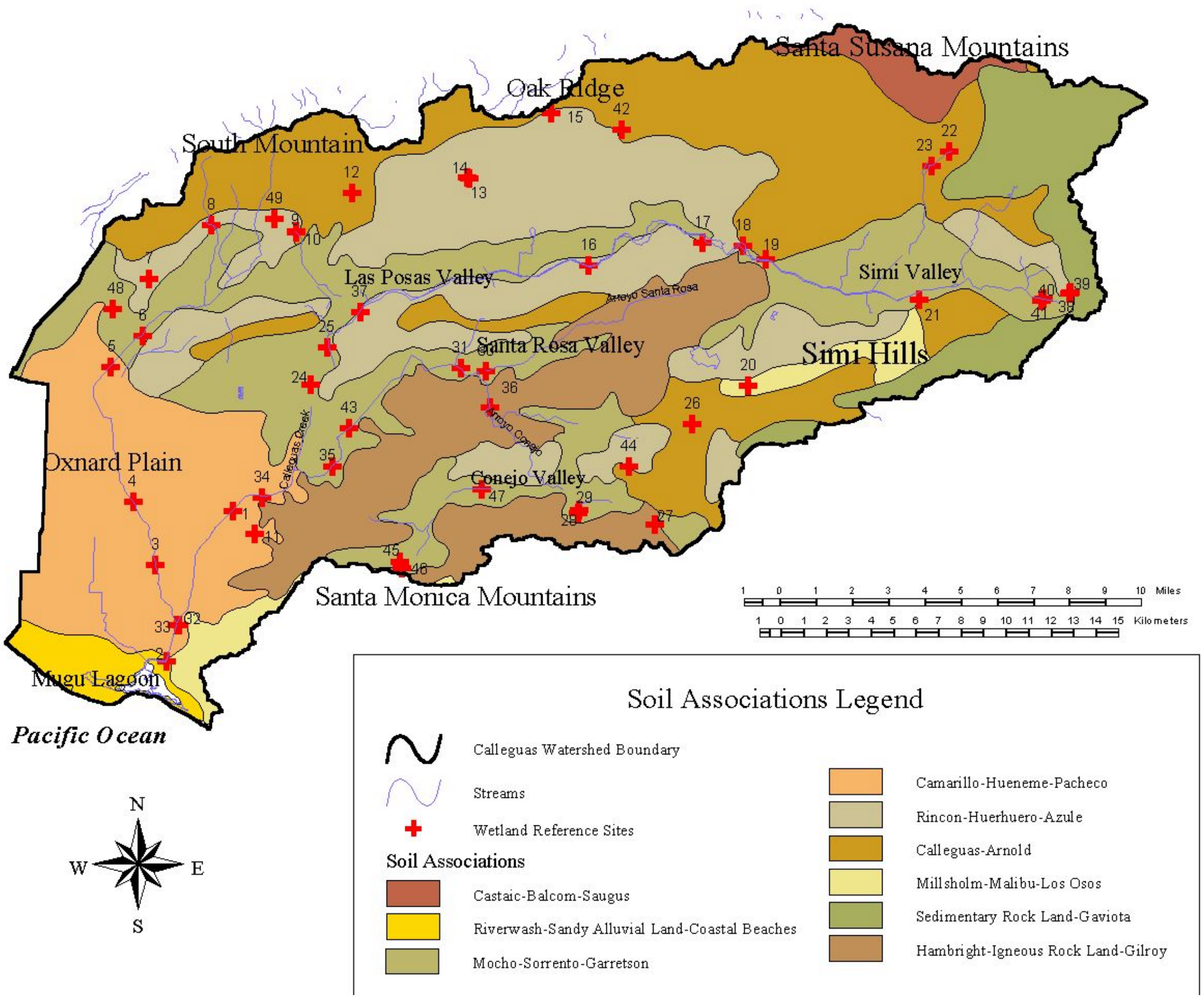
There are twelve broad soil associations in the watershed. Each soil association is strongly correlated with one of three landforms: uplands; terraces; and alluvial fans, plains, and basins (Figure 11, Soil Associations in the Calleguas Creek Watershed)(Edwards et al. 1970).

Upland soils cover approximately 35 percent of the watershed. The primary parent materials are residium and colluvium. Slopes are moderately sloping to very steep. Soils are shallow to very deep, well drained to somewhat excessively drained, various-textured deposits overlying sedimentary or igneous rock.

Terrace soils also cover approximately 35 percent of the watershed. The primary parent material is alluvium. Slopes are level to moderately steep. Soils are very deep, moderately well drained to well drained, very fine sandy loams overlying sandy clays with slow to very slow permeability.

Alluvial fan, plain, and basin soils cover approximately 30 percent of the watershed. The primary parent material is alluvium. Slopes are level to moderately sloping. Soils are very deep, poorly drained to excessively drained, various-textured deposits.

Figure 11. Soil Associations in the Calleguas Creek Watershed



Plant and Wildlife Habitats

During the field surveys performed throughout the watershed, a relatively diverse and rich flora was documented, consisting of at least 173 observed vascular plant species. All vascular plant species observed during field surveys are listed in Appendix A, Name-Code Crosswalk for Plant Species Observed in the Calleguas Creek Watershed. Appendix A is alphabetized by scientific (botanical) name and provides a common name, botanical family name, wetland indicator status (Reed 1988), and Soil Conservation Service species code (SCS 1982) for each vascular plant observed in the field. All botanical and common names are listed according to Hickman 1993, and the plant species' corresponding codes are provided, since they were used in the field data forms, which are provided as Appendix B, reference Site Field Data.

The rich vascular plant flora of the watershed contributes to the diversity of the overall landscape and provides functional habitat for many wildlife and plant species, including threatened or rare plant and animal species. Forty land cover classes were mapped in the watershed (Figure 12, Land Cover Classes in the Calleguas Creek Watershed). The natural plant communities of the watershed are generally categorized as the following 29 vegetation classes:

- 2 grassland types (annual and perennial);
- 11 scrub (Coastal Sage Scrub) types;
- 2 chaparral types (north-facing and burned;
- 2 upland woodland types (oak and eucalyptus);
- 3 transitional types (ecotonal and successional);
- 1 rock outcrop; and
- 8 wetland/riparian types.

Much of the watershed natural habitats are now converted landscapes, including the following 9 classes: Cropland, Hay Fields, Avocado Orchard, Citrus Orchard, Barren/Graded, Golf Course/Park, Developed Commercial/Industrial, Developed Residential, and Pavement. The remaining 2 classes, Water and Shallow Ocean/Kelp Beds, are not described here, as they are beyond the perimeters of watershed. The natural habitats of the watershed are described below.

GRASSLAND

Grassland consists of predominantly low herbaceous and grassy vegetation that forms a continuous ground cover on open hillsides, or as understory patches below a variety of habitat types. Many native flowering herb/bulb species (wildflowers), as well as naturalized annual forbs and invasive exotics, are important contributors to grassland. Areas dominated by grasses are often in early succession, and over time, they tend to revert back to shrublands, or even woodlands, if burning and disturbance frequencies are minimal (Zedler et al. 1997). Two predominant general types of grassland were observed within the Calleguas Creek Watershed: California Annual Grassland (including Ruderal Grassland) and Needlegrass Grassland.

California Annual Grassland

California Annual Grassland Series (Sawyer and Keeler-Wolf 1995) is dominated by annual grasses of various genera that are primarily of Mediterranean origin. The important introduced annual grass species contributing to the overall ground layer generally include: *Avena barbata* (Slender Oat), *A. fatua* (Wild Oat), *Bromus diandrus* (Ripgut Grass), *B. hordeaceus* (Soft Chess), *B. madritensis* ssp. *rubens* (Red Brome), and *Hordeum* spp. (barley). The introduced annual grasses of this series are often referred to as naturalized, and are typically considered important grassland habitat contributors. California Annual Grassland Series occurs on all topographic locations, especially gradual slopes, of all slope aspects and in deep soils, at elevations below 1,200 m (3,937 ft). Species composition varies among stands.

The native herb associates of California Annual Grassland Series include: *Ambrosia psilostachya* var. *californica* (Western Ragweed), *Artemisia douglasiana* (Mugwort), *Gnaphalium californicum* (Green Everlasting), *G. canescens* (White Everlasting), *Phacelia ramosissima* (Branching Phacelia), and *Verbena lasiostachys* (Western Verbena).

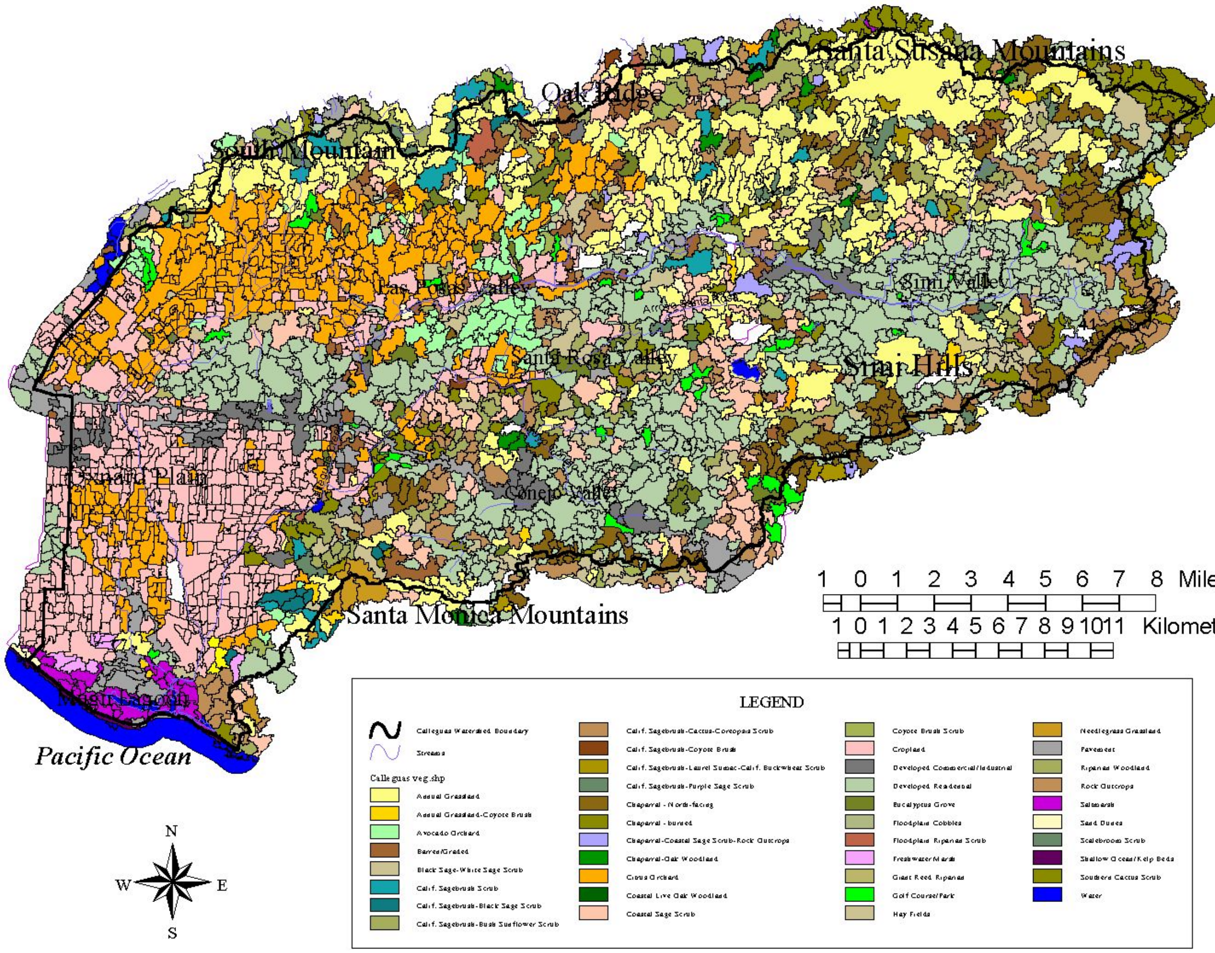
The typical nonnative forb components of annual grassland include: *Anagallis arvensis* (Scarlet Pimpernel), *Brassica nigra* (Black Mustard), *Carduus pycnocephalus* (Italian Thistle), *Chenopodium murale* (Nettle-leaved Goosefoot), *Hirschfeldia incana* (Summer Mustard), *Malva parviflora* (Cheeseweed), *Marrubium vulgare* (White Horehound), *Rumex crispus* (Curly Dock), *Silybum marianum* (Milk Thistle), and *Sonchus oleraceus* (Common Sow-thistle). When these introduces species predominate over native annual herbs, then California Annual Grassland Series becomes Ruderal Grassland.

Needlegrass Grassland

Needlegrass Grassland is dominated by tussock-forming, native perennial grasses, which contribute to at least 10 percent of the total ground layer. Purple Needlegrass Series (Sawyer and Keeler-Wolf 1995) is the predominant Needlegrass Grassland in southern California, which is dominated by *Nassella pulchra* (Purple Needlegrass). Purple Needlegrass Series occurs on all topographic locations, in deep high clay-content soils, and grows at elevations below 1,300 m (4,265 ft) (Sawyer and Keeler-Wolf 1995).

Magney (1992) describes this vegetation type as Southern Coastal Needlegrass Grassland. Native and introduced annuals grow between the open gaps of this once extensive perennial grassland, and the annual grasses often actually exceed the bunchgrass in cover. It is found as small open pockets within Coastal Sage Scrub stands or intergrading with chaparral and woodland communities. This series prefers sites with fine-textured soils that are moist during winter and very dry during summer. Purple Needlegrass Grassland occurs on coastal terraces, foothills, and valleys of California's south coast. The predominant grass associates observed contributing to the ground layer are annual, nonnative grasses of California Annual Grassland Series.

Figure 12. Land Cover Classes in the Calleguas Creek Watershed



COASTAL SAGE SCRUB

Coastal Sage Scrub is a shrubland dominated by drought-deciduous, low-growing shrubs and subshrubs that are soft-leaved and grayish-green in color. Scrub plant size is relative to the available water supply present onsite; however, these semi-woody plants are generally low growing since high temperatures and drying winds cause severe moisture stress. Many Coastal Sage Scrub species resprout between and after recurring fires, and they typically respond to seasonal drought by reducing transpiring surface area through leaf curling and loss of larger leaves. Few small green leaves remain on these shrubs even during the summer, which allows for a quick response to the first fall rains (Zedler et al. 1997.).

Coastal Sage Scrub is common in California generally along the coastward slopes of the Transverse, Central Coast, and Peninsular Ranges, and stands of this vegetation type are adapted to a Mediterranean climate. Coastal Sage Scrub forms variable stands with continuous to open canopies; it occupies dry, gentle to steep, more or less rocky slopes with shallow or heavy soils; and it generally occurs at lower elevations. (Zedler et al. 1997.)

Although Coastal Sage Scrub is a general habitat type, it is mapped as an individual scrub vegetative class, while the other 10, more defined, floristically-based, plant communities, which are included in Coastal Sage Scrub and are mapped throughout the watershed, include:

- Black Sage (*Salvia mellifera*)-White Sage (*S. apiana*) Scrub;
- California Sagebrush (*Artemisia californica*) Scrub, including
  - California Sagebrush-Black Sage Scrub,
  - California Sagebrush-California Bush Sunflower (*Encelia californica*) Scrub,
  - California Sagebrush-Cactus (*Opuntia* spp.)-Coreopsis (*Coreopsis bigelovii*) Scrub,
  - California Sagebrush-Coyote Brush (*Baccharis pilularis*) Scrub,
  - California Sagebrush-Laurel Sumac (*Malosma laurina*)-California Buckwheat (*Eriogonum fasciculatum*) Scrub, and
  - California Sagebrush-Purple Sage (*Salvia leucophylla*) Scrub;
- Southern Cactus (Opuntia littoralis [Coast Prickly-pear]) Scrub; and
- Coyote Brush Scrub (Note: Only the four primary scrub classes are described below in the following subsections, since the remaining six are simply co-dominant variations of California Sagebrush Scrub).

The Coastal Sage Scrub plant communities, listed above and observed throughout the Calleguas Creek Watershed, include several important native associate species, such as: *Brickellia californica* (California Brickellbush), *Lotus scoparius* (Deerweed), *Hazardia squarrosa* (Saw-toothed Goldenbush), *Leymus condensatus* (Giant Wildrye), *Lupinus albifrons* (Silver Bush Lupine), *Mimulus aurantiacus* (Bush Monkeyflower), *Prunus ilicifolia* (Holly-leaf Cherry), *Ribes speciosum* (Fuchsia-flowered Gooseberry), *Solanum xantii* (Chaparral Nightshade), *Toxicodendron diversilobum* (Poison Oak), and *Yucca whipplei* (Our Lord's Candle). Emergent *Quercus* spp. (Valley Oak and Coast Live Oak), *Rhus integrifolia* (Lemonadeberry), and *Sambucus mexicana* (Blue Elderberry) were also observed throughout this habitat type.

The native ground layer associates observed in the Mixed Sage Series include many of those typical of California Annual Grassland and Needlegrass Grassland; however, several scrub-specific herbaceous species were also observed, including: *Achillea millefolium* (White Yarrow), *Calystegia macrostegia* (Morning-glory), *Claytonia perfoliata* (Miners Lettuce), *Galium angustifolium* (Chaparral Bedstraw), *G. aparine* (Goose Grass), *Gnaphalium californicum, Marah fabaceus* (Man-root), and *Verbena lasiostachys*.

The nonnative ground layer associates include: *Atriplex semibaccata* (Australian Saltbush), *Bidens pilosa* var. *pilosa* (Common Beggar-ticks), *Conium maculatum* (Poison Hemlock), *Foeniculum vulgare* (Sweet Fennel), *Gnaphalium luteo-album* (Cudweed Everlasting), *Hirschfeldia incana*, and *Lolium multiflorum* (Italian Ryegrass), *Marrubium vulgare*, *Pennisetum clandestinum* (Kikuyu Grass), and *Polypogon monspeliensis* (Rabbitsfoot Grass).

Black Sage-White Sage Scrub

Black Sage-White Sage Scrub, or Mixed Sage Series (Sawyer and Keeler-Wolf 1995), is an upland plant community consisting of a mixture of at least three specific Coastal Sage Scrub species, including at least one sage (*Salvia* spp.). The native, aromatic, glandular sages observed in this series are White Sage (*S. apiana*) and Black Sage (*S. mellifera*). White Sage is a subshrub with hairy gray leaves and white with lavender flowers. It is common on dry slopes in scrub, chaparral, and Yellow Pine Forest, at elevations below 1,500 m (4,921 ft). Black Sage is a shrub with puckered dark green leaves, and white to pale blue/lavender flowers. Black Sage is common in scrub and lower chaparral communities at elevations below 1,200 m (3,937 ft). (Hickman 1993.)

The predominant sages and other significant associates--such as *Artemisia californica*, *Eriogonum fasciculatum*, *Mimulus aurantiacus*, and *Yucca whipplei*--are equally important to the overall scrub canopy. Three or more species must equally share commonness and cover to be classified as Mixed Sage Series. Associate species include those listed in Coastal Sage Scrub (above). This series forms an intermittent to continuous canopy over a variable ground layer, and grows on sandy, rocky, shallow soils of upland slopes at elevations below 1,200 m. (Sawyer and Keeler-Wolf 1995.)

California Sagebrush Scrub

California Sagebrush Scrub is dominated by *Artemisia californica*, which is a native, aromatic, slender-stemmed shrub with thread-like, soft, greenish-gray leaves, and is a typical Coastal Sage Scrub species of xeric foothills, especially near the coast (Hickman 1993). *A. californica* resprouts from its base both after and between recurring fires, and seedling recruitment is possible in both mature and post-fire stands. Rare animal (*Polioptila californica* [California Gnatcatcher]) and plant species typically occupy California Sagebrush stands (Zedler et al. 1997).

California Sagebrush Series (Sawyer and Keeler-Wolf 1995) forms a continuous to intermittent canopy, consisting of one of many co-dominant shrubs (as listed above in Coastal Sage Scrub), or consisting of several local shrub associates, growing over a variable ground layer. Nonnative annual grasses, an occasional perennial bunchgrass (*Nassella pulchra*), and native or introduced herbs are common in the sagebrush canopy gaps. California Sagebrush Series occurs in shallow alluvial- or colluvial-derived soils, on steep south-facing slopes of infrequently-flooded, low-gradient, alluvial floodplain deposits (below 1,200 m).

Southern Cactus Scrub

Southern Cactus Scrub is dominated by *Opuntia littoralis*. This fibrous-rooted cactus shrub has round, straight, whitish-coated spine clusters, and it produces yellow to reddish flowers and juicy, dark reddish-purple fruit. This highly variable cactus occurs in Coastal Sage Scrub and chaparral plant communities. (Hickman 1993.)

Coast Prickly-pear Series (Sawyer and Keeler-Wolf 1995) consists predominantly of *Opuntia* species with several other malacophyllous (fleshy) associate shrubs and herbs. Emergent *Rhus integrifolia* and *Sambucus mexicana* are often growing among the less than 2-m tall, intermittent to open shrub canopy. This series grows over a variable ground layer of grasses and herbs, which was observed as including two succulent perennial herb species, *Dudleya lanceolata* (Lanceolate Dudleya) and *D. pulverulenta* (Chalky Live-forever). Coast Prickly-pear Series occurs on steep slopes with shallow soils and at elevations below 1,200 m.

Coyote Brush Scrub

Coyote Brush Scrub is dominated by *Baccharis pilularis*, a bright green, glabrous, native, broad-leaved, evergreen shrub with toothed, 3-veined leaves. *B. pilularis* occurs in scrub and oak woodland communities on stabilized dunes of coastal bars, river mouths, coastline spits, coastal bluffs, open slopes, and ecotonal areas with grasslands (Hickman 1993). The variable stands of Coyote Brush Series (Sawyer and Keeler-Wolf 1995) typically include a co-dominant and important associates (such as those listed for Coastal Sage Scrub above) over a variable ground layer. Coyote Brush Scrub forms a continuous or intermittent canopy (less than 2 m tall) and often forms a pure stand. Coyote Brush Series occurs at elevations below 1,000 m (3,281 ft).

CHAPARRAL

Chaparral is a type of shrubland dominated by woody evergreen shrubs with small, thick, leathery, dark green, sclerophyllous leaves. The shrubs are relatively tall and dense, and are adapted to periodic wildfires by stump sprouting or germination from a dormant seed bank. The evergreen shrubs included in chaparral are also adapted to drought by deep extensive root systems, while their small thick leaf structure prevents permanent damage from moisture loss (Zedler et al. 1997). Many shrubs typical of Coastal Sage Scrub also grow intermixed as associates with chaparral species. Chaparral typically occurs on moderate to steep south-facing slopes with dry, rocky, shallow soils. It is more abundant at higher elevations where temperatures are lower and moisture supplies are more ample.

Two chaparral classes mapped for the Calleguas Creek Watershed include Chaparral-north-facing and Chaparral-burned. The shrub species typical of chaparral plant communities include: *Adenostoma fasciculatum* (Chamise), *Arctostaphylos glandulosa* (Eastwood Manzanita), *Ceanothus* spp. (Ceanothus), *Cercocarpus betuloides* (Mountain Mahogany), *Eriogonum fasciculatum*, *Heteromeles arbutifolia* (Toyon), *Malosma laurina*, and *Yucca whipplei*.

ROCK OUTCROP

Rock outcrop is described as exposed parent material with little or no plant species present. Rock outcrop consists of large boulders and exposed bedrock, generally lacking soil. These hard surfaces, consisting of large and small sandstone or granite boulders and some exposed bedrock, provide substrate for being covered or partially covered by nonvascular plants, such as crustose (crust-like) and foliose (leaf-like) lichens. Rock outcrop occurs scattered throughout the dryer, south-facing, chaparral- and Coastal Sage Scrub-covered slopes, and some smaller outcrops were also observed on moister, gentler north-facing, wooded slopes. Scattered scrub shrub species (see Coastal Sage Scrub above) and annual and perennial grasses (see Grassland above) generally inhabit the shallow soils surrounding the rock outcrops scattered throughout the watershed.

WOODLAND

Woodland describes a vegetation type dominated by woody trees with tree-like shrubs, forming various wooded canopies growing over a scattered variety of low-growing shrubs and a grassy ground layer. Some woodland communities may not contain a shrub stratum, and may only form a tall canopy over annual or perennial grassland. The understory of woodland is directly related to the density of the woodland canopy and its percent canopy cover. Permanent shade created by dense woodlands typically inhibits the growth of stratified canopy layers. The predominant upland woodland plant community of the watershed is Coast Live Oak Woodland. Eucalyptus Grove is another woodland community that is common in agricultural areas.

Coast Live Oak Woodland

Coast Live Oak Woodland is dominated by *Quercus agrifolia* var. *agrifolia*, a native broad-leaved, evergreen tree with furrowed dark gray bark and spine-toothed, dark green leaves. *Q. agrifolia* is the most widely distributed of the evergreen oaks, and is capable of achieving large size and old age (Zedler et al. 1997). It occurs in valleys and on slopes of riparian woodland fringes, scattered in grassland or scrub communities, as an element of Mixed Evergreen Forest, or as a contributor to other oak woodlands. Coast Live Oak Series (Sawyer and Keeler-Wolf 1995) occurs on steep north-facing slopes and on raised stream banks or terraces. This series forms a continuous to open canopy (<30 m [98 ft] tall), with a scattered shrub stratum and an herbaceous ground layer, and requires sandstone or shale-derived soils at elevations below 1,200 m.

The associate tree (and large shrub) species observed contributing to the highly variable Coast Live Oak canopies of the watershed include: *Heteromeles arbutifolia*, *Juglans californica* var. *californica* (Southern California Black Walnut), *Malosma laurina*, *Quercus lobata* (Valley Oak), and *Sambucus mexicana*. Depending on each stand, the shrub stratum may include scattered to abundant typical Coastal Sage Scrub species. The herbaceous ground layer consists of annual grasses and herbs of California Annual Grassland Needlegrass Grassland (described above).

Eucalyptus Grove

Eucalyptus Grove is dominated by *Eucalyptus globulus* (Tasmanian Blue Gum Eucalyptus). This introduced, aromatic tree has a smooth straight trunk and is native to southeastern Australia. *E. globulus* is also the most commonly cultivated and naturalized species of Eucalyptus in California (Hickman 1993). Eucalyptus Series (Sawyer and Keeler-Wolf 1995) forms a continuous canopy, of less than 50 m (164 ft) tall, with few other species present except infrequent shrubs growing over a sparse ground layer. This series occurs on all slopes, and generally of disturbed areas, at elevations below 300 m (984 ft). The understory associate species of Eucalyptus Series observed within the watershed are *Artemisia californica*, *Baccharis salicifolia* (Mulefat [tall native riparian shrub]), *Lepidospartum squamatum* (Scalebroom [native floodplain shrub]), and *Tamarix* sp. (Tamarisk [exotic tree]).

TRANSITIONAL

Significant vegetation transitions include ecotonal transitions and successional stages. Ecotonal transitions arise when dominant species exist in an intermixed mosaic that blends one species-dominant plant community into another species-dominant plant community. This transition zone is difficult to classify due to the mixture of species within the generally large areas of ecotones. Plant succession, such as vegetation reestablishment after a fire, causes vegetation to change (or recover from a disturbance) over time, resulting in species dominance and community structure that differs significantly at two or more different times. However, a given landscape generally has a limited set of vegetation types, and vegetation following a disturbance often approaches conditions, over time, similar to those prior to the disturbance (Sawyer and Keeler-Wolf 1995). The three transitional plant communities observed throughout the Calleguas Creek Watershed include the following:

- **Annual Grassland-Coyote Brush Scrub:** consists of equal proportions of ground cover by California Annual Grassland Series and Coyote Brush Series (both described above). Few other significant shrub species occupy this type of mixed stand.
- **Chaparral-Coastal Sage Scrub-Rock Outcrop:** represents a complex ecotone from the woody, evergreen, Chaparral shrubs to the typical semi-woody, soft-leaved, summer-deciduous Coastal Sage Scrub shrubs and subshrubs, with scattered exposed Rock Outcrop (each previously described in their respective subsections). Several species from each of these different habitat types may occupy one stand at once, and species diversity is often high in mixed ecotonal stands such as these.
- **Chaparral-Oak Woodland:** consists of oak trees (*Quercus agrifolia* and *Q. lobata*) plus a significant contribution of tall evergreen chaparral shrubs (particularly *Heteromeles arbutifolia* and *Malosma laurina*). This plant community forms an intermitted to open tree canopy growing over a scattered to intermittent shrub stratum canopy of evergreen shrubs.

WETLAND

Wetlands are lands where saturation with water (at least periodically saturated or covered by water) is the dominant factor determining the nature of the soil development and the type of plant and animal communities occupying the land. Water creates severe physiological problems for most plants and animals, except for those adapted for life in water or saturated soil. Wetlands are transitional between terrestrial and aquatic systems, where the water table is at or near the soil surface, or the land is covered by shallow water. Wetlands consist of one or more of the following three attributes: (1) the land supports predominantly hydrophytic vegetation (plants adapted to living in water), (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season. (Cowardin et al.1979.)

The wetland types (hierarchical wetland system) existing within the Calleguas Creek Watershed are briefly defined below according to Cowardin et al. (1979):

- **Palustrine:** generally includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5‰.
- **Riverine:** includes all wetlands and deepwater habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergents; and (2) habitats with water containing ocean-derived salts in excess of 0.5‰.
- **Estuarine:** consists of deepwater tidal habitats and adjacent tidal wetlands that are usually semi-enclosed by land, but have open, partly obstructed, or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff.

The eight mapped habitat classes established within these different wetland systems are:

- Floodplain Riparian Scrub, including
  - Giant Reed Riparian Scrub,
  - Scalebroom Scrub, and
  - Floodplain Cobbles;
- Riparian Woodland;
- Marsh (Freshwater Marsh and Saltmarsh); and
- Sand Dunes.

The three additional floristic plant series included in Floodplain Riparian Scrub are Mulefat Scrub, Mixed Willow Scrub, and Blue Elderberry Scrub. The three floristic plant series included in Riparian Woodland are Arroyo Willow Woodland, California Sycamore Woodland, and Mixed Willow Woodland. These additional communities are not mapped classes; however, they are described, since they are mentioned in several of the watershed Conceptual Restoration Plans presented below in the Restoration and Preservation Recommendations section of this report.

Floodplain Riparian Scrub

Cowardin et al. (1997) describes this habitat type as Palustrine Scrub-Shrub Broad-leaved Deciduous Wetland, which includes areas dominated by woody, broadleaved, deciduous vegetation less than 6 m (20 ft) tall. The species include true shrubs that are small or stunted because of environmental conditions. Scrub-Shrub Wetlands may represent a successional stage leading to Forested Wetland, or they may be relatively stable communities. They occur only in the Estuarine and Palustrine systems, but are one of the most widespread classes in the U.S. For practical reasons, riparian forests composed of young trees less than 6 m tall are also included.

Floodplain Riparian Scrub is predominantly a mixed riparian scrub plant community that is predominated by several wetland shrub species. The Floodplain Riparian Scrub plant communities of the watershed include: Giant Reed (*Arundo donax*) Scrub, Scalebroom (*Lepidospartum squamatum*) Scrub, Floodplain Cobbles, Mulefat (*Baccharis salicifolia*) Scrub, Mixed Willow (*Salix* spp.) Scrub, and Blue Elderberry (*Sambucus mexicana*) Scrub.

In addition to the dominant species, Floodplain Riparian Scrub was observed as consisting of several important native associate species such as: *Juglans californica*, *Lotus scoparius*, *Typha domingensis* (Southern Cattail), and emergent *Platanus racemosa* (California Sycamore) and *Populus balsamifera* ssp. *trichocarpa* (Black Cottonwood) trees. The two predominant introduced riparian shrub species are *Ricinus communis* (Castor Bean) and *Nicotiana glauca* (Tree Tobacco).

The native ground layer associates include: *Artemisia douglasiana*, *Astragalus douglasii* var. *parishii* (Parish Milkvetch), *Calystegia macrostegia*, *Clarkia unguiculata*, *Cryptantha echinella* (Prickly Forget-me-not), *Eriophyllum confertiflorum* (Golden Yarrow), *Eucrypta chrysanthemifolia* (Eucrypta), *Gnaphalium californicum*, *Marah fabaceus*, *Rumex salicifolius* var. *denticulatus* (Willow Dock), *Senecio douglasii*, *Urtica dioica* ssp. *holosericea* (Hoary Creek Nettle), and *Verbena lasiostachys*.

Giant Reed Riparian Scrub

Giant Reed Riparian Scrub is a specific type of Floodplain Riparian Scrub, which is dominated by the highly invasive, nonnative *Arundo donax*. Giant Reed is a large, 8-m (26-ft) tall, introduced, perennial grass with thick rhizomes, and it is native to Europe (Hickman 1993). The National Inventory of Wetland Plants (Reed 1988) lists this species as a facultative wetland species (wetland indicator status of FACW) that is usually found in wetlands. Giant Reed is an extremely invasive grass (introduced into California in the 1880's) that establishes and persists in riparian areas by reducing and replacing native species by establishing dense monocultures (Sawyer and Keeler-Wolf 1995). It is often described as forming a ground layer, since *A. donax* is technically a grass; however, it is categorized here as forming scrub due to the secondary stratum it creates.

Giant Reed Series (Sawyer and Keeler-Wolf 1995) consists of *A. donax* growing as the sole perennial grass forming a continuous scrubby ground layer with few other species present. Giant Reed Series requires permanently saturated freshwater wetland habitats, with a shallow water table, at elevations below 500 m (1,640 ft). Giant Reed Series was observed within the watershed predominantly as large thickets (patches), and within other riparian communities, and includes scattered native shrubs such as *Atriplex lentiformis* ssp. *breweri* (Big Saltbush), *Baccharis pilularis*, *B. salicifolia*, and *Salix lasiolepis* (Arroyo Willow).

Scalebroom Scrub

Scalebroom Scrub is dominated by *Lepidospartum squamatum*, and it is also important with several other associate shrubs. *L. squamatum* is a round-topped, woolly, broom-like native shrub (less than 3 m [10 ft] tall) with scale-like leaves and yellow flowers. It occurs in sandy or gravely washes and stream terraces at elevations below 1,800 m (Hickman 1993). Scalebroom has a wetland indicator status of (FACW). Parentheses around FACW, indicates wetland status as suggested by the author.

Scalebroom Series (Sawyer and Keeler-Wolf 1995) forms a continuous to intermittent canopy growing under emergent trees and growing over a variable or grassy ground layer. This series occurs in rarely flooded slopes and in low-gradient deposits along streams. Species composition differs greatly among Scalebroom stands, and disturbance may account for this high variation. Magney (1992) further describes this series as Scalebroom Floodplain Scrub, which is a broad-leaved, phreatophytic, evergreen scrub type with *Artemisia californica* and *Sambucus mexicana* as subdominant shrubs. This series is restricted to riverine cobbles, boulders, and sand of floodplain habitats (flooded every five to ten years), which is the driving force maintaining this phreatophytic vegetation type. Many upland species of Coastal Sage Scrub and chaparral communities become established in this streamside habitat.

In addition to the typical riparian scrub species, Scalebroom Series was observed consisting of several important, more upland shrub components as well, including: *A. californica*, *B. pilularis*, *Baccharis salicifolia*, *Encelia californica*, *Eriogonum fasciculatum*, *Isomeris arborea* (Bladderpod), *Rosa californica* (California Wild Rose), *Salvia* spp., *Solanum xantii* (Chaparral Nightshade), *Toxicodendron diversilobum*, and *Yucca whipplei*.

Floodplain Cobbles

Floodplain Cobbles, or Riverine and Palustrine Unconsolidated Bottom Cobble-Gravel (Cowardin et al. 1979), is a sparsely vegetated gravelly area formed by a floodplain. Unconsolidated Bottom includes low-energy, unstable wetlands with at least 25 percent cover of particles smaller than stones (cobbles and gravel), and a vegetative cover less than 30 percent. These habitats are characterized by the lack of large stable surfaces for plant and animal attachment. In the riverine system, the substrate type is largely determined by current velocity, and plants and animals exhibit a high degree of morphological and behavioral adaptation to flowing water.

Although this habitat type is generally sparsely vegetated, several species can be seen attempting to establish these areas. The scattered species observed in Floodplain Cobbles include many of the plants listed above in Floodplain Riparian Scrub and Scalebroom Scrub. In addition to the hydrophytes of riparian scrub, Floodplain Cobbles is generally predominated by several nonnative species such as those introduced species listed in California Annual Grassland Series (above).

Mulefat Scrub

Mulefat Scrub is a Floodplain Riparian Scrub type that is dominated by *Baccharis salicifolia*, which is a glabrous, often sticky shrub with many short, spreading branches. *B. salicifolia* has a wetland indicator status of FACW (Reed 1988). Mulefat Series (Sawyer and Keeler-Wolf 1995) is found at elevations below 1,250 m (4,101 ft), requires freshwater habitats that are seasonally flooded or saturated (i.e. canyon bottoms, irrigation ditches, and stream channels), and occurs in pure stands or may mix with other wetland species (such as those listed above in Floodplain Riparian Scrub).

Mixed Willow Scrub

A scrub form of Mixed Willow Series (Sawyer and Keeler-Wolf 1995) also may represent Floodplain Riparian Scrub, which consists of an array of shrub-sized willows (*Salix* spp.) such as *S. lasiolepis* (Arroyo Willow), *S. laevigata* (Red Willow), and/or *S. sessilifolia* (Sandbar Willow), with *Baccharis salicifolia* as an important contributor as well. All three species of willow are listed with a wetland indicator status of FACW (Reed 1988).

Mixed Willow Series is a plant community in which no one dominant willow is present, and two or more willows are equally important in the canopy. This riparian scrub type typically includes emergent trees and forms a continuous canopy over scattered smaller shrubs and a sparse ground layer of herbs (such as the species listed above for Floodplain Riparian Scrub). Mixed Willow Series occurs in seasonally flooded or saturated, freshwater wetland habitats, such as floodplains and low-gradient depositions along rivers or streams, at elevations below 1,800 m (5,905 ft). (Sawyer and Keeler-Wolf 1995.)

Blue Elderberry Scrub

Blue Elderberry Scrub is dominated by *Sambucus mexicana*, which is a common large shrub that produces cream-colored flowers and bluish-black berries. This species is commonly found growing along streams at elevations below 3,000 m (9,842 ft) (Hickman 1993). Blue Elderberry is listed with a wetland indicator status of FAC, or a facultative species that is equally likely to occur in wetlands as in non-wetlands (Reed 1988).

Blue Elderberry Scrub forms an intermittent tall shrub canopy, of less than 8 m tall, over an array of mixed riparian scrub shrubs and a grassy ground layer. This series occurs in intermittently flooded or seasonally saturated soils of freshwater wetlands, such as stream banks, floodplains, and open riparian forests at elevations below 300 m (984 ft.). *S. mexicana* is also common in many series, often as a small emergent tree over Coastal Sage Scrub, chaparral communities, and as an understory to woodlands. Blue Elderberry Scrub includes important shrub layer associates such as: *Baccharis pilularis*, *B. salicifolia*, *Encelia californica*, and *Solanum douglasii* (Douglas Nightshade). (Sawyer and Keeler-Wolf 1995.)

Riparian Woodland

The Riparian Woodland types, throughout the Calleguas Creek Watershed, generally include Arroyo Willow (*Salix lasiolepis*) Woodland, California Sycamore (*Platanus racemosa*) Woodland, and Mixed Willow Woodland. Only Arroyo Willow Woodland and California Sycamore Woodland are described below, since Mixed Willow Woodland, as a *wooded* plant community, is relatively the same as the Floodplain Riparian Scrub Mixed Willow Scrub (described above), except that the willows (*Salix lasiolepis*, *S. laevigata*, and/or *S. sessilifolia*) and associate species are predominantly trees rather than shrubs.

In addition to the dominant trees of the watersheds' riparian woodlands, the three woodlands also consist of an extensive list of associate species, including: *Juglans californica*, *Phoradendron macrophyllum* (Bigleaf Mistletoe), *Populus balsamifera, Quercus* spp., and *Sambucus mexicana*. The nonnative tree associates are *Eucalyptus globulus*, *Nicotiana glauca, Schinus molle* (Peruvian Pepper Tree), *Tamarix* sp., and *Washingtonia robusta* (Mexican Fan Palm). Common understory scrub-shrub stratum associates include: *Artemisia californica*, *Arundo donax*, *Atriplex lentiformis* ssp. *breweri*, *Baccharis pilularis*, *B. salicifolia*, *Isocoma arborea*, *Malosma laurina*, *Prunus ilicifolia*, *Ricinus communis*, *Toxicodendron diversilobum*, and *Typha domingensis*.

The typical native herbaceous layer of the watershed riparian woodlands include: *Amsinckia menziesii* var. *intermedia, Ambrosia psilostachya* var. *californica*, *Artemisia douglasiana*, *Calystegia macrostegia*, *Cyperus eragrostis* (Umbrella-sedge), *Gnaphalium californicum*, *Phacelia cicutaria* (Caterpillar Phacelia), *P. ramosissima*, *Rorippa nasturtium-aquaticum* (Water Cress), *Urtica dioica* ssp. *holosericea*, *Verbena lasiostachys*, and *Xanthium strumarium*.

The introduced and often invasive ground layer species are *Apium graveolens* (Celery), *Carduus pycnocephalus*, *Chenopodium murale* (Nettle-leaved Goosefoot), *Conium maculatum*, *Foeniculum* *vulgare*, *Hirschfeldia incana*, *Lepidium latifolium* (Broadleaf Peppergrass), *Melilotus* spp. (White Sweetclover, Sourclover), *Piptatherum miliaceum* (Smilo Grass), *Polypogon monspeliensis*, *Senecio mikanioides* (Cape Ivy), *Urtica urens* (Dwarf Nettle), and *Veronica anagallis-aquatica*.

Arroyo Willow Woodland

Arroyo Willow Woodland is a riparian woodland habitat that is dominated by *Salix lasiolepis*. Arroyo Willow is a winter deciduous tree with shinny dark green (upper surface) and white tomentose (lower surface) leaves. This is an abundant species of shores, marshes, meadows, springs, and bluffs (Hickman 1993).

Arroyo Willow Series (Sawyer and Keeler-Wolf 1995) was frequently recorded during the Calleguas Creek Watershed field survey. Arroyo Willow Series forms a continuous canopy that grows over a sparse lower shrub layer, consisting of many of the species listed above in Riparian Woodland, and an absent to abundant ground layer (depending on canopy thickness). This series occurs in seasonally flooded or saturated, fresh water, wetland habitats, such as flood plains and low-gradient depositions along rivers and streams, at elevations below 1,800 m.

California Sycamore Woodland

California Sycamore Woodland is dominated by *Platanus racemosa*. This common, monoecious, wind-pollinated, winter-deciduous tree has large, hairy, palmately lobed leaves and occurs along streamsides and in canyons below 2,000 m (6,562 ft) in elevation (Hickman 1993).

California Sycamore Series (sawyer and Keeler-Wolf 1995) occurs as a widely spaced, 35-m (115-ft) canopy growing above a shrubby thicket of evergreen and deciduous shrubs and a grassy groundlayer (see the species listed above in Riparian Woodland). California Sycamore grows in wetland habitat soils that are permanently saturated at depth. It is common along freshwater riparian corridors, braided depositional channels of intermittent streams, gullies, springs, seeps, stream- and river-banks, and terraces adjacent to floodplains subject to high intensity seasonal flooding (elevations below 2,400 m [7,874 ft]).

Marsh

Marsh, or Emergent Wetland, (Cowardin et al 1979), is characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. This vegetation usually consists of perennial plants and is present for most of the growing season. In areas with relatively stable climatic conditions, Emergent Wetlands maintain the same appearance year after year. Emergent Wetlands are found throughout the U.S., in all system except Marine, but are primarily of the Palustrine and Estuarine systems in the Calleguas Creek Watershed.

The two Marsh types observed in the watershed are Freshwater Marsh (Palustrine Emergent Wetland Persistent) and Saltmarsh (Estuarine Intertidal Emergent Wetland Persistent). These persistent marsh types are specifically characterized as being dominated by species that normally remain standing at least until the beginning of the next growing season (Cowardin et al 1979). Freshwater Marsh and Saltmarsh are described below.

Freshwater Marsh

Freshwater Marsh, or Palustrine Emergent Wetland Persistent, contains a vast array of grass-like plants, but is primarily represented in the watershed by two similar plant communities: Cattail Series, dominated by *T. domingensis*; and Bulrush Series, dominated by *S. californicus* (Sawyer and Keeler-Wolf). Cattail Series and Bulrush Series are important contributors to each other's vegetative cover, and they include other important associate species, such as *Anemopsis californica* (Yerba Mansa), *Carex* spp. (sedges), *Cyperus eragrostis,* and *Distichlis spicata* (Saltgrass). These series form variable herbaceous scrubby covers (continuous to open) less than 4 m (13 ft) tall, and they occur in peaty soils of variably-flooded habitats, with water chemistry of freshwater, mixohaline, hyperhaline, and mixosaline, at elevations below 2,100 m (6,890 ft).

Saltmarsh

Saltmarsh, or Estuarine Intertidal (substrate exposed and flooded by tides) Emergent Wetland Persistent, within the watershed is dominated by *Salicornia virginica* (Virginia Pickleweed), which is a glabrous, green, fleshy perennial herb (subshrub) with inconspicuous flowers. *S. virginica* is typical of saltmarshes and alkaline flats at elevations below 100 m (328 ft) (Hockman 1993). Pickleweed Series (Sawyer and Keeler-Wolf 1995) occurs in estuary habitats with water chemistries of mixohaline, euhaline, hyperhaline, or saline and that are regularly/irregularly flooded or permanently saturated (with a shallow water table). Associate species of Pickleweed Series include: *Disticlis spicada, Frankenia salina* (Alkali Heath), *Scirpus* spp., and *Suaeda californica* (Sea-blite).

Sand Dunes

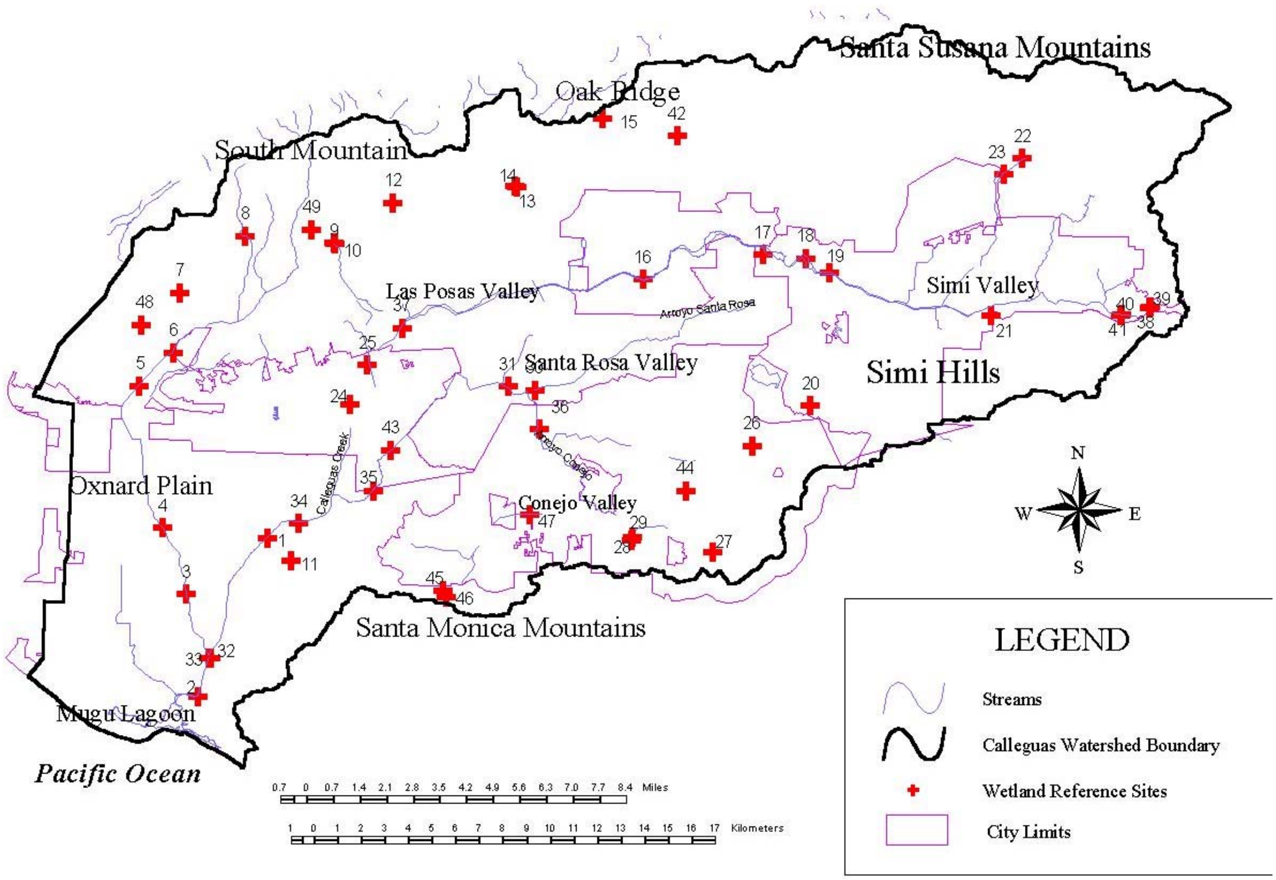
Sand Dunes is represented in the Calleguas Creek Watershed by Sand-verbena-Beach Bursage Series (Sawyer and Keeler-Wolf 1995), which is co-dominated by *Abronia* spp. and *Ambrosia chamissonis* (Beach Bursage), with several important associates including *Camissonia cheiranthifolia* (Sun Cups), *Croton californicus* (California Croton), *Disticlis spicata*, *Eriogonum latifolium* (Dune Buckwheat), and *Lupinus chamissonis* (Dune Lupine). Individual emergent shrubs (such as *Baccharis pilularis*) may be present throughout the open or continuous ground cover created by this series. Sand-verbena-Beach Bursage Series occurs on upland habitats, such as sand dunes of coastal bars, river mouths, and spits along the immediate coastline, and is typically only found at sea level.

INVENTORY OF RIVERINE SYSTEMS

Inventory

The first step undertaken in this effort was to conduct an inventory of the riverine system resources located in the Calleguas Creek Watershed. This was a subjective exercise in which 49 sites were selected as being representative of the riverine system resources in the watershed (Figure 13, Reference Site Locations).

Figure 13. Reference Site Locations



The inventory was performed to:

- Provide an advanced identification and characterization of the watershed riverine systems;
- Document the myriad impacts to riverine system functions;
- Identify watershed-scale restoration and preservation objectives; and
- Identify potential restoration and preservation sites where objectives could best be attained.

Initial sampling took place during March, June, and December 1999. Basic geomorphic and habitat data were collected at the 49 reference sites located throughout the watershed (Appendix B, Reference Site Field Data, and Appendix C, Reference Site Photographs).

General Stream Characteristics in the Calleguas Creek Watershed

STREAMS IN RUGGED TOPOGRAPHY

Streams in rugged topography occur in the upper watershed in high-gradient graded valleys (Photograph 1, Stream in Rugged Topography in the Calleguas Creek Watershed). In- and off-channel soils are well drained to excessively drained silty clay loams to sands and are shallow to deep over consolidated sediments, shale, sandstone, or basic igneous rock. Runoff is rapid and erosion potential is high (Edwards et al. 1970).

Upper watershed drainage areas typically are less than 1 square mile. At the 1:24000 scale, streams are Strahler Stream Order 1-2 (Strahler 1957). Streams are located in ravines and, thus, are confined by local relief. Floodplains, where present, are small. Flows are ephemeral, often lasting for a few days during and directly following winter rains. Slopes typically are greater than 2 percent and may exceed 10 percent. Specific stream powers are moderate but can be locally high, particularly where slopes are high. Streams are supply limited, i.e. streams are incising.

Photograph 1. Stream in Rugged Topography in the Calleguas Creek Watershed

Natural/range is the predominant land use. However, low to high density residential/ commercial development of the upper watershed is an important recent trend.

STREAMS ON ALLUVIAL FANS

Streams on alluvial fans occur on foot slopes and toe slopes of the mountainous terrain (Photograph 2, Stream on an Alluvial Fan in the Calleguas Creek Watershed). Local topography is gently rolling to low slopes. In-channel sediments are very poorly drained to excessively drained fluvial deposits of sands, gravels, and cobbles. Runoff is rapid and erosion potential is severe. Off-channel soils are well drained to excessively drained silty clay loams to loamy sands that formed in alluvium derived primarily from sedimentary rocks. Runoff is slow to medium and erosion potential is none to moderate (Edwards et al. 1970).

Drainage areas are variable, typically ranging from 1.6 to 80 sq. km (1 to 50 sq. mi.). At the 1:24000 scale, streams are Strahler Stream Order 2-4 (Strahler 1957). Most streams in this landscape position are located on fan and plain surfaces and, thus, are unconfined by local relief. However, streams often are entrenched into fan or plain surfaces to depths that may exceed 6 m (20 ft.) and, thus, may be confined by high terrace features. Floodplains, where present, are small. Flows are ephemeral to seasonal. Slopes typically are less than 2 percent. Specific stream powers are low to moderate, although locally high specific stream powers can occur where slopes are high. Streams are supply or transport limited, i.e. streams are incising, unchanging, or filling.

Photograph 2. Stream on an Alluvial Fan in the Calleguas Creek Watershed

Natural/range, citrus or avocado orchards, and low-density residential/commercial development are the predominant land uses. Some row cropping and mining occur adjacent to and/or above these sites. Intensified low to high-density residential/commercial development of these areas is an important recent trend.

STREAMS ON ALLUVIAL VALLEYS

Streams on alluvial valleys occur in low-gradient graded valleys (Photograph 3, Stream on an Alluvial Valley in the Calleguas Creek Watershed). Local topography is level. In-channel sediments are very poorly drained to excessively drained fluvial deposits of sands, gravels, and cobbles. Runoff is rapid and erosion potential is severe. Off-channel soils are moderately well drained and very fine sandy loams to silty clay loams. Runoff is slow and erosion hazard is none to slight (Edwards et al. 1970).

Photograph 3. Stream on an Alluvial Valley in the Calleguas Creek Watershed

Drainage areas typically are greater than 80 sq. km (50 sq. mi.). At the 1:24000 scale, streams are Strahler Stream Order 3-4 (Strahler 1957). Streams in this landscape position are located on valley-bottom surfaces and, thus, are unconfined by local relief. However, streams often are entrenched into valley floor surfaces to depths that may exceed 6 m (20 ft.) and, thus, often are confined by high terrace features. Floodplains can be large. Flows are seasonal to perennial. Slopes are less than 2 percent. Specific stream powers are low to moderate. Streams are supply or transport limited, i.e. streams are incising, unchanging, or filling.

Natural/range, row crop, citrus or avocado orchards, and low- and high-density residential/commercial development are the predominant land uses. Many of these systems are cleared of vegetation, straightened, leveed, and riprapped or concrete lined for flood and erosion control purposes.

STREAMS ON DELTA PLAINS

The broad delta plain is located near the coast where local topography is level (Photograph 4, Stream on the Delta Plain in the Calleguas Creek Watershed).

Photograph 4. Stream on the Delta Plain in the Calleguas Creek Watershed

In-channel sediments are very poorly drained to excessively drained fluvial deposits of sands, gravels, and cobbles. Runoff is rapid and erosion potential is severe. Off-channel soils are poorly drained silty clay loams to loamy sands. Runoff is slow to ponded and there is no erosion hazard (Edwards et al. 1970).

Drainage areas typically are greater than 80 sq. km (50 sq. mi.). At the 1:24000 scale, streams are Strahler Stream Order 4-5 (Strahler 1957). Streams in this landscape position are located on plain surfaces and, thus, are unconfined by local relief. Floodplains can be large. Flows are seasonal to perennial. Slopes are less than 2 percent. Specific stream powers are low to moderate. Streams are predominantly transport limited; that is, most streams are filling.

Streams on the delta plain probably interact extensively with the Semiperched Aquifer. Flows are seasonal to perennial in the streams that discharge to the delta plain.

However, flows are often ephemeral to seasonal on the upper delta plain and seasonal to perennial on the lower delta plain. It is possible that the streams recharge the Semiperched Aquifer on the upper delta plain, and that the Semiperched Aquifer discharges to the stream on the lower delta plain. The discharge from the Semiperched Aquifer on the lower delta plain is augmented by irrigation return flow from deep groundwater pumping. The influx of this irrigation return flow probably changes the chemical constituency of the stream water.

The mainstem Calleguas Creek and Revolon Slough are tidally influenced on the low delta plain. Tidal influence extends up gradient from U.S. Highway 1. The bed elevation of Calleguas Creek is substantially higher than the bed elevation of Revolon Slough due to extensive sediment deposition in the Calleguas Creek floodway. Therefore, tidal influence extends further up Revolon Slough.

Row crop and low- and high-density residential/commercial development are the predominant land uses. Many of these systems are cleared of vegetation, straightened, leveed, and riprapped or concrete lined for flood and erosion control purposes.

DEVELOPMENT AND IMPACTS

Historical Development in the Watershed

Prior to the middle 16th Century, the Chumash tribe populated the region. They were a hunter-gatherer society who left few permanent marks on the watershed.

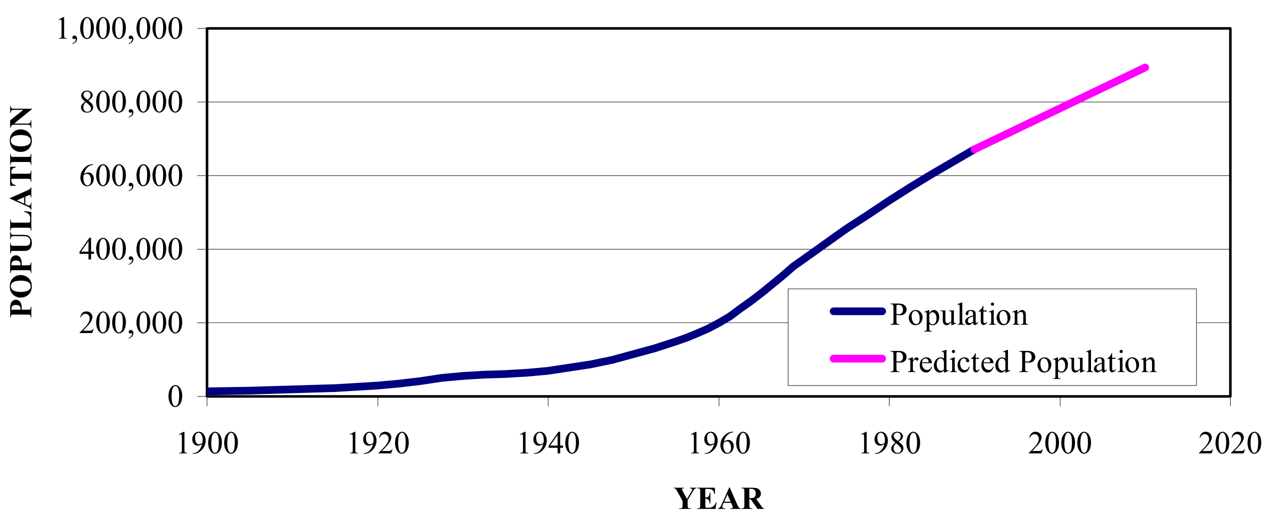
The Spanish, led by Juan Cabrillo, visited the region as early as 1542. However, permanent Spanish-Mexican settlements did not become established until the late 18th Century. The Mission San Buenaventura was established in 1782, and by the 1830s there were 19 land grant ranches in the region. The land grant ranches were used primarily for grazing by cattle, sheep, horses, and mules.

California was ceded to the United States by Mexico in 1848 following the Mexican War. Soon thereafter, ranching was largely replaced by dry-farmed cropping. The Southern Pacific Railroad was completed in 1887 and facilitated cropping expansion as export markets were tapped. The large land grant ranches were subdivided and more settlers moved into the region. Irrigation was largely introduced in the latter part of the 19th Century and facilitated the expansion of agriculture. Orchards and row crops were introduced and gradually replaced dry-farmed crops.

Prior to agricultural development, Calleguas Creek discharged to the delta plain through distributary channels near Camarillo. Surface waters recharged aquifers, and sediments were deposited on the upper fan surface. By 1889, residents had channelized Calleguas Creek to the confluence with Arroyo Conejo. By the 1920s, levees had been constructed below Lewis Road, which confined flows to the Mugu Lagoon. This initiated severe channel incision on the mainstem Calleguas Creek, which was translated up gradient to the alluvial plains, alluvial fans, and the uplands (USDA-NRCS 1995). Concomitantly, dry-farmed cropping moved onto the uplands. Increased runoff, vegetation removal, and soil disturbance resulted in the initiation of gullies, most of which can be observed today and the mechanisms of which are discussed below.

Agricultural development has continued throughout the 20th Century, but urban expansion has gradually became more prominent. Population increased slowly during the first half of the 20th Century, and then surged following World War II. Population continues to surge and projections indicate that the population of Ventura County will increase from 671,600 in 1990 to 894,000 in 2010 (Figure 14, Population Trends in Ventura County). The passage of the Save our Open Space and Agricultural Resources (SOAR) initiative may slow this surge; however, it will not reverse the general trend.

Figure 14. Population Trends in Ventura County



Impacts to Streams as a Result of Development

Many of the streams within the Calleguas Creek watershed have been impacted by development, from conversion of natural vegetation to agricultural crops or urban or commercial buildings (and associated flood control facilities and roads and highways). These development activities change many natural wetland physical parameters, such as:

- Stream discharge;
- Sediment supply;
- Channel morphology;
- Water quality; and
- Plant and wildlife habitat.

Each parameter is discussed in detail below.

STREAM DISCHARGE, SEDIMENT SUPPLY, AND CHANNEL MORPHOLOGY

Stream Discharge

Grazing and orchard cultivation are characterized by vegetation removal and soil compaction. Canopy interception and evapotranspiration decrease so more water is available for runoff. Furthermore, infiltration is decreased so Hortonian overland flow begins earlier in a storm event. Finally, vegetation removal results in increased overland flow velocities (Dabney et al. 1995, Meyer et al. 1995, Prosser et al. 1995). Thus, intensive grazing and orchard cultivation can result in higher peak flows earlier in a storm event (Likens et al. 1970, Davis 1984, McGurk and Davis 1996).

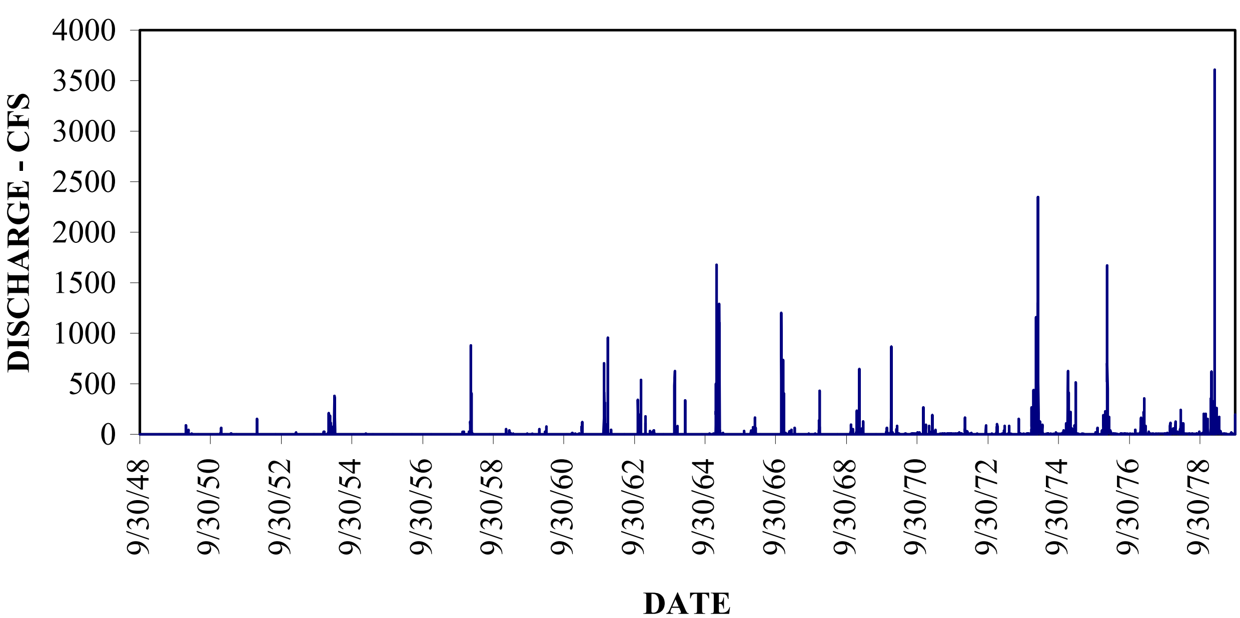
Orchard cultivation and row cropping typically require irrigation, particularly late in the growing season. Groundwater pumping can dewater streams, particularly where shallow, alluvial aquifers are tapped (Dunlap et al. 1985, McGurk and Davis 1996). Additionally, irrigation water can discharge to streams thereby maintaining base flows later into the dry season (i.e., nuisance flows). In some cases, ephemeral and seasonal streams can be transformed into perennial streams. This can result in the transition from drought-tolerant plant species to hydrophytic plant species. Often, this also is a transition from native plant species to nonnative plant species.

Urban development is characterized by the mass transition from pervious to impervious surfaces (e.g. permeable soils to concrete and asphalt). Furthermore, drainage is enhanced by way of gutters, storm water culverts, and straightened and leveed stream networks. The net effect is that infiltration is decreased and runoff is increased during storm events. Water is drained from the urban landscape and is discharged to the stream network more rapidly. Thus, urban development results in profound changes in stream hydrologic regimes. Direct measurements and hydrologic simulations have repeatedly demonstrated the results of urbanization: the peak discharge for a given rainfall intensity increases by a factor of 2 to 5 (Hollis 1975); the duration of a given flow magnitude increases by a factor of 5 to 10 (Barker et al. 1991); and channel instability, as measured by sudden changes in width and depth, occurs predictably when the effective impervious surface of the watershed exceeds 10 percent (Booth and Jackson 1997).

Urban flood flows are exacerbated by the construction of levees. Levees, by design, keep water in the floodway and off of the floodplain, so all of the additional water that is being discharged to the stream network must be passed by the narrow floodway. Rather than spreading some floodwaters onto a floodplain and, therefore, decreasing the amount of water in the channel at a given moment in time, the leveed stream network must pass all of the floodwaters that it receives. This occurs at the same time that local urban developments are adding additional water at increased rates. An analogy can be made to freeway vehicle traffic control. During peak travel hours, vehicle traffic on freeways may be moderated by the placement of traffic lights on freeway on ramps. The traffic lights serve to limit the number of vehicles on a given stretch of freeway at a given time so that vehicle traffic proceeds smoothly. Floodplains provide a similar function for rivers. During peak travel times (i.e. floods), stream flow may be moderated by the existence of floodplains. The floodplains temporarily store water and, therefore, limit the amount of water in a given reach of river at a given time so that stream flow proceeds smoothly.

The effects of development activities in the Calleguas Creek Watershed can be seen in changes in mean daily discharges on Arroyo Simi near Simi Valley (Figure 15, Mean Daily Discharge on Arroyo Simi near Simi Valley [1953-1982]). The frequency and magnitude of moderate and high discharges increased steadily during the rapid development phase beginning in the post-World War II era. Assuming that climate has been in a state of quasi-equilibrium during this interval, the increases in frequency and magnitude of moderate and high discharges can only be explained as steam flow responses to development activities.

Figure 15. Mean Daily Discharge on Arroyo Simi near Simi Valley [1953-1982]



The effects of development activities in the Calleguas Creek Watershed have been documented through stream flow modeling efforts. The modeling effort covered five land use periods: Native American settlement, Spanish-Mexican settlement, 1932, 1990, and 2010. The results of the modeling effort for Gabbert Canyon, which includes a substantial portion of the City of Moorpark, indicate that discharges of a given return interval have increased and will continue to increase as a result of watershed development. For example, the 2-year discharge is projected to increase approximately 850 percent from the Native American period to the year 2010, and the 5-year discharge in 2010 is project to be roughly equivalent to the 100-year discharge during the Native American period (Table 5, Modeled Flows in Cubic Feet per Second for Gabbert Canyon with Significant Urbanization) (USDA-NRCS 1995).

Table 5. Modeled Flows in Cubic Feet per Second for Gabbert Canyon with Significant Urbanization

Return Interval (years)	Native American	Spanish-Mexican	Year		
			1932	1990	2010
2	120	320	620	890	1,020
5	300	750	1,160	1,500	1,620
10	500	1,040	1,530	1,850	1,980
25	1,070	1,810	2,370	2,700	2,850
50	1,210	2,000	2,550	2,890	3,040
100	1,650	2,550	3,090	3,450	3,610

USDA-NRCS (1995)

Sediment Supply

Each of the agricultural activities in the watershed results in the removal of the natural vegetation. Bare soils are common, even during active cultivation, i.e., between rows of crops and in orchard understories. Vegetation removal typically decreases precipitation interception. This enhances the effects of rain splash erosion and, thus, facilitates the mobilization of sediments (Dunne and Leopold 1978). Vegetation removal also decreases soil cohesion. Fine- and coarse-roots contribute to sediment cohesion by creating a composite material in which elastic fibers of relatively high tensile strength (i.e. roots) are embedded in a matrix of relatively plastic particle masses (i.e. sediments)(Gray 1974, Gray and Leiser 1989). One result is that the critical shear stress, or the shear stress required to mobilize sediment, is substantially lower for unvegetated slopes (Prosser et al. 1995). The net result of vegetation removal can be increased sediment supply to stream networks (Roberts and Church 1986).

Rapidly developing urban areas, like those in the Calleguas Creek Watershed, also are characterized by large tracts of unfinished rough- and fine-graded lands (i.e. unfinished construction sites). Construction sites can be substantial sediment sources since they are characterized by unvegetated, unconsolidated deposits. Increased rain splash erosion (Dunne and Leopold 1978), decreased soil erosion resistance (Prosser et al. 1995), and higher overland flow velocities (Dabney et al. 1995, Meyer et al. 1995, Prosser et al. 1995) contribute to increased sediment mobilization from construction sites.

The specific effects of development activities on sediment supply in the Calleguas Creek Watershed have been documented. Prior to development, the estimated gross erosion rate was 165,107,634 kilograms [kg] (182,000 tons) per year. Under 1990 land use conditions, the estimated gross erosion rate was 1085900 kg (1,197,000 tons) per year. Of this amount, an estimated 373,760,137 kg (412,000 tons) per year was delivered to the stream network. The primary sources of the stream network sediment yield are stream banks (137,892,090 kg [152,000 tons] per year), orchards (67,131,675 kg [74,000 tons per year], construction (48,080,794 kg [53,000 tons] per year), natural areas (40,823,316 kg [45,000 tons] per year), and roads other than orchard roads (20,865,250 kg [23,000 tons] per year)(USDA-NRCS 1995).

Stream Morphology

Stream morphology is determined, in part, by the balance between discharge and sediment supply (see review of Lane 1954 in Bull 1991). The maintenance of this balance results in stable channel morphology where morphological attributes such as width and depth remain reasonably constant over periods of decades. The alteration of the discharge:sediment supply ratio, through alterations to stream discharge and increases in sediment supply, can result in the alteration of stream morphology (e.g. Eschner et al. 1983, Hecht 1984, Bull 1991, Ligon et al. 1995, Booth and Jackson 1997, Johnson 1997).

The Calleguas Creek Watershed discharge:sediment supply ratio has been altered, and therefore, stream morphology is more varied. Sediment deposition in the floodway has occurred which can decrease channel capacity (i.e. increase flooding) (Griggs 1984) and/or increase channel width (i.e. increase rates of bank erosion) (Schumm 1961). Channel incision also has occurred which disconnects channels from floodplains. Floodplains provide accommodation space for short-term storage of floodwater and long-term storage of sediment (Wright and Marriott 1993, Allred et al. 1998, Blum and Price 1998, Dalrymple et al. 1998). Where channels and floodplains are disconnected, water and sediment are confined to the channel network and must be passed down stream or deposited in the channel. Another consequence of channel incision could be local declines in shallow groundwater. Streams and shallow alluvial aquifers often are tightly linked (Alden and Munster 1997, Rains 1999). Stream water elevations decline where channel incision occurs, and if the shallow alluvial aquifers are tightly linked to the stream water elevations, then local shallow groundwater elevations, which are in close proximity to the stream, may decline as well (Scott et al. 1998).

WATER QUALITY

Vegetation removal also has been correlated with increases in dissolved ion concentrations in stream water. The conversion of chaparral to grassland, a typical response to extensive grazing, 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.

In 1992, Mugu Lagoon, Calleguas Creek, Revolon Slough, and Beardsley Wash were identified as impaired water bodies by the California State Water Resources Control Board. Impaired water bodies are those bodies of surface water that cannot reasonably be expected to attain or maintain applicable water quality standards. They received said designation due to the occurrences of high levels of agricultural pesticides in sediments and fish tissues including the cancelled substances DDT, dieldrin, toxaphene, and chlordane. High levels of PCB's of undetermined origin, nitrates, and ions capable of forming salts also have been recorded (USDA-NRCS 1995).

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).

PLANT AND WILDLIFE HABITAT

Conversion, destruction, and fragmentation of plant and wildlife habitats are obvious consequences of agricultural and urban development. This is especially true in riverine systems, in which a common prerequisite for development is stream channelization and concomitant disconnection of channels and floodplains. Specific impacts to wetland functions include, but are not limited to, the following:

- Temporary or permanent losses of foraging and cover habitats for aquatic and semi-aquatic species including Western Aquatic Two-Stripped Garter Snake, and the Pacific Chorus Frog;
- Temporary or permanent losses of foraging and cover habitats for terrestrial wildlife including birds of prey and a variety of mammals;
- Disturbance of breeding and nesting activities of various songbirds, and fall migratory birds, depending on the timing of development construction; and
- Long-term changes in the composition of aquatic fauna due to permanent changes in morphology, channel substrate, and water chemistry.

A less obvious consequence of agricultural and urban development is that alterations to the physical and biological attributes and processes in the watershed can lead to further habitat degradation. Many riparian species have evolved life-history strategies that are tightly linked to stream flow regimes. For example, many riparian tree species time their seed release to coincide with annual flood flows (Walker et al. 1986, Scott et al. 1996). Riparian tree establishment depends upon the availability of bare, moist sediments created by flood scour or deposition, while riparian tree persistence depends upon access to shallow groundwater and protection from scouring flows (McBride and Strahan 1984, Scott et al. 1996). Furthermore, vegetation establishment depends upon a source of propagules such as those provided by other local intact ecosystems. Thus, alterations to the physical attributes and processes, coupled with habitat conversion, destruction, and fragmentation, can reduce the resilience of remaining riparian habitats. These riparian habitats may be locally protected; however, they may not persist, which can lead to continued habitat degradation in the watershed.

Habitat destruction and fragmentation have occurred throughout the history of development in the Calleguas Creek Watershed. This trend likely will continue. Prior to the passage of SOAR (Save Open Space and Agriculture Resources Initiatives of 1999), the amount of the watershed in urban development was expected to increase, from 21 percent in 1990 to 38 percent in 2010, with most of the new urbanization resulting from the conversion of open space (USDA-NRCS 1995).

APPROACH AND RATIONALE

OVERALL OBJECTIVES

The Conservancy outlined their concerns for the Calleguas Creek Watershed in the 23 January 1998 Request for Proposals. The Conservancy is particularly concerned with sedimentation of the Mugu Lagoon and the loss of riparian plant and wildlife habitat throughout the watershed.

It is a widely-held belief that rivers are conduits through which physical and biological interactions occur in the up and down stream directions and, therefore, that ecosystem integrity at any point in the stream network is, to some extent, inextricably tied to ecosystem integrity at all other points in the stream network (Vannote et al. 1980). Thus, it is widely assumed that restoration projects on streams provide benefits outside the immediate project area (McGurrin and Forsgren 1997, Toth et al. 1997). Regional-scale flood attenuation benefits are suggested by Hey and Philippi (1995) who propose that the 1993 Mississippi Valley floods could be attenuated with strategically placed floodplain restoration in the upper Mississippi Valley. Furthermore, water quality benefits – which are translated down gradient by surface and ground water flow – have been tied to the restoration of gravel bars and riffles (Vervier et al. 1993). This operational paradigm recommends taking a watershed-scale approach to the rectification of these problems in the Calleguas Creek Watershed.

The Conservancy and the NRCS believe that floodplain reclamation efforts are critical components of this effort. The DMEC team agrees that watershed-scale riparian restoration is best accomplished through the restoration of channel-floodplain connections. Doing so is the most effective method of restoring the physical, chemical, and biological integrity of the stream network to historic or near historic conditions. However, the DMEC team also believes that an approach emphasizing restoration of channel-floodplain connections without addressing source control is doomed to failure. In many instances, the degradation of river systems is merely symptomatic of watershed-scale, root-cause diseases (National Research Council 1992); that is, the degradation of river systems such as the Calleguas Creek are the symptomatic results of anthropogenic activities within the watershed that ignore the requirements or needs of a healthy fluvial system or processes.

The myriad existing impacts and the continued rapid rate of development require that an aggressive approach be employed in the restoration and preservation of the Calleguas Creek Watershed. Merely removing on-site impacts will not result in ecosystem restoration (Kondolf 1993). Thus, the approach must include restoration of watershed-scale attributes and processes if it is to be successful. For example, the restoration of a natural flow regime, which has been deemed critical in successful restoration of riverine ecosystems (Poff et al. 1997), requires that on- and off-site impacts be addressed. The recommendations outlined below could be part of an aggressive approach that includes elements of source control and amelioration.

As outlined in "Watershed Characterization", above, the Calleguas Creek Watershed is experiencing different and incompatible development pressures in the upper and lower watersheds.

In the upper watershed, development pressures are resulting in fundamental alterations to the amount and timing of water and sediment delivery to the stream network. Stated simply, water and sediment are delivered to the stream network in greater volumes and at greater rates. In the lower watershed, development pressures are resulting in the disconnection of channels and floodplains. Thus, the stream network must pass more water and sediment without engaging historical floodplains. Successful restoration and management of the Calleguas Creek Watershed must include components of source control through preservation of the upper watershed and amelioration through restoration of the lower watershed.

In this regard, the DMEC approach focuses on the management of ecosystem- and watershed-scale functions. The DMEC philosophy is that riverine systems cannot be managed through the management of separate functions. Rather, riverine systems must be managed as whole systems comprising hydrology/geomorphology, biogeochemistry, plant habitat, and wildlife habitat functions. Further, the DMEC approach focuses on the prevention and amelioration of watershed-scale cumulative effects. This effort, therefore, combines source control efforts, often in the upper watershed, with amelioration efforts, often in the lower watershed.

THE APPLICATION OF A TRUNCATED HGM APPROACH

Background

The Clinton Administration's Wetlands Policy (1993) expressed the need for improved wetland assessment techniques to allow for better consideration of wetland functions in the Clean Water Act – Section 404 process. The hydrogeomorphic approach to functional assessment (HGM) has been developed in recent years to suit that purpose (Brinson 1993, Brinson et al. 1995, Smith et al. 1995). Currently, HGM is commonly used in the technically focused stages of practicable alternatives analysis, impact minimization, impact assessment, mitigation, and monitoring.

The HGM Approach Explained

The HGM approach is based upon three components: the classification of wetlands based upon hydrogeomorphic factors; the identification of functions performed by the wetland class in question; and the establishment of a regionalized reference data set for the wetland class in question (Smith et al. 1995).

Wetland classification is based upon geomorphic setting, the dominant source of water, and the hydrodynamics. Seven hydrogeomorphic classes have been previously identified: riverine, depressional, slope, mineral soil flats, organic soil flats, estuarine fringe, and lacustrine fringe (Brinson 1993). Typically, these are further subdivided into subclasses based upon regional characteristics. Classification makes assessments more precise and efficient by accounting for the natural variation attributable to geomorphic setting, water source, and hydrodynamics (Brinson 1993, Smith et al. 1995).

Each of the seven wetland classes listed above performs specific functions. For example, consider a slope wetland adjacent to a riverine wetland during a hypothetical rain event. During the high intensity rainfall, the subsurface storage in the slope wetland is filled and/or the rainfall rate exceeds the infiltration capacity. Either way, the result is overland flow to the riverine wetland. Meanwhile, river stage rises and the stream water floods onto the floodplain. During the dry period following the storm, overland flow stops in the slope wetland but subsurface water continues to discharge from the slope wetland to the riverine wetland. Meanwhile, river stage falls and stream water recedes into the channel network. However, base flow is maintained, in part due to the contribution from the adjacent slope wetland. Each of these wetlands is performing, in this case, hydrologic functions. However, the nature of those hydrologic functions is quite different. Thus, the functions characteristic to a particular wetland class must be identified to avoid the assessment of functions that are inappropriate for a given wetland class. Even if functions overlap significantly between classes, which they often do, the functions are likely to be performed at different intensities and in different ways. Furthermore, the field indicators used to assess each function differ sufficiently to require separate treatment (Smith et al. 1995).

Regionalized reference data sets are used to develop profiles of the wetland class in question. These profiles are composed of physical, chemical, and biological data that indicate the range of conditions found in the wetland subclass (Smith et al. 1995). The profiles are used in two ways. First, the profile is used to develop functional assessment models that are used to detect changes in ecosystem functions due to proposed or completed activities. Second, the profile is used as a template for designing ecosystem restoration or as components in a monitoring program (Lee et al. 1997).

The HGM Approach Used in this Document

The HGM approach used in this document is a truncated version of the approach outlined above. The approach was modified to be specific to this watershed since a Calleguas Creek Watershed HGM guidebook is not available; the most applicable HGM guidebook is unready for use in the Calleguas Creek Watershed; and HGM does not assess cumulative effects.

The most applicable HGM guidebook is the Guidebook to Hydrogeomorphic Functional Assessment of Riverine Wetlands in the Santa Margarita Watershed (Lee et al. 1997, hereafter cited as the Santa Margarita Guidebook). The Santa Margarita Guidebook was among the first guidebooks to be developed nationally. The current draft of the Santa Margarita Guidebook was peer reviewed in October 1997 (National Wetland Science Training Cooperative 1998). The peer reviewers (including some DMEC team members) made substantial comments, explicitly stating that substantial revisions needed to be made prior to application. The authors agreed with this assessment. To date, these revisions have not been made. Thus, decisions based solely upon the Santa Margarita Guidebook would be of questionable benefit since the document has been deemed too immature for application, even in the established reference domain.

Guidebooks to the application of the hydrogeomorphic approach to functional assessment must be calibrated to regional conditions. The current draft of the Santa Margarita Guidebook has not been calibrated to the conditions characteristic to the Calleguas Creek Watershed. The authors explicitly state that the potential domain includes the area inclusive of the Calleguas Creek Watershed but, to date, no formal effort has been undertaken to calibrate the Santa Margarita Guidebook in this area. Thus, decisions based solely upon the Santa Margarita Guidebook would be of questionable benefit since the document has not been calibrated to the regional conditions.

The HGM approach is, by definition, a site-specific approach. It was developed specifically for analyses of pre- and post-project conditions at the site-specific scale. HGM does not assess cumulative effects at a watershed scale. The Calleguas Creek Watershed effort is an effort to ameliorate the cumulative effects of centuries of agricultural and urban development. Thus, HGM is not the appropriate tool to be used solely for understanding the net effects of our proposed restoration and preservation activities.

In spite of these shortcomings, a truncated version of the HGM approach was employed in this effort. As previously noted, the authors of the Santa Margarita Guidebook explicitly state that the potential domain includes the area inclusive of the Calleguas Creek Watershed. Thus, the Santa Margarita Guidebook, as modified by the peer review process of October 1997 (National Wetland Science Training Cooperative 1998), was used to identify critical functions for riverine wetlands in the Calleguas Creek Watershed. The current performance and the potential for restoration of these functions were considered during the site selection process. Data were collected as part of the watershed characterization process but no formal and documented HGM functional assessment was performed. This flexible approach allowed us to take advantage of the strengths of the Santa Margarita effort, while emphasizing the unique attributes of the Calleguas Creek Watershed and the importance of watershed-scale linkages, which would not be possible with a strict application of the Santa Margarita Guidebook.

Ecosystem Functions Defined

Riverine wetlands in the Calleguas Creek Watershed can be characterized as performing various hydrology/geomorphology, biogeochemistry, plant habitat, and wildlife habitat functions (Table 6, Ecosystem Functions of Riverine Wetlands in the Calleguas Creek Watershed). These functions cannot be assessed independently due to the inherent interconnections in ecosystems in general and in riverine ecosystems in particular. Thus, functional assessment of riverine ecosystems must include reference to the entire suite of hydrology/geomorphology, biogeochemistry, plant habitat, and wildlife habitat functions.

Table 6. Ecosystem Functions of Riverine Wetlands in the Calleguas Creek Watershed

Function	Definition
Hydrology/Geomorphology	
Maintain Alluvial Corridor Integrity	Maintenance of physical attributes and processes that result in characteristic channel width, depth, slope, and roughness.
Maintain Surface Water Hydrology	Maintenance of a characteristic hydrograph, including the amount and time of water delivery to the channel network.
Maintain Subsurface Water Hydrology	Maintenance surface and ground water interactions between the channel and the local and regional aquifers.
Sediment Mobilization, Transport, and Storage	Maintenance of a characteristic sediment regime through the maintenance of a hydrograph and sediment delivery to the stream network.
Biogeochemistry	
Element and Compound Cycling	Abiotic and biotic processes that convert elements and compounds from one form to another.
Organic Carbon Export	Export of dissolved and particulate carbon, primarily through leaching and flushing.
Plant Habitat	
Maintain Native Plant Association	Maintenance of characteristic plant associations in terms of species composition of trees, saplings, seedlings, shrubs, and herbs.
Maintain Spatial Structure of Plant Association	Maintenance of the structural characteristics required for supporting native plant habitat and their animal associates.
Maintain Characteristic Detrital Biomass	The production, accumulation, and dispersal of dead plant biomass of all sizes. The sources may be up slope, up gradient, or on site.
Maintain Interspersion and Connectivity for Plant Populations	Maintenance of characteristic spatial relationships between plant habitats such that native plant species are capable of completing their life cycles.
Wildlife Habitat	
Maintain Native Vertebrate Associations	Maintenance of the diversity, density, and spatial distribution of aquatic and terrestrial vertebrates.
Maintain Native Invertebrate Associations	Maintenance of the diversity, density, and spatial distribution of aquatic and terrestrial invertebrates.
Maintain Interspersion and Connectivity for Animal Populations	Maintenance of characteristic spatial relationships between animal habitats such that native animal species are capable of completing their life cycles.

SITE SELECTION CRITERIA

Site selection criteria were used to screen the list of potential restoration and preservation sites. Initial sampling took place at 49 sites throughout the watershed (see Figure 12, Reference Site Locations). Recall that these sites were selected to represent the range of conditions in the watershed to facilitate a watershed analysis and were not simply an initial pool of sites from which to select restoration sites. Thus, initial screening identified 27 sites of the 49 reference sites that could clearly benefit from technically and economically feasible restoration (Table 7, List of Reference Sites and Preliminary Action Recommendations).

Table 7. List of Reference Sites and Preliminary Action Recommendations[3]

Site No.	Site Name	Potential
1	Calleguas Creek at CSU Channel Islands	Restore
2	Calleguas Creek at U.S. Highway 1 Crossing	Restore
3	Revolon Slough at Hueneme Road Crossing	No Action
4	Revolon Slough at Laguna Road Crossing	No Action
5	Beardsley Wash at Central Avenue Crossing	No Action
6	Beardsley Wash at Wright Road near New Golf Course	Restore
7	Unnamed at La Vista Avenue Crossing	No Action
8	Milligan Barranca at La Loma Avenue Crossing	Restore
9	Fox Barranca at Barylwood Road Crossing, Up-Gradient	Preserve
10	Fox Barranca at Barylwood Road, Down-Gradient	Restore
11	Long Grade Canyon Creek at CSU Channel Islands	Restore
12	Coyote Canyon at Bradley Road Crossing	Restore
13	Long Canyon at Stockton Road Crossing, Down-Gradient	Preserve
14	Long Canyon at Stockton Road Crossing, Up-Gradient	Restore
15	Unnamed on Grimes Road near Watershed Boundary	Preserve
16	Arroyo Simi at end of Spring Road, Moorpark	No Action
17	Arroyo Simi near Oak County Park	Restore
18	Arroyo Simi near Simi Recycling Center	Restore
19	Arroyo Simi at Madera Road Crossing	No Action
20	Sycamore Canyon at Wood Ranch	Restore
21	Meier Canyon at end of Tapo Canyon Road	Restore
22	Gillibrand Canyon at Tapo Canyon Park	Restore
23	Gillibrand Canyon at Bennett Road Crossing	Preserve
24	Calleguas Creek at Adolfo Road Crossing	No Action
25	Calleguas Creek at Upland Road	Restore
26	Unnamed below Lang Ranch	Preserve
27	Unnamed across U.S. 101 from T.O. Civic Center	Preserve
28	Unnamed above Los Robles Country Club	Preserve
29	Unnamed on Los Robles Country Club	No Action
30	Arroyo Santa Rosa at Arroyo Conejo	Restore
31	Arroyo Conejo at Fitzgerald Ranch (Santa Rosa Valley)	Restore
32	Calleguas Creek/Revolon Slough Confluence	Restore
33	Calleguas Creek/Revolon Slough Confluence	Restore
34	Calleguas Creek at Camarillo Regional Park	Restore
35	Arroyo Conejo at Winding Brook Farm/Pancho Road	Restore
36	Arroyo Conejo in Hill Canyon	Preserve
37	Arroyo Las Posas near Somis	Restore
38	Arroyo Simi at Corriganville Park	No Action

[3] See Appendix C, Reference Site Photographs, for photographs of each reference site.

Site No.	Site Name	Potential
39	Arroyo Simi at Corriganville Park	Preserve
40	Arroyo Simi/Junipero Channel Confluence	Restore
41	Arroyo Simi/Junipero Channel Confluence	Restore
42	Happy Camp Canyon	Preserve
43	Arroyo Conejo at U.S. 101	Restore
44	Arroyo Conejo tributary at SR 23 and Janss Road	Restore
45	South Branch Arroyo Conejo at Santa Monica Mountains Park	Preserve
46	South Branch Arroyo Conejo Tributary in Conejo Valley	Preserve
47	South Branch Arroyo Conejo at Borchard Road	Restore
48	Unnamed Drainage at Santa Clara Avenue	Restore
49	Orchard at Barylwood and Aggen Roads	Restore

The site selection criteria outlined below were applied to each of the 27 sites. The 10 sites selected for further analysis were those sites that best fit the site selection criteria when those criteria were applied at a watershed scale. For example, an effort was made to space the sites throughout the watershed and, in particular, to locate sites in agricultural and wildland landscapes between high-density urban centers. This last criterion does not reflect an opinion as to the relative value of agricultural and wildland versus urban land uses. Rather, this last criterion reflects an operational paradigm wherein it is substantially easier to acquire and restore agricultural and wildland resources than it is to acquire and restore urban resources.

Site selection criteria are outlined below. No formal decision matrix is included since decision matrices imply discrete selection processes. The selection processes herein were not discrete in nature. Rather, the selection processes were characterized by the need to optimize the various selection criteria at a watershed scale.

- Substantial Amelioration. Some sites were selected to ameliorate the impacts of development. Amelioration activities are focused on a) restoring channel-floodplain interactions to provide accommodation space for floodwaters and sediment deposition, and b) restoring large tracts of plant and wildlife habitat in the urban-suburban-rural matrix. Development in the Calleguas Creek Watershed is characterized by major urban centers embedded in a suburban-rural matrix. Large suburban-rural areas between the major urban centers provide ample opportunities to preserve and restore riverine wetlands. Thus, impacts of the major urban centers (e.g. peak discharge and sediment supply increases, local habitat degradation and destruction) can be ameliorated between the major urban centers.
- Substantial Source Control. Some sites were selected to provide source control benefits. Source control activities are focused on controlling peak discharges and sediment production through the restoration and preservation of key portions of the watershed. Key portions of the undeveloped upper watershed have been identified and singled out for preservation. Additionally, potentially destabilizing and/or habitat degrading influences in and adjacent to streams are identified for removal. For example, stream bank stabilization and alternative orchard management strategies are recommended to reduce the influx of sediment into the stream network.

- Substantial Restoration or Preservation of Physical and Biological Processes. All sites selected will facilitate the restoration or preservation of key physical and biological processes in the watershed. The restoration and preservation of physical and biological processes is critical for the sustainability of riverine ecosystem functions. The mere enhancement of selected attributes, without restoration of the processes, can result in the development of dysfunctional systems that cannot perpetuate themselves.

- Landscape-Scale Relationships. Some sites were selected to provide connectivity between adjacent ecosystems. For example, preference was given to sites that would connect relatively undisturbed riparian and/or upland habitats. Additionally, some sites were selected to provide unique ecosystem functions to a region. For example, some sites were selected to provide channel-floodplain connectivity between high-density urban development centers.

- Relevance. All sites that were selected will provide substantial watershed-scale benefits following restoration. This criterion includes issues such as the size of the site and the need for restoration (i.e. the need to ameliorate for upstream and/or onsite impacts).

- Feasibility. All sites were generally assessed for technical and financial feasibility. Sites where restoration did not appear to be feasible were not selected. Feasibility from a political perspective was not assessed for two reasons. First, the DMEC team was contracted to provide *technical* assistance to this effort. Political assessment of the restoration recommendations was not a part of the project scope, nor is it our expertise. Second, politics can change rapidly, and certainly could change within the lifespan of this document. Thus, this document is intended to provide technical assistance to policymakers in a changing political landscape.

- Cost Savings. Some sites were selected to provide cost savings in the watershed. For example, some sites were selected to provide flood control, to reduce in-channel sedimentation, or to improve internal drainage of agricultural fields.

A NOTE ON LIMITATIONS

The episodic nature of weather and, therefore, stream discharge and sediment supply bears discussion. Flood events are episodic on the South Coast of California. For example, over a 29-year period (water years 1960-1988), annual peak flows in the Ventura River near Meiners Oaks varied from 1.1 cms to 793 cms (38 cfs to 28,000 cfs) (USGS Gage #11116550). Daily variations in flows also can be highly variable. During the 12 February 1992 flood, discharge in the Ventura River near Ventura increased from 2.8 cms to 1,323 cms (100 cfs to 46,700 cfs) in a period of three hours (Keller and Capelli 1992).

High sediment flux events also are episodic and often are related to wildfires coupled with high flows. Sediment rating curves may shift upwards 10 to 20 percent following significant wildfires, resuming their pre-fire relationships after two to five years (Wells and Brown 1982; Taylor 1983; Hecht 1984). A specific example is the Sisquoc River near Santa Maria, California where more than half of the bed load transported during a 60-year period was probably associated with the 1966 fire that burned approximately 35 percent of the watershed and the January to February 1969 high flows (Hecht 1993).

Fluvial geomorphologists have long recognized the unique geomorphic responses to episodic flood/high sediment flux events in arid and semi-arid regions. 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).

The episodic nature of flows and sediment fluxes cannot be controlled in stream restoration efforts. Thus, restoration in episodic stream systems must account for this inherent uncertainty. The episodic paradigm is based on episodic cycles of perturbation and recovery, not on the development of equilibrium landforms and mature habitats. Concepts and tools that are useful in other systems, such as channel-forming discharge dimensions, are less useful and must assume less significant roles. Similarly, design specifications and success criteria must be flexible to allow the natural physical processes to operate on the landscape.

RESTORATION AND PRESERVATION RECOMMENDATIONS

OVERVIEW

The wetlands and floodplains in the Calleguas Creek watershed are considered to be significantly degraded, particularly in the lowland areas. Urbanization of the lowland areas, and agricultural practices of the past century have significantly degraded many of the watersheds wetlands. Degradation of watershed wetland functions generally increases downstream as a result of upstream impacts of urbanization and agriculture.

However, these degradations provide opportunities for wetland function restoration, especially since large areas adjacent to Calleguas Creek and it major tributaries are not completely constrained by permanent structures or housing and commercial development. Since impacts such as sedimentation and erosion, flooding, and loss of habitat generally increase downstream as the watershed wetlands have been degraded upstream, our general approach to wetland function restoration is concentrated in the lower portions of the watershed.

Of the ten sites examined for restoration in this plan, DMEC attempted to identify and assess sites throughout the watershed. Since the watershed wetlands have been so severely degraded in the past, numerous potential restoration sites exist throughout the watershed. The ten sites recommended for restoration here are simply examples that DMEC believes provides excellent restoration potential and provides an efficient approach to watershed wetland function restoration.

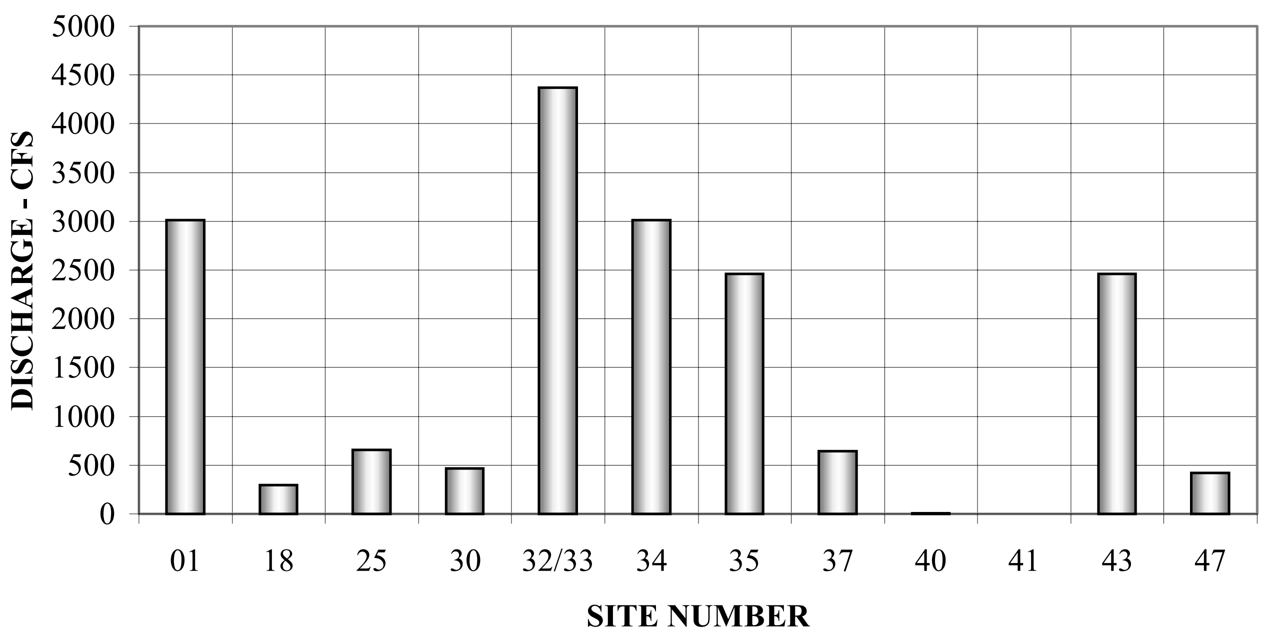
EXAMPLE DESIGN RATIONALE

This effort provides order of magnitude design specifications for purposes of facilitating planning discussions and efforts. These data should not be interpreted as final design specifications, which are beyond the scope of this effort. The example design criteria included herein include bankfull width, mean bankfull depth, and surface water slope. These minimal design criteria were used to develop the example design figures, below. Final design criteria will be far more inclusive and accurate, and will be the result of more focused hydrological, geomorphological, and ecological analyses at each site.

Width, depth, and velocity vary with discharge as simple power functions (Leopold and Maddock 1953, Leopold et al. 1992, Eschner 1983). At-a-station hydraulic geometry is the practice of exploring these relationships. At-a-station hydraulic geometry shows that natural channels conform to consistent geometric patterns and that deviations from these geometric patterns will result is erosion and deposition as channels trend toward the quasi-equilibrium form (Dunne and Leopold 1978). Thus, at-a-station hydraulic geometry equations commonly are used to generally predict the width, mean depth, and velocity at a range of discharges. Specifically, a design discharge is selected and used to develop design channel widths and depths through the application of the hydraulic geometry equations.

The most commonly used design discharge is the bankfull discharge. Bankfull discharge is the discharge that results in the maintenance of natural channel morphology (Wolman and Leopold 1957). The bankfull discharge is typically considered to be the discharge that, on the average and over many years, performs the most work on the river system. The primary geomorphic response to that 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, and it these moderate discharges that typically dominate sediment transport and channel morphology maintenance over long periods of time (Wolman and Miller 1960). There are many methods by which bankfull discharge can be estimated (Williams 1978). In many circumstances, however, numerous methods return the same range of values (Larsen et al. unpublished data). For the purposes of this effort, bankfull discharge was assumed to have a 1.5-year recurrence interval based upon an annual flood series (Figure 16, Discharge with a 1.5-Year Recurrence Interval Calculated from the Annual Maximum Series for the Selected Restoration Sites). The true bankfull discharge may occur more or less frequently than this, but a 1.5-year recurrence interval based upon the annual flood series is quite typical (Wolman and Leopold 1957, Williams 1978) and will suffice for this planning-level effort.

Figure 16. Discharge with a 1.5-Year Recurrence Interval Calculated from the Annual Maximum Series for the Selected Restoration Sites



*Flow values computed from ratio of drainage area above site to drainage area at stream gage.

River response to changing discharge depends upon a variety of factors including, but not limited to, climate, geology, and land use. Thus, at-a-station hydraulic geometry relationships are regionally specific and should be performed with data from within the same hydrophysiographic region. At-a-station hydraulic geometry analyses were performed using data from two stream gaging stations in the Calleguas Creek Watershed. Calleguas Creek at Camarillo State Hospital (Water Year 1998) was used to develop a Delta Plain Hydraulic Geometry Model, and Arroyo Simi at Madeira Road Bridge (Water Year 1983) was used to develop an Alluvial Valley Hydraulic Geometry Model.

At all gage locations, width, mean depth, and velocity increase with discharge in log-linear fashion. The relationships can be modeled as simple power functions.

Calleguas Creek at Camarillo State Hospital (Delta Plain Hydraulic Geometry Model):

$$w = 15.27\, Q^{0.33}$$
$$H = 0.11\, Q^{0.42}$$
$$u = 0.55\, Q^{0.26}$$

Arroyo Simi at Madeira Road Bridge (Alluvial Valley Hydraulic Geometry Model):

$$w = 4.21\, Q^{0.46}$$
$$H = 0.27\, Q^{0.27}$$
$$u = 0.86\, Q^{0.28}$$

where

w = width (ft)

H = mean depth (ft)

u = mean velocity (fs)

Q = discharge (cfs)

It must be emphasized that these relationships are simple power functions based upon field observations made during the stated water years. Certainly, each channel cross-section was modified prior to and during the collection of these data. The channel response to varying discharge was measured in the context of these modifications which likely included, but were not necessarily limited to, sediment delivery above natural background rates, vegetation removal, and channel training.

The natural channel response to varying discharge in the absence of channel modification cannot be ascertained from these data via this method. Furthermore, the episodic nature of the climate, and therefore stream discharge throughout southern California, renders quasi-equilibrium concepts such as bankfull channel dimensions less useful than in some other physiographic regions (see "Notes on Limitations", above). Nevertheless, this effort was undertaken since the data do provide adequate planning-level information.

GENERAL RECOMMENDATIONS

This section provides general recommendations by DMEC to those concerned with managing, restoring, or maintaining wetlands, water quality, sedimentation, erosion, or wildlife habitat within the Calleguas Creek Watershed. These recommendations include preserving key portions of the watershed, implementations of storm water management plans, maintaining storm water management facilities as wetland and wildlife habitat, restoring and stabilizing natural stream banks, reducing sediment discharges from orchards, and replacing undersized culverts and bridges with larger ones. The wetlands within the watershed will be greatly improved in these general recommendations are implemented over then next decade.

Preserve Key Portions of the Watershed

UPLAND PORTIONS OF THE UPPER WATERSHED

Development imposes a variety of changes on stream networks. These changes have profound physical and biological implications, many of which are obvious even to the casual observer. Unfortunately, most restoration attention is directed toward the channel and floodplain systems. It is rarely recognized that the stream network itself drains a watershed and, therefore, the specific characteristics of a stream reach are products of the cumulative impacts in the contributing area. Thus, the cumulative impacts to the upland portions of the contributing areas are commonly ignored in spite of the fact that the National Research Council has clearly articulated a position stating that changes in uplands are important in determining overall stream function (National Research Council 1992).

Large areas of the upper Calleguas Creek Watershed are currently undeveloped. Access is difficult and slopes are steep, so these areas often are of low priority insofar as development is concerned. However, development of these areas is an important recent trend, in part due to the scarcity of undeveloped land in the lowlands (Photograph 5, Development of the Rugged Terrain of the Upper Calleguas Creek Watershed). Unfortunately, these upland areas are characterized by rapid runoff and high erosion potential, even in their undisturbed states (Edwards et al. 1970), and development of these areas exacerbates these problems. For example, stream discharge in Gabbert Canyon, a rapidly urbanizing upper watershed area, has increased markedly as a function of increased agricultural and urban land development (see Table 5) (USDA-NRCS 1995). Thus, the preservation of large tracts of upper watershed is critical to the effective, long-term maintenance of the physical processes of the stream network.

Photograph 5. Development of the Rugged Terrain of Upper Calleguas Creek Watershed

GROUNDWATER RECHARGE ZONES

Surface water recharge to unconfined aquifers is a function of three parameters: a) the amount of surface water that is not lost to evapotranspiration or runoff, b) the vertical hydraulic conductivity of the recharge zone, and c) the transmissivity and the potentiometric gradient of the unconfined aquifer which determines the rate at which the recharge zone is evacuated of recently recharged water. Surface water recharge to confined aquifers occurs as a function of these same three parameters in locations where confining layers are absent (e.g. at outcrops)(Fetter 1994).

The development of recharge zones profoundly affects the first two parameters. The construction of concrete-lined channels and levees that reduce over bank flows increase runoff and limit the availability of surface water to recharge zones. Soil compaction and/or other soil disturbances reduce vertical hydraulic conductivities, while the construction of impervious surfaces eliminates infiltration completely. The net effect is two-fold. The reduction in ground water recharge must necessarily be coupled with an increase in evapotranspiration and/or runoff. Additionally, the reduction in groundwater recharge could result in a reduction in the availability of future groundwater resources.

Surface water is recharging the unconfined Semiperched Aquifer on the eastern Oxnard Pressure Plain Basin and the unconfined recent alluvium aquifers throughout the watershed. Most surface water recharge to deeper aquifers, including the extensively developed Fox Canyon and Grimes Canyon aquifers, occurs at outcrops in the South Las Posas, Santa Rosa, and Tierra Rejada Basins (Izbicki and Martin 1997, Bookman-Edmonston Engineering, Inc. 1998). Limited surface water recharge to aquifers also occurs at outcrops in the North Las Posas Basin (Table 8, Recharge and Discharge Characteristics of the Primary Groundwater Basins in the Calleguas Creek Watershed). The exact locations and hydrogeologic characteristics of these recharge zones is beyond the scope of this effort. However, their identification and preservation could provide important watershed-scale benefits. Furthermore, the restoration of some of the channel-floodplain connections could stimulate additional groundwater recharge during overbank flow events.

Table 8. Recharge and Discharge Characteristics of the Primary Groundwater Basins in the Calleguas Creek Watershed[4]

Groundwater Basin	Primary Recharge Mechanism	Primary Discharge Mechanism
Eastern Oxnard Pressure Plain	Surface and subsurface inflow	Pumping; subsurface outflow
Pleasant Valley	Subsurface inflow	Pumping; subsurface outflow infrequent
North Las Posas	Limited infiltration of precipitation and stream runoff	Pumping; subsurface outflow probable
South Las Posas	Infiltration of precipitation, stream runoff, irrigation return flow, and urban water runoff; some subsurface inflow	Pumping; subsurface outflow
Santa Rosa	Infiltration of precipitation, stream runoff, irrigation return flow, and urban water runoff; some subsurface inflow	Pumping; subsurface outflow
Tierra Rejada	Infiltration of precipitation, stream runoff, irrigation return flow, and urban water runoff; some subsurface inflow	Pumping; subsurface outflow

LARGE, INTACT CHANNEL-FLOODPLAIN SYSTEMS

Throughout this document we have emphasized the importance of restoring and maintaining channel-floodplain connections. Indeed, the basic tenet of this watershed-scale restoration approach is that the restoration and maintenance of channel-floodplain connections is fundamental to the overall success of this effort. Thus, it is considered essential for the few remaining large, relatively intact channel-floodplain systems to be preserved.

There are few large, relatively intact channel-floodplain systems remaining in the Calleguas Creek Watershed. Some of the more prominent examples include Arroyo Simi between Simi Valley and Moorpark and Arroyo Las Posas near Somis. Portions of these systems are included as restoration sites, below. However, their mere preservation will continue to provide watershed-scale benefits regardless of the extent of the restoration activities.

Implement Storm Water Management Plans

Regardless of the amount of watershed that is preserved, the stream network of the Calleguas Creek Watershed will continue to suffer the net effects of flow regime alterations caused by the construction of impervious surfaces. One way to ameliorate this problem, which appears to be

[4]From Izbicki and Martin (1997) and Bookman-Edmonston Engineering, Inc. (1998).

underused in the Calleguas Creek Watershed, is the storage of storm water in small volumes as near to the source as possible (Dunne and Leopold 1978, Booth and Jackson 1997).

Storm water storage facilities can be linked as a series of ponds and/or vaults that are spread along a chain from sources to sinks. In some areas, flat-roofed buildings are designed to hold up to three inches of water in rooftop retention and detention (R&D) facilities. Storm water is released from rooftop storage to nearby R&D ponds and/or underground R&D vaults. The water is put through physical oil-water separation and grit removal systems prior to discharge to natural stream networks. If the subsurface is sufficiently permeable, the water is discharged to ground water recharge basins or to uplands through spreader pipes.

If a storm water reduction approach is to be employed, then the philosophy of the design standards must be determined. Peak standards are the most commonly employed and the least costly design standards. Peak standards seek to maintain peak discharges for given rainfall intensities at their predevelopment levels. If successful, however, peak standards by themselves must necessarily increase flow durations since there is a greater volume of total runoff. Duration standards are more difficult and more costly to develop and employ. Duration standards seek to maintain the duration of sediment-transporting discharges at their predevelopment levels. The successful implementation of duration standards requires solving the problem of the additional volume of total runoff. This problem can be solved through an aggressive approach to ground water recharge or through the determination of a threshold discharge below which sediment transport does not occur (Booth and Jackson 1997).

Details of a storm water management plan are beyond the scope of this document. Specific storm water management options are discussed in the California Storm Water Best Management Practice Handbooks (Camp, Dresser, & McKee et al. 1993). King County, Washington also has a very well developed and tested storm water reduction program that could serve as a model for the development of a similar program for the Calleguas Creek Watershed.

Manage Storm Water Facilities for Plant and Wildlife Habitat

As previously noted, the DMEC team believes that successful ecosystem management requires multiple-element approaches that recognize interconnections between physical and biological attributes and processes. Typically, storm water management strategies suffer from a single-element focus, which often results in systems that are functional in one way (e.g. flood control) but dysfunctional in many others (e.g. plant and wildlife habitat). In this regard, the DMEC team proposes that some storm water management strategies can serve as multiple-element approaches that can reduce flood risks while providing critical habitat for plants and wildlife.

This approach has been successfully implemented in portions of the Sacramento Valley. In its natural condition, the Sacramento Valley flooded annually and an "inland sea" formed and remained throughout much of the wet season. Early attempts to contain floodwaters focused on the construction of levees. However, natural flood basins - the Butte, Sutter, and Yolo Basins - directly up stream from Sacramento continued to flood through annual and permanent levee breaches.

Ultimately, these natural flood basins were developed as floodwater bypass facilities. Flood waters are removed from the Sacramento River above Sacramento through weirs, channeled through the Butte, Sutter, and Yolo Bypasses, and discharged to the Sacramento-San Joaquin Delta below Sacramento near Rio Vista (Fischer 1994, Kelley 1997). Farmed during the dry season, these areas are flooded and abandoned during the wet season when they form critical habitat for numerous wildlife species including migratory waterfowl and anadromous fish.

In 1989, local citizens initiated an effort to manage portions of the Yolo Bypass for plant and wildlife habitat. In 1991, the California Department of Fish and Game purchased 1,275 ha (3,150 acres) of farmland in the Yolo Bypass. Since that time, additional acreage has been purchased or annexed to bring the total acreage up to 1,498 ha (3,700 acres). In 1995, Ducks Unlimited contracted the U.S. Army Corps of Engineers to design the hydrologic specifications for a highly managed plant and wildlife preserve. The plan was implemented over the following years, and on 15 November 1997, the Yolo Bypass Wildlife Area was dedicated. The result is a 1,498-ha plant and wildlife preserve that also serves as critical flood control for hundreds of thousands of Sacramento Valley residents.

Restore and Stabilize Stream Banks

The USDA-NRCS (1995) estimates that stream bank erosion contributes 137,892,090 kg (152,000 tons) of sediment annually to the Calleguas Creek stream network. This constitutes more than 35 percent of the current annual sediment delivery to the stream network. Thus, the long-term strategy for the restoration and preservation of the Calleguas Creek Watershed should include restoration and stabilization of stream banks.

There are numerous manuals detailing bank stabilization procedures (see The Federal Interagency Stream Restoration Working Group 1998 and references therein). Traditional approaches to stream bank stabilization involve the construction and maintenance of artificial structures. Current solutions in the Calleguas Creek Watershed are trapezoidal-shaped channels without additional modification, pipe and wire bank revetment, trapezoidal-shaped channels with soft beds and riprapped banks, trapezoidal- and rectangular-shaped concrete channels, and underground concrete box and pipe culverts. Unfortunately, these management strategies suffer from a single-element focus and represent missed opportunities to stabilize banks while restoring other physical and biological function to the river system.

Vegetating stream banks can be an important element in a bank stabilization effort. Steinman (1992), citing mathematical models, flume experiments, and in situ measurements, showed that bank vegetation reduces velocity and boundary shear stress in the near bank environment. The effects of this have been extensively documented by field observations and experiments. In situ experimentation on braided rivers indicates that banks with lush herbaceous and scrub-shrub vegetation are 20,000 times more resistant to erosion than comparable banks without vegetation (Smith 1976). Using aerial photography, Beeson and Doyle (1995) noted that unvegetated bends were nearly 5 times more likely than vegetated bends to have detectable erosion following a single flood. Furthermore, major bank erosion was 30 times more prevalent on the unvegetated bends.

McKenney et al. (1995) monitored channel morphology and vegetation on 89 channel cross-sections for 3 to 4 years. Their study determined that, during high flows, vegetated beds and banks can accrete sediment while unvegetated beds and banks typically experience high rates of erosion. Finally, Shields (1991) showed that vegetated riprap provided substantially more bank protection than unvegetated riprap along the Sacramento River.

In addition to the plethora of published literature on the subject of stream bank stability, the Ventura Resource Conservation District in conjunction with the USDA Natural Resources Conservation Service has an ongoing demonstration project in the Calleguas Creek Watershed. The project is located on Long Canyon up stream from the Stockton Road crossing (Photograph 6, Stream Bank Stabilization Demonstration Project Coordinated by the Ventura Resource Conservation District and Natural Resources Conservation Service; and Photograph 7, Demonstration Stream Bank Restoration Project in the Calleguas Creek Watershed). The Ventura RCD (Telephone: 805/386-4685) leads periodic tours detailing successful implementation of a variety of bank stabilization products.

Photograph 6. Stream Bank Stabilization Demonstration Project Coordinated by the Ventura Resource Conservation District and NRCS

Photograph 7. Demonstration Stream Bank Restoration Project in the Calleguas Creek Watershed

Reduce Sediment Discharges from Orchards

The USDA-NRCS (1995) estimates that orchard erosion contributes 74,000 tons of sediment annually to the Calleguas Creek stream network. This constitutes more than 15 percent of the current sediment delivery to the stream network. Thus, the long-term strategy for the restoration and preservation of the Calleguas Creek Watershed should include alternative orchard management strategies.

The typical orchard has little understory vegetation, and young orchards also lack extensive canopy coverage and ground litter (Photograph 8, Typical Orchard with Little Understory Vegetation). Prosser et al. (1995) performed in situ flume experiments to study the effects of herbaceous vegetation on surface wash erosion and channel incision by overland flow. Their study determined that as much as 90 percent of the flow resistance is due to surface biomass, and that complete clipping of the surface biomass reduces critical shear stress by as much as 90 percent. Thus, sediments are much more easily mobilized where surface vegetation is removed. Similarly, flume experiments have shown that stiff-grass hedges trap and retain sediment by altering flow hydraulics (Meyer et al. 1995, Dabney et al. 1995). Given these results, it is not surprising that sheet and rill erosion are the primary mechanisms of sediment delivery from orchards to the stream network (USDA-NRCS 1995). Thus, orchard restoration and management strategies should be focused on the reduction of sheet and rill erosion.

Photograph 8. Typical Orchard with Little Understory Vegetation

Citrus orchard along Santa Rosa Road with a barren understory that can readily loose topsoil.

The USDA-NRCS (1995) developed an extensive orchard restoration and management strategy. The strategy utilizes understory vegetation, contour grading, and subsurface drainage features to limit the amount of sediment production. The DMEC team agrees with the general approach outlined therein and, therefore, the reader is referred to that document for further details regarding implementation and costs. These recommendations are general in nature and could be applied to virtually any orchard in the Calleguas Creek Watershed.

Redesign and Replace Undersized Culvert and Bridge Spans

The California Rivers Assessment (CARA), a cooperative project organized by the California Resources Agency, estimates that there are 832 stream crossings in the Calleguas Creek Watershed (California Rivers Assessment). The CARA study was conducted at a 1:100,000 scale, so the true number of road crossings in the Calleguas Creek Watershed undoubtedly is much greater than this.

Culvert and bridge spans in the Calleguas Creek Watershed are chronically undersized. Perhaps the most important influence of undersized culverts and bridge spans is their profound effect on up and down stream flow velocities. This is most simply explained with respect to the following equation for discharge at a cross-section:

$$Q = Au$$

where

Q = *discharge*
A = *cross-sectional area*
u = *flow velocity*

Undersized culverts and bridge spans decrease cross-sectional areas so, to maintain discharge, flow velocities must increase. These high velocity waters have high stream powers and high sediment transport capacities. Therefore, bed scour and bank erosion typically occur under and directly downstream of undersized culverts and bridge spans (Photograph 9, Scour and Bank Erosion Under and Down Stream of an Undersized Culvert)(Dunne and Leopold 1978). However, there are limits to the degree to which flow velocities can increase. If velocities cannot increase to the extent that all of the available discharge can be passed through the undersized culvert or bridge span, then water is "stacked up" just as if a dam were constructed across the floodway.

Photograph 9. Scour and Bank Erosion Under and Downstream of an Undersized Culvert

Stacking water up stream increases stream stage (i.e. stream water surface elevation) and can lead to increased flood hazards. Additionally, stacked waters have lower flow velocities, reduced stream powers, and reduced sediment transport capacities (Dabney et al. 1995, Meyer et al. 1995). Thus, sediment is deposited upstream from undersized culverts and bridge spans leading to a reduction in channel capacity (Photograph 10, Sediment Deposition Upstream from an Undersized Culvert).

Photograph 10. Sediment Deposition Upstream from an Undersized Culvert

Undersized culverts and bridge spans are chronic problems throughout the Calleguas Creek Watershed. In fact, the inventory data set has numerous examples of undersized culverts and bridge spans including, but not limited to, Sites 9, 10, 12, and 36. Removal or redesign and reconstruction of these crossings using sound hydraulic analyses can provide incremental benefits at the watershed-scale. Furthermore, the use of sound hydraulic analyses in the construction of new culverts and bridge spans can prevent further degradation.

Clearly, the cost of culverts and bridge spans is proportional to their size, in that large culverts and bridge spans are more costly than small culverts and bridge spans. However, large culverts and bridge spans may in fact be cumulatively less expensive when considered in the context of the costs of increased flood risk and sediment removal upstream of the constriction, and bank protection and land loss down stream of the constriction.

SPECIFIC RESTORATION SITE RECOMMENDATIONS

Overview

DMEC, in close coordination with the Coastal Conservancy and the EPA, has selected ten specific sites within the Calleguas Creek Watershed for restoration. These ten sites provide excellent opportunities to accomplish watershed-scale restoration of ecosystem function. However, the specific sites referenced herein are not nearly as important as is the general philosophy being employed. Other sites not identified by this document could provide similar opportunities. These currently unidentified sites should be considered for restoration, too, if they are shown through future analyses to be consistent with the general philosophy of this plan. Conceptual designs for restoration are provided for the ten sites below:

- ♣ Calleguas Creek/Revolon Slough Confluence (Sites 32/33);
- ♣ Calleguas Creek at California State University Channel Islands (Site 1);
- ♣ Calleguas Creek at Camarillo Regional Park (Site 34);
- ♣ Arroyo Conejo at Winding Brook Farm (Site 35);
- ♣ Arroyo Conejo at U.S. 101 (Site 43);
- ♣ Calleguas Creek from Somis to Upland Road (Sites 25/37);
- ♣ Arroyo Santa Rosa at Arroyo Conejo (Site 30);
- ♣ Arroyo Simi at Simi Recycling Center (Site 18);
- ♣ Arroyo Conejo at Borchard Road (Site 47); and
- ♣ Arroyo Simi/Junipero Channel Confluence at Kuehner Road (Sites 40/41).

The existing conditions at each of these sites have been assessed for potential restoration, from the site-specific and watershed scales. These 10 sites represent, in DMEC's opinion, some of the best potential restoration sites, providing excellent opportunities to restore integrity to the Calleguas Creek Watershed. The restoration designs presented below are conceptual in nature, and should not be considered final or suitable for implementation without specification details first being prepared.

Benefits

These projects – except for Arroyo Conejo at Arroyo Santa Rosa (Site 30) – are focused on the restoration of channel-floodplain interactions. The deleterious effects of the disconnection of channels from floodplains have been enumerated throughout this document. Thus, a complete understanding of the DMEC rationale behind the site-specific and watershed-scale benefits of these projects can be obtained only through a careful reading of this document. However, a brief summary of the projected changes in ecosystem functions as a result of the completion of these projects can be outlined using the HGM approach explained above (Table 9, Rationale for Projected Increases in Ecosystem Functions).

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Table 9. Rationale for Projected Increases in Ecosystem Functions

Wetland Function	Example Rationale
Hydrology/Geomorphology	
Maintain Alluvial Corridor Integrity	Levee removals and/or setbacks allow channels to freely meander, and freely meandering channels are subject to more natural physical processes that result in characteristic channel morphologies.
Maintain Surface Water Hydrology	Channel-floodplain reconnection provides accommodation space for short- and long-term storage of flood waters, which removes water from the active floodway during high flows and decreases peak flows in down stream reaches.
Maintain Subsurface Water Hydrology	Channel-floodplain reconnection provides surface water for shallow ground water recharge during and directly following overbank flow events. Levee removals and/or setbacks allow for bank exchange between surface water in the channel and ground water in the shallow alluvial aquifers.
Sediment Mobilization, Transport, and Storage	Channel-floodplain reconnection provides accommodation space for short- and long-term storage of sediment on the floodplain surface rather than in the active floodway. Furthermore, restored channels with vegetated banks can improve sediment transport, since sediment transport is more efficient in narrow, deep channels than in broad, shallow washes.
Biogeochemistry	
Element and Compound Cycling	Plant and animal association restoration provides plants and animals that process nutrients through uptake, conversion, storage, release, and decay processes.
Organic Carbon Export	Plant association restoration provides plants that fix organic carbon through photosynthetic processes. This organic carbon may be slowly exported to down stream ecosystems where it provides fuel for a variety of ecosystem processes.
Plant Habitat	
Maintain Native Plant Association	Plant associations will be restored using native stock. Long-term trends in species composition are, in part, determined by initial conditions. In other words, native plant associations typically beget native plant associations.
Maintain Spatial Structure of Plant Association	Channel-floodplain reconnection restores natural physical processes such as flooding, sediment deposition, and channel meandering, which can maintain complex mosaics of emergent marsh, wet meadow, scrub-shrub, and/or riparian forest of varied maturities.
Maintain Characteristic Detrital Biomass	Plant association restoration provides detrital biomass. Furthermore, channel-floodplain reconnection provides accommodation space for the storage of vegetation mobilized during high flow events.
Maintain Interspersion and Connectivity for Plant Populations	Plant association restoration can provide a local source of propagules that can be available to establish and persist in up- and down-stream areas.
Wildlife Habitat	
Maintain Native Vertebrate Associations	Plant association restoration provides resting, refuge, feeding, and nesting opportunities for vertebrates, particularly those that utilize floodplains for all or part of their life history.
Maintain Native Invertebrate Associations	Channel and plant association restoration provides habitat as well as autochthonous and allochthonous carbon sources for aquatic macroinvertebrates.
Maintain Interspersion and Connectivity for Animal Populations	Plant association restoration may provide linkages from the active floodway, across the floodplain, and into adjacent upland habitats.

Conceptual Restoration Plans

Conceptual restoration plans have been developed for ten specific sites within the Calleguas Creek Watershed. (Note: many more sites could have been analyzed for inclusion here if funding was not restricted; therefore, DMEC and the review team selected a set of representative sites for the analysis). These plans are conceptual in nature, and do not represent final plans in any way. Significant site-specific investigations and analyses must be conducted at each site before detailed restoration plans can be designed. These plans represent a concept of what may be feasible at each site.

Each site possesses one or more constraints that potentially affect what restoration, if any, can actually be accomplished at each site. Regardless, DMEC believes that some form of wetland restoration could occur at each of the sites, and that the watershed environment would be greatly benefited if all of DMEC's recommendations were implemented.

All plant series/communities, mentioned for the following Existing Conditions and Example Design Conditions subsections (below), are described in detail in the Plant and Wildlife Habitat subsection of the Watershed Characterization section (above).

Probably the greatest constraint to implementation of wetland restoration in the Calleguas Creek Watershed is funding, or lack of it. Some of the proposed projects will be quite expensive to implement, primarily because large quantities of earth will need to be moved and existing infrastructure will need to be moved or modified. Some of these changes can be accommodated in conjunction with other projects; however, coordination with many agencies and entities will be required to make them happen.

The restoration sites are presented, generally, from downstream to upstream, and does not relate to the designated number of each site, which is simply a function of the order in which each reference site as visited during the field investigations.

CALLEGUAS CREEK/REVOLON SLOUGH CONFLUENCE (SITES 32/33)

Location

Calleguas Creek/Revolon Slough Confluence (Sites 32/33) is located on the delta plain south of U.S. 101 and north of U.S. Highway 1 (se Figure 12, Reference Site Locations). This site is bounded on the west and north by Lewis Road and agricultural fields, on the east by agricultural fields and Santa Monica Mountains, and on the south by U.S. Highway 1 and Mugu Lagoon.

Existing Conditions

At this point, Calleguas Creek is Strahler Stream Order 5 (1:24,000)(Strahler 1957) and has a contributing area of approximately 422 sq. km (264 sq. miles), while Revolon Slough is Strahler Stream Order 4 (1:24,000)(Strahler 1957) and has a contributing area of approximately 94 sq. km (59 sq. miles); Mugu Lagoon is directly down stream.

Calleguas Creek and Revolon Slough are straightened and confined between levees throughout this reach. A central levee maintains separation between Calleguas Creek and Revolon Slough until they both discharge to Mugu Lagoon (Figure 17, Aerial Photograph of the Calleguas Creek/Revolon Slough Confluence [Sites 32/33]; Figure 18, Cross-sectional Survey of the Calleguas Creek/Revolon Slough Confluence [Sites 32/33]; and Photograph 11, Current Conditions of Calleguas Creek/Revolon Slough Confluence [Sites 32/33]). On Calleguas Creek, field estimates of bankfull width and mean bankfull depth are 38.4 m and 0.5 m (126 ft. and 1.5 ft.), respectively. The floodprone area width – the width that is inundated at moderately high flows – is 119 m (390 ft.). On Revolon Slough, field estimates of bankfull width and mean bankfull depth are 21.3 m and 1.8m (70 ft and 6 ft.), respectively. The floodprone area width – the width of inundation at moderately high flows - is 47.9 m (157 ft.). Channel slopes are in the 0-2 percent class; precise field measurement would undoubtedly indicate that they less than 1 percent. Channel bed materials are natural, predominantly sand-sized grains. Levee banks are rock riprap. Both reaches probably are freshwater tidal, at least at spring tides.

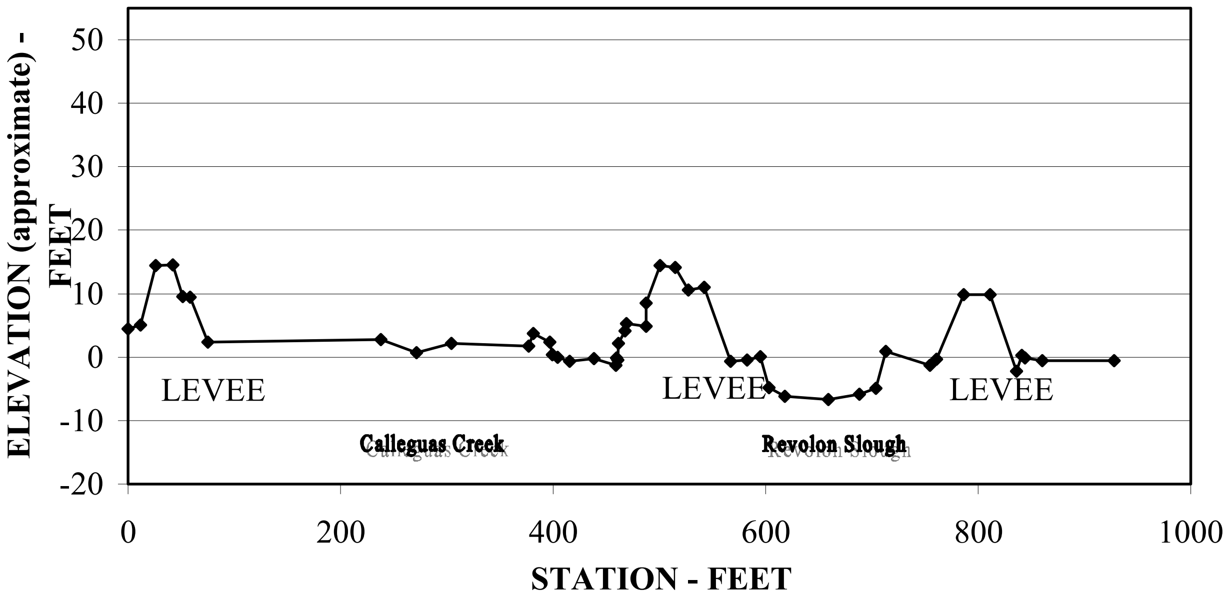
The rock riprap banks are essentially devoid of vegetation, but abundant riparian vegetation persists within the active floodway. Bulrush Series (Sawyer and Keeler-Wolf 1995) predominates in the active floodways, while Giant Reed Series and Floodplain Riparian Scrub occupy the stream banks. Agricultural lands comprise most of the delta plain area on both sides of the channels.

Note that the Calleguas Creek channel bed is approximately 1.5 m (5 ft.) higher than the Revolon Slough channel bed (Figure 18, Cross-sectional Survey of the Calleguas Creek/Revolon Slough Confluence [Sites 32/33]). Implications of this in terms of the site restoration are discussed below.

Las Posas Road is setback and is not on a levee on river right (river right and river left are referenced to a down stream view). A Las Posas Road bridge spans the upper end of Revolon Slough, and U.S. Highway 1 bridges span the lower ends of Calleguas Creek and Revolon Slough. There are no other structures of import in the area.

Figure 17. Aerial Photograph of the Calleguas Creek/Revolon Slough Confluence (Sites 32/33)

Figure 18. Cross-sectional Survey of the Calleguas Creek/Revolon Slough Confluence (Sites 32/33)



Photograph 11. Current Conditions of Calleguas Creek/Revolon Slough Confluence

a. Downstream view of Calleguas Creek from levee

b. Upstream view of Revolon Slough on levee

Example Design Conditions

The basic design is to use levee setbacks and levee removals to restore channel confluence and channel-floodplain interactions. The central levee separating the two channels would be removed. The levee on river right would be setback to provide some channel-floodplain interaction while still providing protection for Las Posas Road. The levee on river left would be removed, and the Santa Monica Mountains would be used to contain floodwaters to the east of the channel.

The assumed bankfull discharge is approximately 123.8 cms (4,370 cfs) (see Figure 14, Discharge with a 1.5-Year Recurrence Interval Calculated from the Annual Maximum Series for the Selected Restoration Sites). A broad, shallow channel would be constructed, with a bankfull width of approximately 73.2 m (240 ft.) and a mean bankfull depth of approximately 1.1 m (3.7 ft.) (Delta Plain Hydraulic Geometry Model). The channel would meander freely across the site, and might be distributary in nature consistent with historical reports. Channel slope would remain less than 1 percent. Channel bed materials would be natural, and would be composed of predominantly sand-sized grains. The bed elevation of the current Revolon Slough would rise to equilibrium with the current Calleguas Creek.

Portions of the active floodway and all of the restored floodplain would be revegetated with native species characteristic to the region and landscape position. Plant communities may include, but are not limited to, California Bulrush Series in the active floodway and a mosaic of Mixed Willow Series and Mulefat Series on the floodplain areas (Sawyer and Keeler-Wolf 1995)(Figure 19, Conceptual Restoration Design for the Calleguas Creek/Revolon Slough Confluence [Sites 32/33]). Again, the Calleguas Creek bed is approximately 1.5 m (5 ft.) higher than the Revolon Slough bed (see Figure 18).

The reconnection of these channels likely would result in bed degradation on Calleguas Creek and bed aggradation on Revolon Slough. If true, then local stream stage could drop on Calleguas Creek and rise on Revolon Slough. These changes in local stream stage could affect local irrigation drainage, improving local irrigation drainage to Calleguas Creek while restricting local irrigation drainage to Revolon Slough. However, changes in bed elevation would be coupled with increases in channel width so it is more probable that stream stage will decline or remain unchanged so irrigation drainage to both streams will be improved or unchanged. Nevertheless, careful hydraulic and sedimentologic analyses would be required to ascertain the most likely outcome prior to initiation of this project.

The total project site area is approximately 115 ha (283 acres). The total area that would be restored to wetlands under this proposal is approximately 81 ha (200 acres), which would consist of Palustrine and estuarine wetlands and have at least some tidal influence from Mugu Lagoon.

Restoration of this site will increase wetland functionality (see Table 9 for a description of each wetland function) by improving:

- Alluvial corridor integrity;
- Surface water hydrology;
- Subsurface water hydrology;
- Sediment mobilization, transport, and storage;
- Element and compound cycling;
- Organic carbon export;
- Native plant associations;
- Spatial structure of plant associations;
- Characteristic detrital biomass;

- Interspersion and connectivity for plant populations;
- Native vertebrate associations;
- Native invertebrate associations; and
- Interspersion and connectivity for animal populations.

In other words, restoring the floodplain and estuarine saltmarsh habitat at the confluence of Revolon Slough and Calleguas Creek will increase the functionality of the all the known wetland functions in the 115-ha (283-acre) site substantially. The current configuration of the site restricts the level at which each wetland function can function, as the primary objective of the current design is to funnel flood waters into Mugu Lagoon, with no consideration for the other wetland functions.

Constraints

The primary constraints on this project are related to land ownership, incompatibilities with current land uses, and the need to protect future land uses. Specifically,

- Adjacent land must be purchased;
- Agricultural activities on the purchased land may continue on portions of the site on a seasonal basis;
- Floodwaters must not back up irrigation drainage;
- The Navy is concerned about wetlands that may generate additional waterfowl, which may pose additional aircraft bird strike incidents;
- Soils in the Oxnard Plain are known to contain pesticide residues (e.g. DDT and derivatives), which should be tested before prior to moving substantial quantities of soil;
- Any public or private utilities must be relocated or sufficiently buried; and
- A setback levee must be constructed on river right to continue to protect Las Posas Road.

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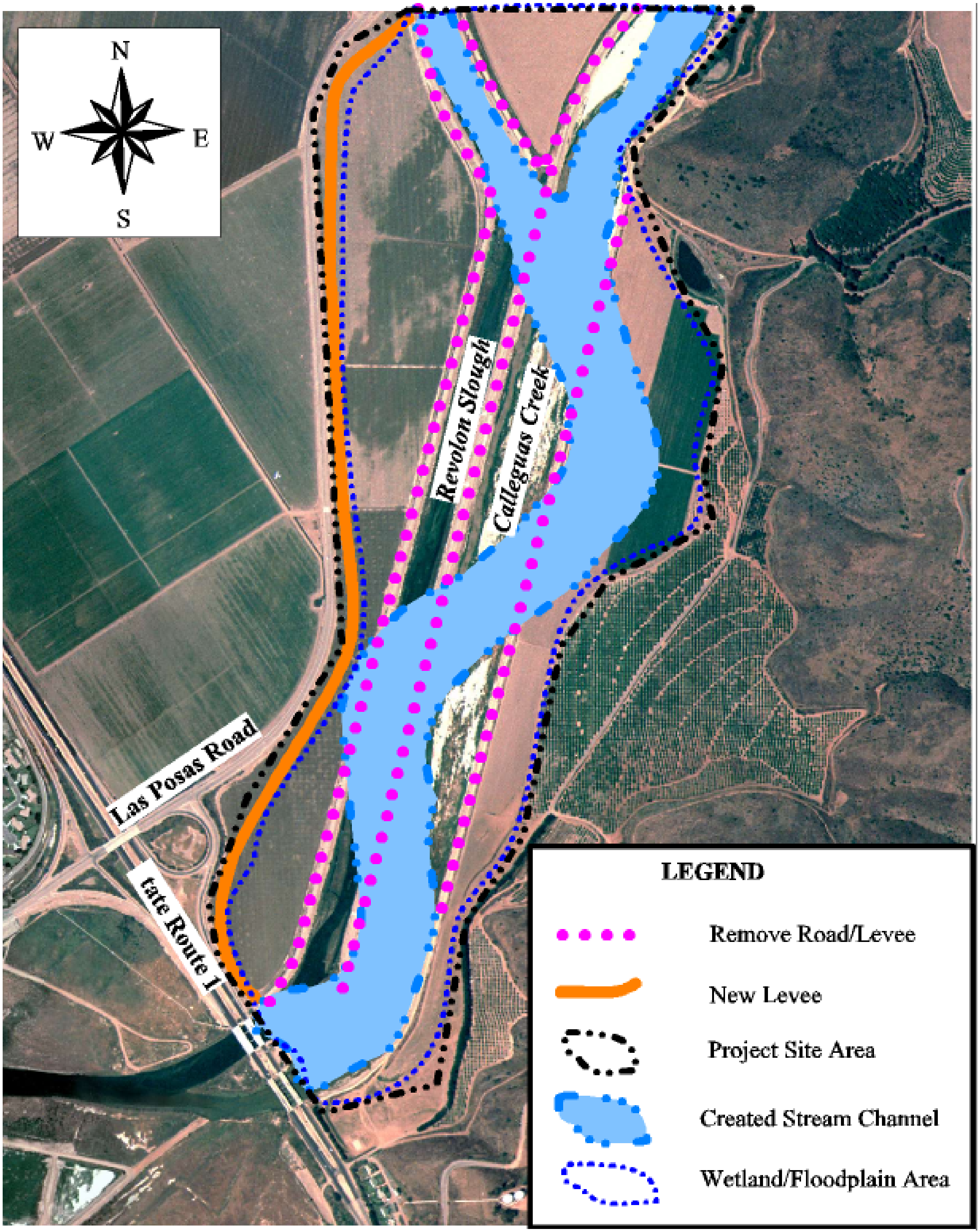
Figure 19. Conceptual Restoration Design for the Calleguas Creek/Revolon Slough Confluence (Sites 32/33)



CALLEGUAS CREEK AT CALIFORNIA STATE UNIVERSITY, CHANNEL ISLANDS (SITE 1)

Location

Calleguas Creek at CSU Channel Islands (Site 1) is located on the delta plain south of U.S. 101 and north of U.S. Highway 1 (see Figure 13, Reference Site Locations). It is bounded on the west by Lewis Road and on the north, east, and south by agricultural fields, the Santa Monica Mountains, and the CSU Channel Islands and Camrosa Water District facilities.

Existing Conditions

At this point, Calleguas Creek is Strahler Stream Order 5 (1:24,000)(Strahler 1957) and has a contributing area of approximately 397 sq. km (248 sq. mi.). Mugu Lagoon is located approximately 7.7 river-km (4.8 river mi.) down stream.

Calleguas Creek is straightened and confined between levees throughout this reach (Figure 20, Aerial Photograph of Calleguas Creek at CSU Channel Islands [Site 1]; Figure 21, Cross-sectional Survey of Calleguas Creek at CSU Channel Islands [Site 1]; and Photograph 12, Current Conditions of Calleguas Creek at CSU Channel Islands [Site 1]). Field estimates of bankfull width and mean bankfull depth are 24.4 m and 2 m (80 ft. and 6.5 ft.), respectively. The floodprone area width – the width of inundation at moderately high flows - is 36.6 m (120 ft.). Channel slope is in the 0-2 percent class; precise field measurement would undoubtedly indicate that it is less than 1 percent. Channel bed materials are natural, predominantly sand-sized grains. Levee banks are rock riprap.

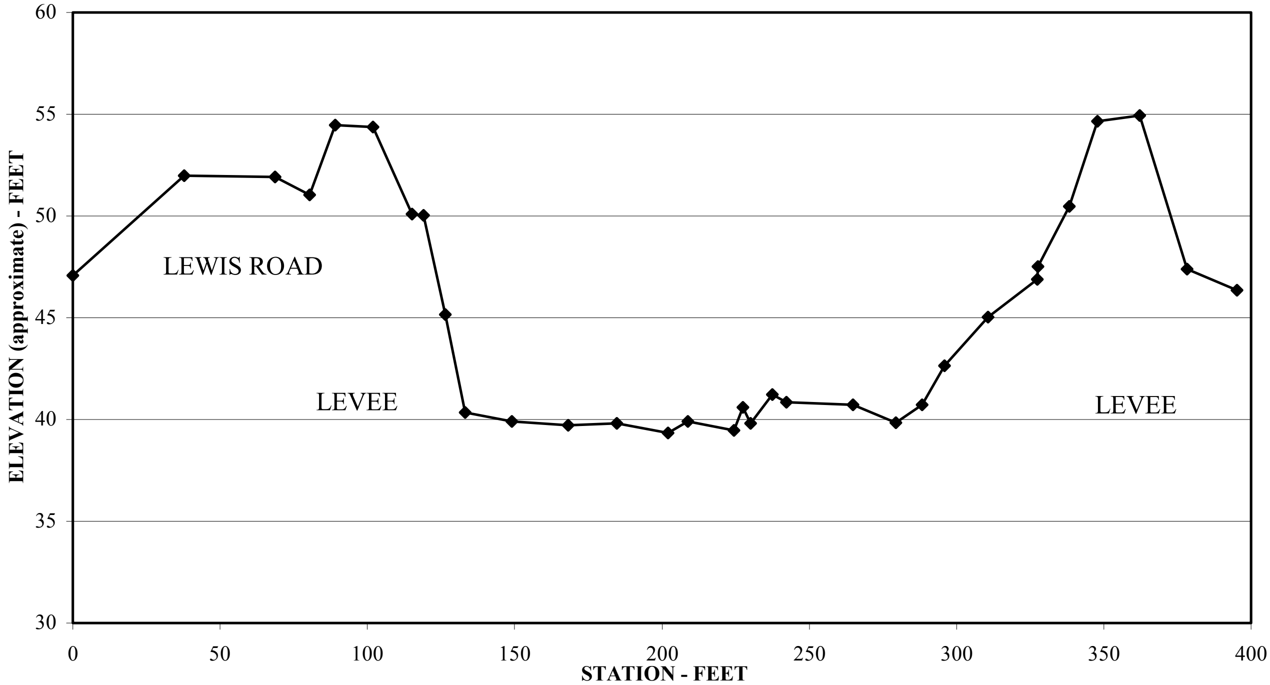
Photograph 12. Current Conditions of Calleguas Creek at CSU Channel Islands (Site 1)

View upstream of levee-confined channel bounded by agriculture.

The rock riprap banks are essentially devoid of vegetation, but sparse riparian vegetation persists within the active floodway. California Bulrush Series (Sawyer and Keeler-Wolf 1995) predominates the site, while Floodplain Riparian Scrub with an Annual Grassland groundlayer is also scattered throughout. Various nonnative plant species form scattered ground cover throughout the site, most notably Giant Reed (*Arundo donax*), a well-known nonnative and invasive species. Agricultural lands comprise most of the delta plain area on both sides of the channel. Lewis Road is on the levee on river left. Lewis Road bridges span the upper and lower ends of the reach. The only other structures of import in the area are the CSU Channel Islands and Camrosa Water District facilities. Both facilities are set back on and adjacent to the Santa Monica Mountains.

Figure 20. Aerial Photograph of Calleguas Creek at CSU Channel Islands (Site 1)

Figure 21. Cross-sectional Survey of Calleguas Creek at CSU Channel Islands (Site 1)



Example Design Conditions

The basic design is to setback the levees on river left and to restore channel-floodplain interactions. Lewis Road would be relocated to the levee on river right. The bridges that span the upper and lower ends of the reach would remain to provide access to the CSU Channel Islands and Camrosa Water District facilities. The levee on river left would be removed, and would be replaced by a levee extended in a broad loop across the agricultural fields. This new levee would restore some channel-floodplain interaction while still providing protection for the CSU Channel Islands and Camrosa Water District facilities.

The assumed bankfull discharge is approximately 85.4 cms (3,015 cfs) (see Figure 16). A broad, shallow channel would be constructed, with a bankfull width of approximately 65.5 m (215 ft.) and a mean bankfull depth of approximately 1 m (3.2 ft.) (Delta Plain Hydraulic Geometry Model). The channel would meander freely across the site, and might be distributary in nature consistent with historical reports. Channel slope would remain less than 1 percent. Channel bed materials would be natural, and would be composed of predominantly sand-sized grains.

Portions of the active floodway and all of the restored floodplain would be revegetated with native species characteristic to the region and landscape position. Plant communities may include, but are not limited to, California Bulrush Series in the active floodway and a mosaic of California Sycamore Series, Arroyo Willow Series, Mixed Willow Series, and Mulefat Series on the floodplain (Sawyer and Keeler-Wolf 1995)(Figure 22, Conceptual Restoration Design for Calleguas Creek at CSU Channel Islands [Site 1]).

A survey used during the CSU Channel Islands planning procedure suggests that the agricultural field ground surface is lower than the Calleguas Creek bed surface near the Camrosa Water District facility (i.e. on river left near the outlet from the site). This is not reflected in the cross-sectional survey (see Figure 21) but, nevertheless, it may be true at locations not surveyed during this effort. If this is true, then extensive grading may be required to ensure that water does not back up throughout the project site. Grading likely would be required down stream of the project site to re-establish an appropriate grade throughout the entire reach. Most, or perhaps all, of the graded material could be used on site. Regardless, any excavated surface material should be carefully stock piled and returned to the freshly graded site to initiate natural vegetation regeneration.

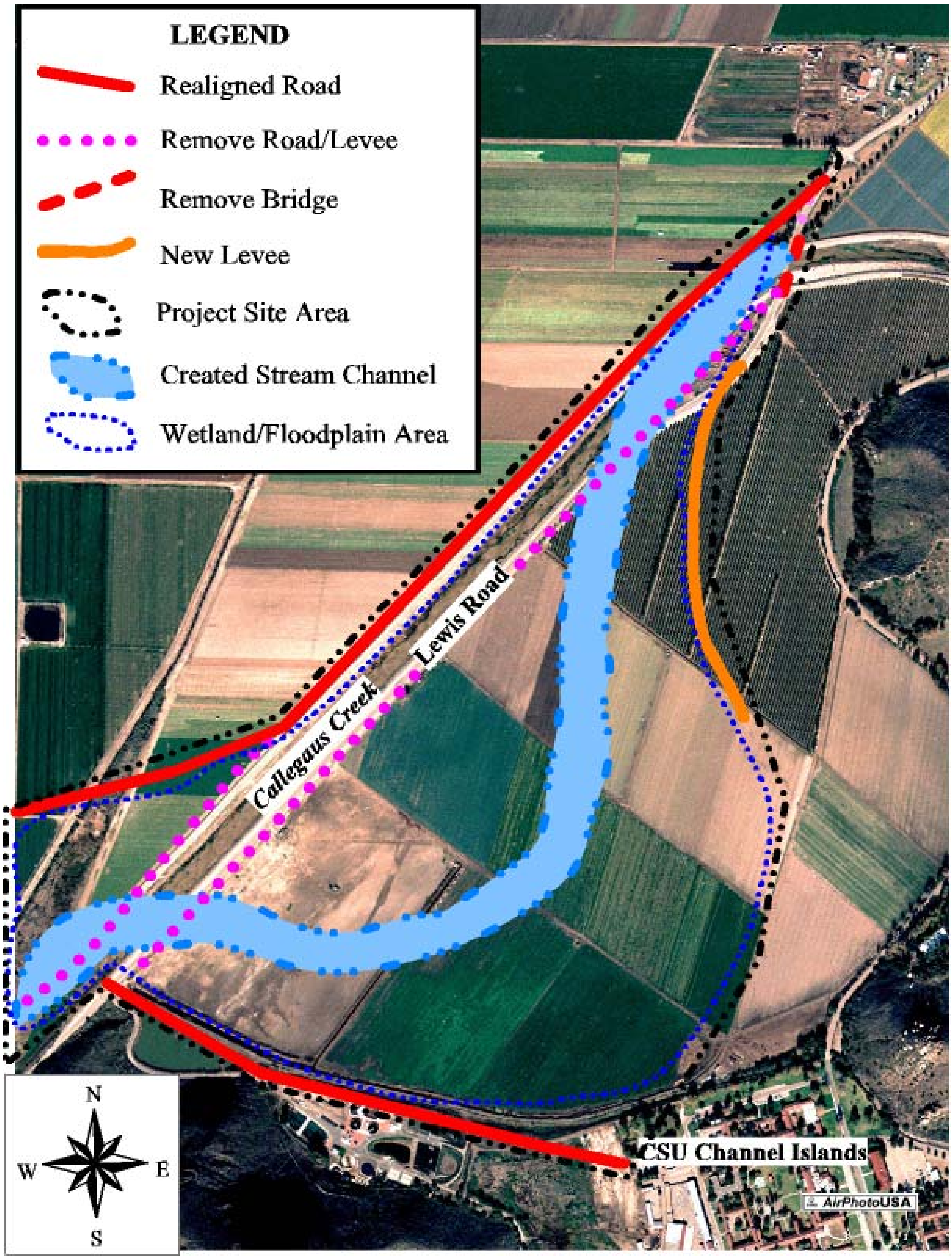
The total project site area is approximately 135 ha (334 acres). The total area that would be restored to wetlands under this proposal is approximately 113 ha (280 acres), which would consist of Palustrine and Riverine wetlands. A large (wide) river floodplain would be restored/created at this site, which would help ameliorate flooding of downstream properties as a result of increased runoff from upstream.

Restoration of this site will increase wetland functionality (see Table 9 for a description of each wetland function) by improving:

- Alluvial corridor integrity;
- Surface water hydrology;
- Subsurface water hydrology;
- Sediment mobilization, transport, and storage;
- Element and compound cycling;
- Organic carbon export;
- Native plant associations;
- Spatial structure of plant associations;
- Characteristic detrital biomass;
- Interspersion and connectivity for plant populations;
- Native vertebrate associations;
- Native invertebrate associations; and
- Interspersion and connectivity for animal populations.

In other words, restoring the floodplain habitat at the confluence of Revolon Slough and Calleguas Creek will increase the functionality of the all the known wetland functions in the 135-ha (334-acre) site substantially. The current configuration of the site restricts the level at which each wetland function can function, as the primary objective of the current design is to funnel flood waters towards the Pacific Ocean as quickly as possible, with no consideration for the other wetland functions.

Figure 22. Conceptual Restoration Design for Calleguas Creek at CSU Channel Islands (Site 1)



Constraints

The primary constraints on this project are related to land ownership, incompatibilities with current land uses, and the need to protect future land uses. Specifically,

- Adjacent land must be secured (through purchase or conservation easement);
- Agricultural activities on the purchased land may continue on portions of the site on a seasonal basis;
- Floodwaters must not back up irrigation drainage;
- Any public or private utilities must be relocated or sufficiently buried;
- Soils in the Oxnard Plain are known to contain pesticide residues (e.g. DDT and derivatives), which should be tested before prior to moving substantial quantities of soil;
- Lewis Road - currently located on the levee along river left - must be moved to the levee on river right; and
- A setback levee must be constructed to continue to protect the CSU Channel Islands and Camrosa Water District facilities.

CALLEGUAS CREEK AT CAMARILLO REGIONAL PARK (SITE 34)

Location

Calleguas Creek at Camarillo Regional Park (Site 34) is located on the delta plain south of U.S. 101 and north of U.S. Highway 1 (see Figure 13, Reference Site Locations). It is bounded on the north by levee-protected agricultural fields and on the east, south, and west by the Camarillo Regional Park and the Santa Monica Mountains.

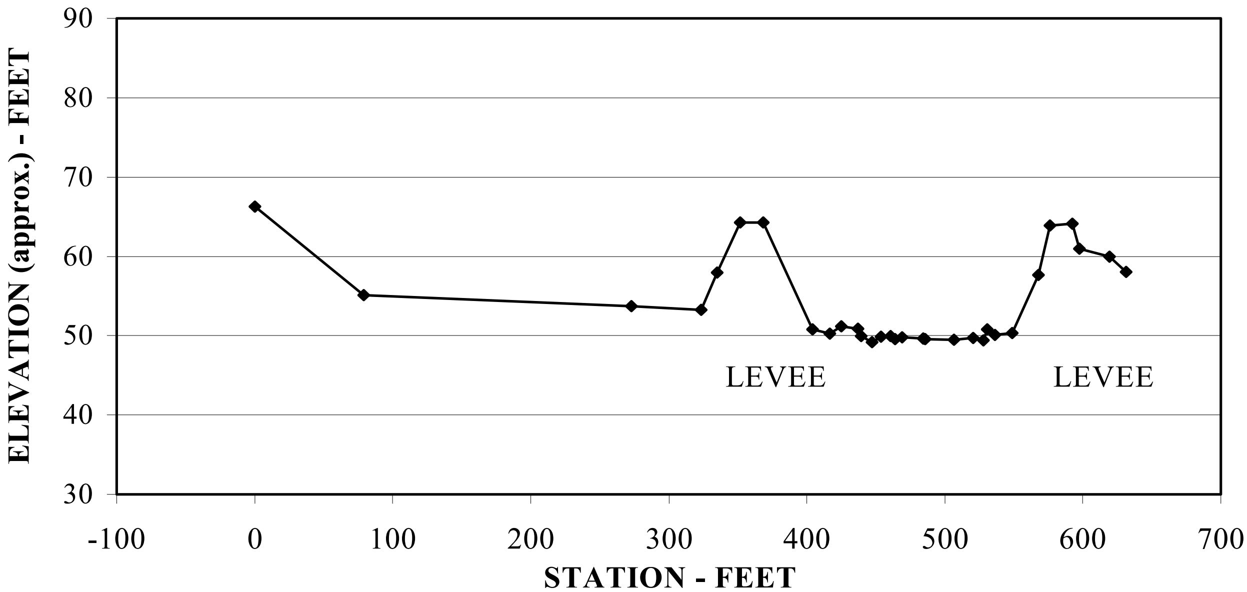
Existing Conditions

At this point, Calleguas Creek is Strahler Stream Order 5 (1:24,000)(Strahler 1957) and has a contributing area of approximately 397 sq. km (248 sq. mi.). Mugu Lagoon is approximately 9 river-km (5.6 river-miles) down stream.

Calleguas Creek is straightened and confined between levees throughout this reach (Figure 23, Aerial Photograph of Calleguas Creek at Camarillo Regional Park [Site 34]; Figure 24, Cross-sectional Survey of Calleguas Creek at Camarillo Regional Park [Site 34]; and Photograph 13, Current Conditions of Calleguas Creek at Camarillo Regional Park [Site 34]).

Figure 23. Aerial Photograph of Calleguas Creek at Camarillo Regional Park (Site 34)

Figure 24. Cross-sectional Survey of Calleguas Creek at Camarillo Regional Park (Site 34)



Field estimates of bankfull width and mean bankfull depth are 32.9 m and 0.61 m (108 ft. and 2.0 ft.), respectively. The floodprone area width – the width of inundation at moderately high flows - is 48.5 m (159 ft.). Channel slope is in the 0-2 percent class; precise field measurement would undoubtedly indicate that it is less than 1 percent. Channel bed materials are natural, predominantly sand-sized grains. Levee banks are rock riprap.

Sparse riparian vegetation persists on the rock riprap banks and within the active floodway. Floodplain Riparian Scrub, including many ruderal (nonnative) species (Sawyer and Keeler-Wolf 1995) predominates, with Giant Reed Series and Arroyo Willow Series (with Cattail associations) elsewhere. Various nonnative plant species form scattered ground cover throughout the site. Abundant hydric soils and hydrophytic vegetation persist on the Camarillo Regional Park land south of the channel. These are separated from the active floodway by a levee. Agricultural lands comprise most of the delta plain area north of the channel.

The channel is spanned down stream by the north access road for the CSU Channel Islands and Camrosa Water District facilities. An unpaved road is maintained on the toe slope of the Santa Monica Mountains and provides access to the levees, the Camarillo Regional Park facilities, and some Camrosa Water District facilities. There are no other major structures on the site.

Example Design Conditions

The basic design is to remove the levees on river left and to restore channel-floodplain interactions. The natural topography of the Santa Monica Mountains would contain floodwaters. The bridge that spans the lower end of the reach would remain to provide access to the CSU Channel Islands and Camrosa Water District facilities.

The assumed bankfull discharge is approximately 85.4 cms (3,015 cfs) (see Figure 16). A broad, shallow channel would be constructed, with a bankfull width of approximately 65.5 m (215 ft.) and a mean bankfull depth of approximately 1 m (3.2 ft.) (Delta Plain Hydraulic Geometry Model).

The channel would meander freely across the site, and might be distributary in nature consistent with historical reports. Channel slope would remain less than 1 percent. Channel bed materials would be natural, and would be composed of predominantly sand-sized grains.

Photograph 13. Current Conditions of Calleguas Creek at Camarillo Regional Park (Site 34)

Very little vegetation restoration would be required on the historical floodplain since so much native, hydrophytic vegetation persists. However, portions of the active floodway and the adjacent uplands would be revegetated with native species characteristic to the region and landscape position. Plant communities may include, but are not limited to, California Bulrush Series, Arroyo Willow Series, and Cattail Series in the active floodway and a mosaic of Mulefat-Coyote Brush Series, Blue Elderberry Series, and California Sagebrush-California Buckwheat Series in the uplands (Sawyer and Keeler-Wolf 1995) (Figure 24, Conceptual Restoration Design for Calleguas Creek at Camarillo Regional Park [Site 34]).

The total project site area is approximately 95 ha (235 acres). The total area that would be restored to wetlands under this proposal is approximately 32 ha (80 acres), which would consist of Palustrine and Riverine wetlands.

Restoration of this site will increase wetland functionality (see Table 9 for a description of each wetland function) by improving:

- Alluvial corridor integrity;
- Surface water hydrology;
- Subsurface water hydrology;
- Sediment mobilization, transport, and storage;
- Element and compound cycling;
- Organic carbon export;
- Native plant associations;
- Spatial structure of plant associations;
- Characteristic detrital biomass;
- Interspersion and connectivity for plant populations;
- Native vertebrate associations;
- Native invertebrate associations; and
- Interspersion and connectivity for animal populations.

In other words, restoring the floodplain habitat of Calleguas Creek at Camarillo Regional Park will increase the functionality of the all the known wetland functions in the 95-ha (235-acre) site substantially. The current configuration of the site restricts the level at which each wetland function can function, as the primary objective of the current design is to funnel flood waters towards the Pacific Ocean as quickly as possible, with no consideration for the other wetland functions.

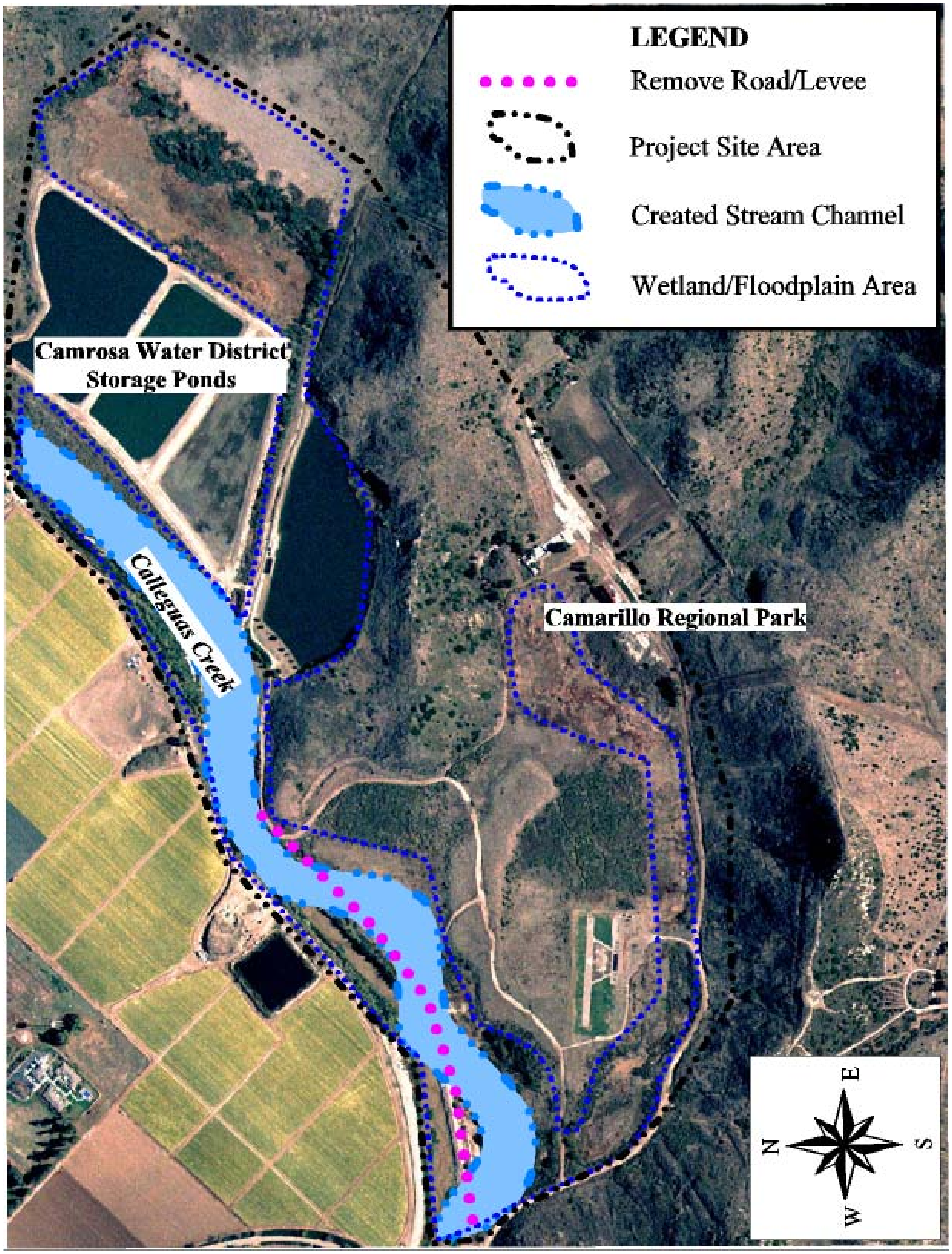
Constraints

The primary constraints on this project are related to incompatibilities with current land uses and the need to protect future land uses. Specifically,

- The Camarillo Regional Park land use must be redefined;
- The access road on the toe slope of the Santa Monica Mountains must be protected, perhaps through the use of a combination of bioengineering and engineered rock riprap: and
- Any public or private utilities must be relocated or sufficiently buried.

DMEC

Figure 25. Conceptual Restoration Design for Calleguas Creek at Camarillo Regional Park (Site 34)



ARROYO CONEJO AT WINDING BROOK FARM (SITE 35)

Location

Lower Arroyo Conejo (Conejo Creek) (Site 35) is located on the delta plain south of U.S. 101 and north of U.S. Highway 1 (see Figure 13, Reference Site Locations), on property currently referred to as Winding Brook Farm. It is bounded on all sides by levee-protected agricultural fields. It is further bounded on the east, south, and west by the Conejo Mountains.

Existing Conditions

At this point, Arroyo Conejo is Strahler Stream Order 4 (1:24,000)(Strahler 1957) and has a contributing area of approximately 106 sq. km (66 sq. miles). Mugu Lagoon is approximately 13 river-km (8.1 river-miles) down stream.

Arroyo Conejo is straightened and confined between setback levees throughout this reach (Figure 26, Aerial Photograph of Lower Arroyo Conejo [Site 35]; and Photograph 14, Current Conditions of Lower Arroyo Conejo [Site 35]). Field estimates of bankfull width and mean bankfull depth are 11.9 m and 0.6 m (39 ft. and 2.0 ft.), respectively. The floodprone area width – the width of inundation at moderately high flows - is 32 m (105 ft.). Channel slope is in the 0-2 percent class; precise field measurement would undoubtedly indicate that it is less than 1 percent. Channel bed and bank materials are natural, predominantly sand-sized grains. Small, setback levees are constructed of fill soils.

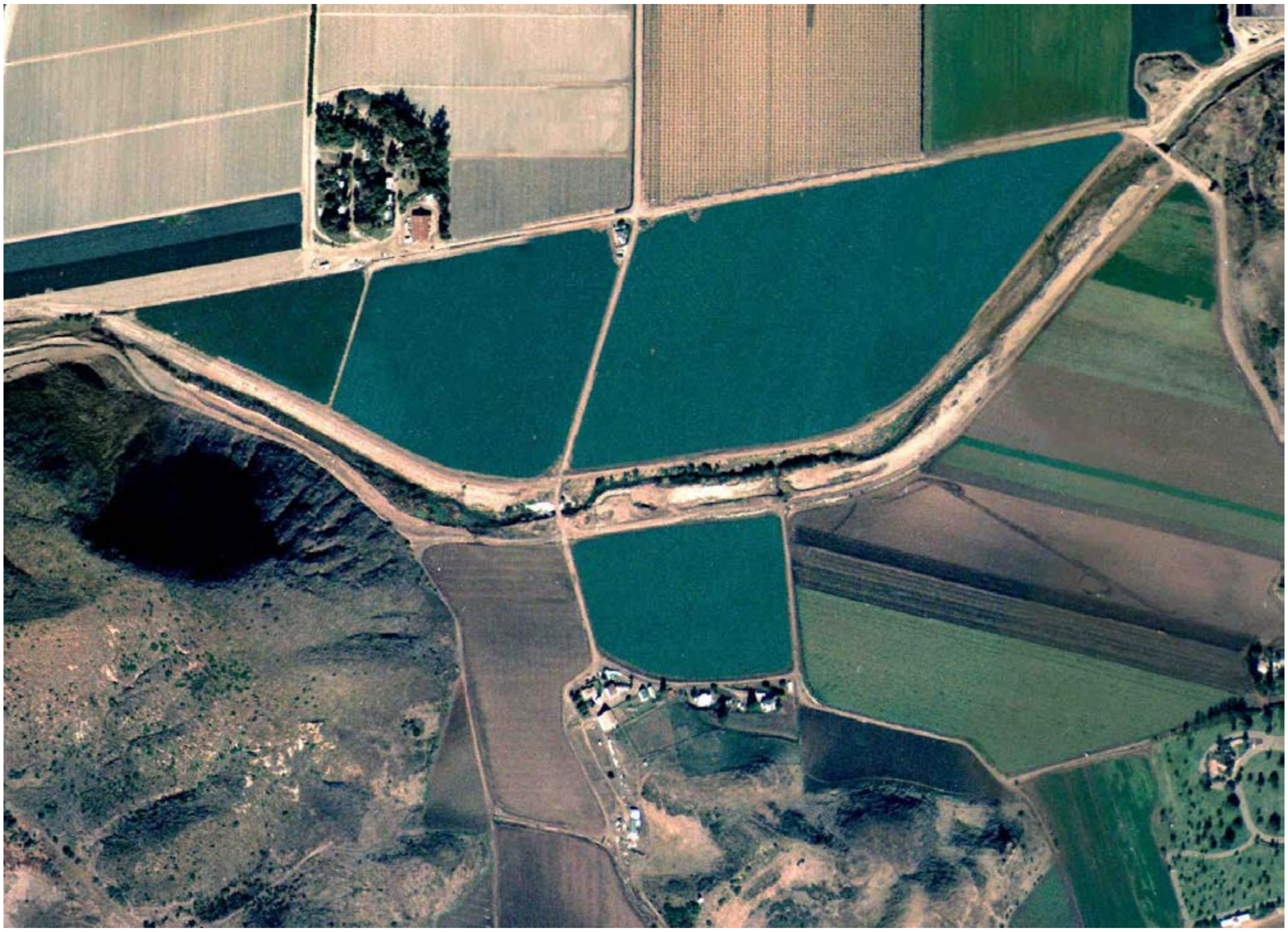
Abundant riparian vegetation persists within the active floodway. Arroyo Willow Series (Sawyer and Keeler-Wolf 1995) predominates with Cattail Series as understory thickets. Various nonnative plant species form a sparse ground layer throughout the site. Agricultural lands comprise most of the historic floodplain and nearby upland areas. Howard Road spans the channel up stream, and the natural extension of Pancho Road - which serves as an agricultural access road - spans the channel down stream. There are no other major structures on the site.

Photograph 14. Current Conditions of Arroyo Conejo at Winding Brook Farm (Site 35)

a. View southeastward of lower reach of Arroyo Conejo, where riparian vegetation is periodically cut down.

b. View northeastward looking upstream from near middle of site on Pancho Road (extension) bridge.

Figure 26. Aerial Photograph of Arroyo Conejo at Winding Brook Farm (Site 35)



Example Design Conditions

The basic design is to remove the levees on river left and to restore channel-floodplain interactions. The natural topography of the Conejo Mountains would contain floodwaters (Figure 27, Conceptual Restoration Design for Lower Arroyo Conejo [Site 35]). The bridges that span the upper and lower ends of the reach would remain. However, both bridges could be extended to ensure that they do not constrict high flows.

The assumed bankfull discharge is approximately 69.7 cms (2,460 cfs) (see Figure 16). A broad, shallow channel would be constructed, with a bankfull width of approximately 61 m (200 ft.) and a mean bankfull depth of approximately 0.9 m (2.9 ft.) (Delta Plain Hydraulic Geometry Model). The channel would meander freely across the site, and might be distributary in nature consistent with historical reports. Channel slope would remain less than 1 percent. Channel bed materials would be natural, and would be composed of predominantly sand-sized grains.

The total project site area is approximately 147 ha (264 acres). The total area that would be restored to wetlands under this proposal is approximately 32 ha (80 acres), which would consist of Palustrine and Riverine wetlands.

Restoration of this site will increase wetland functionality (see Table 9 for a description of each wetland function) by improving:

- Alluvial corridor integrity;
- Surface water hydrology;
- Subsurface water hydrology;
- Sediment mobilization, transport, and storage;
- Element and compound cycling;
- Organic carbon export;
- Native plant associations;
- Spatial structure of plant associations;
- Characteristic detrital biomass;
- Interspersion and connectivity for plant populations;
- Native vertebrate associations;
- Native invertebrate associations; and
- Interspersion and connectivity for animal populations.

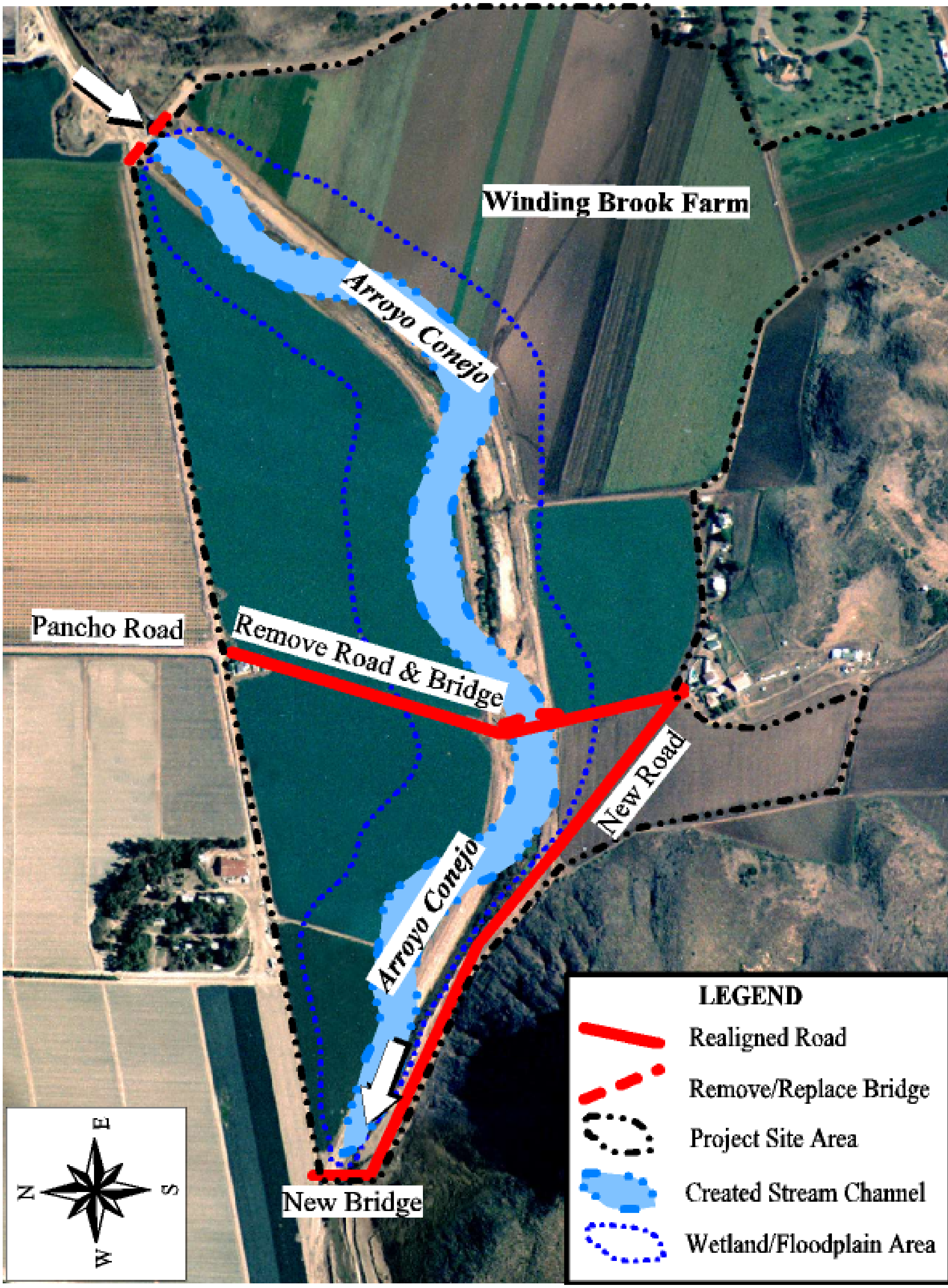
In other words, restoring the floodplain habitat along the lower reach of Arroyo Conejo (just upstream of it's confluence with Calleguas Creek) will increase the functionality of the all the known wetland functions in the 147-ha (264-acre) site substantially. The current configuration of the site restricts the level at which each wetland function can function, as the primary objective of the current design is to funnel flood waters towards the Pacific Ocean as quickly as possible, with no consideration for the other wetland functions.

Constraints

The primary constraints on this project are related to land ownership, incompatibilities with current land uses, and the need to protect future land uses. Specifically,

- Adjacent land must be secured (through purchase or conservation easement);
- Agricultural activities on a portion of the purchased land may continue on portions of the site on a seasonal basis;
- A domestic water line that parallels the dirt road bisecting the property – and any other public or private utility - must be relocated or sufficiently buried;
- Soils in the Oxnard Plain are known to contain pesticide residues (e.g. DDT and derivatives), which should be tested before prior to moving substantial quantities of soil;
- The road and bridge on the farm road representing the logical extension of Pancho Road must be relocated; and
- The Howard Road bridge to the rock quarry and cemetery should be replaced with a wider spanning bridge.

Figure 27. Conceptual Restoration Design for Lower Arroyo Conejo (Site 35)



ARROYO CONEJO AT U.S. 101 (SITE 43)

Location

Arroyo Conejo at U.S. 101 (Site 43) is located on the delta plain down stream of and adjacent to U.S. 101 (see Figure 13, Reference Site Locations). It is bounded on all sides by agricultural fields.

Existing Conditions

At this point, Arroyo Conejo is Strahler Stream Order 4 (1:24,000)(Strahler 1957) and has a contributing area of approximately 106 sq. km (66 sq. miles). Mugu Lagoon is approximately 13.8 river-km (8.6 river-miles) downstream.

Arroyo Conejo is straightened and confined between levees throughout this reach (Figure 28, Aerial Photograph of Arroyo Conejo at U.S. 101 [Site 43]; Figure 29, Cross-sectional Survey of Arroyo Conejo at U.S. 101 [Site 43]; and Photograph 15, Current Conditions of Arroyo Conejo at U.S. 101 [Site 43]). Field estimates, of bankfull width and mean bankfull depth, are 29.2 m and 0.3 m (96 ft. and 1 ft.), respectively. The floodprone area width – the width of inundation at moderately high flows - is 31.1 m (102 ft.). Channel slope is in the 0-2 percent class; precise field measurement would undoubtedly indicate that it is less than 1 percent. Channel bed and bank materials are natural, predominantly sand-sized grains. Small levees are constructed of fill dirt.

Sparse riparian vegetation persists within the active floodway. Floodplain Riparian Scrub, (Sawyer and Keeler-Wolf 1995) predominates, while Ruderal Grassland also occur on the east bank. Various nonnative plant species form scattered ground cover throughout the site. Agricultural lands comprise most of the historical floodplain area on both sides of the channel.

U.S. 101 spans the channel up stream, and Ridge View Street spans the channel down stream, which turns into Adohr Lane to the west. The Camarillo Springs Golf Course is nearby on the south and west edge of the site. There are no other major structures on the site.

Example Design Conditions

The basic design is to remove the levee on river left and to restore channel-floodplain interactions. A small levee would be constructed along Ridge View Street to protect the road and the Camarillo Springs Golf Course from flooding. The bridges that span the upper and lower ends of the reach would remain. However, the Ridge View Street bridge could be extended to ensure that it does not constrict high flows.

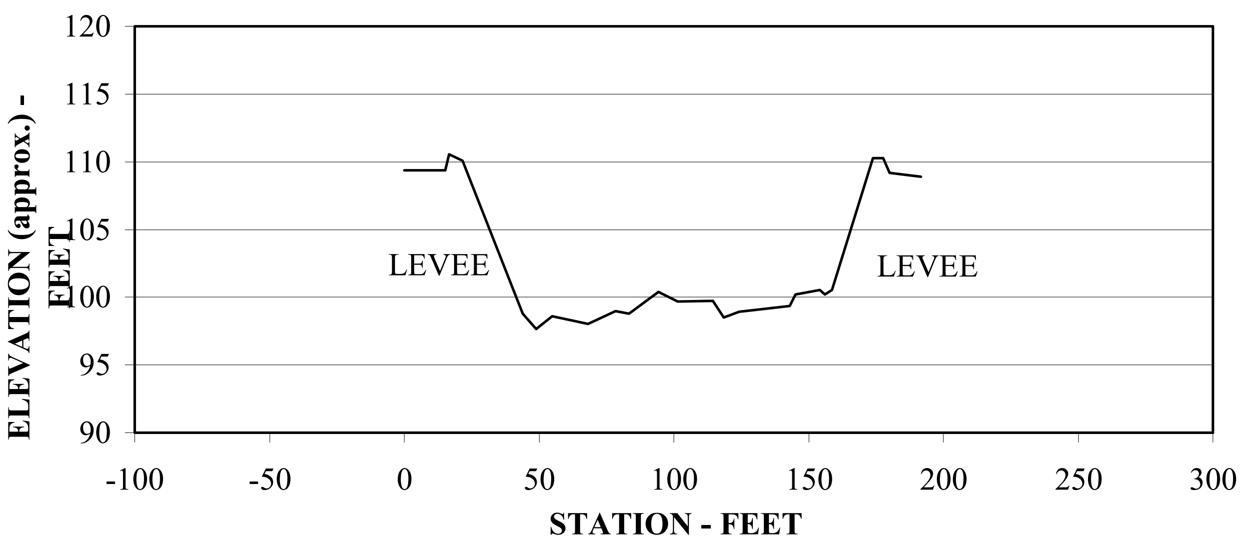
The assumed bankfull discharge is approximately 69.7 cms (2,460 cfs) (see Figure 16). A broad, shallow channel would be constructed, with a bankfull width of approximately 61 m (200 ft.) and a mean bankfull depth of approximately 0.9 m (2.9 ft.) (Delta Plain Hydraulic Geometry Model).

Figure 28. Aerial Photograph of Arroyo Conejo at U.S. 101 (Site 43)

The channel would meander freely across the site, and might be distributary in nature consistent with historical reports. Channel slope would remain less than 1 percent. Channel bed materials would be natural, and would be composed of predominantly sand-sized grains.

Portions of the active floodway and all of the restored floodplain would be revegetated with native species characteristic to the region and landscape position. Plant communities may include, but are not limited to, Bulrush Series and Mixed Willow Series in the active floodway and a mosaic of Mixed Willow Series, California Sycamore Series, and Mulefat Series on the floodplain (Sawyer and Keeler-Wolf 1995) (Figure 30, Conceptual Restoration Design for Arroyo Conejo at U.S. 101 [Site 43]).

Figure 29. Cross-sectional Survey of Arroyo Conejo at U.S. 101 (Site 43)



The total project site area is approximately 22 ha (54 acres). The total area that would be restored to wetlands under this proposal is approximately 16 ha (40 acres), which would consist of Palustrine and Riverine wetlands.

Restoration of this site will increase wetland functionality (see Table 9 for a description of each wetland function) by improving:

- Alluvial corridor integrity;
- Surface water hydrology;
- Subsurface water hydrology;
- Sediment mobilization, transport, and storage;
- Element and compound cycling;
- Organic carbon export;
- Native plant associations;
- Spatial structure of plant associations;
- Characteristic detrital biomass;
- Interspersion and connectivity for plant populations;
- Native vertebrate associations;
- Native invertebrate associations; and
- Interspersion and connectivity for animal populations.

In other words, restoring the floodplain habitat along this portion of Arroyo Conejo will increase the functionality of the all the known wetland functions in the 22-ha (54-acre) site substantially. The current configuration of the site restricts the level at which each wetland function can function, as the primary objective of the current design is to funnel flood waters towards the Pacific Ocean as quickly as possible, with no consideration for the other wetland functions.

Constraints

The primary constraints on this project are related to land ownership, incompatibilities with current land uses, and the need to protect future land uses. Specifically,

- Adjacent land must be secured (through purchase or conservation easement);
- Agricultural activities on the purchased land may continue on portions of the site on a seasonal basis;
- Floodwaters must not back up irrigation drainage;
- Any public or private utilities must be relocated or sufficiently buried;
- Soils in the Oxnard Plain are known to contain pesticide residues (e.g. DDT and derivatives), which should be tested before prior to moving substantial quantities of soil;
- The Ridge View Street bridge must be extended and maintained;
- Ridge View Street and Camarillo Springs Golf Course must be protected from flooding; and
- U.S. 101 must be protected from backwater flooding.

DMEC

Photograph 15. Current Conditions of Arroyo Conejo at U.S. 101 (Site 43)

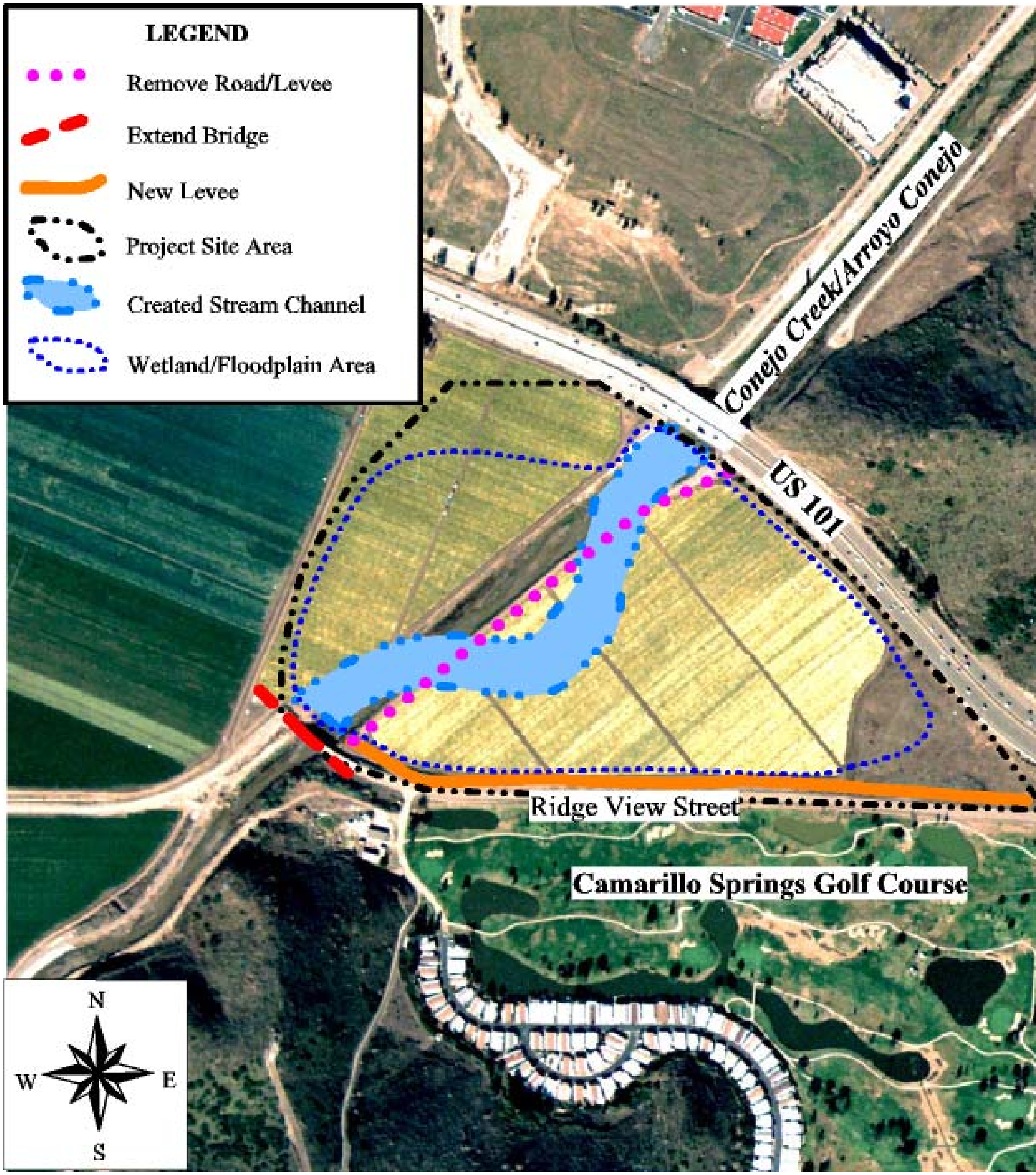
a. View north at U.S. 101 bridge over Arroyo Conejo

c. View east across Arroyo Conejo towards golf course.

b. View upstream towards U.S. 101 bridge. Channel bed is routinely dredged by Ventura County Flood Control District.

d. View downstream of Arroyo Conejo from below U.S. 101 bridge, with agricultural water extraction pond in foreground.

Figure 30. Conceptual Restoration Design for Arroyo Conejo at U.S. 101 (Site 43)



CALLEGUAS CREEK FROM SOMIS TO UPLAND ROAD (SITES 25/37)

Location

Calleguas Creek from Somis to Upland Road (Site 25/37) is located on the alluvial valley up stream of Upland Road and down stream of Somis (see Figure 13, Reference Site Locations). It is bounded on the west and north by Las Posas Road and agricultural fields, and it is bounded on the east and south by St. John Seminary and natural vegetation.

Existing Conditions

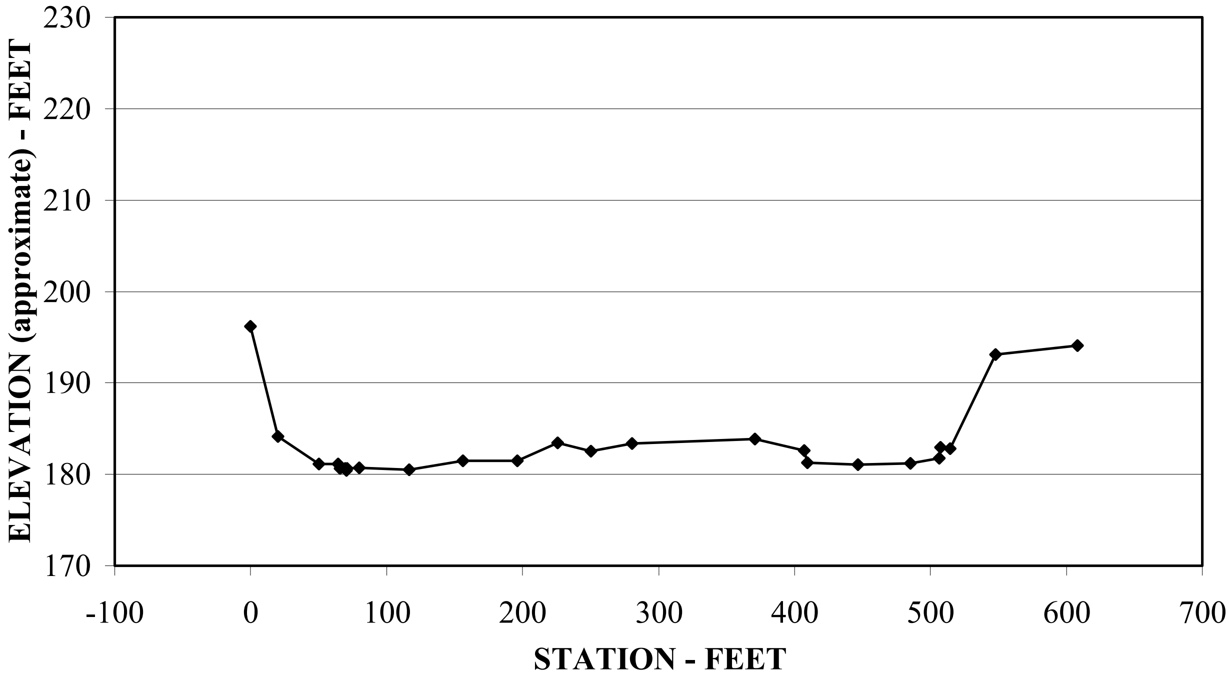
At this point, Calleguas Creek is Strahler Stream Order 4 (1:24,000)(Strahler 1957) and has a contributing area of approximately 253 sq. km (158 sq. miles). Mugu Lagoon is approximately 17.6 river-km (11 river-miles) down stream. Calleguas Creek is broad and shallow along this reach (Figures 30, Aerial Photograph of Calleguas Creek from Somis to Upland Road [Sites 25/37]; Figure 32, Cross-sectional Survey of Calleguas Creek from Somis to Upland Road [Sites 25/37]; and Photograph 16, Current Conditions of Calleguas Creek from Somis to Upland Road [Sites 25/37]). Field estimates of bankfull width and mean bankfull depth are 57.6 m and 0.3 m (189 ft. and 1.0 ft.), respectively. The floodprone area width – the width of inundation at moderately high flows - is 102.4 m (336 ft.). Channel slope is in the 0-2 percent class; precise field measurement would undoubtedly indicate that it is less than 1 percent. Channel bed and bank materials are natural, predominantly sand-sized grains.

Figure 31. Aerial Photograph of Calleguas Creek from Somis to Upland Road

Sparse riparian vegetation persists within the active floodway. Several plant communities predominate, including Mixed Willow Series, Mulefat Series, Giant Reed Series (Sawyer and Keeler-Wolf 1995), and Floodplain Riparian Scrub. Various nonnative plant species form the sparse ground cover growing below these series throughout the site. Agricultural lands comprise most of the historical floodplain area on both sides of the channel.

A low-water bridge spans the channel at the upper end of the reach near Somis, a St. John's Seminary access bridge spans the channel in the middle of the reach, and Upland Road spans the channel at the lower end of the reach. Most major structures on the site are located well above the active flooding on high terraces and hillsides.

Figure 32. Cross-sectional Survey of Calleguas Creek from Somis to Upland Road



Example Design Conditions

The basic design is to relieve the channel constrictions, construct a naturally functioning channel, revegetate the floodplain, and restore channel-floodplain interactions. The low water bridge that spans the channel at the upper end of the reach near Somis would be removed, or alternatively, it could be completely reconstructed. The bridges that span the middle and lower end of the reach would remain; however, both bridges should be extended to ensure they do not constrict high flows.

The assumed bankfull discharge is approximately 18.4 cms (650 cfs) (see Figure 16). A broad, shallow channel would be constructed, with a bankfull width of approximately 16.8 m (55 ft.) and a mean bankfull depth of approximately 0.8 m (2.7 ft.) (Alluvial Valley Hydraulic Geometry Model). The channel would meander freely across the site, and might be distributary in nature consistent with historical reports. Channel slope would remain less than 1 percent. Channel bed materials would be natural, and would be composed of predominantly sand-sized grains.

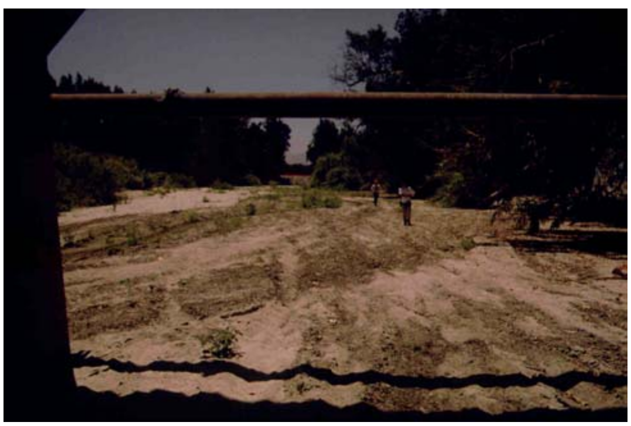
Portions of the active floodway and all of the restored floodplain would be revegetated with native species characteristic to the region and landscape position. Plant communities may include, but are not limited to, Mixed Willow Series and Arroyo Willow Series in the active floodway and a mosaic of California Sycamore Series, various willow series, and Mulefat Series on the floodplain (Sawyer and Keeler-Wolf 1995)(Figure 33, Conceptual Restoration Design for Calleguas Creek from Somis to Upland Road [Sites 25/37]).

The key element for this effort is the restoration of a naturally functioning channel, i.e. a channel that is narrower and deeper than that which currently exists so that the sediment delivered to the site can be passed naturally rather than accumulating up stream of the constrictions.

Photograph 16. Current Conditions of Calleguas Creek from Somis to Upland Road (Site 25/37)

a. View downstream towards Upland Road of channel bed full of sediments and little vegetation.

c. View upstream from St. John's Seminary Road of bed full of sediments



b. View southward from under St. John's Seminary Rd.

d. Bridge with only 15 inches of freeboard near Somis

Channel bed shear stress is related to the product of the water depth times the water slope (i.e. the depth-slope product). Shields' dimensionless shear stress calculations are widely used to estimate the mobility of particles in channels (Shields 1936, Komar 1987, Pitlick 1992, Buffington 1995). Shields' dimensionless shear stress is calculated as follows:

$$\tau^*_{cr} = (hs)/((\rho_s / \rho_w - 1)D)$$

where

τ^*_{cr} = Shields' dimensionless shear stress

h = water depth

s = energy slope (approximated as the water surface slope)

ρ_s = grain density

ρ_w = water density

D = grain diameter.

The result is that bed shear stress decreases with decreasing depth and, thus, sediment transport decreases with decreasing depth. Therefore, low thalweg and mean depths result in low rates of sediment transport (sediment deposition occurs in shallower channels rather than in deeper channels).

A narrower and deeper channel than that which currently exists could be maintained through planting abundant vegetation on the channel banks and floodplain and by constructing bridge spans that are wide enough to pass bankfull and floodflows and, therefore, sediment. Failure to adequately revegetate the channel banks could result in excessive rates of bank erosion and the development of a broader and shallower channel (see "Restore and Stabilize Banks", above). Failure to construct adequate bridge spans could result in backwater and sediment and the development of a broader and shallower channel deposition (see "Redesign and Replace Undersized Culvert and Bridge Spans", above).

The total project site area is approximately 36 ha (88 acres). The total area that would be restored to wetlands under this proposal is approximately 32 ha (80 acres), which would consist of Palustrine and Riverine wetlands. The portion adjacent to St. John's Seminary (Site 25) is approximately 7.7 ha (19 acres) while the portion upstream (Site 37) and measures approximately 23 ha (58 acres).

Restoration of this site will increase wetland functionality (see Table 9 for a description of each wetland function) by improving:

- Alluvial corridor integrity;
- Surface water hydrology;
- Subsurface water hydrology;
- Sediment mobilization, transport, and storage;
- Element and compound cycling;
- Organic carbon export;
- Native plant associations;
- Spatial structure of plant associations;
- Characteristic detrital biomass;
- Interspersion and connectivity for plant populations;
- Native vertebrate associations;
- Native invertebrate associations; and
- Interspersion and connectivity for animal populations.

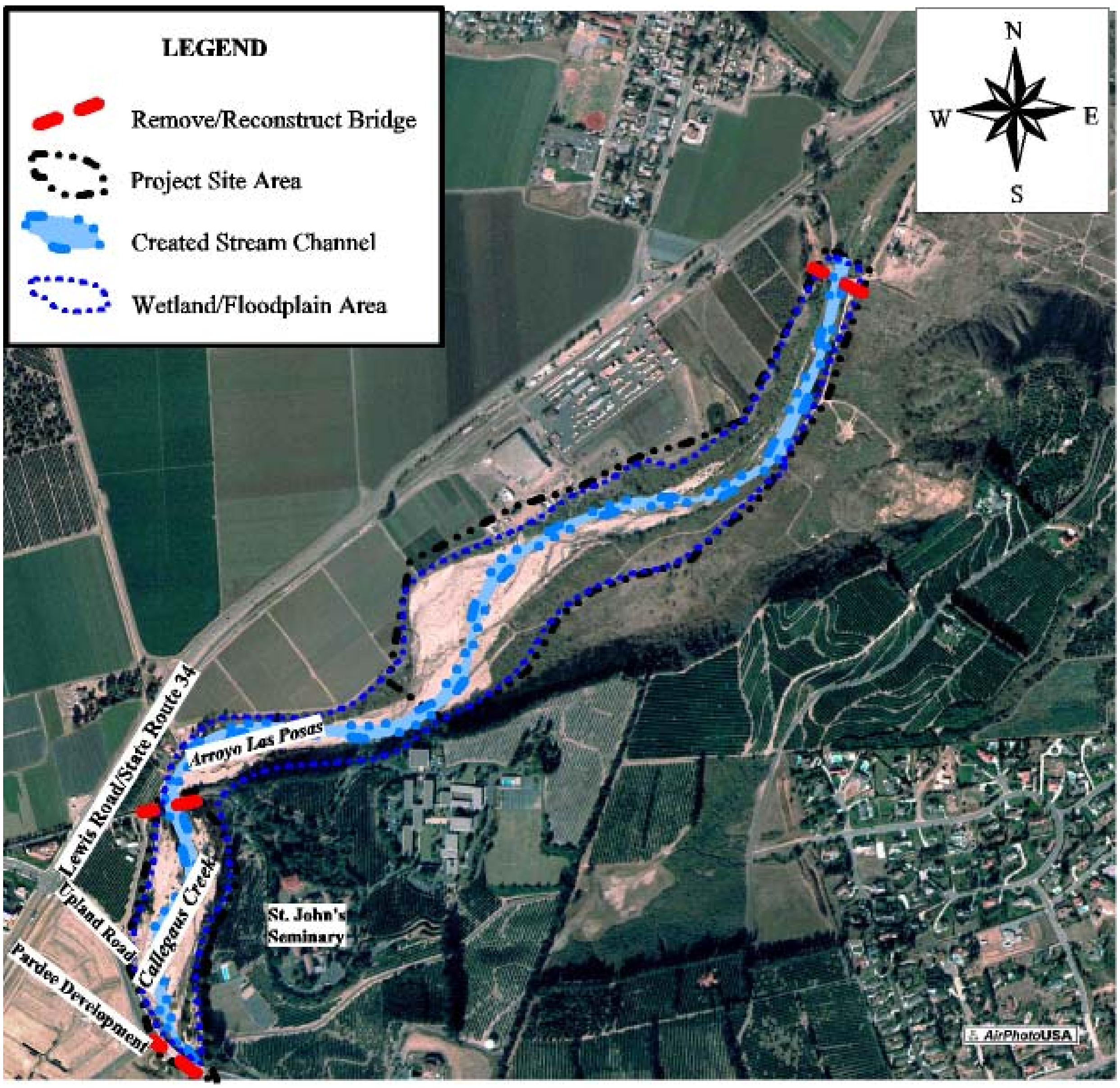
In other words, restoring the floodplain habitat along Arroyo Las Posas (Calleguas Creek) upstream and downstream of St. John's Seminary will increase the functionality of the all the known wetland functions in the 36-ha (88-acre) site substantially. The current configuration of the site restricts the level at which each wetland function can function, and results in extensive lateral erosion of adjacent property.

Constraints

The primary constraints on this project are related to incompatibilities with current land uses and the need to protect future land uses. Specifically,

- Any public or private utilities must be relocated or sufficiently buried;
- The low water bridge at the upper end of the reach must be removed and alternative access must be provided to the current land owners who use the bridge or a new bridge that adequately spans the channel must be constructed; and
- The St. John's Seminary access road bridge and the Upland Road bridge should be extended to ensure that they do not constrict flows.

Figure 33. Conceptual Restoration Design for Calleguas Creek from Somis to Upland Road (Sites 25/37)



ARROYO SANTA ROSA AT ARROYO CONEJO (SITE 30)

Location

Arroyo Santa Rosa at Arroyo Conejo (Site 30) is located on the alluvial fan deposits at the outlet of Hill Canyon (see Figure 13, Reference Site Locations). It is bounded on the north by a citrus orchard, and on the east, south, and west by the Santa Monica Mountains.

Existing Conditions

At this point, Arroyo Conejo is Strahler Stream Order 3 (1:24,000)(Strahler 1957) and has a contributing area of approximately 20 sq. km (12.5 sq. miles). Mugu Lagoon is approximately 16.6 river-km (10.4 river-miles) down stream.

Arroyo Conejo is deeply entrenched throughout this reach (Figure 34, Aerial Photograph of Arroyo Santa Rosa at Arroyo Conejo [Site 30]; and Photograph 17, Current Conditions of Arroyo Santa Rosa at Arroyo Conejo [Site 30]). Field estimates of bankfull width and mean bankfull depth are 5.5 m and 0.6 m (18 ft. and 2.0 ft.), respectively. The floodprone area width – the width of inundation at moderately high flows - is 7.3 m (24 ft.). Channel slope is in the 0-2 percent class; precise field measurement would undoubtedly indicate that it is less than 1 percent. Channel bed and bank materials are natural, predominantly sand- and gravel-sized grains.

Abundant riparian vegetation persists within the active floodway. Arroyo Willow Series (Sawyer and Keeler-Wolf 1995) occupies the entire site with *Artemisia douglasiana* (Mugwort) as an important understory groundlayer associate. However, the dissected fan deposits that form the high terrace between Arroyo Conejo and Arroyo Santa Rosa are essentially devoid of vegetation, thereby fragmenting the adjacent wildland habitats of the local Santa Monica Mountains.

A buried pipeline roughly parallels Hill Canyon Road. There are no other major structures on the site.

Example Design Conditions

The basic design is to restore vegetation to the dissected fan deposits and to reconnect the channel, fan, and upland habitats at the Hill Canyon outlet. There would be no alteration to Arroyo Conejo or Arroyo Santa Rosa since both channels are so deeply entrenched into the fan deposits.

The high terrace would be revegetated with native species characteristic to the region and landscape position. Plant communities may include, but are not limited to, various willow series in microtopographic lows, and California Sycamore Series and Coast Live Oak Series in the microtopographic highs (Sawyer and Keeler-Wolf 1995) (Figure 35, Conceptual Restoration Design for Arroyo Santa Rosa at Arroyo Conejo [Site 30]).

The total project site area is approximately 20 ha (50 acres). The total area that would be restored to wetlands under this proposal is approximately 8 ha (20 acres), which would consist of Palustrine wetlands.

Restoration of this site will increase wetland functionality (see Table 9 for a description of each wetland function) by improving:

- Alluvial corridor integrity;
- Surface water hydrology;
- Subsurface water hydrology;
- Sediment mobilization, transport, and storage;
- Element and compound cycling;
- Organic carbon export;
- Native plant associations;
- Spatial structure of plant associations;
- Characteristic detrital biomass;
- Interspersion and connectivity for plant populations;
- Native vertebrate associations;
- Native invertebrate associations; and
- Interspersion and connectivity for animal populations.

In other words, restoring the floodplain habitat at the confluence of Arroyo Conejo and Arroyo Santa Rosa will increase the functionality of the all the known wetland functions in the 20-ha (50-acre) site substantially. The current deeply incised channel configurations of the two creeks restricts the level at which each wetland function can function.

Figure 34. Aerial Photograph of Arroyo Santa Rosa at Arroyo Conejo (Site 30)

Photograph 17. Current Conditions of Arroyo Santa Rosa at Arroyo Conejo (Site 30)

a. View upstream of area north of Arroyo Santa Rosa

c. View southward towards Arroyo Conejo from Hill Canyon Road bridge over Arroyo Santa Rosa.

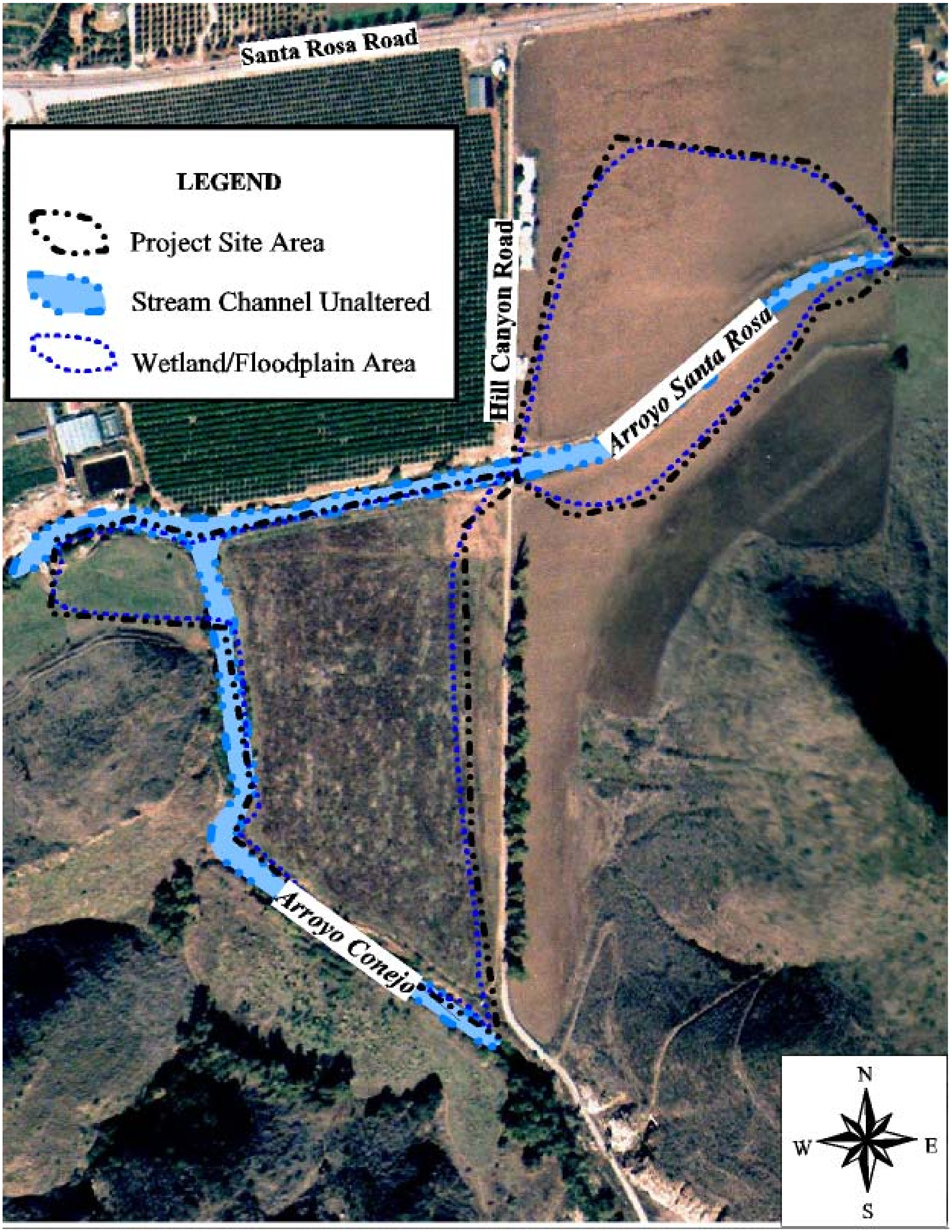
b. View downstream of Arroyo Santa Rosa towards confluence with Arroyo Conejo.

Constraints

The primary constraints on this project are related to land ownership and incompatibilities with current land uses. Specifically,

- Soils in the Santa Rosa Valley are known to contain pesticide residues (e.g. DDT and derivatives), which should be tested before prior to moving substantial quantities of soil;
- Adjacent land must be secured (through purchase or conservation easement); and
- Clearing activities on the purchased land must be discontinued.

Figure 35. Conceptual Restoration Design for Arroyo Santa Rosa at Arroyo Conejo (Site 30)



ARROYO SIMI AT SIMI RECYCLING CENTER (SITE 18)

Location

Arroyo Simi at Simi Recycling Center (Site 18) is located in the alluvial valley just down stream of Simi Valley (see Figure 13, Reference Site Locations). It is bounded on the north by various light industrial activities and on the south by the Simi Hills.

Existing Conditions

At this point, Arroyo Simi is Strahler Stream Order 4 (1:24,000)(Strahler 1957) and has a contributing area of approximately 113.6 sq. km (71 sq. miles). Mugu Lagoon is approximately 40.6 river-km (25.4 river-miles) down stream. The active floodway is relatively intact along this reach. Most of the local impacts to this reach are the effects of the light industrial activities on the historical floodplain and the adjacent uplands (Figure 36, Aerial Photograph of Arroyo Simi at Simi Recycling Center [Site 18]; and Photograph 18, Current Conditions of Arroyo Simi at Simi Recycling Center [Site 18]).

Field estimates of bankfull width and mean bankfull depth are 29.3 m and 0.8 m (96 ft. and 2.5 ft.), respectively. The floodprone area width – the width of inundation at moderately high flows - is 31.4 m (103 ft.). Channel slope is in the 0-2 percent class; precise field measurement would undoubtedly indicate that it is less than 1 percent. Channel bed and bank materials are natural, predominantly sand-sized grains. There are no levees, although fill material from the light industrial activities is impinging on the active floodway on river right.

Abundant native riparian vegetation persists in the active floodway and on portions of the floodplain. Mixed Willow Series (Sawyer and Keeler-Wolf 1995), as scrub and woodland stands, and stands of Arroyo Willow Series predominate onsite. Vegetation has been replaced by light industrial activities on much of the floodplain and the adjacent uplands on river right. The Arroyo Willow Series (Sawyer and Keeler-Wolf 1995) predominates in the riparian-upland ecotone on river left.

Numerous structures exist in the riparian-upland ecotone and the uplands on river right. These structures are owned and maintained by a variety of businesses. The channel is not spanned nearby since there is little development on river left.

Example Design Conditions

The basic design is to remove the incompatible uses from the riparian-upland ecotone and the uplands on river right. This would restore channel-floodplain interactions. Moreover, this would reduce sediment and chemical constituent input to the channel network and would reconnect riparian and upland habitats that currently are severed by industrial activities.

Figure 36. Aerial Photograph of Arroyo Simi at Simi Recycling Center (Site 18)

DMEC

Photograph 18. Current Conditions of Arroyo Simi at Simi Recycling Center (Site 18)

a. View southeast of Southdown Concrete Products facilities on fill placed in Arroyo Simi floodplain

d. View northwest of restoration site from north edge of Arroyo Simi with Southdown facilities on right.

b. View from Los Angeles Ave. of restoration site with Southdown Concrete Products facility on left.

e. View northeastward of Southdown facilities from north edge of Arroyo Simi with Arroyo Willow on right.

c. View south at west edge of small Mulefat-dominated drainage to Arroyo Simi.

f. View northward of small drainage next to concrete facility. Drainage dominated by Mulefat.

The assumed bankfull discharge is approximately 9.5 cms (335 cfs) (see Figure 16). A broad, shallow channel would be constructed, with a bankfull width of approximately 18.6 m (61 ft.) and a mean bankfull depth of approximately 0.4 m (1.3 ft.) (Alluvial Valley Hydraulic Geometry Model). The channel would meander freely across the site, constrained by the Simi Hills on river right and river left. Channel slope would remain less than 1 percent. Channel bed materials would be natural, and would be composed of predominantly sand-sized grains.

The restored riparian-upland ecotone and the uplands on river right would be revegetated with native species characteristic to the region and landscape position. Plant communities may include, but are not limited to, various willow series and Mulefat Series in the riparian-upland ecotone, and California Sycamore Series and Coast Live Oak Series in the uplands with Coyote Brush, and Mixed Sage Series as an understory to the woodland canopy (Sawyer and Keeler-Wolf 1995) (Figure 37, Conceptual Restoration Design for Arroyo Simi at Simi Recycling Center [Site 18]).

The total project site area is approximately 13 ha (32 acres). The total area that would be restored to wetlands under this proposal is approximately 11 ha (28 acres), which would consist of Palustrine and Riverine wetlands.

Restoration of this site will increase wetland functionality (see Table 9 for a description of each wetland function) by improving:

- Alluvial corridor integrity;
- Surface water hydrology;
- Subsurface water hydrology;
- Sediment mobilization, transport, and storage;
- Element and compound cycling;
- Organic carbon export;
- Native plant associations;
- Spatial structure of plant associations;
- Characteristic detrital biomass;
- Interspersion and connectivity for plant populations;
- Native vertebrate associations;
- Native invertebrate associations; and
- Interspersion and connectivity for animal populations.

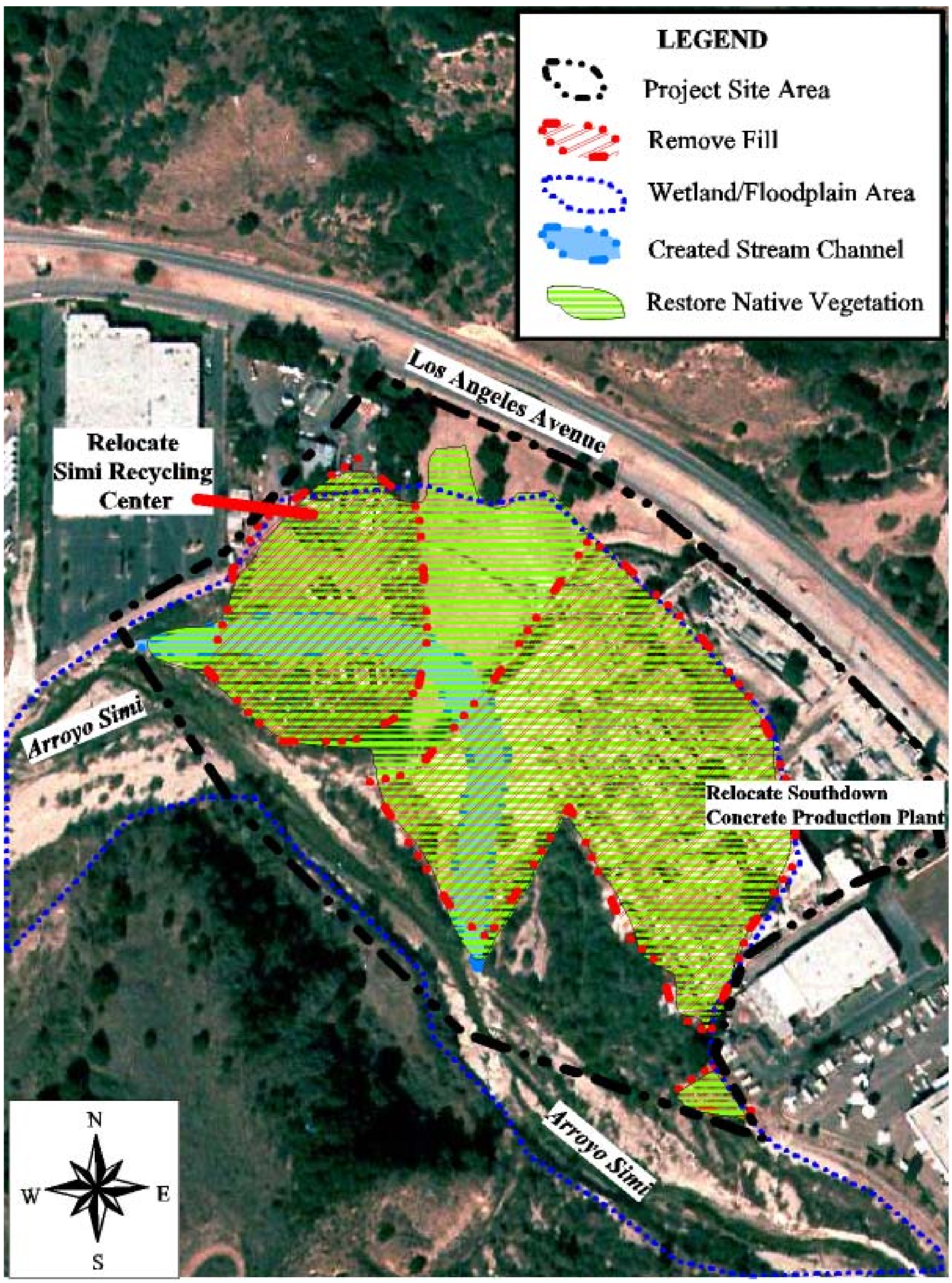
In other words, restoring the floodplain habitat of Arroyo Simi at the site of the Simi Recycling Center and concrete processing plant will increase the functionality of the all the known wetland functions in the 13-ha (32-acre) site substantially. The current configuration of the site limits the level at which each wetland function can function, as the current adjacent land uses encroach upon the historic floodplain and may contribute to downstream bank erosion and flooding problems.

Constraints

The primary constraints on this project are related to land ownership and incompatibilities with current land uses. Specifically,

- Adjacent land must be secured (through purchase or conservation easement);
- Light industrial activities on the purchased land must be discontinued; and
- Any public or private utilities must be relocated or sufficiently buried.

Figure 37. Conceptual Restoration Design for Arroyo Simi at Simi Recycling Center (Site 18)



ARROYO CONEJO AT BORCHARD ROAD (SITE 47)

Location

Arroyo Conejo at Borchard Road (Site 47) is located on the small alluvial valley up stream of Borchard Road and adjacent to U.S. 101 (see Figure 13, Reference Site Locations). It is bounded on the north by U.S. 101, on the east by Borchard Road, and on the south and west by residential neighborhoods.

Existing Conditions

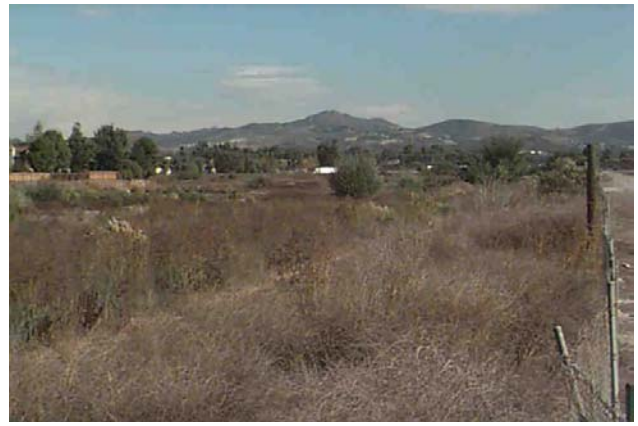
At this point, Arroyo Conejo is Strahler Stream Order 3 (1:24,000)(Strahler 1957) and has a contributing area of approximately 17.9 sq. km (11.2 sq. miles). Mugu Lagoon is approximately 22.2 river-km (13.9 river-miles) down stream.

Arroyo Conejo is straightened and confined between levees throughout this reach (Figure 38, Aerial Photograph of Arroyo Conejo at Borchard Road [Site 47]; and Photograph 19, Current Conditions of Arroyo Conejo at Borchard Road [Site 47]). Field estimates of bankfull width and mean bankfull depth are 17.4 m and 0.5 m (57 ft. and 1.5 ft.), respectively. The floodprone area width – the width of inundation at moderately high flows - is 25.6 m (84 ft.). Channel slope is in the 0-2 percent class; precise field measurement would undoubtedly indicate that it is less than 1 percent. Channel bed/bank materials are natural, predominantly sand-sized grains. Levees are constructed of fill dirt.

Figure 38. Aerial Photograph of Arroyo Conejo at Borchard Road (Site 47)

Photograph 19. Current Conditions of Arroyo Conejo at Borchard Road (Site 47)

a. View westward from near middle of site, which is predominantly isolated wetland habitat.



b. View eastward from southwestern corner of site, along levee of South Branch Arroyo Conejo.

The active floodway is essentially devoid of vegetation, while the historical floodplain supports Coyote Brush Series (Sawyer and Keeler-Wolf 1995) and Fennel Ruderal Grassland. Various nonnative plant species form scattered ground cover throughout the historical floodplain.

U.S. 101 spans the channel upstream. The residential neighborhood to the north and west is slightly elevated above the historical floodplain, presumably to protect against episodic flood events where floodwaters collect outboard of the levees on the historical floodplain. A utility corridor parallels the levee on river left. There are no other major structures on the site.

Example Design Conditions

The basic design is to remove the levee on river left and to restore channel-floodplain interactions. A small levee would be constructed around the perimeter of the residential neighborhood to the north and west and along U.S. 101 to protect against flooding. The U.S. 101 bridge that spans the lower end of the reach would remain.

The assumed bankfull discharge is approximately 11.9 cms (420 cfs) (see Figure 16). A broad, shallow channel would be constructed, with a bankfull width of approximately 21.3 m (70 ft.) and a mean bankfull depth of approximately 0.4 m (1.4 ft.) (Alluvial Valley Hydraulic Geometry Model). The channel would meander freely across the site, constrained on river right by the existing levee and on river left by the setback levee that protects the residential neighborhood and U.S. 101. Channel slope would remain less than 1 percent. Channel bed materials would be natural, and would be composed of predominantly sand-sized grains.

Portions of the active floodway and all of the restored floodplain would be revegetated with native species characteristic to the region and landscape position. Plant communities may include, but are not limited to, Mixed Willow Series and Cattail Series in the active floodway and a mosaic of Mulefat Series and Arroyo Willow Series on the floodplain (Sawyer and Keeler-Wolf 1995) (Figure 39, Conceptual Restoration Design for Arroyo Conejo at Borchard Road [Site 47]).

The total project site area is approximately 17.4 ha (43 acres). The total area that would be restored to wetlands under this proposal is approximately 16 ha (40 acres), which would consist of Palustrine and Riverine wetlands.

Restoration of this site will increase wetland functionality (see Table 9 for a description of each wetland function) by improving:

- Alluvial corridor integrity;
- Surface water hydrology;
- Subsurface water hydrology;
- Sediment mobilization, transport, and storage;
- Element and compound cycling;
- Organic carbon export;
- Native plant associations;
- Spatial structure of plant associations;
- Characteristic detrital biomass;
- Interspersion and connectivity for plant populations;
- Native vertebrate associations;
- Native invertebrate associations; and
- Interspersion and connectivity for animal populations.

In other words, restoring the floodplain habitat of the South Branch of Arroyo Conejo at this site along U.S. 101 will increase the functionality of the all the known wetland functions in the 17.4-ha (43-acre) site substantially. The current configuration of the site limits the level at which each wetland function can function, as the current adjacent land uses and flood control levees encroach upon the historic floodplain and may contribute to downstream bank erosion and flooding problems.

Constraints

The primary constraints on this project are related to land ownership, incompatibilities with current land uses, and the need to protect future land uses. Specifically,

- Adjacent land must be secured (through purchase or conservation easement);
- Any public or private utilities must be relocated or sufficiently buried; and
- The residential neighborhoods and U.S. 101 must be protected from flooding.

Figure 39. Conceptual Restoration Design for Arroyo Conejo at Borchard Road (Site 47)

ARROYO SIMI/JUNIPERO CHANNEL CONFLUENCE AT KUEHNER ROAD (SITES 40/41)

Location

Arroyo Simi/Junipero Channel Confluence at Kuehner Road (Sites 40/41) is located on the alluvial fan deposits at the southeastern edge of Simi Valley (see Figure 13, Reference Site Locations). It is bounded on the west and north by residential neighborhoods, on the east by Kuehner Road and residential neighborhoods, and on the south by Smith Road and the Simi Hills.

Existing Conditions

At this point, Arroyo Simi is Strahler Stream Order 2 (1:24,000)(Strahler 1957) and has a contributing area of approximately 3 sq. km (1.9 sq. miles), while Junipero Channel is Strahler Stream Order 1 (1:24,000)(Strahler 1957) and has a contributing area of approximately 1 sq. km (0.68 sq. mile). Mugu Lagoon is approximately 56 km (35 miles) down stream.

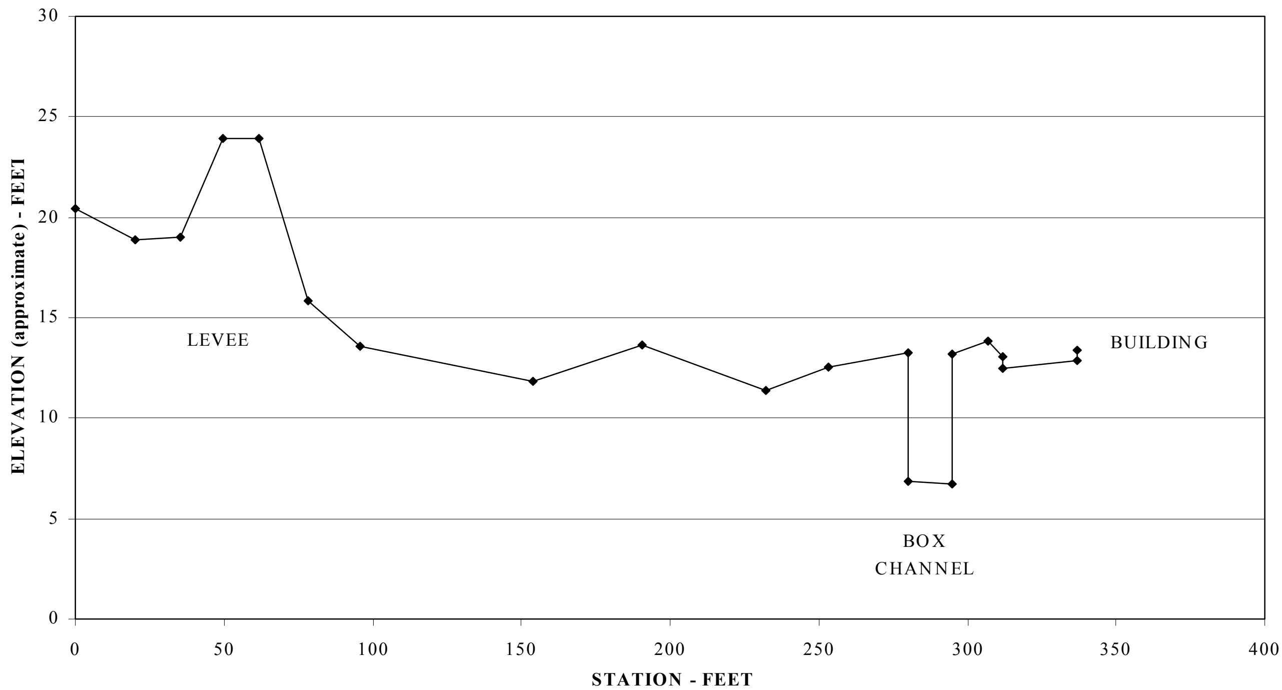
Arroyo Simi is straightened and confined within a concrete-lined culvert throughout this reach, while Junipero Channel is straightened and confined between levees throughout this reach (Figure 40, Aerial Photograph of Arroyo Simi/Junipero Channel Confluence at Kuehner Road [Sites 40/41]; Figure 41, Cross-sectional Survey of Arroyo Simi/Junipero Channel Confluence at Kuehner Road [Sites 40/41]; and Photograph 20, Current Conditions of Arroyo Simi/Junipero Channel Confluence at Kuehner Road [Sites 40/41]). On Arroyo Simi, field estimates of bankfull width and mean bankfull depth are 4.3 m and 0.3 m (14 ft. and 1 ft.), respectively. The floodprone area width – the width that is inundated at moderately high flows - is 4.3 m (14 ft.). On Junipero Channel, field estimates of bankfull width and mean bankfull depth are 6.1 m and 0.2 m (20 ft. and 0.5 ft.), respectively. The floodprone area width – the width of inundation at moderately high flows - is 7.3 m (24 ft.). Channel slopes are in the 0-2 percent class; precise field measurement would undoubtedly indicate that they less than 1 percent. Channel bed and bank materials are concrete in Arroyo Simi and natural, predominantly sand-sized grains in Junipero Channel.

The active floodways are essentially devoid of vegetation, while the historical floodplains support California Annual Grassland Series, California Walnut Series, Coast Live Oak Series, Scalebroom Series (Sawyer and Keeler-Wolf 1995), and Floodplain Riparian Scrub with a significant association with ruderal invasive plant species. Various nonnative plant species form scattered ground cover throughout the historical floodplains.

A vernal pool is located between the two channels near the base of the large rock outcrop (Figure 40). In March 1999, vernal pool fairy shrimp (*Branchinecta lyndallii*) were observed by DMEC, Impact Sciences, and Glenn Lukos & Associates, Inc. personnel.

Figure 40. Aerial Photograph of Arroyo Simi/Junipero Channel Confluence at Kuehner Road (Sites 40/41)

Figure 41. Cross-sectional Survey of Arroyo Simi/Junipero Channel Confluence at Kuehner Road (Sites 40/41)



Furthermore, nesting sites were recorded for the White-throated Swift, the Violet-green Swallow, and the Cliff Swallow. Insofar as DMEC knows, this is the lowest known nesting site for the Black-throated Swift in southern California. Kuehner Road spans Arroyo Simi upstream, and Smith Road spans Arroyo Simi downstream. There are residential neighborhoods to the west and north. There are no other major structures on the site.

Photograph 20. Current Conditions of Arroyo Simi/Junipero Channel Confluence at Kuehner Road (Sites 40/41)

Example Design Conditions

The basic design is to remove the Arroyo Simi concrete culvert down stream of Kuehner Road and to remove the Junipero Channel levee on river right between Smith Road and Arroyo Simi and to restore channel confluence and channel-floodplain interactions. Small levees would be constructed to protect the residential neighborhood to the north and Kuehner Road. The small Junipero Channel levee on river left would be maintained to protect the residential neighborhood to the west.

The assumed bankfull discharge for Arroyo Simi and Junipero Channel are approximately 0.2 cms and 0.1 cms (8 cfs and 3 cfs), respectively (see Figure 16). Arroyo Simi and Junipero Channel would be restored, with bankfull widths of approximately 11 feet and 7 feet, respectively, and mean bankfull depths of approximately 15 cm and 12 cm (0.5 ft. and 0.4 ft.), respectively (Alluvial Valley Hydraulic Geometry Model). The channels would meander freely across the site, constrained on the north, east, and west by levees and on the south by the topography of the Simi Hills. Channel slope would remain less than 1 percent. Channel bed materials would be natural, and would be composed of predominantly sand-sized grains.

The active floodways and the restored floodplain would be revegetated with native species characteristic to the region and landscape position. Plant communities may include, but are not limited to, California Bulrush-Cattail Series and Arroyo Willow Series in the active floodway; a mosaic of California Sycamore Series and Mulefat Series on the floodplain; and Mulefat-Coyote Brush Series and California Sagebrush/Black Sage-White Sage Series in the uplands (Sawyer and Keeler-Wolf 1995) (Figure 42, Conceptual Restoration Design for Arroyo Simi/Junipero Channel Confluence at Kuehner Road [Sites 40/41]).

This project will serve the additional purpose of vernal pool restoration. Vernal pool restoration is consistent with the long-term vernal pool recovery strategy that has been developed by the U.S. Fish & Wildlife Service (U.S. Fish & Wildlife Service 1998).

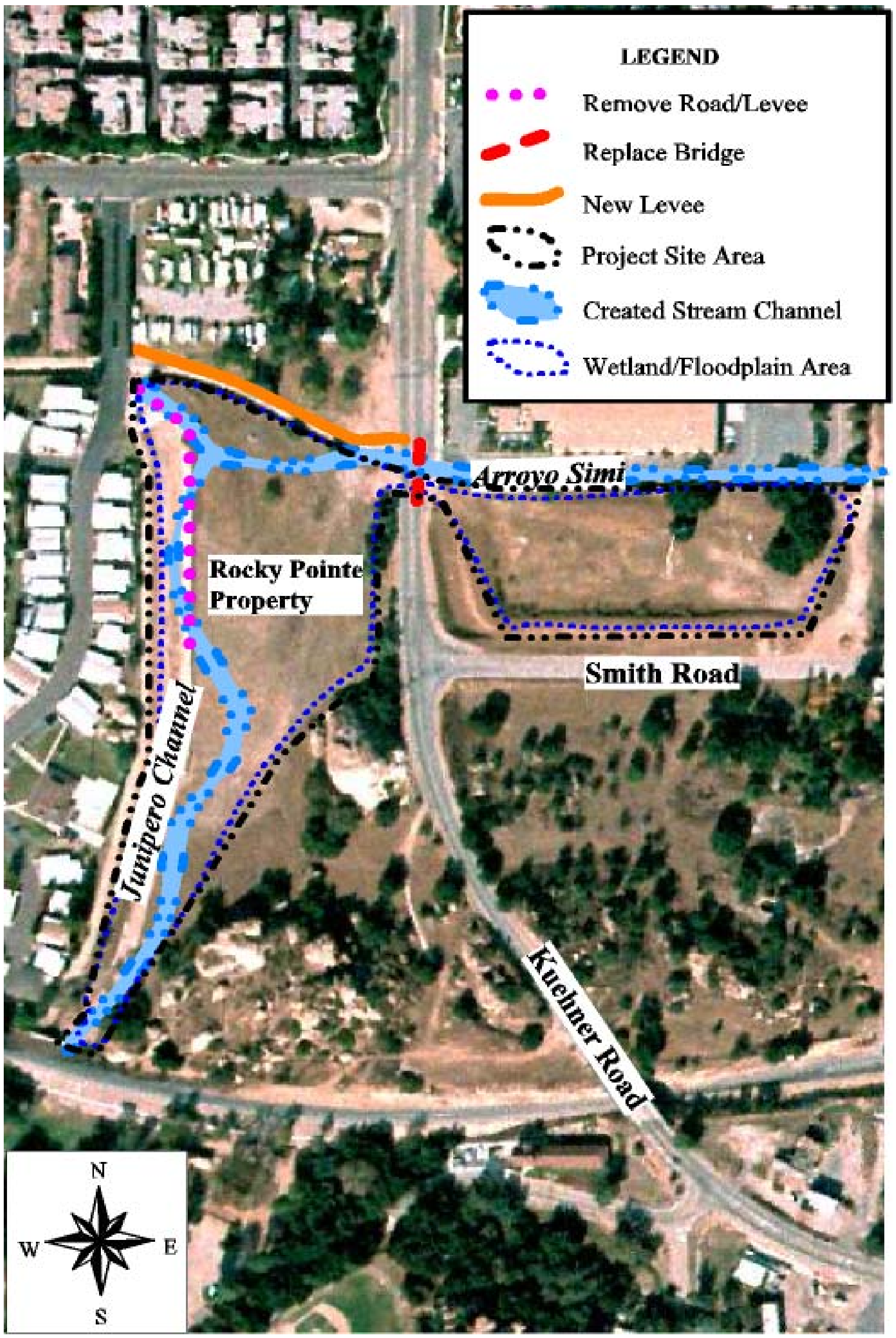
The total project site area is approximately 6 ha (15 acres). The total area that would be restored to wetlands under this proposal is approximately 4 ha (10 acres), which would consist of Palustrine and Depressional wetlands.

Restoration of this site will increase wetland functionality (see Table 9 for a description of each wetland function) by improving:

- Alluvial corridor integrity;
- Surface water hydrology;
- Subsurface water hydrology;
- Sediment mobilization, transport, and storage;
- Element and compound cycling;
- Organic carbon export;
- Native plant associations;
- Spatial structure of plant associations;
- Characteristic detrital biomass;
- Interspersion and connectivity for plant populations;
- Native vertebrate associations;
- Native invertebrate associations; and
- Interspersion and connectivity for animal populations.

In other words, restoring the floodplain habitat at the confluence of Arroyo Simi and the Junipero Channel will increase the functionality of the all the known wetland functions in the 6-ha (15-acre) site substantially. The current configuration of the site restricts the level at which each wetland function can function, as the primary objective of the current design is to funnel flood waters down stream as quickly as possible, with no consideration for the other wetland functions. In fact, current channel design precludes nearly all wetland functions except surface water conveyance.

Figure 42. Conceptual Restoration Design for Arroyo Simi/Junipero Channel Confluence at Kuehner Road (Sites 40/41)



Constraints

The primary constraints on this project are related to land ownership, incompatibilities with current land uses, and the need to protect future land uses. Specifically,

- Adjacent land must be secured (through purchase or conservation easement);
- Any public or private utilities must be relocated or sufficiently buried; and
- The residential neighborhoods, Kuehner Road, and Smith Road must be protected from flooding.

CONCLUSIONS

The rivers and wetlands in the Calleguas Creek Watershed have been seriously reduced in area and function over the last 200 years, primarily during the last century. Agricultural and urban development have resulted in significant losses in natural habitats, both upland and wetland habitats. Overall, more than 90 percent of the historic wetlands have been lost.

Agricultural and urban development also have increased the frequency and magnitude of high stream discharges and the rates of erosion and sediment delivery to the stream network. An aggressive policy of channel training – straightening, channelizing, and leveeing – has been employed throughout the 20th Century. Chemical constituents, some of which are cancelled substances known or suspected to be harmful to human health and welfare, are found in the waters and biota of extensive portions of the stream network.

Millions of taxpayers dollars have been spent by public agencies to protect private properties from damage caused by flooding and sedimentation. Hundreds of thousands of dollars are spent each year by the Ventura County Flood Control District to maintain existing flood control facilities.

Generally, the state of the wetlands in the watershed is poor; however, significant opportunities remain in the watershed for restoration of river and wetland functions. The restoration of river and wetland functions would achieve several goals pertaining to the biodiversity and function of the Calleguas Creek Watershed.

This document outlines one approach to restoring and managing the river and wetland ecosystem resources in the Calleguas Creek Watershed. The fundamental essence of this approach is the restoration of physical, chemical, and biological integrity to the stream network, largely through the preservation of uplands in the upper watershed and the restoration of channel-floodplain interactions throughout the middle and lower watershed.

The general recommendations of this document can be summarized as follows:

- Preserve upland portions of the upper watershed, groundwater recharge zones, and large, intact channel floodplain systems.
- Implement aggressive storm water management plans.
- Manage storm water facilities for plant and wildlife habitat.
- Stabilize stream banks using bioengineering and stream bank vegetation restoration.
- Reduce sediment discharges from orchards.
- Redesign and replace undersized culverts and bridge spans.
- Restore channel-floodplain interactions to ten sites located throughout the middle to lower watershed.

This study has identified numerous opportunities to correct many of the degraded conditions for the wetlands and water quality of the Calleguas Creek Watershed. Partnerships by government agencies at all levels with property owners are necessary for successful wetland and floodplain restoration. The end-results of implementation of this study's recommendations will benefit the citizens, plants, and wildlife of the watershed and eventually reduce maintenance costs and costs resulting from flooding and erosion.

Data gathered on the wetlands of the watershed as part of this study will provide a foundation for a regional watershed riverine Hydrogeomorphic model that may be developed in the near future.

This document, however, is not a plan per se; rather, this document outlines an approach to ecosystem restoration and management. There is more than one way to solve some of the problems in the watershed; however, the preparers believe the approaches presented in this plan will greatly benefit the environment of the watershed while solving or reducing many of the problems the residents of the watershed are currently experiencing.

The recommendations outlined herein represent excellent opportunities to accomplish the overall goal of improving watershed-scale ecological integrity. However, the emphasis in this document is on an approach based on basic hydrological and ecological principles and not on the specific restoration site recommendations. Any activities that lead to the restoration of natural stream flow regimes, natural sediment delivery and transport rates, natural water quality, and natural plant and wildlife habitats should be considered to be consistent with the philosophical approach of this plan. The end result will be a watershed that has higher wetland functions than occurring in the watershed today, and reductions in damage and maintenance costs borne by the taxpayers to protect resources and property.

DMEC

ACKNOWLEDGEMENTS

This report was written by David Magney and Mark Rains. Plant and Wildlife Sections were written by Mr. Magney and Cher Wellonen. Mr. Magney edited the report. Fieldwork (wetlands inventory and general site characterizations) was conducted by Mr. Magney, Mr. Rains, and Ms. Wellonen.

Mitch Swanson & Associates gathered transect data at selected sites. Steven Brady, of SECOR International Incorporated performed hydrogeologic investigations and analysis of the watershed and assisted with selecting wetland restoration sites. Greg Sutter, of Wildlands, Inc., provided guidance and advise on the restoration opportunities and constraints of selected sites. Katherine Warner and Emily Constantine of Geo InSight International, Inc. created the GIS database for the project using ArcView 3.2.

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APPENDICIES

APPENDIX A. NAME-CODE CROSSWALK FOR UPLAND SPECIES OBSERVED IN THE CALLEGUAS CREEK WATERSHED

APPENDIX B. REFERENCE SITE FIELD DATA

APPENDIX C. REFERENCE SITE PHOTOGRAPHS

APPENDIX A.
NAME-CODE CROSSWALK FOR UPLAND SPECIES OBSERVED IN THE CALLEGUAS CREEK WATERSHED

Scientific Name[1]	SCS Code[2]	Common Name	Family	Wetland Indicator Status[3]
Adenostoma fasciculatum	ADFA	Chamise	Rosaceae	.
Agrostis exarata	AGEX	Western Bentgrass	Poaceae	FACW
*Agrostis stolonifera**	AGST2	Creeping Bentgrass	Poaceae	FACW
Ambrosia psilostachya var. *californica*	AMPSC	Western Ragweed	Asteraceae	FAC
Amsinckia menziesii var. *intermedia*	AMMEI	Ranchers Fire	Boraginaceae	.
*Anagallis arvensis**	ANAR	Scarlet Pimpernel	Primulaceae	FAC
Anemopsis californica var. *californica*	ANCAC	Yerba Mansa	Saururaceae	OBL
*Apium graveolens**	APGR2	Celery	Apiaceae	FACW*
Aristolochia californica	ARCA10	California Pipevine	Aristolochiaceae	.
Artemisia californica	ARCA11	California Sagebrush	Asteraceae	.
Artemisia douglasiana	ARDO3	Mugwort	Asteraceae	FACW
*Arundo donax**	ARDO4	Giant Reed	Poaceae	FACW
Asclepias fascicularis	ASFA	Narrowleaf Milkweed	Asclepiadaceae	FAC
Astragalus douglasii var. *parishii*	ASDOP	Parish Milkvetch	Fabaceae	.
Atriplex lentiformis ssp. *breweri*	ATLEB	Brewers Big Saltbush	Chenopodiaceae	FAC
*Atriplex semibaccata**	ATSE	Australian Saltbush	Chenopodiaceae	FAC
*Avena barbata**	AVBA	Slender Oat	Poaceae	.
*Avena fatua**	AVFA	Wild Oat	Poaceae	.
Baccharis pilularis	BAPI	Coyote Brush	Asteraceae	.
Baccharis salicifolia	BASA*	Mulefat	Asteraceae	FACW
Bidens pilosa var. *pilosa**	BIPIP	Common Beggar-ticks	Asteraceae	FACW
*Brassica nigra**	BRNI	Black Mustard	Brassicaceae	.
Brickellia californica	BRCA3	California Brickellbush	Asteraceae	FACU
*Bromus diandrus**	BRDI3	Ripgut Grass	Poaceae	(FACU)
*Bromus hordeaceus**	BRHO*	Soft Chess	Poaceae	FACU-
Bromus madritensis ssp. *rubens**	BRMAR*	Red Brome	Poaceae	NI
Bromus techtorum var. *techtorum**	BRTET*	Cheat Grass	Poaceae	.
Calystegia macrostegia	CAMA24	Morning-glory	Convolvulaceae	.

[1] Scientific names are according to Hickman 1993.
* = naturalized nonnative taxon.
[2] SCS Code is the standardized abbreviated code set for each species of plant (SCS 1982).
* = species code derived by DMEC according to SCS protocols.
[3] Wetland Indicator Status code definitions according to Reed (1988):
OBL = obligate wetland species, occurs almost always in wetlands (>99% probability).
FACW = facultative wetland species, usually found in wetlands (67-99% probability).
FAC = facultative species, equally likely to occur in wetlands or nonwetlands (34-66% probability).
FACU = facultative upland species, usually found in nonwetlands (67-99% probability).
\+ or - symbols are modifiers that indicate greater or lesser affinity for wetland habitats.
NI = no indicator has been assigned due to a lack of information to determine indicator status.
* = a tentative assignment to that indicator status by Reed (1988).
Parentheses around indicator status indicates the wetland indicator status as suggested by David L. Magney based on extensive field observations.

DMEC

Scientific Name[1]	SCS Code[2]	Common Name	Family	Wetland Indicator Status[3]
Capsella bursa-pastoris var. *bursa-pastoris**	CABUB	Shepherds Purse	Brassicaceae	FAC-
*Carduus pycnocephalus**	CAPY2	Italian thistle	Asteraceae	.
*Carpobrotus edulis**	CAED3	Hottentot Fig	Aizoaceae	.
*Centaurea melitensis**	CEME2	Tocalote	Asteraceae	.
*Chamomilla suaveolens**	CHSU*	Pineapple weed	Asteraceae	FACU
*Chenopodium ambrosioides**	CHAM	Mexican Tea	Chenopodiaceae	FAC
*Chenopodium murale**	CHMU2	Nettle-leaved Goosefoot	Chenopodiaceae	(FACU)
Clarkia unguiculata	CLUN	Elegant Clarkia	Onagraceae	.
Claytonia perfoliata	CLPE	Miners Lettuce	Portulaceae	FAC
Clematis ligusticifolia	CLLI2	Virgins Bower	Ranunculaceae	FAC
*Conium maculatum**	COMA2	Poison Hemlock	Apiaceae	FACW
Conyza canadenisis	COCA5	Horseweed	Asteraceae	FAC
*Cotula coronopifolia**	COCO7	African Brass-buttons	Asteraceae	FACW+
Cryptantha echinella	CREC	Prickly Forget-me-not	Boraginaceae	.
*Cynodon dactylon**	CYDA	Bermuda Grass	Poaceae	FAC
Cyperus eragrostis	CYER	Umbrella-sedge	Cyperaceae	FACW
Datura wrightii	DAWR2	Jimson Weed	Solanaceae	.
Dichelostemma capitatum ssp. *capitatum*	DICAC*	Blue Dicks	Amaryllidaceae	.
Diplachne uninervia	DIUN*	Mexican Sprangletop	Poaceae	FACW
Dudleya pulverulenta	DUPU	Chalky Live-forever	Crassulaceae	.
Encelia californica	ENCA	California Bush Sunflower	Asteraceae	.
Epilobium ciliatum	EPCI	Northern Willow-herb	Onagraceae	FACW
Eremocarpus setigerus	ERSE	Dove Weed	Euphorbiaceae	.
Eriogonum fasciculatum	ERFA2	California Buckwheat	Polygonaceae	.
Eriogonum sp. *(butterworthianum?)*	ER?	Buckwheat	Polygonaceae	.
Eriophyllum confertiflorum	ERCO16	Golden Yarrow	Asteraceae	.
*Erodium botrys**	ERBO	Broadleaf Filaree	Geraniaceae	.
*Erodium cicutarium**	ERCI6	Redstem Filaree	Geraniaceae	.
*Erodium moschatum**	ERMO7	Broadleaf Filaree	Geraniaceae	.
*Eucalyptus camaldulensis**	EUCA2	River Red Gum	Myrtaceae	(FACU)
*Eucalyptus globulus**	EUGL	Tasmanian Blue Gum	Myrtaceae	.
Eucrypta chrysanthemifolia	EUCH	Eucrypta	Hydrophyllaceae	.
*Euphorbia lathyris**	EULA4	Gopher Plant	Euphorbiaceae	.
*Euphorbia peplus**	EUPE6	Petty Spurge	Euphorbiaceae	.
*Foeniculum vulgare**	FOVU	Sweet Fennel	Apiaceae	FACU+
Frankenia salina	FRSA*	Alkali Heath	Frankeniaceae	FACW+
Galium aparine	GAAP2	Goose Grass	Rubiaceae	FACU

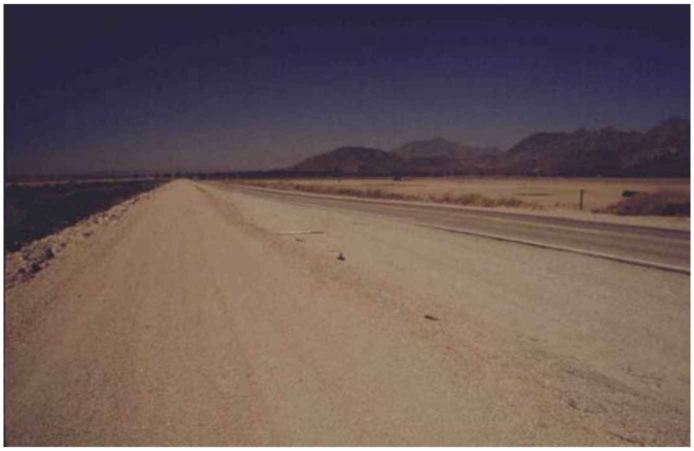
Scientific Name[1]	SCS Code[2]	Common Name	Family	Wetland Indicator Status[3]
*Geranium dissectum**	GEDI	Dissected Geranium	Geraniaceae	.
Gnaphalium californicum	GNCA	Green Everlasting	Asteraceae	.
Gnaphalium canescens	GNCA1*	White Everlasting	Asteraceae	.
*Gnaphalium luteo-album**	GNLU	Cudweed Everlasting	Asteraceae	FACW-
Hazardia squarrosa	HASQ*	Saw-toothed Goldenbush	Asteraceae	.
*Hedera canariensis**	HECA*	Algerian Ivy	Araliaceae	.
Heteromeles arbutifolia	HEAR5	Toyon	Rosaceae	.
Heterotheca grandiflora	HEGR7	Telegraph Weed	Asteraceae	.
*Hirschfeldia incana**	HIIN3	Summer Mustard	Brassicaceae	.
Hordeum marinum ssp. *gussoneanum**	HOMAG*	Mediterranean Barley	Poaceae	FAC
Hordeum murinum ssp. *glaucum**	HOMUG*	Summer Barley	Poaceae	.
Hordeum murinum ssp. *leporinum**	HOMAL*	Hare Barley	Poaceae	NI
Isomeris arborea	ISAR	Bladderpod	Capparaceae	.
Juglans californica var. *californica*	JUCAC	So. Calif. Black Walnut	Juglandaceae	FAC
Juncus sp.	JUNCU	Rush	Juncaceae	FACW/OBL
*Lactuca serriola**	LASE	Prickly Wild Lettuce	Asteraceae	FAC
*Lepidium latifolium**	LELA2	Broadleaf Peppergrass	Brassicaceae	FACW
Lepidospartum squamatum	LESQ	Scalebroom	Asteraceae	(FACW)
Lessingia filaginifolia	LEFI*	Cudweed Aster	Asteraceae	.
Leymus condensatus	LECO*	Giant Wildrye	Poaceae	FACU+
*Lolium multiflorum**	LOMU*	Italian Ryegrass	Poaceae	FAC*
Lotus scoparius	LOSC2	Deerweed	Fabaceae	.
Lupinus albifrons	LUAL4	Silver Bush Lupine	Fabaceae	.
Lupinus longifolius	LULO	Long-leaved Bush Lupine	Fabaceae	.
Lupinus succulentus	LUSU3	Fleshy Lupine	Fabaceae	.
Malacothamnus fasciculatus var. *nuttallii*	MAFA	Nuttall Bush Mallow	Malvaceae	.
Malacothrix saxatilis	MASA2	Cliff-aster	Asteraceae	.
Malosma laurina	MALA*	Laurelleaf Sumac	Anacardiaceae	.
*Malva parviflora**	MAPA5	Cheeseweed	Malvaceae	.
Marah fabaceus	MAFA3	Man-root	Cucurbitaceae	.
*Marrubium vulgare**	MAVU	White Horehound	Lamiaceae	FAC
*Melilotus alba**	MEAL2	White Sweetclover	Fabaceae	FACU+
*Melilotus indica**	MEIN2	Sourclover	Fabaceae	FAC
Mimulus aurantiacus	MIAU	Bush Monkeyflower	Scrophulariaceae	.
Nassella pulchra	NAPU*	Purple Needlegrass	Poaceae	.
*Nicotiana glauca**	NIGL	Tree Tobacco	Solanaceae	FAC
*Opuntia ficus-indica**	OPFI	Mission Fig	Cactaceae	.

Scientific Name[1]	SCS Code[2]	Common Name	Family	Wetland Indicator Status[3]
Opuntia littoralis	OPLI3	Coastal Prickly Pear	Cactaceae	.
Pellaea andromedifolia	PEAN2	Coffee Fern	Pteridaceae	.
*Pennisetum clandestinum**	PECL2	Kikuyu Grass	Poaceae	FACU*
Phacelia cicutaria	PHCI	Caterpillar Phacelia	Hydrophyllaceae	.
Phacelia ramosissima	PHRA2	Branching Phacelia	Hydrophyllaceae	.
*Phalaris minor**	PHMI3	Canary Grass	Poaceae	FAC-
Phoradendron macrophyllum	PHMA*	Bigleaf Mistletoe	Viscaceae	.
*Picris echioides**	PIEC	Bristly Ox-tongue	Asteraceae	FAC*
Pinus sp.	PINUS	Pine (planted)	Pinaceae	.
*Piptatherum miliaceum**	PIMI*	Smilo Grass	Poaceae	(FACU)
*Pittosporum undulatum**	PIUN2	Victorian Box	Pittosporaceae	.
*Plantago major**	PLMA2	Broadleaf Plantain	Plantaginaceae	FACW-
Platanus racemosa var. *racemosa*	PLRA	California Sycamore	Platanaceae	FACW
Pluchea sp.	PLUCH	Pluchea	Asteraceae	FACW
*Poa annua**	POAN	Annual Bluegrass	Poaceae	FACW-
Polygonum amphibium var. *emersum*	POAME	Water-smartweed	Polygonaceae	OBL
*Polygonum arenastrum**	POAR11	Common Knotweed	Polygonaceae	FAC
*Polypogon monspeliensis**	POMO5	Rabbitsfoot Grass	Poaceae	FACW+
Populus balsamifera ssp. *trichocarpa*	POBAT	Black Cottonwood	Salicaceae	FACW
Populus fremontii ssp. *fremontii*	POFRF	Fremont Cottonwood	Salicaceae	FACW
Prunus ilicifolia ssp. *ilicifolia*	PRILI	Holly-leaved Cherry	Rosaceae	.
Quercus agrifolia ssp. *agrifolia*	QUAG	Coast Live Oak	Fagaceae	.
Quercus lobata	QULO	Valley Oak	Fagaceae	FAC+
*Raphanus sativus**	RASA2	Wild Radish	Brassicaceae	.
Rhamnus crocea	RHCR	Spiny Redberry	Rhamnaceae	.
Rhus integrifolia	RHIN2	Lemonade Berry	Anacardiaceae	.
Rhus ovata	RHOV	Sugar Bush	Anacardiaceae	.
Ribes speciosum	RISP	Fuchsia-flowered Gooseberry	Grossulariaceae	.
*Ricinus communis**	RICO3	Castor Bean	Euphorbiaceae	FACU+
Rorippa nasturtium-aquaticum	RONA*	Water Cress	Brassicaceae	OBL
Rosa californica	ROCA2	California Wild Rose	Rosaceae	FAC+
Rubus ursinus	RUUR	California Blackberry	Rosaceae	FACW*
*Rumex crispus**	RUCR	Curly Dock	Polygonaceae	FACW-
Rumex salicifolius var. *denticulatus*	RUSAD	Willow Dock	Polygonaceae	OBL
Salix exigua	SAEX	Narrow-leaved Willow	Salicaceae	FACW
Salix laevigata	SALA*	Red Willow	Salicaceae	FACW
Salix lasiolepis	SALA6	Arroyo Willow	Salicaceae	OBL

Scientific Name[1]	SCS Code[2]	Common Name	Family	Wetland Indicator Status[3]
Salix sessilifolia	SASE3	Sandbar Willow	Salicaceae	FACW
Salix sp.	SALIX	Willow	Salicaceae	
*Salsola tragus**	SATR	Tumbleweed	Chenopodiaceae	FACU+
Salvia apiana	SAAP2	White Sage	Lamiaceae	.
Salvia leucophylla	SALE3	Purple Sage	Lamiaceae	.
Salvia mellifera	SAME3	Black Sage	Lamiaceae	.
Sambucus mexicana	SAME5	Blue/Blue Elderberry	Caprifoliaceae	FAC
*Schinus molle**	SCMO	Peruvian Pepper Tree	Anacardiaceae	.
*Schinus terebenthifolius**	SCTE	Arabian Pepper Tree	Anacardiaceae	.
Scirpus californicus	SCCA	California Bulrush	Cyperaceae	OBL
Scrophularia californica ssp. *californica*	SCCA2	California Figwort	Scrophulariaceae	FAC
*Senecio mikanioides**	SEMI	Cape Ivy	Asteraceae	(FACW)
*Silene gallica**	SIGA	Windmill Pink	Caryophyllaceae	.
*Silybum marianum**	SIMA3	Milk Thistle	Asteraceae	.
Sisyrinchium bellum	SIBE	Blue-eyed Grass	Iridaceae	FAC
Solanum douglasii	SODO	Douglas Nightshade	Solanaceae	FACU
Solanum xantii	SOXA	Chaparral Nightshade	Solanaceae	.
*Sonchus asper**	SOAS	Prickly Sow-thistle	Asteraceae	FAC
*Sonchus oleraceus**	SOOL	Common Sow-thistle	Asteraceae	NI*
Stachys albens	STAL	Woolly Hedge Nettle	Lamiaceae	OBL
Tamarix sp.*	TAMAR2	Tamarisk	Tamaricaceae	FAC
Toxicodendron diversilobum	TODI	Poison Oak	Anacardiaceae	(FACU)
*Tradescantia fluminensis**	TRFL	Spiderwort	Commelinaceae	.
Typha angustifolia	TYAN	Slender Cattail	Typhaceae	OBL
Typha domingensis	TYDO	Southern Cattail	Typhaceae	OBL
Urtica dioica ssp. *holosericea*	URDIH	Hoary Creek Nettle	Urticaceae	FACW
*Urtica urens**	URUR	Dwarf Nettle	Urticaceae	.
Venegasia carpesioides	VECA	Canyon-sunflower	Asteraceae	.
Verbena lasiostachys	VELA	Western Verbena	Verbenaceae	FACW
*Veronica anagallis-aquatica**	VEAN2	Common Speedwell	Scrophulariaceae	OBL
*Vicia sativa**	VISA	Spring Vetch	Fabaceae	.
*Washingtonia robusta**	WARO*	Mexican Fan Palm	Arecaceae	.
Xanthium strumarium	XAST	Cocklebur	Asteraceae	FAC+
Yucca whipplei	YUWH	Our Lord's Candle	Agavaceae	.

APPENDIX B.
REFERENCE SITE FIELD DATA

APPENDIX C.
REFERENCE SITE PHOTOGRAPHS



Site 1-Photograph 1. Calleguas Creek at Lewis Road, north of CSU, Channel Islands.

Site 1-Photograph 4.

Site 1-Photograph 2.

Site 2. Calleguas Creek at Hwy 1 bridge, up-gradient.

Site 1-Photograph 3.

Site 3. Revolon Slough at Hueneme Road bridge, up-gradient.

Site 4. Revolon Slough-Hueneme Road bridge, up-gradient.

Site 6-Photograph 2.

Site 5. Beardsley Wash at Central Avenue bridge, up-gradient.

Site 6-Photograph 3.

Site 6-Photograph 1. Beardsley Wash, north of Wright Road, near golf course.

Site 7. Unnamed tributary at La Vista Avenue bridge, down-gradient

(No picture available for Site 8)

Site 8. Milligan Barranca at La Loma Avenue bridge crossing, down-grade.

Site 10. Fox Barranca at Barylwood Road, down-gradient.

Site 9. Fox Barranca at Barylwood Road crossing, up-gradient.

Site 11-Photograph 1. Long Grade Canyon Creek at CSU Channel Islands Police Station.

Site 11-Photograph 2.

Site 13. Long Canyon at Stockton Road bridge, down-gradient.

Site 12. Coyote Canyon at Bradley Rd. crossing, down-gradient

Site 14-Photo 1. Long Canyon at Stockton Road bridge, up-gradient.

Site 14-Photograph 2.

Site 14-Photograph 3. Example of slope stabilization material.

Site 14-Photograph 5.

Site 14-Photograph 4.

Site 14-Photograph 6.

Site 14-Photograph 7. Example of slope stabilization material.

Site 17. Arroyo Simi on Los Angeles Avenue, near Oak County Park.

Site 15. Unnamed tributary at Grimes Road near watershed boundary.

Site 18. Arroyo Simi near Simi Recycling Center.

Site 16. Arroyo Simi at end of Spring Road, Moorpark.

Site 19. Arroyo Simi at Madera Road crossing, down-gradient.

Site 20-Photograph 1. Sycamore Canyon at Wood Ranch**.**

Site 20-Photograph 2.

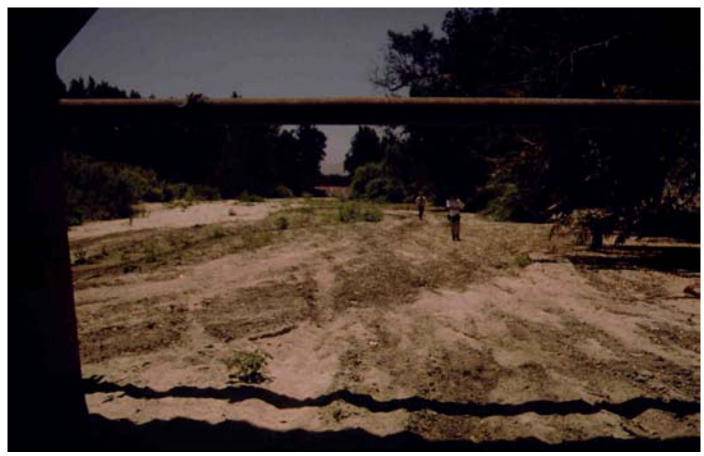
Site 21. Meier Canyon at end of Tapo Canyon Road.

Site 22-Photograph 1. Gillibrand (Tapo) Canyon at Tapo Canyon Park.

Site 22-Photograph 2.

Site 23. Gillibrand (Tapo) Canyon at Bennett Road crossing.

Site 25-Photograph 1. Calleguas Creek, Las Posas andUpland Roads (St. John's Seminary).



Site 25-Photograph 2.

Site 24. Calleguas Creek at Adolfo Road bridge, down-gradient.

Site 25-Photograph 3.

Site 26. Unnamed tributary below Lang Ranch.

Site 29. Unnamed tributary on Los Robles Country Club, north of bridge.

Site 27. Unnamed tributary across Hwy 101 at T.O. Civic Arts Center.

Site 30. Arroyo Santa Rosa at and above the Arroyo Conejo confluence

Site 28. Unnamed tributary above Los Robles Country Club, south of bridge.

Site 31. Conejo Creek at Fitzgerald Ranch in Santa Rosa Valley.

Site 32/33-Photograph 1. Calleguas Creek at the Calleguas Creek/Revolon Slough confluence.

Site 33. Revolon Slough at its confluence with Calleguas Creek.

Site 32/33-Photograph 2.

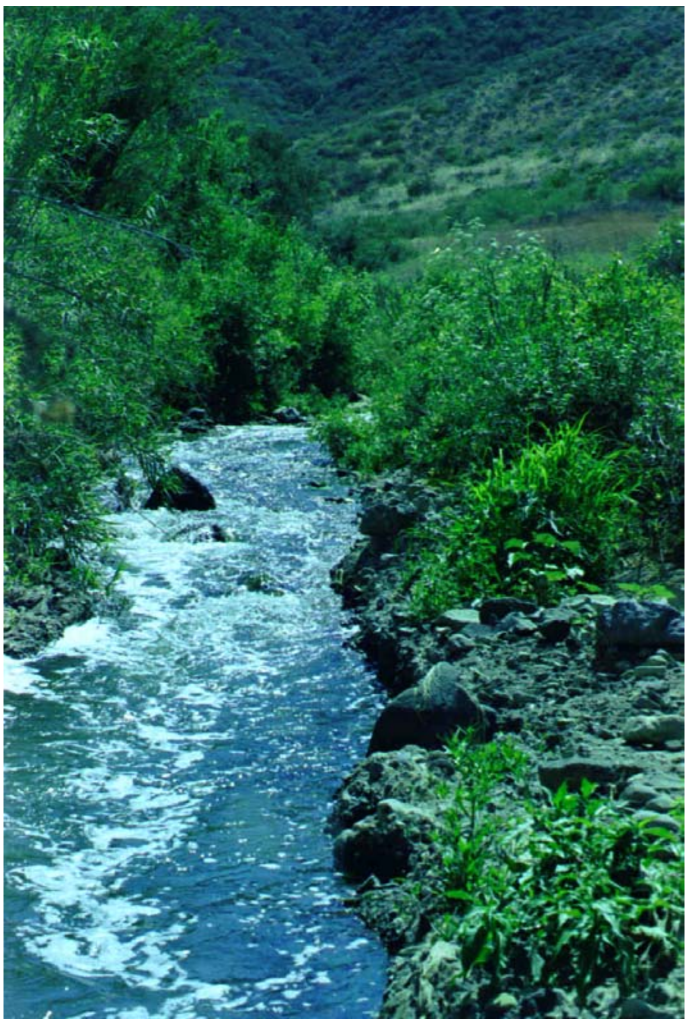
Site 34. Calleguas Creek at Camarillo Regional Park.

Site 32/33-Photograph 3.

Site 35-Photograph 1. Conejo Creek near Pancho Road, down-gradient.

Site 35-Photograph 2.

Site 36-Photograph 2.



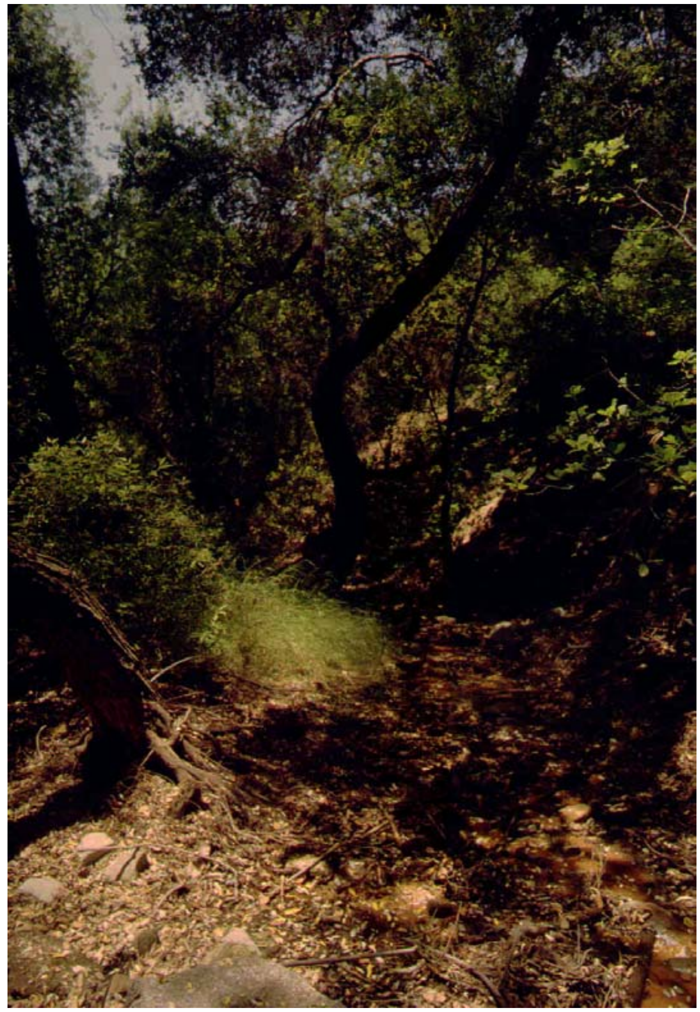
Site 36-Photograph 1. Arroyo Conejo in Hill Canyon.

Site 36-Photograph 3.

DMEC

Site 37. Arroyo Las Posas near Somis.

Site 38-Photograph 1. Uppermost Arroyo Simi at Corriganville Park (movie set).



Site 39-Photograph 1. Uppermost Arroyo Simi at Corriganville Park (downstream of Site 38).

Site 38-Photograph 2.

Site 39-Photograph 2.

Site 39-Photograph 3.

Site 40-Photograph 2.

Site 39-Photograph 4.

Site 41. Arroyo Simi at Rocky Pointe in Santa Susana Knolls.

Site 40-Photograph 1. Junipero Channel at Rocky Pointe in Santa Susana Knolls.

Site 42-Photograph 1. Happy Camp Canyon.

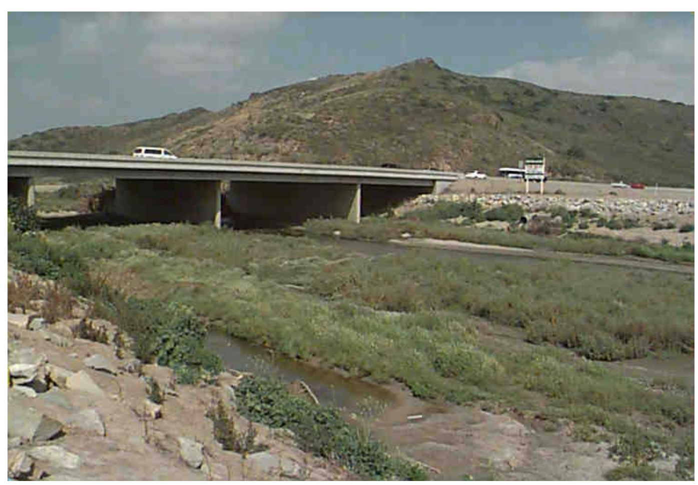
Site 42-Photograph 2.

Site 43-Photograph 1. Conejo Creek South of Hwy 101.

Site 42-Photograph 3.

Site 43-Photograph 2.

Site 42-Photograph 4.



Site 43-Photograph 3.

Site 43-Photograph 4.

Site 43-Photograph 7.

Site 43-Photograph 5.

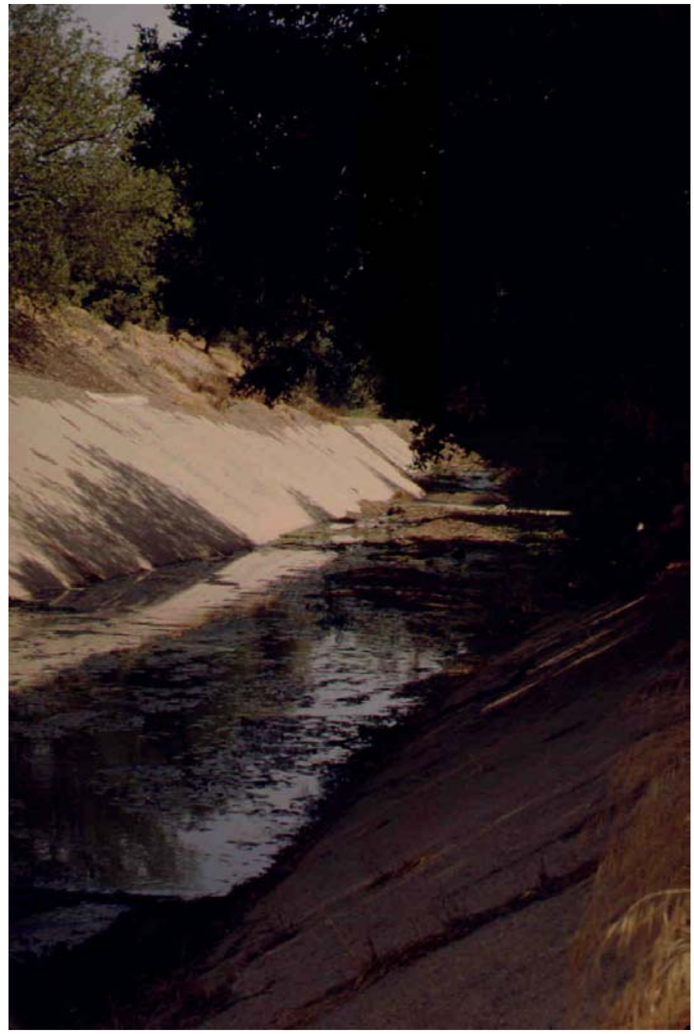
Site 43-Photograph 8.

Site 43-Photograph 6.

Site 43-Photograph 9.

DMEC

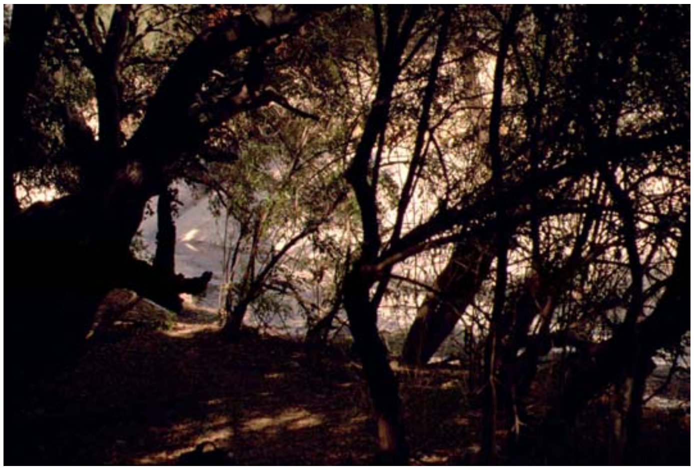
Site 43-Photograph 10.



Site 44-Photograph 2.

Site 44-Photograph 1. Conejo Creek tributary at SR 23 & Janss Road in Thousand Oaks.

Site 44-Photograph 3.



Site 44-Photograph 4.

Site 47-Photograph 1. South Branch Arroyo Conejo at Borchard Road and US 101, Newbury Park.

Site 45. South Branch Arroyo Conejo at Santa Monica Mountains Park.

Site 47-Photograph 2.

Site 46. South Branch Arroyo Conejo tributary in Conejo Valley.

Site 47-Photograph 3.

Site 47-Photograph 4.

Site 48-Photograph 2.

Site 47-Photograph 5.

Site 49-Photograph 1. Orchard at Barylwood Road and Aggen Road (example).

Site 48-Photograph 1. Unnamed drainage on Santa Clara Avenue (example)

Site 49-Photograph 2.