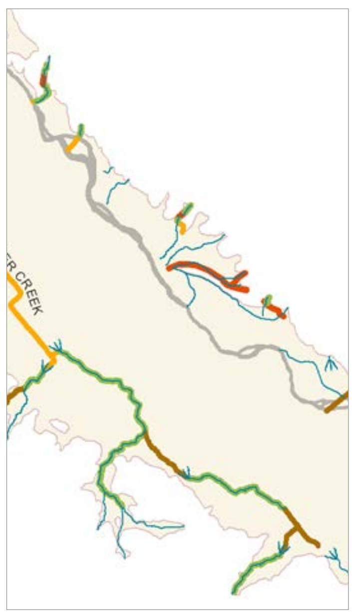
PART IV //

LANDSCAPE CHANGE

Part IV assesses how the historical landscape has been transformed into present-day conditions. In the first section, we summarize major events in the land use history of the watershed. Next we describe the trajectories of change in landscape features and associated habitats. In the final section, we discuss some of the implications for watershed restoration and management.



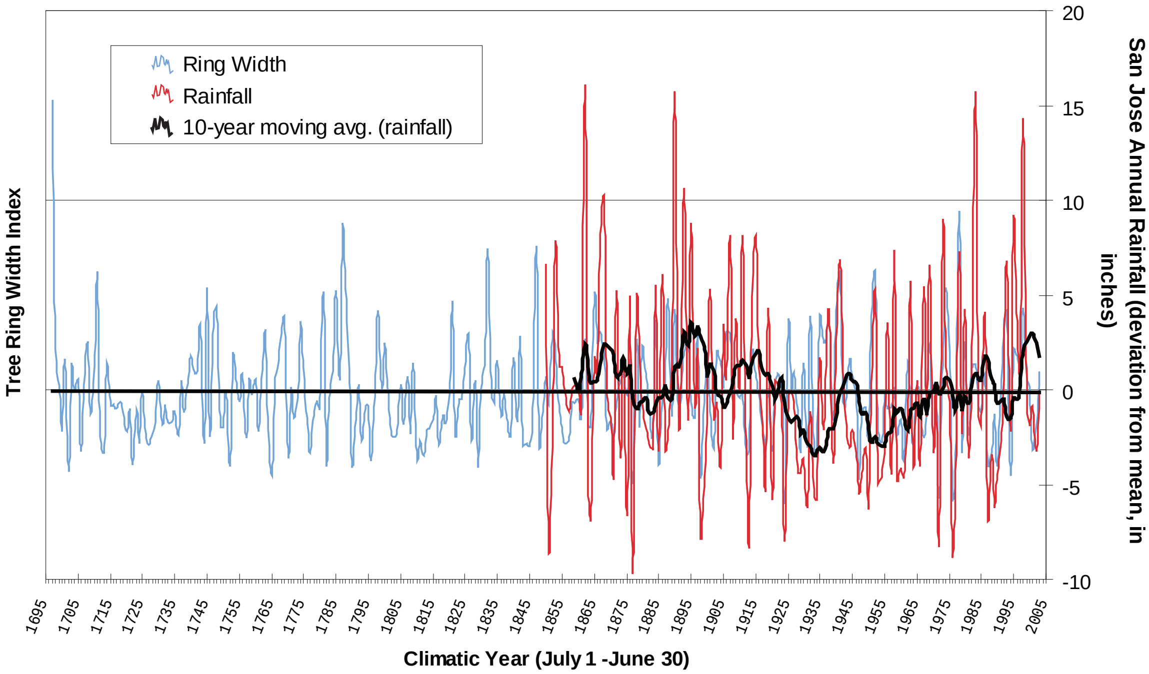


FIGURE IV-1. CLIMATE TIMELINE FOR SANTA CLARA VALLEY. Rainfall data for San Jose, 1874-2004, with 1850-1873 extrapolated based upon San Francisco data, courtesy of Jan Null. Tree ring data from a blue oak near Alum Rock Park (unpublished data provided by David Stahle, University of Arkansas).

LAND USE CHRONOLOGY

The present-day landscape is the product of previous land use events and activities, superimposed upon natural landscape patterns. Climatic variation and catastrophic events also drive landscape change (**FIGURE IV-1**). Understanding landscape change is particularly important in urban watersheds with complex histories of modification, where streams are responding to a combination of recent and historical impacts. This section summarizes the land use history of the Coyote Creek watershed. Several of the major land use trends affecting Coyote Creek are illustrated in **FIGURE IV-2** using a single temporal axis. The following chronology summarizes some of the significant impacts to provide a basis for the discussion of landscape trajectories.

1769: SPANISH EXPEDITIONS ENTER AN OHLONE VALLEY

At the initiation of Euro-American contact, Santa Clara Valley has been intensively managed by a dense indigenous population for at least 5,000 years. While much remains to be learned about the Native management practices (Striplen 2005), the Spanish diaries describe numerous villages, extensive trail networks, and the effects of controlled burns on vegetation patterns and productivity.

1777: MISSION AND PUEBLO ESTABLISHMENT

With the establishment of Mission Santa Clara and Pueblo San Jose, aggressive colonization and widespread disease decimate Native culture. Over the next several decades, Native management of botanical resources declines. Santa Clara Valley changes from a landscape maintained by Natives for specific dietary and utilitarian needs and hunting, to a European-style ranching operation.

~1812: PUEBLO RANCHING ALONG COYOTE CREEK REACHES MODERATE LEVELS

Cattle reported by the Pueblo, which would have grazed in the Coyote Creek watershed, remain rela-

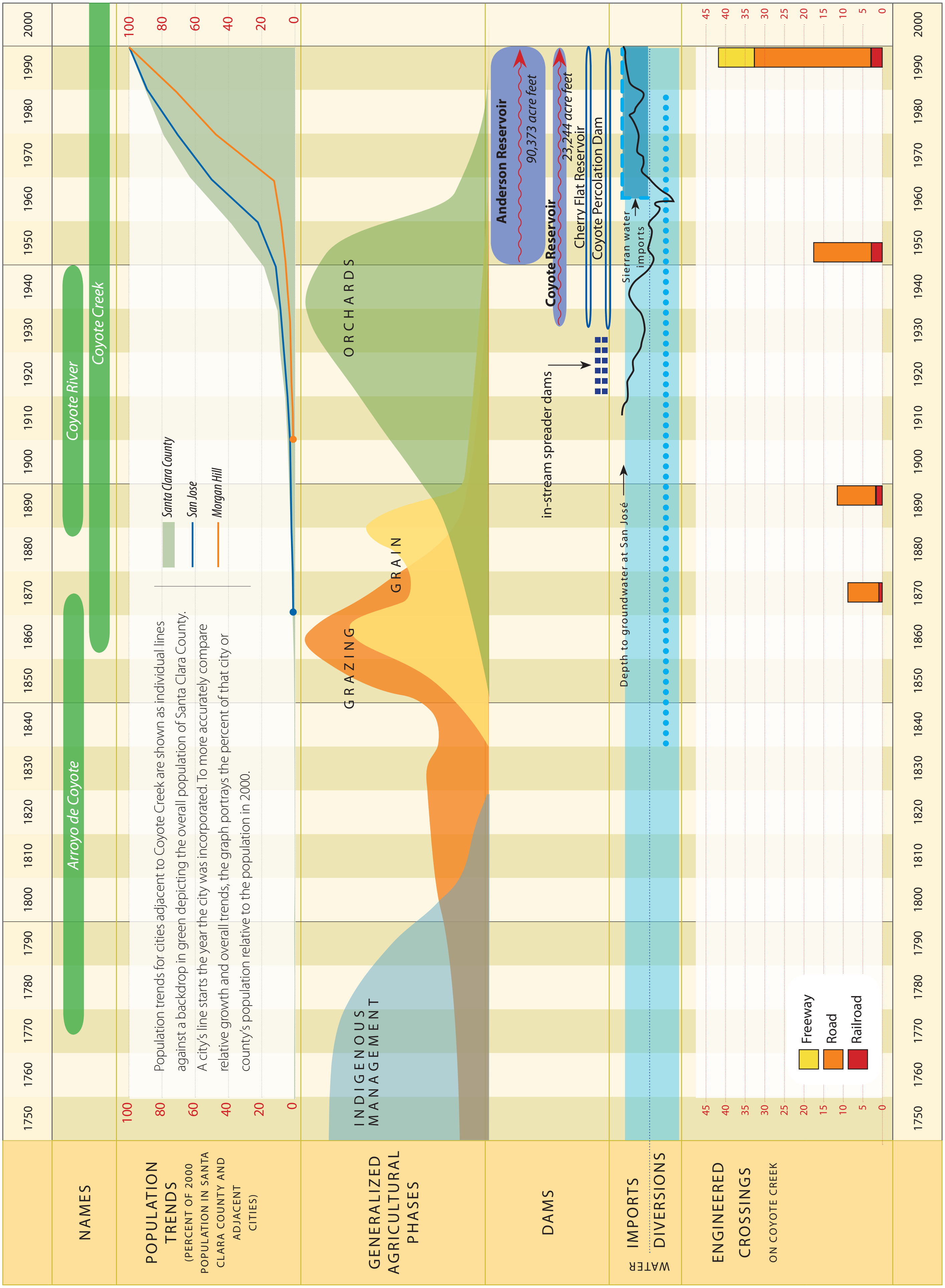


FIGURE IV-2. LAND USE TIMELINE FOR COYOTE CREEK.

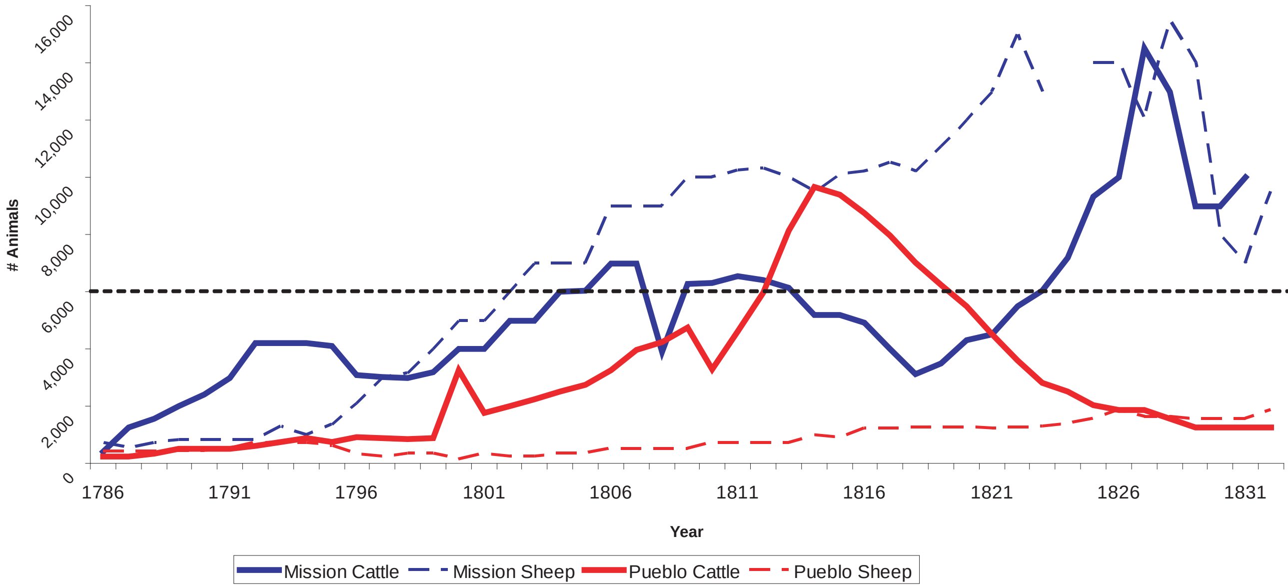


FIGURE IV-3. MISSION ERA STOCKING LEVELS IN THE SANTA CLARA VALLEY. In 1798 Guadalupe River was established as the eastern boundary for the Mission Santa Clara ranch (Friedly 2000: 126), so Pueblo San Jose activities are most relevant to Coyote Creek. While the Mission reported high numbers of sheep, Pueblo ranching seems to have focused primarily on cattle. Numbers increased gradually until about 1810, reached a moderately high level for about a decade, then decreased steadily. The dashed black line indicates what would be a moderate stocking density of one cow in 10 acres (Bancroft 1890), based upon our estimate of the Pueblo's valley floor ranchland. Stocking data from Broek (1932), Jackson and Castillo (1995), and Friedly (2000).

tively low for the first quarter-century of operation. By 1812, Pueblo cattle stocking levels correspond to a moderate density (dashed black line = ~1 cow in 10 acres; Bancroft 1890). Intensity increases, then decreases for the next two decades (**FIGURE IV-3**).

1834: SECULARIZATION OF THE MISSIONS, INTENSIFICATION OF RANCHING

The Mission era ends. Lands held in trust by the church for the native population are instead almost exclusively distributed to prominent Mexican residents, establishing the land grants. Much of the Pueblo lands are also dispersed. Substantial parts of the Valley go unmanaged during the transitional 1830s, but grazing density quickly increases to, at least in places, levels much higher than under the Pueblo and Mission. For example, Chaboya had "about 3000 cattle" in 1835 on less than 10,000 acres of valley floor land of the Yerba Buena Rancho (Pico 1854: 11).

1848: SANTA CLARA VALLEY "MOVES" FROM MEXICO TO THE U.S.

U.S. acquires California in the Treaty of Guadalupe Hidalgo after defeating Mexico in the Mexican-American war.

1849: THE GOLD RUSH MAKES THE VALLEY "CENTRALLY LOCATED"

Previously at the far end of Spanish, Mexican, then American continental interest, Santa Clara Valley is suddenly near the epicenter of mass immigration, financial power, and new markets in the San Francisco Bay Area. Conversion from intensive ranching to intensive agriculture begins.

~1850: ESTABLISHMENT OF DIXON LANDING

Dixon builds warehouses along the tidal reaches of Coyote Creek for hay storage and transport to San Francisco by barge (McArthur and Fuller 1975: 31).

1852: DIVERSION OF PENITENCIA CREEK

A farmer diverts the upper portion Penitencia Creek, which previously flowed in a discontinuous series of channels and wetlands parallel to Coyote Creek at Berryessa Rd., directly into Coyote. This diversion may have been an accident (Loomis 1982: 67), but given its straight course along Berryessa Road, was more likely constructed to reduce flooding and drain the marshy land downstream (Arbuckle 1986: 419).

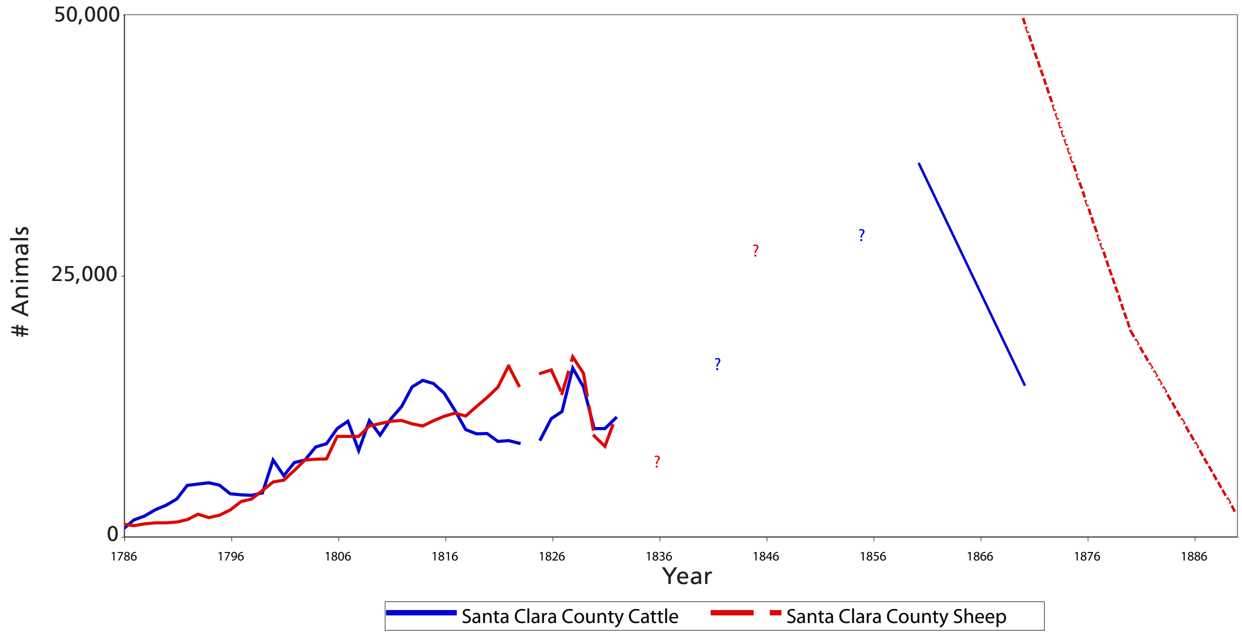


FIGURE IV-4. REPORTED NUMBERS OF CATTLE AND SHEEP IN SANTA CLARA COUNTY, 1786-1896. This graph looks at the entire County, not just Coyote Creek. During the Mission era, stock numbers show an overall increase until the disbanding of the missions in the early 1830s. It is likely that numbers increased substantially during the 1840s, based upon individual rancho reports. Numbers prior to 1834 are the sum of Pueblo San Jose and Mission Santa Clara values; County livestock data from Broek (1932).

1864: VALLEY SHIFTS FROM CATTLE TO WHEAT

Widespread starvation of cattle during severe drought decimates the ranching industry, facilitating the conversion from pasture to farm (**FIGURE IV-4**; Broek 1932: 61-62).

1869: SOUTHERN PACIFIC CROSSING

A branch of the Western Pacific Railroad (now SP) crosses Coyote Creek (at the present-day location, near Oakland Road) — connecting San Jose to Niles, and, through Niles Canyon, the rest of the country (Thompson and West 1876: 12, Unknown ca. 1960).

1870s: THE "BARBAROUS FENCE"

The invention of barbed wire makes fence building economical. New laws make ranchers responsible for cattle damage to crops, hastening the transformation of the open range into divided farms (Broek 1932: 63).

Early 1870s: COYOTE CREEK BREAKOUTS

Coyote Creek jumps its channel in several places downstream of San Jose, causing extensive flooding and damage to agricultural lands, and leading to extensive levee construction upstream of today's Highway 237 (Westdahl and Morse 1896-97).

1872: CALIFORNIA'S FIRST CITY PARK ESTABLISHED ON PENITENCIA CREEK

Springs and surrounding land are protected in Alum Rock Regional Park.

1874: HIGH POINT FOR WHEAT PRODUCTION

Rapid soil depletion and shifting markets lead to the decline of wheat farming, which peaked at an estimated 60,000 acres within the County, and replacement largely by orchards (see **FIGURE IV-2**; Broek 1932: 106).

1897-99: DRY YEARS FOLLOW AGRICULTURAL BOOM

Local agriculture, which expanded and intensified greatly during two decades of relatively high rainfall, begins turning to groundwater pumping and increased creek diversions in response to several drier years (Tibbetts and Kiefer 1921: 56).

1907-1910: SECOND SEQUENCE OF DRY YEARS INITIATES WIDESPREAD GROUNDWATER PUMPING

Dry seasons following a brief wet sequence preclude effective irrigation from stream flow and cause rapid expansion of groundwater use (Tibbetts and Kiefer 1921: 24).

1911: COYOTE CREEK FLOOD

The largest well-documented flood on Coyote Creek causes widespread flooding (Loomis 1986: 63, Duryea et al. 1977, SCVWD n.d.).

~1913: RAILROAD SPUR BUILT TO COYOTE GRAVEL MINE

Large-scale commercial gravel mining has been initiated by this time. Over the next 30 years gravel companies operate between Coyote Narrows and the Ogier Ponds area (**FIGURE IV-5**; Duval pers. comm.; USGS 1917).

1916: END OF RELATIVELY WET QUARTER-CENTURY

A period of relatively high rainfall despite a few dry years during which agriculture intensified, comes to an end (Poland and Ireland 1988: 16-18).

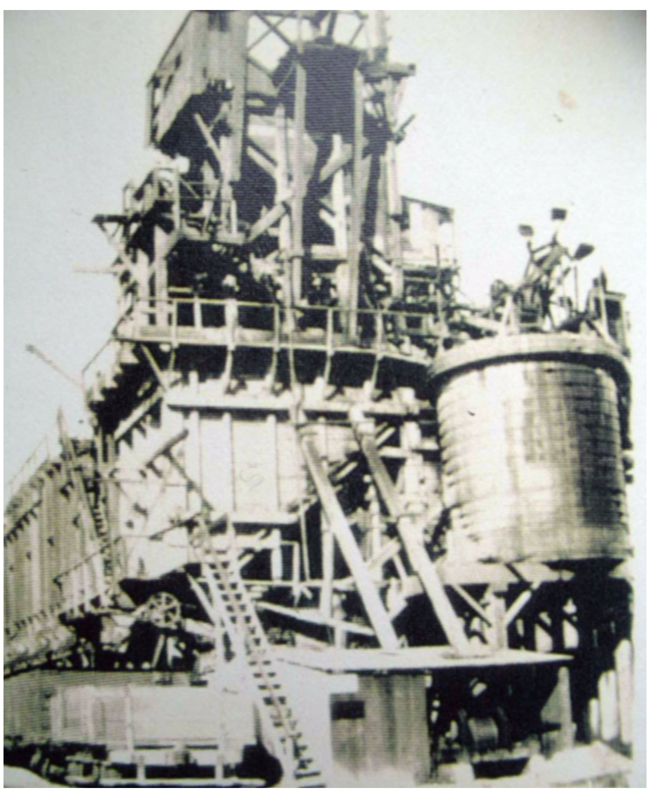


FIGURE IV-5. COYOTE ROCK CRUSHER. The Crusher used gravel from Coyote Creek near Malech Rd. Image by an unknown photographer (Unknown [194-?]); courtesy Charlene Duval, Sourisseau Academy.

1920s: GROUNDWATER RECHARGE EFFORTS BEGIN

As groundwater levels decline following increased pumping and lower rainfall, local farmers form the Valley Water Conservation Association to construct small sack dams on creeks for groundwater replenishment.

1921: SECOND COYOTE CREEK RAILROAD CROSSING

The Western Pacific establishes the second railroad crossing on Coyote Creek, just north of Story Road (construction started in 1917).

1927-1934: DROUGHT

A series of below average rainfall years affects land use locally and throughout the West. While not as extreme locally, the Dust Bowl drought was one of the extreme moisture anomalies of the past 500 years (Fye et al. 2003) and hastened groundwater decline. The Santa Clara Valley Water Conservation District was created.

1930s: GRAVEL PONDS BECOME IN-STREAM DAMS FOR GROUNDWATER RECHARGE

The Santa Clara Valley Water Conservation District develops a percolation area on Coyote Creek, using ponds created by prior gravel extraction, constructing a removable flashboard dam to spread the stream flow over a 60-acre parcel area, which becomes a permanent concrete dam (Coyote Percolation Ponds) within a few years. Metcalf Percolation Pond was first installed in 1935 (McArthur

FIGURE IV-6. TIMING OF SALT POND DEVELOPMENT AT THE NORTHERN END OF SANTA CLARA VALLEY. The area at the mouth of Coyote Creek (right side) was one of the last Bayland areas in the region to be diked (2002 Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

1981: 51, Joe Aguilera, SCVWD in Buchan and Randall 2003: G3, G15).

1932: STANDISH DAM INSTALLED

Local farmers construct a seasonal dam on lower Coyote Creek to limit saltwater intrusion during the summer months (Roessler et al. 2001, Buchan and Randall 2003).

1932-1960: CONVERSION OF TIDAL MARSHLAND TO SALT PONDS

Tidal marshland along the tidal reaches of Coyote Creek (to the Mud Slough confluence) is among the last tidal marshland in the entire San Francisco Bay-Delta to be diked (**FIGURE IV-6**; Collins and Grossinger 2004).

1933: LAND SURFACE SUBSIDENCE RECOGNIZED

The US Coast and Geodetic Survey first noticed subsidence near San Jose in 1919, but more complete resurveying of the Valley did not take place until 1933. Poland and Ireland conclude that little or no subsidence and groundwater decrease took place prior to 1915. Land subsidence continues until at least 1967 (Poland and Ireland 1988: 18, Ingebritsen and Jones 2000).

1936: COYOTE CREEK FLOW THROUGH COYOTE VALLEY DIVERTED

Approximately one half mile downstream from Andersen Dam, the Coyote Creek Diversion Dam diverts water into the concrete Coyote Canal to control water table elevation for the benefit of agricultural production. The canal follows the foothills for approximately 6 miles before reintroducing flow below the Narrows (Buchan and Randall 2003).

1936: COYOTE RESERVOIR CREATED

The first major dam and reservoir are constructed in the Coyote watershed, to capture seasonal stream flow for groundwater recharge during summer months (McArthur 1981).

1936: CHERRY FLAT RESERVOIR CREATED

Dam installed on Penitencia Creek (Buchan and Randall 2003).

1950: ANDERSON LAKE CREATED

The second large reservoir on Coyote Creek is constructed, with about four times the capacity of Coyote Reservoir (McArthur 1981).

Circa 1950s: HIGHWAY 101 FOLLOWS COYOTE CREEK

Highway 101 crisscrosses the creek and is constructed partially from gravel extracted from the streambed, creating Ogier Ponds (Buchan and Randall 2003: G15).

1953: SADA COE DONATES LAND FOR HENRY W. COE STATE PARK

The largest state park in Northern California protects a significant portion of the upper watershed (Pine Ridge Association 2005).

1956: WATER TREATMENT PLANT IS CONSTRUCTED AT TIDAL MARSH EDGE

The San Jose-Santa Clara Water Pollution Control Plant becomes a major component of the watershed's tidal interface, discharging treated effluent into sloughs. The plant also maintains an agricultural buffer while surrounding bottomlands are developed.

1960s: COYOTE CREEK PARKWAY INITIATED

San Jose and Santa Clara County begin land acquisitions to buffer Coyote Creek with parkland.

1972: FLOOD CONTROL PROJECT ON MID-COYOTE REACH

Project straightens Coyote Creek between Montague Expressway and Highway 880.

1976-1977: DROUGHT

A relatively brief but intense dry period causes groundwater levels to drop as reservoirs run dry (SCVWD n.d.).

1979: LAND PRESERVATION

The City of San Jose, Santa Clara County, and the SCVWD agree to preserve land along Upper Penitencia Creek.

1983: WIDESPREAD FLOODING

Milpitas, Alviso, and South County areas are flooded. Anderson Reservoir exceeds capacity and spills over into Coyote Creek (SCVWD n.d.).

1987-1992: DROUGHT

Low rainfall years continue until 1993 (SCVWD n.d.).

1996: LOWER COYOTE CREEK FLOOD CONTROL PROJECT

Setback levees protect the Alviso area and provide some floodplain access for the creek downstream of Montague Expressway.

1997: COYOTE ACCIDENTALLY DIVERTS INTO OGIER PONDS

A levee break causes the creek to abandon sections of the historical channel and flow through former gravel ponds (Buchan and Randall 2003: 70).

LANDSCAPE TRAJECTORIES

Landscape change is continual — with or without anthropogenic influences — but variable in rate and type. In most densely populated parts of the world, the rates and types of landscape change during the past two centuries have been very different from those preceding. As a result, we presently inhabit and manage landscapes that are responding to both long-term, natural processes and unusual, intensive, recent land use impacts. Understanding the trajectories established during the past two centuries is essential to predicting future landscape trajectories.

CHANNEL CHANGE: COYOTE CREEK TRIBUTARIES

This section describes changes to the smaller, discontinuous channels of the watershed. Direct changes to Coyote Creek itself are discussed in the following section.

CHANNEL STRAIGHTENING AND LENGTHENING

Channel modifications in many parts of the world have involved the conversion of sinuous, natural channels to straighter, engineered channels. That process is a significant but not dominant impact to the tributaries to Coyote Creek. Quite a few streams have, in fact, been straightened by replacement with artificial channels. These include Lower Penitencia, Arroyo de los Coches, lower Berryessa, and lower Norwood Creeks. Artificial channels replacing historical creeks represent about 16% of the present-day valley floor drainage tributary to Coyote Creek; (**FIGURES IV-7A** and **IV-7B**).

The most dramatic modification, however, has been not the alteration of existing channels but the creation of new ones. Artificial channels serving formerly undrained areas make up almost 50% of the present valley floor drainage network tributary to Coyote. Most of this expansion is the simple extension or lengthening of distributary streams in artificial channels across the lower valley floor, from the former terminus (the point of historical distribution) to the Coyote mainstem.

The proportion of natural versus artificial channel varies significantly by creek (**FIGURE IV-8**), mostly depending how far across the valley floor the channel extended under natural conditions. Many of our present-day creeks are, at least on the valley floor, primarily drainage canals created to remove water. Streams such as Upper Penitencia, Thompson, and Silver are mostly historical creeks. Lower Silver Creek and Miguelita Creek are essentially man-made.

EXPANSION OF THE DRAINAGE NETWORK

The dramatic expansion of drainage networks across the valley floor is one of the most significant Euro-American alterations to the Coyote Creek watershed. Increases in both the absolute density of water courses and in their connectivity have fundamentally altered how fast, how much, and which water and sediment are conveyed from the hills to the Coyote mainstem and the Bay. These basic system modifications affect

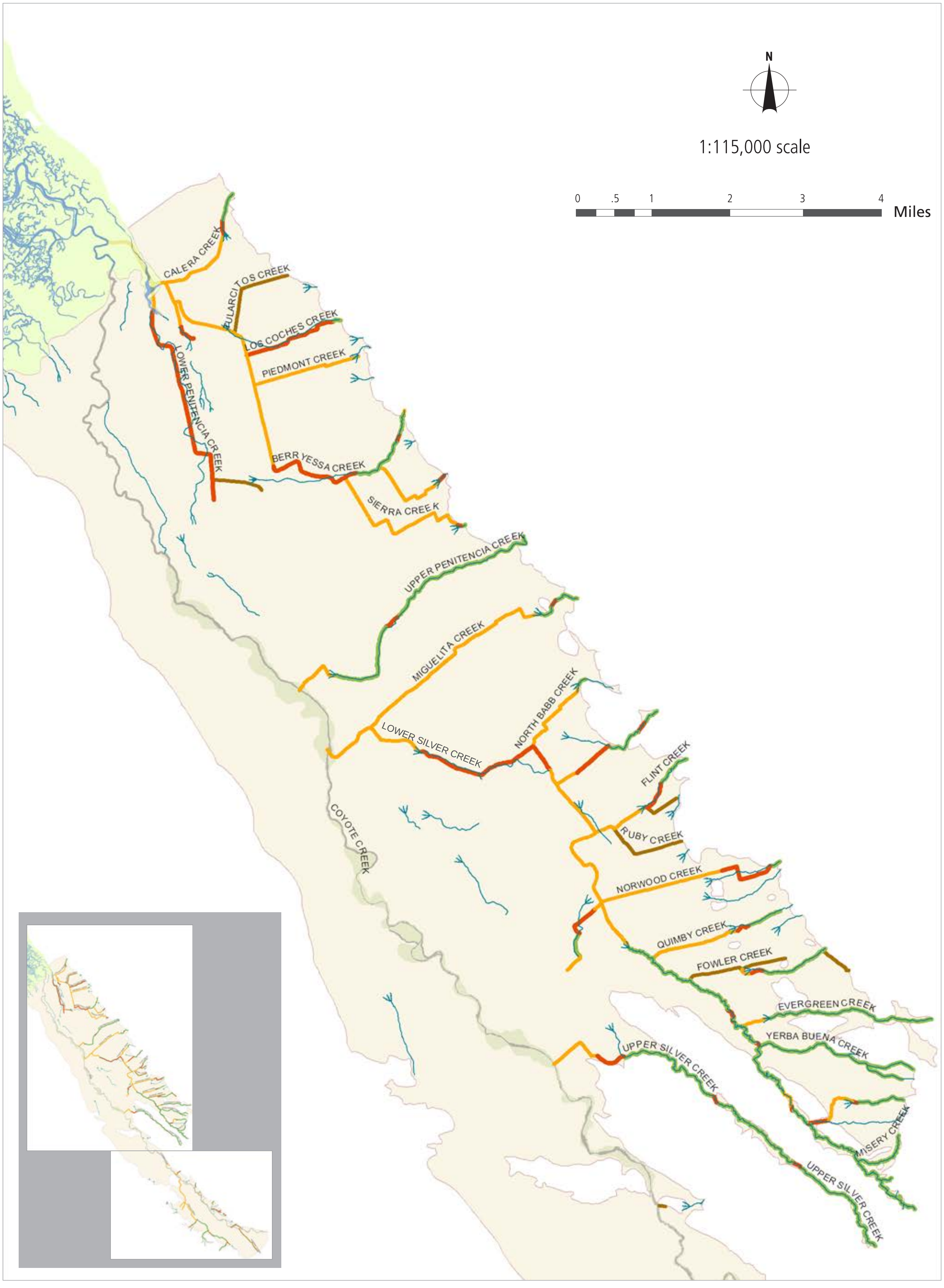


FIGURE IV-7A. EXPANSION OF THE COYOTE CREEK WATERSHED DRAINAGE NETWORK WITH CONSTRUCTED CHANNELS. These maps show both the historical and present-day valley floor creek network. The historical data was developed by SFEI as part of this project. To assess the origin of modern creeks, we compared the historical data to the recently-developed SCVWD GIS. Some very small constructed channel segments may be excluded. See legend on facing page.

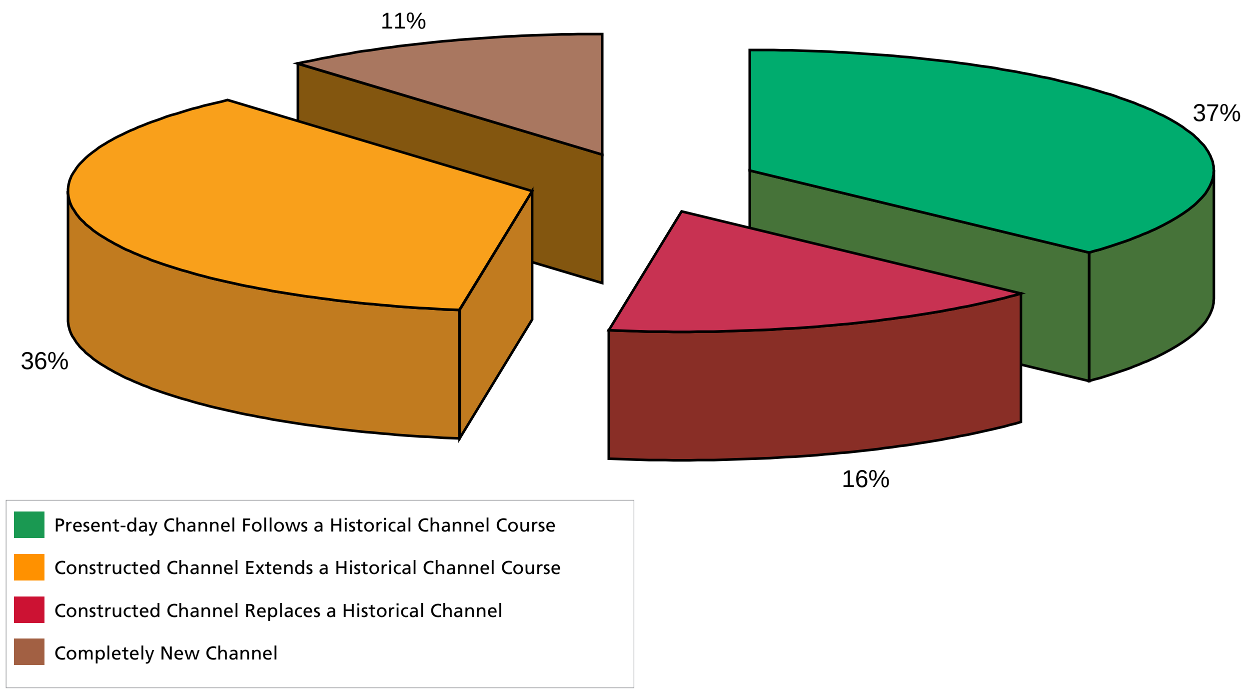


FIGURE IV-7B. ORIGIN OF MODERN CREEKS TRIBUTARY TO COYOTE CREEK (TOP). Nearly two thirds of the tributary drainage network on the valley floor is artificial channel, mostly created to extend discontinuous creeks to the Coyote mainstem.

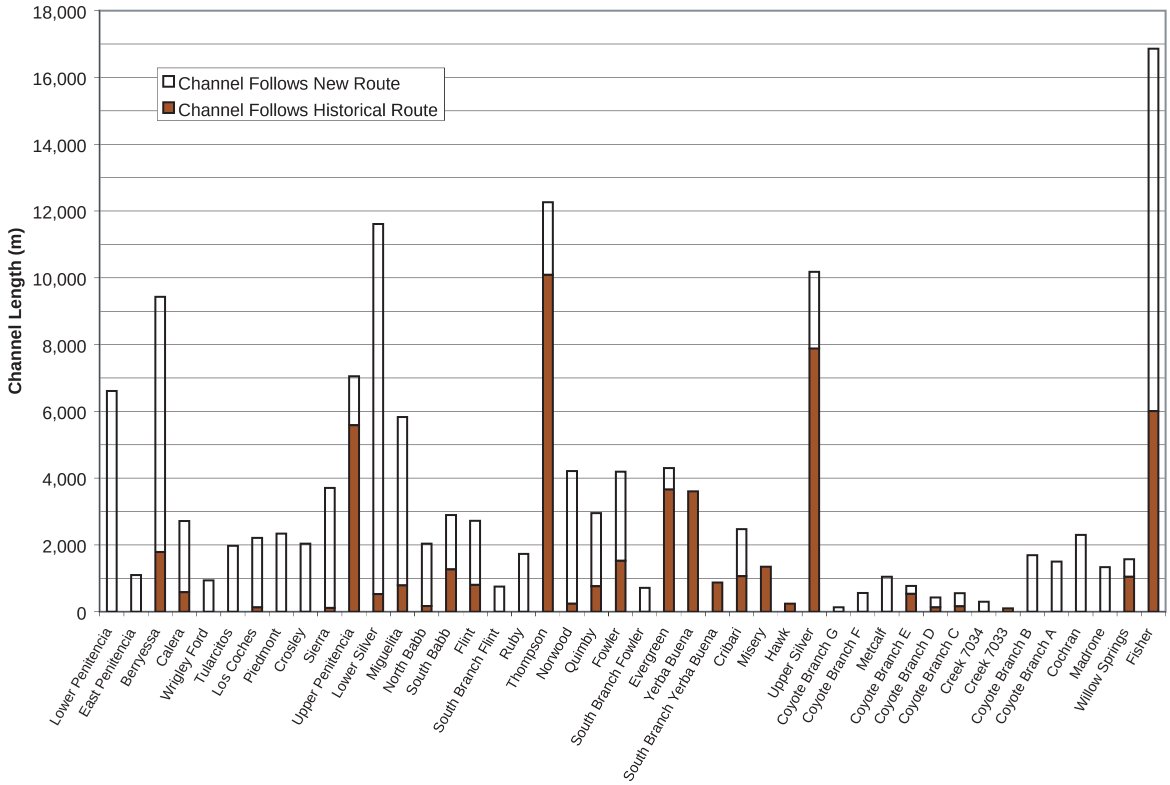


FIGURE IV-8. **RELATIVE PROPORTION OF NATURAL VERSUS ARTIFICIAL CHANNEL BY CREEK.** This chart considers the valley floor portion of each tributary creek in the Coyote watershed. Some occupy their historical channel across most of the valley floor, while others were mostly created by engineering.

almost every watershed function — from groundwater recharge to the peak and timing of the flood hydrograph, to channel stability. But since many of these modifications took place over a century ago, their continuing effect on current watershed conditions has been largely unrecognized. Understanding early watershed modification is important because it reveals both fundamental alterations to the natural hydrology of the watershed, and also a range of potential opportunities for redesigning watershed drainage in the light of evolving conditions and priorities.

Prior to Euro-American modifications, approximately 105 miles of fluvial channel drained the valley portion of the Coyote Creek watershed. Coyote Creek, by far the longest stream in the Santa Clara Valley, nevertheless accounted for little more than one third of this length, about 39 miles (**TABLE IV-1**). Discontinuous creeks — that is, streams that did not extend continuously from the hills to the Bay or the Coyote mainstem — represented the majority of drainage, 66 miles. (For the purposes of discussion we will also refer to the discontinuous creeks, now mostly tributaries to Coyote, as tributary creeks.) The natural condition of the system maximized the amount of water retained by the basin, both as surface water in the bottomlands and groundwater recharged to aquifers through the alluvial fans.

Since Coyote Creek appears by all evidence to have extended continuously to the Bay under natural conditions, drainage network expansion has taken place exclusively among the other creeks of the watershed. Drainage network increase has occurred in spite of the infilling of about half of the tributary (non-Coyote) creeks that occupied the valley floor. On Lower Penitencia Creek, overflow channels (such as that along lower Coyote Creek), and the lower reaches of many distributary creeks have been infilled.

	HISTORICAL LENGTH (mi.)	*HISTORICAL DENSITY (mi./mi.²)*	*MODERN LENGTH (mi.)*	*MODERN DENSITY (mi./mi.²)*
[Dis]tributaries	66	0.74	34	0.38
Artificial Channels	0	0	58	0.65
Total (above-ground)	66	0.74	92	1.02
Underground Storm Drains (>24" dia.)	0	0	873	9.74
Total	66	0.74	965	10.8

TABLE IV-1. CHANGES IN THE DENSITY OF DRAINAGE SERVING THE VALLEY FLOOR ALONG COYOTE CREEK. This table presents the total length of natural channel, constructed channel, and large underground storm drains, and calculates the resulting drainage density. Drainage density is calculated both for all aboveground channels and all drainage including storm drains (Area =89.6 mi^2). Because Coyote Creek length has not changed appreciably, these data focus on the tributaries and exclude Coyote Creek(~35 mi.). Storm drain data provided by William Lettis and Associates.

DRAINAGE DENSITY

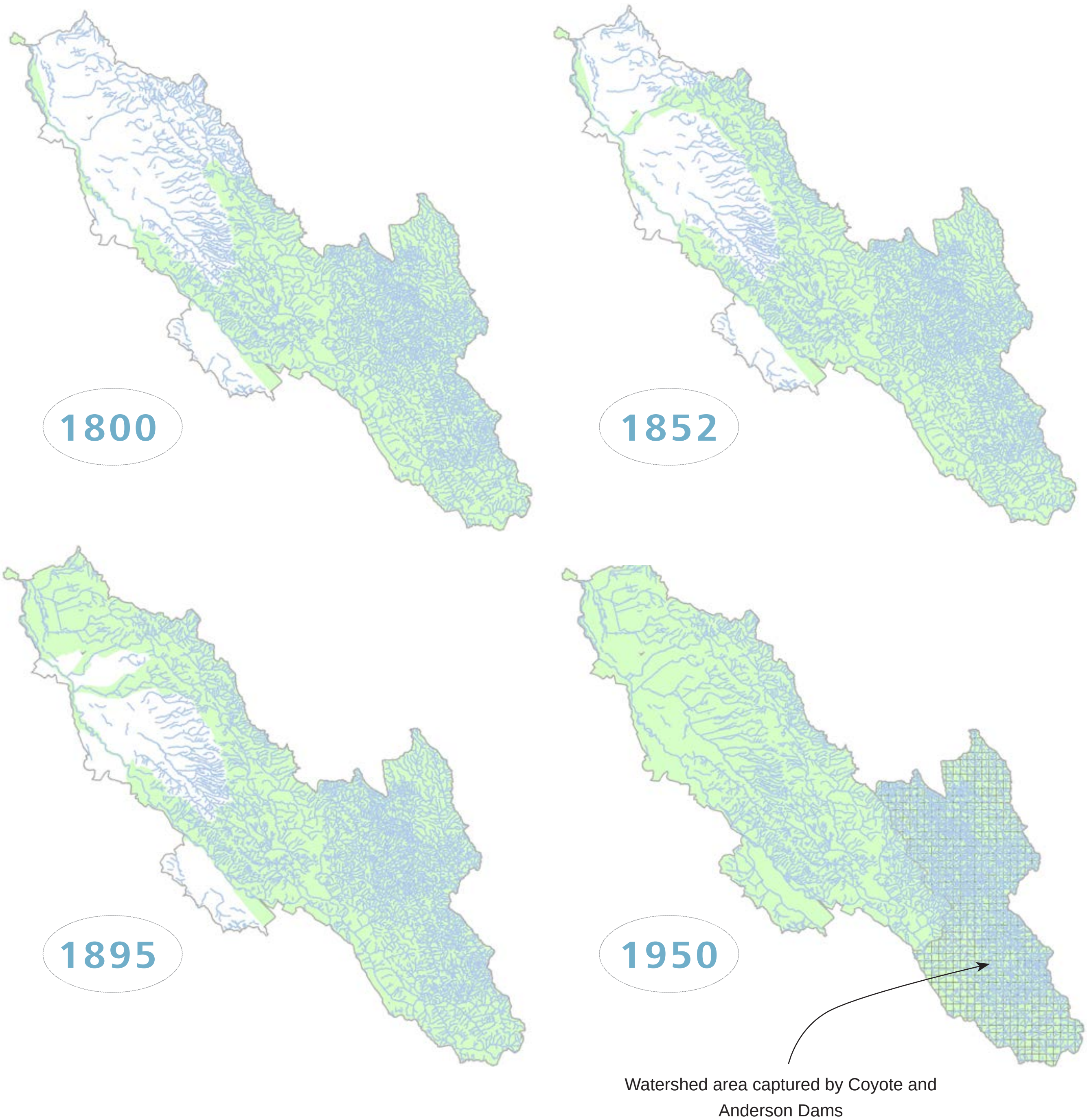
This loss in historical channel length has been more than compensated by the creation of constructed channels totaling nearly the original length of natural channel. As a result, aboveground drainage density (excluding Coyote Creek) has increased by almost 40% (**TABLE IV-1**).

WATERSHED CONNECTIVITY AND FUNCTIONAL WATERSHED AREA

Increasing connectivity across the valley floor makes the upper watershed more directly linked to the mainstem of Coyote Creek. Prior to modifications, with no direct channel connection to the mainstem, subwatersheds discharged water and sediment to the alluvial fans and bottomlands of the valley floor, where they were largely attenuated before reaching the mainstem.

The process of connecting the upper watershed to the mainstem was initiated early (**FIGURE IV-9**). Originally, with no natural tributaries downstream of Coyote Narrows, Coyote Creek received direct runoff only from the areas above present-day Anderson Reservoir, plus the small eastside tributaries in Coyote Valley. In 1852, the lands above Upper Penitencia Creek were connected directly to Coyote. (Fisher Creek was at least partly extended to Coyote even earlier, but this effort to drain Laguna Seca was apparently unsuccessful.) By 1895, northern tributaries such as Arroyo de los Coches, Calera Creek, and Lower Penitencia Creek had also been connected to the Coyote mainstem. The disconnected watersheds farther south were connected to Coyote Creek by the early 1940s (USACE 1943).

As a result of these efforts to improve valley floor drainage, the directly connected watershed area of Coyote Creek increased by more than 50%. However, simultaneous with the full connection of the upper watershed to Coyote Creek, the construction of Coyote and Anderson Dams in the mid-20th century reduced connectivity. The



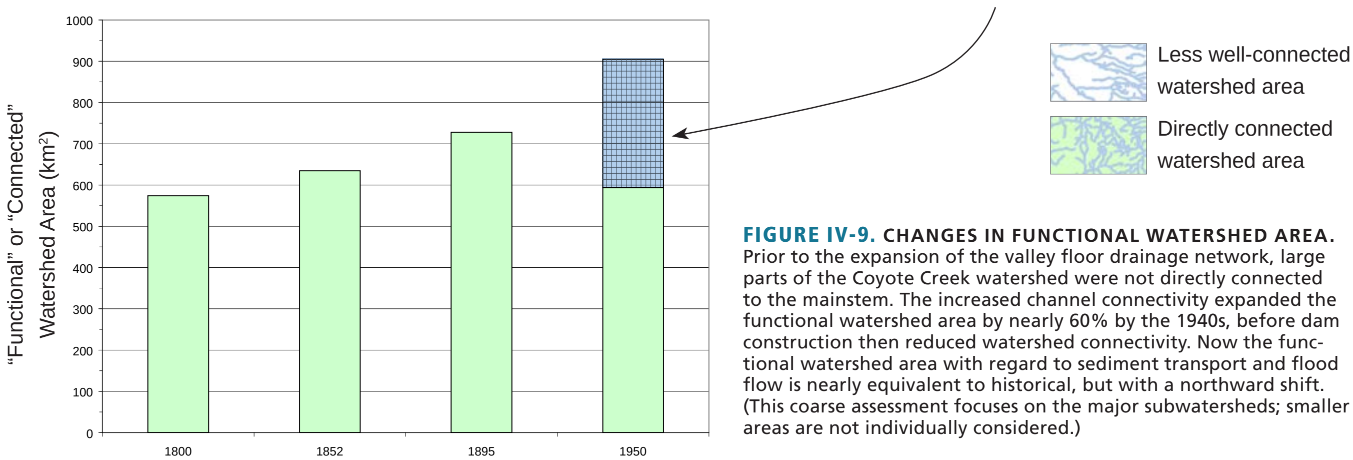


FIGURE IV-9. CHANGES IN FUNCTIONAL WATERSHED AREA. Prior to the expansion of the valley floor drainage network, large parts of the Coyote Creek watershed were not directly connected to the mainstem. The increased channel connectivity expanded the functional watershed area by nearly 60% by the 1940s, before dam construction then reduced watershed connectivity. Now the functional watershed area with regard to sediment transport and flood flow is nearly equivalent to historical, but with a northward shift. (This coarse assessment focuses on the major subwatersheds; smaller areas are not individually considered.)

present area behind these dams, where water and sediment are significantly attenuated from reaching Coyote Creek, is nearly equivalent to that gained from the other subwatersheds. As a result, Coyote Creek's directly connected or functional watershed area has shifted to the north. Because of historical hydromodification, Coyote Creek receives more direct watershed input (e.g. flood flows, sediment) from the subwatersheds immediately to the east (e.g. Silver, Thompson, Norwood, Upper Penitencia). This results in a flashier hydrograph. Farther upstream, the creek receives less direct watershed input.

CONTINUED INCREASE IN VALLEY FLOOR DRAINAGE DENSITY: MODERN "HYDROMODIFICATION"

Channel extension has resulted in the connection of more watershed area to the Bay, either directly or through the Coyote mainstem. Instead of spreading across the valley floor, water from the tributaries is now directly input into the Coyote mainstem. Another type of drainage expansion increases the drainage of the valley floor itself, removing water that falls directly on the alluvial plain. These hydrological features include ditches and storm drains and are designed to drain impervious surfaces in urban areas.

The growth of urban areas has resulted in the massive expansion of drainage network through storm drain construction. On the Coyote Creek valley floor, there are now 873 miles of underground storm drains greater than 24 inches in diameter (see **TABLE IV-1**; data from William Lettis and Associates). For every mile of aboveground channel tributary to Coyote Creek, there are 10 miles of large storm drains underground.

GROUNDWATER RECHARGE EFFECTS

One of the effects of the increased connectivity of upper watersheds to the Bay has been reduced infiltration to groundwater, as water is moved efficiently across the valley floor to prevent flooding. Where many creeks used to spread broadly over the unconfined zone of the Santa Clara Valley Groundwater Subbasin, new channels and storm drains now carry stream flow across the natural recharge areas, reducing natural percolation. We do not know how much natural percolation has been reduced, but it is likely substantial given that "uncontrolled" (unmodulated by management) recharge through creeks still represents approximately 20% of all present-day groundwater recharge (SCVWD 2005). The expansion of the drainage network, and resulting reduction in groundwater recharge, probably contributed to the decline of groundwater levels during the early and mid-20th century.

An indication of the extent to which natural recharge functions have been altered is suggested by the extent of new drainage network constructed directly above the unconfined zone. This portion of the drainage network is designed to rapidly remove surface water that would, in large part, otherwise percolate through these soils to recharge groundwater. Over 25% (~23 miles) of the present-day valley floor channel network tributary to Coyote Creek is new, constructed channel overlying the unconfined zone of the Santa Clara

Valley Subbasin. Even more significantly, 120 miles of large, concrete storm drains (greater than 2 feet in diameter) remove water from the unconfined zone.

The massive extent of constructed drainage within the unconfined zone suggests that there may be potential water supply benefits from strategic drainage redesign. Projects which slow water removal using natural geomorphic features such as swales, floodplains, and natural streambeds in place of concrete beds should be considered for multiple benefits including habitat restoration, flood stage reduction, and groundwater supply.

CHANNEL INCISION

Erosion of channel banks and bed has been recognized as a significant concern on the present-day tributaries to Coyote Creek, because of the effects on both adjacent property and downstream channel conditions. Channel instability is a possible result of channel extension, if constructed channels have established a new gradient and base level where they meet the natural channel (Jordan et al. 2005), potentially propagating upstream downcutting. Increased and flashier runoff from the expanded drainage network would also be expected to cause erosion. Rates and extent of channel incision are clearly highly variable within the watershed, though, even among adjacent streams on the valley floor. For example, we compared an 1854 GLO description of South Babb Creek channel geometry to present-day conditions and found little or no net change over the 150 year period (**FIGURE IV-10**). However, on other Diablo Range tributaries, incision of 5-10 feet or more has been observed in recent decades (Scott Katric, personal communication; Richard McMurtry, personal communication).

Detailed local assessment was beyond the scope of this project, but we were able to identify several sources for long and short-term rates of change in channel geometry. In particular, the field notes of the General Land Office surveys, cross-sectional information from City of San Jose "as-builts," and Santa Clara County historical surveys and bridge-related project field notes are potentially valuable sources of information. Combined with strategic fieldwork, these data should be able to help determine the extent of channel instability and whether observed changes are of recent origin or part of long-term trends.

CHANNEL AGGRADATION

While incision is a concern on the upper alluvial plain, aggradational processes on the lower reaches of tributaries to Coyote Creek are a significant maintenance problem. Hundreds of thousands of cubic yards of sedi-

FIGURE IV-10. CHANNEL FORM AT SOUTH BABB CREEK JUST ABOVE CLAYTON ROAD. Sherman Day described channel geometry at the site in 1854 (p. 509): "deep gully (8 feet deep) 50 links [= 33 ft.] wide." Channel geometry at this site, which has relatively little upstream development, appears to have been highly stable over this period.

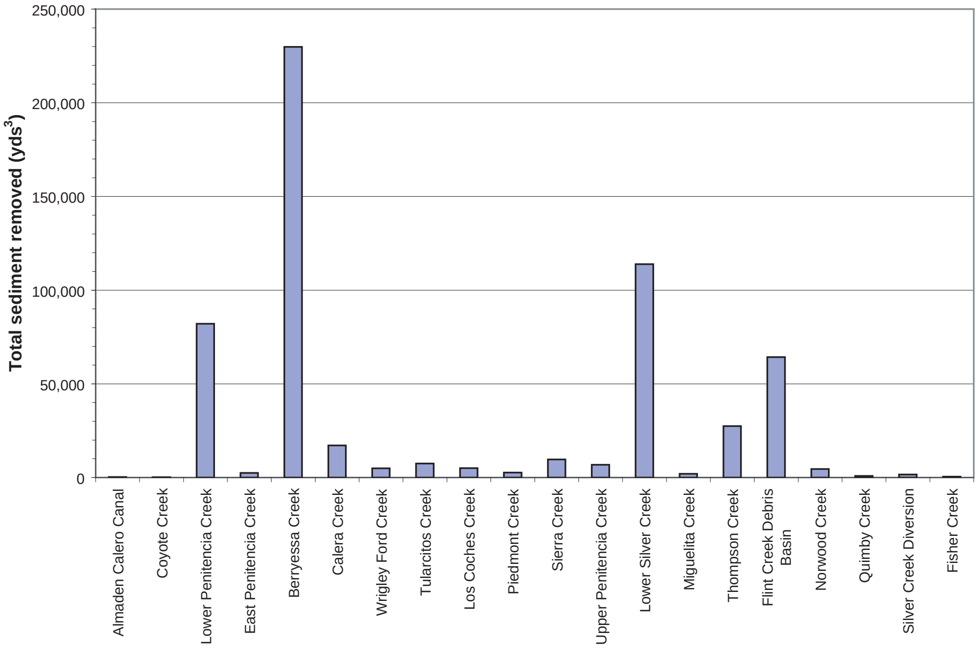


FIGURE IV-11. STREAM SEDIMENT REMOVAL 1977-2004. The extent of maintenance sediment removal varies substantially among Coyote watershed streams. When compared to **FIGURE IV-9**, the major aggradation problems are associated with streams with a high proportion of artificial channel (Lower Penitencia, Berryessa, and Lower Silver Creeks). Sediment data provided by SCVWD.

ment have been removed from these tributaries over the past 25 years, at substantial expense.

As might be expected, stream sediment maintenance removal has been greatest in the stream reaches that were artificially extended across the lower alluvial plain (**FIGURE IV-11**; see also Figure 6-32 in the Baylands Chapter, SCVWD 2005). The streams with the highest amount of total sediment removed — Berryessa Creek and Lower Silver Creek — are almost completely constructed channels extending downstream from the historical distributary point (where aggradation historically precluded a defined channel). In these areas, stream power was naturally insufficient to move watershed sediment across the low-gradient valley bottom. High rates of sediment aggradation on Lower Penitencia Creek, which was, in contrast, a historical stream, are presumably related to increased sediment supply and/or oversized constructed channel dimensions.

CHANNEL CHANGE: COYOTE CREEK

This section describes historical changes to the Coyote Creek channel, including plan form, cross-sectional geometry, active surfaces, and other characteristics. First, we summarize the natural, or pre-modification morphology of the stream. Then we assess specific changes. The extent and character of modification vary substantially by reach and fluvial characteristic. Some attributes of Coyote Creek have experienced dramatic alteration. Other characteristics of the creek, such as plan form, are remarkably unchanged for an urban stream.

PRE-MODIFICATION MORPHOLOGY

Coyote Creek exhibited several distinct geomorphic reaches prior to Euro-American modification (**FIGURE IV-12**). Channel geometry in the tidal reach was controlled primarily by tidal flows, rather than the much smaller fluvial inputs (Atwater et al. 1979). But the freshwater influence did affect channel form through its influence on vegetation. Input from the creek allowed the growth of fresh and brackish channelside vegetation (which can extend lower into the intertidal zone than saltmarsh) resulting in fewer mudflats and narrower, less extensive channel networks (Grossinger 1995). In the tidal reach, Coyote Creek was a distributary system transporting tidal and fluvial water and sediment into and out of a branching network of tidal sloughs.

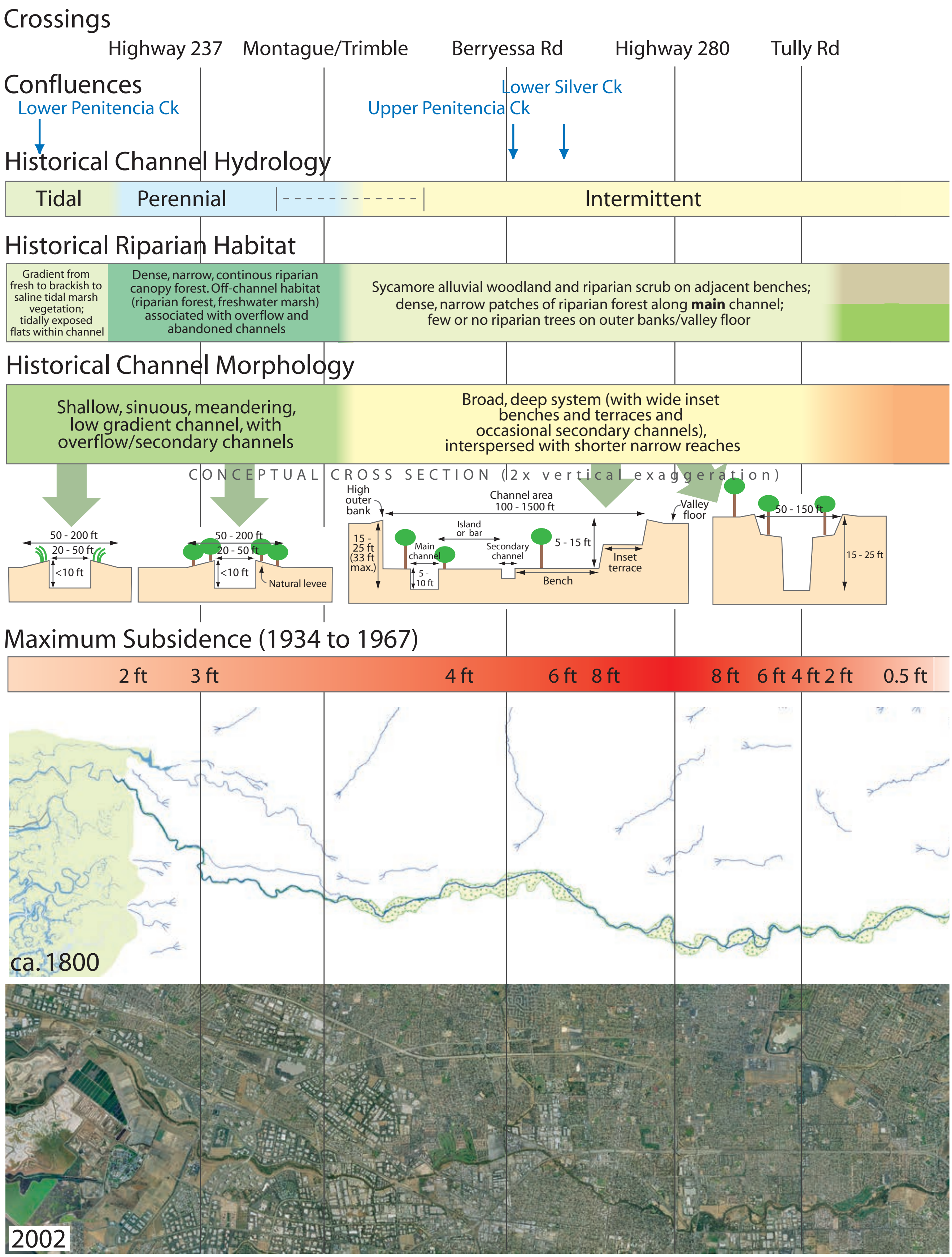
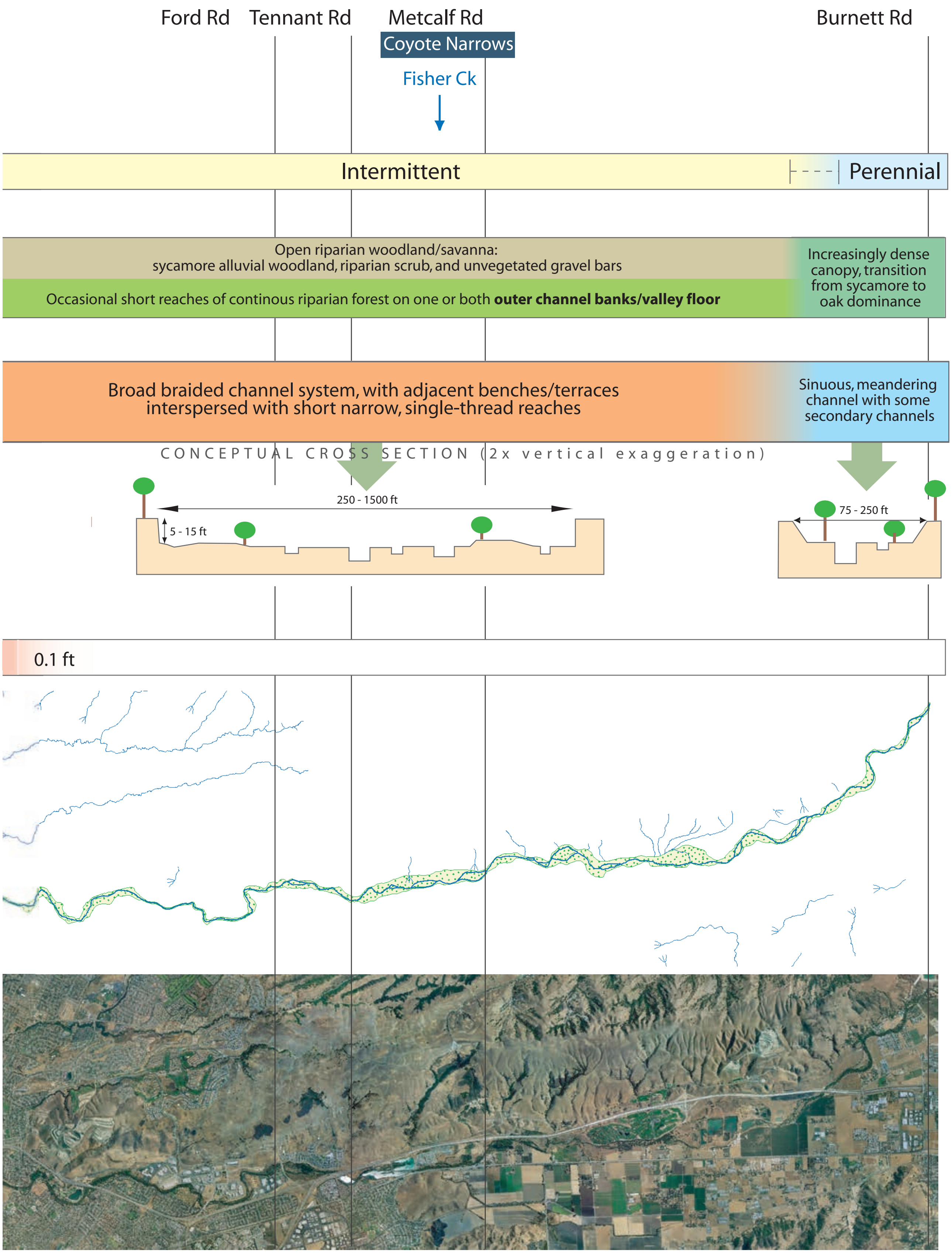


FIGURE IV-12. HISTORICAL MORPHOLOGY, HYDROLOGY, AND HABITAT OF COYOTE CREEK. This diagram shows how key attributes of the creek varied naturally by reach. The close relationships between morphology, habitat, and hydrology indicate how physical and ecological processes are interrelated. Transitions between reaches were gradual and varied through time. Cross-sections are generalized to illustrate reaches based upon historical data (2002 Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).


Ford Rd
Tennant Rd
Metcalf Rd
Coyote Narrows
Fisher Ck
Burnett Rd
Intermittent
Perennial
Open riparian woodland/savanna:
sycamore alluvial woodland, riparian scrub, and unvegetated gravel bars
Occasional short reaches of continous riparian forest on one or both outer channel banks/valley floor
Increasingly dense canopy, transition from sycamore to oak dominance
Broad braided channel system, with adjacent benches/terraces interspersed with short narrow, single-thread reaches
Sinuous, meandering channel with some secondary channels
CONCEPTUAL CROSS SECTION (2x vertical exaggeration)
250 - 1500 ft
5 - 15 ft
75 - 250 ft
0.1 ft

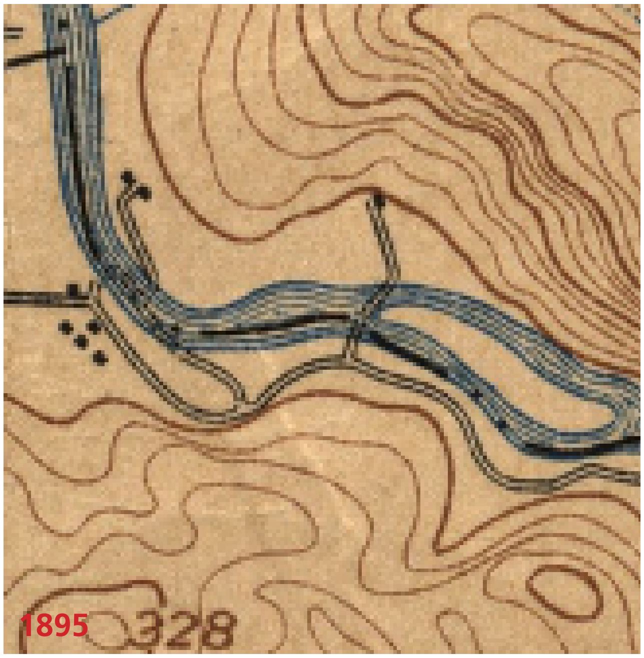
Upstream from tidal influence, Coyote Creek was a relatively shallow, narrow, single thread channel with many of the classic characteristics of a meandering, low-gradient stream. Perennial flow supported dense riparian forest. Channel banks were frequently overtopped during flood events, sending flow broadly across the lower valley floor and through overflow channels. This also deposited fine sediment, contributing to the building and maintenance of natural levees.

Upstream of present-day Montague Expressway, channel morphology shifted distinctly to the broad, entrenched system that characterized most of Coyote Creek's middle reaches. Here the channel was deeper, with wide adjacent benches inset substantially below the adjacent valley floor. This imposing morphology served as a natural buffer to development immediately along the main channel. Several shorter, narrow reaches without broad benches provided important sites for early crossings (e.g. Southern Pacific Railroad, Oakland Road, Santa Clara Avenue). There were occasional secondary channels and associated bars or islands. The main channel was well-defined but dynamic, with some riparian forest. This entrenchment may reflect Holocene downcutting (or even the draining of the hypothesized Pleistocene Lake San Benito (Jenkins 1973)) before human settlement.

In the vicinity of Tully Road-Capitol Expressway, stream morphology shifted gradually to a wide, braided channel system that continued upstream through most of Coyote Valley. In these reaches, the main channel was less well-defined, comprised of a wide, largely unvegetated area with multiple channels and braid bars. As in the reaches downstream, there were occasional narrow segments with more continuous riparian forest.

While some elevated benches along the braided channel were farmed by 1939, most of the channel area was too gravelly for agriculture. In contrast, the reaches farther downstream supported extensive agriculture within the channel area, presumably on more silty soils. A similar shift is observed in stream substrate today, with small cobble and gravel shifting to silt and sand in the vicinity of Capitol Expressway (Cloak and Buchan 2001: 58). This is also the location in the Valley where unconfined aquifer shifts to confined. The channel area was probably less entrenched than farther downstream, although a 1906 cross-section for one of the intervening narrow reaches indicates that the narrow "nodes" (*sensu* Thorne et al. 2003: 200-201) may have been quite deep (22-23 feet, Herrmann 1905). Another indication of the general shift in morphology above Tully Road is the lack of bridges or crossings upstream of Tully Road. While the six crossings between Trimble and Tully Roads are each shown with distinct bridges in 1895 (USGS San Jose 1899), the upstream crossings are shown as fords without bridges (**FIGURE IV-13**). Fords across the channel bed indicate a less entrenched system, similar to the crossing still in use at the Coyote Creek Golf Club. Additional historical depth data for this reach would be useful to assess bed incision/aggradation.

Braided channel morphology with occasional narrow "nodes" continued upstream through much of Coyote Valley to roughly the present-day Ogier Ponds complex.



The spatial extent of braided channel corresponds closely to the portion of Coyote Creek bordered by steep Diablo Range hills immediately to the east. These small but steep watersheds, which are relatively well-connected to the main channel, may have contributed to the high coarse sediment supply associated with the braided channel pattern (Collison personal communication). The braided reaches appear slightly steeper, albeit not substantially, than downstream reaches — but the longitudinal profile data available for the stream length is likely not sufficiently detailed for this kind of assessment (see **FIGURE IV-19**). Limited historical depth data also suggests a relatively shallow channel. Historical gravel mining and percolation ponds are closely associated with the coarse, permeable bed materials of the braided reaches.

Upstream of Ogier Ponds/Highway 101, braided channel morphology transitioned to a sinuous, meandering channel with common secondary channels. This more thickly wooded reach corresponds largely with perennial flow conditions downstream from the canyon mouth.

CHANNEL STRAIGHTENING AND MEANDER REMOVAL

Along most of the creek (with a few significant exceptions) Coyote Creek's natural plan form has not been substantially straightened by flood control projects. As can be seen in the overlays of the historical landscape map on modern aerial photography in **PART III**, the historical course of the main channel closely matches the present-day channel location in almost all places.

FIGURE IV-13. COYOTE CREEK CROSSINGS IN 1895. As we would expect based upon channel evidence, bridges are commonly shown across the Mid-Coyote reach (lower image, Story Road, note "carrots" on either side of creek indicating a bridge) while fords (indicated by a dashed line) across the channel bed are shown further upstream (upper image, present-day Highway 101 crossing near Cottonwood Lake, USGS [1895]1899, courtesy Earth Science & Map Library, UC Berkeley).

FIGURE IV-14. COYOTE CREEK AT KELLEY PARK, 1939 (LEFT) AND 2002 (RIGHT). Coyote Creek follows a highly sinuous course in this reach. Historical maps (Hermann 1905, Thompson and West 1876) also show secondary channels, which appear to correspond with lines of riparian vegetation distinct from the main channel in 1939 (AAA 1939). By 1939, farms occupy most of the floodplain bench area along the creek; presently, orchard remnants, a parking lot, and several large sycamore trees can be found. A housing development was recently built on the odd peninsula jutting into the creek area at lower middle (2002 Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

There are some significant local changes, however, with the most major alterations associated with the Mid-Coyote reach and gravel mining/percolation ponds in the braided channel reaches. The latter changes are particularly evident in **MAPS 3B-2002** and **4B-2002**. Channel routing through the Ogier Ponds and Coyote Percolation Ponds represents a major alteration in morphology, with many recognized impacts (Buchan and Randall 2003). The SCVWD's 1972 flood control project straightened a mile-long reach of Mid-Coyote Creek, from Montague Expressway to Highway 880, with substantial loss of meanders (see **MAPS 2A-2002**). Along Lower Coyote Creek, meanders have also been removed above and below Highway 237 (see **MAPS 1A-2002**). While the meander immediately south of Highway 237 was removed after 1939, the "S"-bend just north of the highway was removed (or cut off naturally) much earlier, between 1873 and 1897 (see **MAPS 1A-1939**). As a result, this reach would be expected to now be steeper than it was previously, which can cause localized grade adjustments if the reach does not have grade controls (concrete sills, etc).

There remains some uncertainty about alterations to the main channel in the Mid-Coyote reach from Berryessa Road through Watson Park. Here the main channel appears anomalously straight, but sources as early as 1876 show essentially the same course. It is possible that the channel was straightened even earlier, or the alignment may be natural.

APPARENT NATURAL CHANNEL MIGRATION

Interestingly, some of the largest historical changes in the position of Coyote Creek's main channel appear to be the result of natural channel migration.

As discussed in **PART III**, surveyor Howe described dynamic channel conditions in 1851 just south of the Coyote Creek Golf Club, and a 1903 survey confirms lateral migration of about 700 feet. We documented similar changes just downstream of Coyote Narrows based upon GLO notes and Pickwell and Smith (1938). White's reliable 1850 map reveals that a major realignment of the main channel in the mile-long reach surrounding the present-day Highway 280 crossing took place between 1850 and 1876, establishing the current alignment.

Another historical realignment was described just south of this reach at Kelley Park by Ouchi (Ouchi 1983 in Schumm et al. 2000; **FIGURE IV-14**). By comparing USGS quadrangles from 1895 and 1961, he identified a substantial increase in channel sinuousity, which was ascribed to gradient alteration resulting from land subsidence. However, we found that most, if not all, the "new" meanders were, in fact, shown by other early maps (e.g. Thompson and West 1876, McMillan 1904) as primary or secondary channels. These local maps were produced at a more detailed scale than the USGS sources.

It appears that any channel change at this site involved flow-switching (transfer or relocation of the dominant discharge-carrying channel) between primary and secondary channels and, like that observed to the north, took place prior to most land subsidence. Considering these two contiguous reaches together, the interpretation most well supported by historical data is that this highly sinuous reach has been naturally dynamic during historical times.

All of the lateral channel movement observed at the sites discussed above has taken place within the well-defined outer channel banks documented along most of the creek's length. Within this area, the channel appears to have maintained a degree of dynamic equilibrium, with lateral migration contained within the overall channel area of flood-prone benches and terraces.

CHANNEL FILLING

The broad benches along Coyote Creek, particularly those within the original city limits of San Jose (approximately from Berryessa Rd. to Phelan Ave.), served for many decades as a sort of nearby wasteland, providing available space for otherwise undesirable city activities. Local guards turned to "the bed of the Coyote" as the "only safe place to shoot near town" (San Jose Weekly Mercury 1863: 3). These areas were also used as garbage dumps. Gardner et al. (1958: 99) describes how, as late as 1941, these areas were "utilized for grazing, for dumping dirt or building refuse, and as a source of sand and gravel." Since these elevated surfaces of the channel lay 10 or more feet below the adjacent land surface, they provided substantial volume for waste disposal.

Like many early land use activities, the filling of Coyote Creek had been mostly forgotten. For example, present-day Watson Park operated as a city dump for several decades prior to the 1930s and was developed into a city park in the 1960s with no consideration of its prior use (Lynch 2005; **FIGURE IV-15**).

Filling of these benches has had several significant effects. As with Bay fill, Coyote Creek landfill represents a potential source of contaminants to groundwater and, through Coyote Creek, to the Bay. Recent discoveries of elevated levels of lead, arsenic, and other contaminants at Watson Park, where community gardens have been tended for years, has caused substantial community concern and resulted in park closure (Lynch 2005). The City of San Jose is currently assessing contaminant levels and exploring mitigation options (Napp Fukuda, personal communication).

Given the prevalence of wide natural benches along Coyote Creek within the early city limits, it is likely that the Watson Park example is not unique and that other places along the creek received illegal or city-sanctioned dumping. Since historical dump sites represent an important source of some contaminants delivered to the Bay (McKee et al. 2003), landfill along Coyote Creek may represent a significant concern.

Another effect of Coyote Creek landfill was to elevate the level of these channel surfaces, presumably reducing their flood frequency. This is obviously of benefit for certain land uses. But it also suggests an opportunity for "natural flood protection." Floodplain restoration on incised streams often involves excavating new floodplain benches that can be accessed by high flows. In this case, sculpting floodplain benches as part of multi-objective recreational areas could restore them to original elevation and flood capacity.

In fact, most of these former benches still lie substantially below the adjacent valley surface (**FIGURE IV-15**) and many flooded in January 1997 (SCVWD 1997). By reducing channel gradient, subsidence may actually have made flood-prone benches along the Mid-Coyote reach, upstream of the Upper Penitencia Creek confluence, more accessible to high flows than they otherwise would be, and more important for flood protection.

The landfill history may, in some places, provide another incentive for strategic removal of some Coyote Creek landfill. Since areas such as Watson Park still lie within the range of major floods, landfill capping is not a viable option (Fukuda personal communication). In these areas, combining floodplain restoration, increased high flow capacity, and contaminant removal could provide a range of benefits and tap multiple sources of funding.

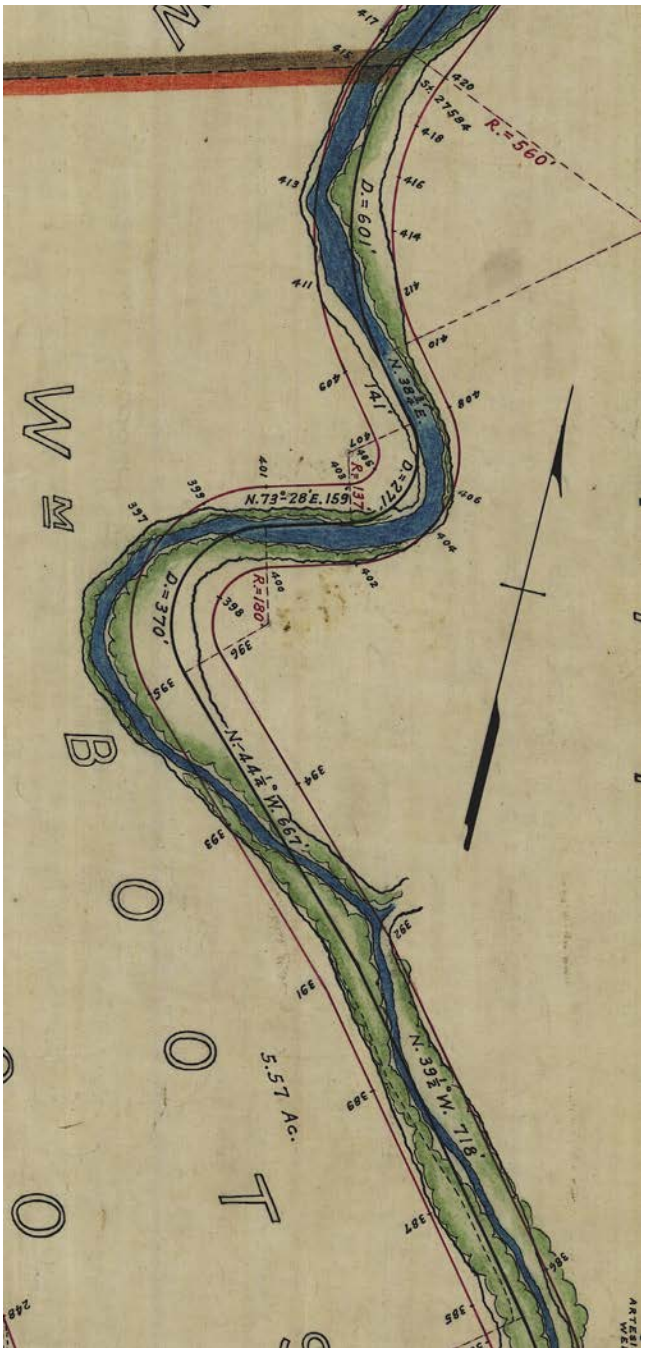
REDUCTION OF CHANNEL AREA

One of the important land use impacts to Coyote Creek has been the encroachment into the broad channel area of parking lots, mobile home parks, commercial buildings, percolation ponds, and other features. Some of this land use involves landfill, but in many other places activity has simply moved into the creek channel area. As early as 1874, Herrmann's Coyote River Survey noted "Bank leveled down and planted in orchard" (Herrmann 1874a) and calculated the area each streamside landowner stood to gain by reclaiming stream benches through the "Proposed Improvements" (**FIGURE IV-16**). Cumulative encroachment of the channel has inevitably reduced overall capacity while placing structures within the range of predictable flooding. An illustration of the reduction of the active channel or riparian area is given in **FIGURE IV-29** and discussed in the section on riparian change.

HIGH FLOW EVENTS AND "BREAKOUTS"

Previous reports have documented flooding along Coyote Creek in the years 1911, 1917, 1931, 1958, 1969, 1982, 1983, and 1997 (WMI 2003: 7-138). Historical data collected in this project indicate flooding also in 1852, 1853, and, likely, 1862. Presumably there were additional flooding events between 1853 and 1911.

FIGURE IV-15. STREAM BENCHES ALONG MID-COYOTE CREEK. Despite filling and grading, these features are still evident along many parts of the creek as distinct "drops" below the adjacent valley floor terrace. Locations are, clockwise from upper left: the Santa Clara Valley Water District's Coyote Creek Outdoor Classroom; private residences on Arroyo Way near William Street Park; Watson Park; Kelley Park; Nordale Ave. near Kelley Park; and private residences on Arroyo Way.



Duryea et al. (1977) speculated that additional floods might have occurred in February 1869; January 19, 1895; and January 14, 1911. Apparently by examining local newspaper accounts corresponding to periods of high rainfall or regionally documented flooding, they evaluated a number of other potential flood events but found "nothing reported in San Jose" for December 1861, January/February 1862, December 1871, November 1885, and November 21, 1900.

A 1927 flood event caused widespread flooding throughout the state and may have also had impacts on Coyote Creek, but does not seem to be noted by these sources. Historical flood accounts for the Valley do, in fact, indicate the heterogeneous and local nature of extreme rainfall events and associated flooding. While most local streams have flooded at times over the past century, flood years vary substantially from stream to stream. Flooding on a given stream is not necessarily matched by flooding on neighboring streams.

On Coyote Creek, high flows during major events caused "breakouts" at specific points along the stream where flood waters overtopped banks. The most well documented area of repeated flooding along Coyote Creek was on its sinuous, shallow lower reaches, below the present-day Southern Pacific railroad crossing, where floods created a massive zone of overflow as Guadalupe, Coyote, and Penitencia merged together and flowed into the marshlands.

In testimony for the land grant case for this area, a local resident described the flooding in 1852 and 1853,

FIGURE IV-16. DETAILED MAP OF LOWER COYOTE CREEK, 1874. Part of Herrmann's 1874 Coyote River Survey, this map shows the main channel and dense, narrow riparian forest along a sinuous channel, immediately downstream of present-day Highway 237. The set of smooth parallel lines illustrates the proposed flood control project, which involved widening the channel and some straightening, while mostly following the general course. For each adjacent landowner, the map indicates the amount of land that stands to be reclaimed by the project (e.g. 5.57 acres are indicated to the right of "Boots") (Herrmann 1874c, courtesy Santa Clara County Surveyors Office).

in response to questioning:

> **Court:** "Were you there during the high water of the winter of 1852 and 1853 and if so did not the Coyote and Guadalupe overflow their banks and run down through the sloughs?"
> **Pomeroy:** "I was there and the whole country was overflowed with fresh water" (Pomeroy 1860).

Coyote Creek broke out at several distinct places in this reach, as illustrated in Herrmann's survey two decades later (**FIGURE IV-17**). Just downstream from Trimble Road (present-day Montague Expressway crossing), the creek diverted through the Malovos property and continued west all the way to the Guadalupe River. At the present-day Highway 237 crossing, flow spread both east and west, joining Lower Penitencia Creek and occupying the overflow channels extending northwest into the marshlands.

This event triggered the extensive Coyote River Survey of 1874(c) by County Surveyor Herrmann, as well as consternation about slow County response. The San Jose Mercury reported that:

> "At the junction of the Alviso and Milpitas Road (Highway 237) with the Coyote, the water has backed up and formed a dangerous mudhole, which will long be remembered by all who have had occasion to pass that way. We are glad to be able to state that under the superintendency of the efficient roadmaster Dudley Wells, rocks are being hauled from the hills and a roadbed built across the slough" (Loomis 1986: 29-30).

Herrmann & Herrmann (1876) surveyed a longitudinal profile of the creek below Highway 237, showing that the shallow channel ("slough") had completely filled with sediment and proposed excavation to 4-6 feet depth.

Herrmann's proposed flood control project does not appear to have been constructed as designed, but major levees were constructed along lower Coyote between Highway 237 and Trimble Road before the turn-of-the-century, apparently privately funded:

> "Mr. Malovos secured 260 acres of land, on Coyote Creek in 1870, and at once commenced to improve it. The soil was exceedingly rich and fertile, as it consisted almost entirely of silt deposited by the waters of Coyote Creek, which in winter time formerly spread over the land. Mr. Malovos constructed a levee along the bank of the stream, at great expense, from thirty to forty feet wide at the base, and from ten to fifteen feet in height, for a distance of more than a mile. The work was done most thoroughly, and the levee is safe for all time" (Shortridge 1896: 181).

Malovos understandably had a large incentive, given the breakout route of Coyote Creek through his property shown by Herrmann (1874c) and noted in other maps such as Thompson and West (1876). (Unfortunately, his name was not safe for all time, currently misspelled as Mauvais Lane (USGS 1980) and Malovis Road (CSAA 1998).

In 1897, Westdahl and Morse (1896-97) show continuous levees along both sides of Coyote Creek begin-

FIGURE IV-17. LOWER COYOTE CREEK HISTORICAL OVERFLOW PATTERNS. This map shows the series of "breakouts" along Coyote Creek. Overflow channels extended all the way to Guadalupe River and Lower Penitencia Creek. It also shows the pattern of wide and narrow stream reaches (Herrmann 1874d, courtesy Santa Clara County Surveyors Office).

ning at present-day Highway 237 and extending upstream past the present-day Tasman Drive crossing to about Sycamore Drive (in the area of the Cisco complex). The map ends here, so this flood protection engineering undoubtedly extended some distance farther upstream. Combined with the description of the Malovos levee, the map extends 19th-century levee construction upstream nearly to Trimble Road, that is, almost to the downstream limit of broad channel. In the accompanying descriptive report, Westdahl affirms the extent of early engineering on this reach:

> "To protect the valuable orchards and fields in the low country through which it flows Coyote Creek has been dyked. These dykes rise twenty and more feet above the general level at the Southern limit of the sheet, are broad enough for a road along the top, and are covered with willows and bushes" (Westdahl 1897c: 2-3).

The exact year in which the many breakouts documented by Herrmann (1874c) occurred has not been determined, but examination of newspaper records for the previous several years shows no obvious mention of major flooding. It is possible that the damage was caused by the famous 1862 flood which affected much of California (Charlene Duval personal communication). The lower reach was clearly aggradational and shallow, with substantial sediment supply.

The other important early flood event took place March 7-9, 1911. Local residents were quoted as describing this flood as the largest since 1862, at least on the Guadalupe, and since 1880 on Coyote (Duryea et al. 1977). Accounts of this flood, considered the flood of record on Coyote, describe a similarly broad zone of overflow from Coyote merging with Guadalupe River. The strength of the current is illustrated in a story recounted by Loomis (1986: 63) about the evacuation of a tavern on the Alviso-Milpitas Road west of Milpitas. George Files was forced to evacuate "when the overflow from the Guadalupe River and Coyote Creek began spilling over his polished bar." The boat that rescued him was unable to buck the current and spent the night in Alviso.

Interestingly, while earlier descriptions of Coyote flooding and Herrmann's 1874(c) survey focus exclusively on breakouts downstream of the Southern Pacific Railroad crossing, the 1911 accounts focus farther upstream. Research notes by Duryea et al. (1977), provided by Jim Wang of the SCVWD, report overflowing east of San Jose, the loss of the William Street bridge, and a breakout point at Shallenberger. It is also reported that "water escaped from Coyote through irrigation ditches on Heinlein Place 1 mile south of fill near Coyote Edenvale Hillsdale area."

The Shallenberger breakout point was probably at or near the present-day Brokaw Road crossing. In 1911, Shallenberger Road continued farther north than it does today and joined Brokaw Road (McMillan 1902-1903). The road had been constructed within Coyote's broad active channel area, immediately alongside the main channel, likely on fill. It is not clear if this road segment between Shallenberger and Brokaw was lost due to flooding.

FIGURE IV-18. COYOTE CREEK AT WILLIAM AND OLINDER PARKS IN 1850 (LOWER LEFT), 1939 (UPPER LEFT), AND 2002 (RIGHT). Some evidence of the former main channel course shown by White (1850; courtesy Santa Clara County Surveyors Office) is visible in 1939 (AAA 1939) as less vigorous orchard growth. Martin Park (the triangular green field in the upper right corner of the modern photo) corresponds with the former main channel (2002 Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

It is notable that breakouts were not noted along lower Coyote Creek in 1911. Apparently the levees constructed to protect agricultural land along the narrow, shallow channel below Trimble were successful. At the same time, the tidal reaches were being effectively channelized by the construction of salt ponds (see **FIGURE IV-6**). Reduced flood area along lower Coyote, however, may have increased flood stages upstream. Flooding would also have tended to increase along the broad middle reaches, as benches that previously contained overflow were now reclaimed by fill, orchards, and other land uses. In contrast to the 1911 flooding, in 1888 Foote had authoritatively stated that Coyote Creek's deep and wide channel presented no danger of overflow within the San Jose City limits, (west side of creek approximately from Berryessa Road to Phelan Avenue (see text box at right)). The description of the Edenvale-Hillsdale area flooding also appears associated with early channel modifications including fill and ditches. Additionally, channel scars spreading from the Coyote channel that can be seen in 1939 aerial photography are most prominent in the Shallenberger (Montague Expressway) area, further suggesting upstream migration of flooding effects. Historical flood data and channel morphology also suggest that the large natural flood capacity of the Mid-Coyote reach made flooding of old town San Jose relatively minimal prior to channel modifications.

A present-day potential breakout point of concern is located just upstream of William Street at the Selma Olinder Park (Sibley personal communication, SCVWD 2005).

Horace S. Foote's exceedingly detailed 1888 account of Coyote Creek through San Jose describes channel morphology, lack of flooding, eroding banks composed of coarse sediment, and City-County partnerships for bioengineered stabilization (bold added for emphasis):

> "Coyote River forms the eastern boundary [of San Jose]. **It has a deep, very wide and irregular channel along the city line, and there is no danger of overflow at any place adjoining city territory.** It has been found necessary, however, to protect **its westerly bank, which reaches a height of twenty-two to twenty-five feet**, and consists of a sandy loam, interstratified with sand and fine gravel from the action of the current. This work was done immediately north and south of the crossing of Santa Clara Street, during the years 1875 and 1876, at which time the bank had to be sustained by willow fascine facings and wing-dams, which have ever since remained intact, the willows now forming a dense living barrier, as it were, to further encroachments of the river at these points. The expenditures incurred for this work amounted in the aggregate to the sum of $2,449.70. There was also expended for a somewhat **extensive breakwater embankment, built about one-half mile south of the city** [present-day Kelley Park], during the year 1872, the sum of $3,866.86, this being one-half of its cost, the other half having been paid by the county of Santa Clara. **The embankment was built to avert the danger of overflows from the river at this locality, where its strong current during times of freshets made rapid progress in the destruction of its westerly bank, which consists here also of a sedimentary sandy loam and yields very readily to the undermining and abrading action of flood-waters.** The total cost of river improvement to date has been $44,087.41" (Foote 1888: 160).

Flood-prone conditions here may result in part from the unusually extreme reduction in channel area at the site, where a flood-prone bench historically extended more than 1000 feet to the east (**FIGURE IV-18**). Prior to fill, this reach also likely had a significant secondary channel that meandered all the way to Martin Park (and which was the primary channel circa 1850; White 1850). The secondary channel and large available high flow capacity on the adjacent benches likely reduced historical flooding extent at the site. Now, with more effective flood protection along much of the creek, remnants of these features may provide some of the few remaining conduits for flood flow.

As would be expected, many of the currently flood-prone areas as shown by the 1% Flood Area Map (WMI 2003: 7-135) and SCVWD data are associated with historical channels or wetlands. Projected overflow at the Olinder site would be prevented from returning to the channel by its natural levee and continue into the willow grove and *laguna* area at the downstream end of Upper Penitencia Creek. The flood-prone areas west of Coyote Creek upstream of Highway 280 correspond largely with historical wet meadows, as do areas in Coyote Valley and East San Jose. Most of the areas at flood risk immediately alongside Coyote Creek are developments (or parks) located on Coyote's adjacent benches.

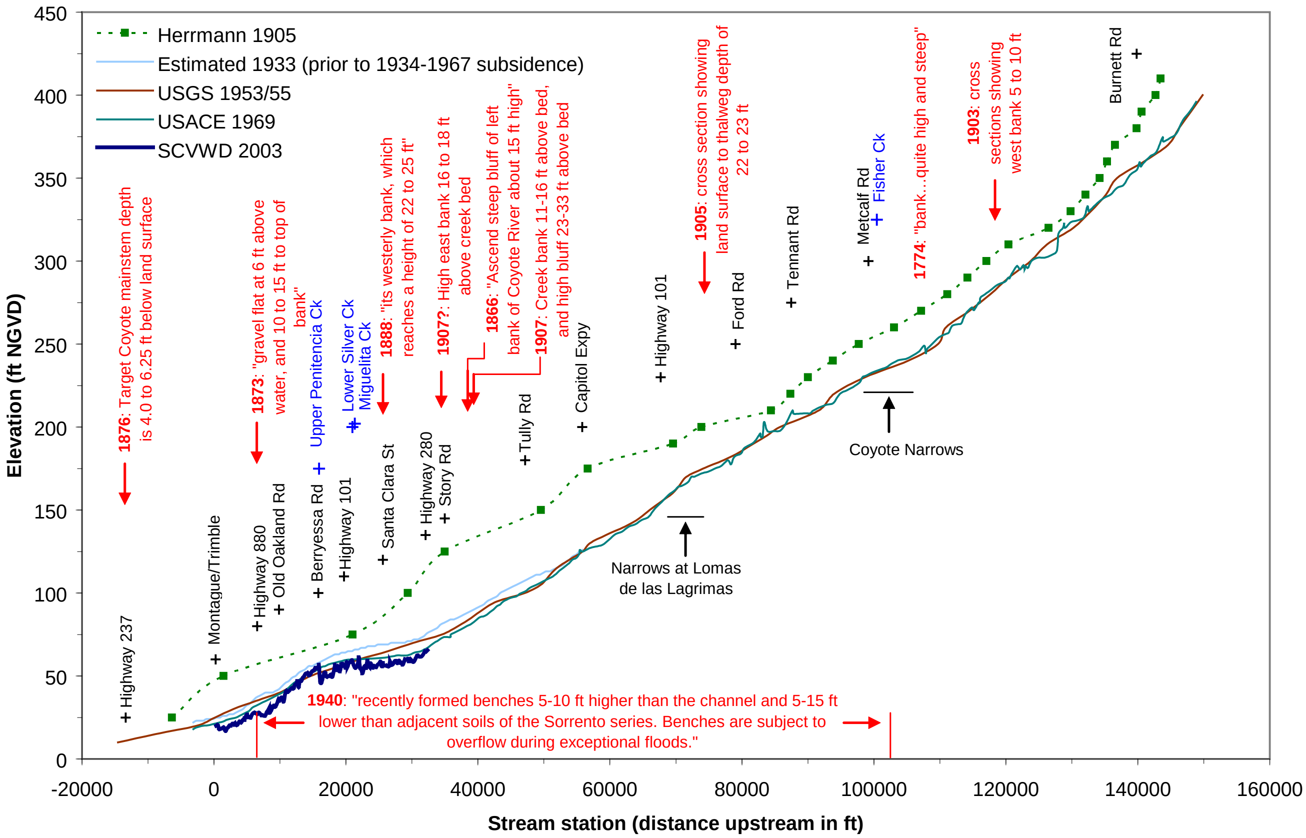


FIGURE IV-19. HISTORICAL AND MODERN LONGITUDINAL PROFILE DATA FOR COYOTE CREEK. See text for details. Comparison to the other data sets indicates that the profile based on Herrmann (1905) is not of comparable accuracy. The Mid-Coyote reach is shown in more detail in **FIGURE II-20**.

VERTICAL CHANGES

Some amount of channel incision could be expected on Coyote Creek in response to the reduction in overall channel area and capacity. The loss of stream sediment to Anderson and Coyote Dams also creates sediment-starved water with a tendency to erode channel banks and bed, although stream power and associated erosive energy have at the same time been reduced by winter flow regulation since 1936 (see **FIGURE IV-27**). Perhaps more importantly, flashier and sediment-depleted peak flows from the now-continuous tributary channels (and associated storm drain networks) may trigger erosion of the Coyote mainstem. Even the increase in riparian tree density, by hardening channel banks, can result in accelerated bed erosion. On the other hand, land surface subsidence in San Jose has created artificially low-gradient reaches that might have a tendency to aggrade rather than incise.

Analysis of change in a stream's longitudinal profile requires both historical information and contemporary data derived from fieldwork. Unfortunately, recent data are only available for the Mid-Coyote reach. We were able to compile several other sources of long profile data, as well as substantial early historical vertical data, but these are of less analytical value until comparable present-day data are developed.

We compiled a longitudinal profile for the entire Coyote Creek valley floor length from the 1969 survey by the US Army Corps of Engineers (US ACE [1969]1970; **FIGURES IV-19** and **IV-20**). We also created a standard longitudinal profile based on contour lines from the current USGS 7.5 minute quadrangles. These data, often the only stream gradient information available for a watershed, have generally not been updated since their original creation. In the case of Coyote Creek, the USGS contour data are truly historical, originating in 1953-1955.

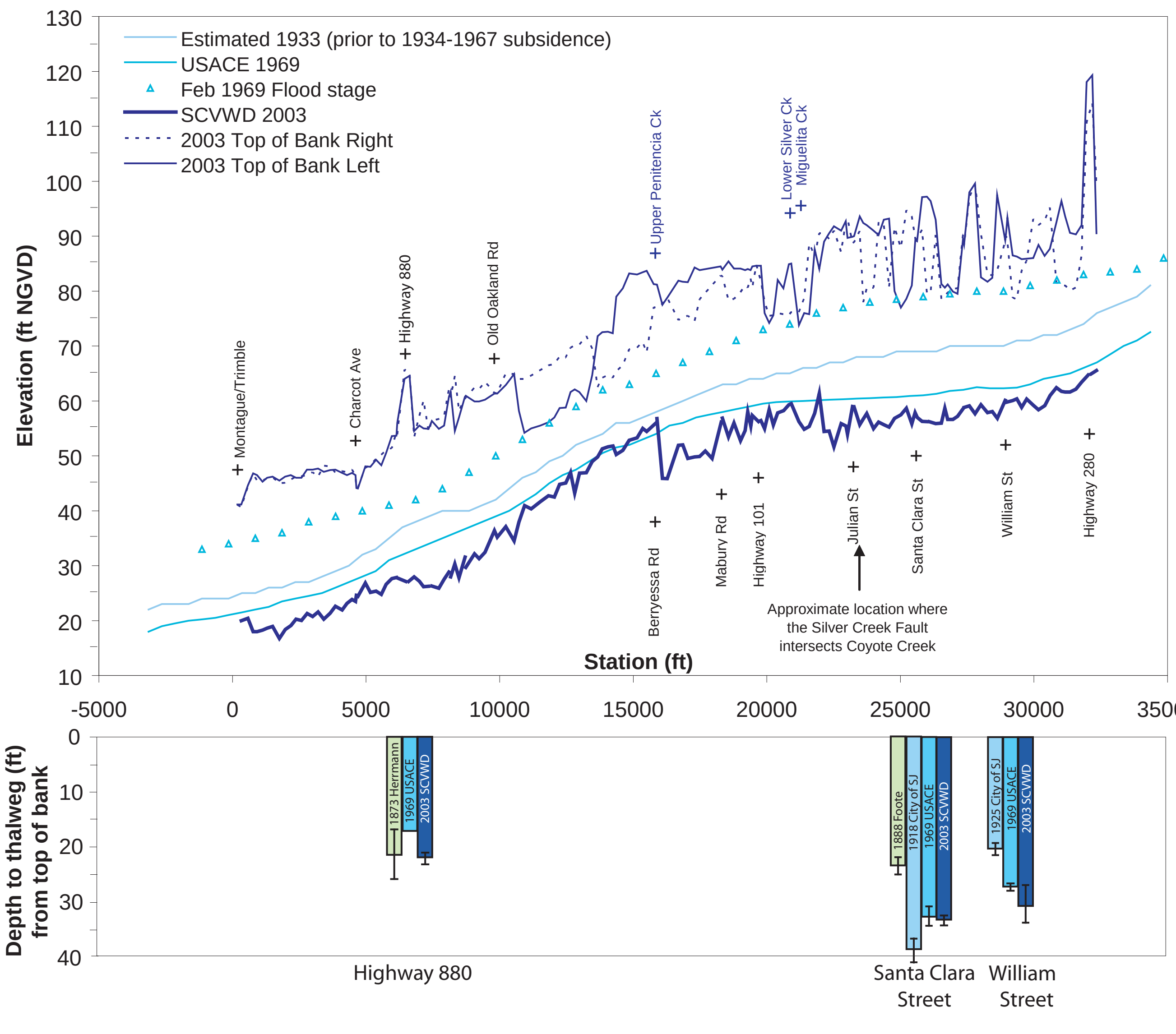


FIGURE IV-20. HISTORICAL AND MODERN LONGITUDINAL PROFILE DATA FOR COYOTE CREEK. See text for details. Since some historical data were not referenced to NGVD (and given changes due to subsidence), we also compiled channel depth data in reference to "top of bank" for this reach (lower part). Error bars on the lower chart indicate the data range (e.g. narrative information such as "22-25 feet" or variability among depths measured from profile).

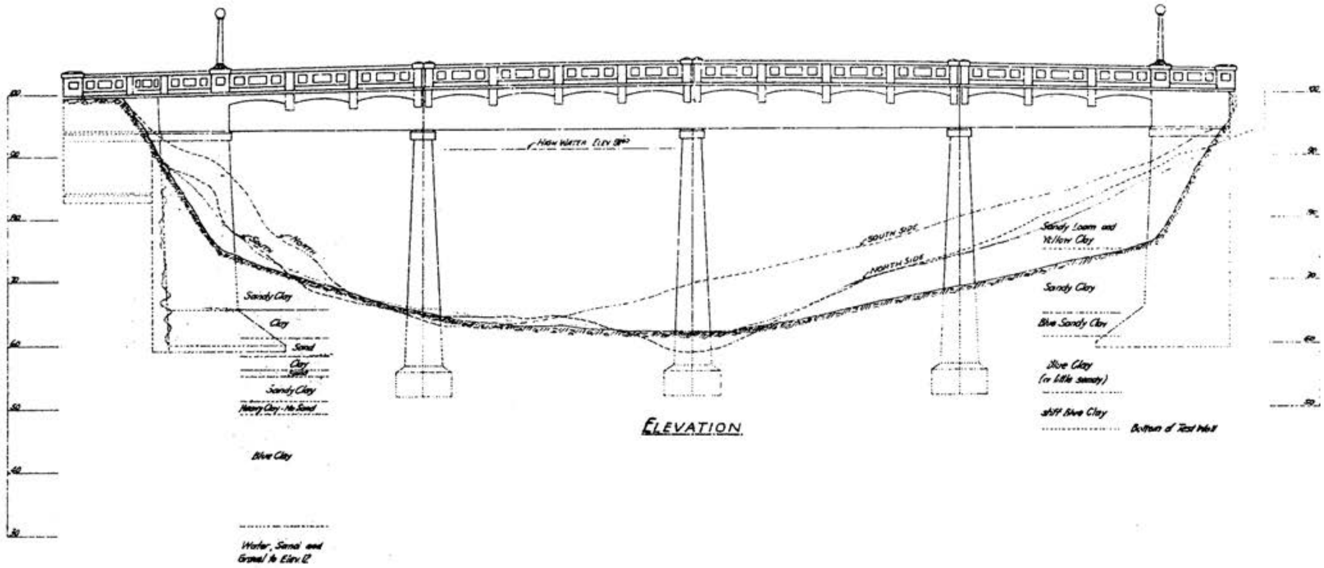


FIGURE IV-21. CONSTRUCTION DIAGRAM FOR THE "SANTA CLARA ST. BRIDGE OVER THE COYOTE RIVER." Courtesy City of San Jose, Department of Public Works (1918).

We also developed a longitudinal profile from the earliest map depicting the full valley floor length of Coyote Creek with fairly detailed contour lines (Herrmann 1905). To account for the documented effects of subsidence, we incorporated a profile created by SCVWD staff (provided in hardcopy) to reflect conditions prior to the well-recorded 1934-1967 subsidence. This profile appears to have been created by adjusting a contemporary profile with the subsidence contours created by Poland and Ireland (1988). We made similar adjustments to compensate for subsidence in comparing NGVD-based cross-sections.

We found over a dozen reliable pre-1925 sources of evidence about channel depth, ranging from surveyed cross sections to explicit narrative descriptions. These include an 1863 description of using the creek bed for shooting practice because the "bluff banks effectually prevent any accident from random shots" (from 200 feet distance) and a 1774 explorer's account, as well as a number of late 19th and early 20th-century professional surveys. An example bridge "as-built" providing evidence for historical channel geometry is presented in **FIGURE IV-21**.

This new data set provides evidence along the valley floor length of the creek, although with more information closer to early San Jose (**TABLE IV-2**). These data, including the recent longitudinal data for the Mid-Coyote reach (SCVWD 2003/5), are compiled in **FIGURES IV-19** and **IV-20**. Reconstructed historical cross-sections are presented in **FIGURE IV-22** through **IV-26** in comparison with nearby modern cross-sections.

At present, there are only a few sites where direct comparison is possible. There are also some uncertainties in comparison that could be resolved through fieldwork, namely confirming which channel surface is referred to in bridge as-builts (see William Street example). Based upon these available data, however, we can make some general observations and provide several specific examples. The historical data obtained here provide baseline data for assessing vertical channel change through time more accurately through reoccupation in the field.

Available data at the several sites do suggest that Coyote Creek has generally incised through recorded history. Current low flow channel elevation is consistently lower than or at a similar level to historical elevation.

CREEK	LOCATION	YEAR	EVIDENCE	BED DEPTH	SOURCE
Coyote Creek	immediately downstream of Highway 237	1876 (June)	long profile showing anticipated grade for excavating Coyote Creek following channel breaks. "Old channel" and "waterline" are shown as 1 to 3 feet below land surface. Target depth for "ditch" is just 4-6.25 feet. While the existing depth represents recent aggradation, the shallow target depth is probably indicative of, if not deeper than, prior depth.	<5 feet	Herrmann & Herrmann 1876
Coyote Creek	in the vicinity of Milpitas, probably somewhere downstream of Montague Expressway	circa 1905	two landscape photographs of the same site at different times of year show top of bank~2-3 feet above water surface—water depth likely not more than 3 feet?	5-6 feet?	Hare circa 1905a
Coyote Creek	near Brokaw Road crossing	circa 1880	field notes describe channel geometry in concert with survey: "gravel flat at 6 feet above water" and "10 to 15 feet to top line of bank" [from gravel bar]	16-21 feet	Hermann 1874a
Coyote Creek	just downstream of SP railroad crossing	1874-76	presence of schoolhouse ("Orchard School") in active channel suggests a relatively shallow ("high") inset terrace	NA	Herrmann 1874b, Thompson and West 1876
Coyote Creek	Oakland Road and SP Railroad Crossings	1896	depth cannot be assessed precisely, but bridge piers are fairly high, suggesting top of bank at least 10-15 feet above bed	≥10-15 feet?	Shortridge 1896: 20,174
Coyote Creek	approximately Trimble Road to Coyote Narrows	1940-41	description of benches along Coyote Creek: "The soils occupy small, recently formed "benches" that are generally 5 to 10 feet higher than the channel of Coyote Creek and 5 to 15 lower than the adjacent soils of the Sorrento series"	10-25 feet	Gardner et al. 1958: 99
Coyote Creek	San Jose	1863	"TARGET EXCURSIONS.—The San Jose Zouaves and San Jose Union Guards had their second target practice on Thanksgiving day. The only safe place to shoot near town is in the bed of the Coyote where the bluff banks effectually prevent any accident from random shots"		
Coyote Creek	reaches within the city of San Jose; suggests the vicinity of Santa Clara St.	1888	"Coyote River forms the eastern boundary [of San Jose]. It has a deep, very wide and irregular channel along the city line, and there is no danger of overflow at any place adjoining city territory. It has been found necessary, however, to protect its westerly bank, which reaches a height of twenty-two to twenty-five feet, and consists of a sandy loam, interstratified with sand and fine gravel from the action of the current. This work was done immediately north and south of the crossing of Santa Clara Street, during the years 1875 and 1876..."	22-25 feet	Foote 1888: 160
Coyote Creek	just upstream of Julian St.	1891	Depiction of thousand foot stretch of creek annotated with "Garden Land submerged at high water" (describing bar or terrace between outer line of creek and presumable low flow channel) - a relatively narrow straight reach, perhaps similar to the South 14th St. houses near William Street.		Sanborn 1891: 10
Coyote Creek	Story Road	1907 (?)	500 foot longitudinal profile shows present creek bed 16-18 feet below "High E. Bank" and "Sand Bank" between old and new channels 8 to 10 feet above creek bed.	16-18 feet	Santa Clara County Surveyor 1907 (?)
Coyote Creek	Phelan Ave.	1907	creek "bank" 11-16' feet above bed, and "high bluff" 23-33' feet above bed	22-23	
Coyote Creek	at Needles Drive (just downstream of Phelan)	1866	"Ascend steep bluff of left bank of Coyote River about 15 feet high."	15 feet	Thompson 1866: 166
Coyote Creek	Shady Oaks Park (city; near Silver Valley Road crossing)	1905 (February)	cross-section showing adjacent land elevation (196.7-197.7) and what appears to be a fairly low flow "water level" (175.90); bed elevation may be a little lower (drawing, if to scale, suggests water depth less than 1 foot)	22-23 feet (measured depth to bar surface plus estimated water depth of 1-2 feet)	Herrmann & Bros. 1905
Coyote Creek	South end of Coyote Creek Golf course/ North end of Ogier ponds	1903 (April)	four cross sections along 1000 foot reach; East Bank (may intersect adjacent topography) 14-18 feet above bed, West Bank 5-10 feet	West Bank 5-10 feet	Campbell 1903
Coyote Creek	northern Coyote Valley—the creek approaches El Camino Real in the vicinity of Coyote Creek Golf course	1774 (November 26)	"we came upon a large riverbed, very lined with cottonwoods, sycamores and willows, though without any water; we commenced following along its bank, which was quite high and steep..."		Palou 1774 in Brown 2005: 51-52
Coyote Creek	Gilroy Hot Springs to Anderson Reservoir	1952-53	as part of Master's thesis in geology at UC Berkeley, Frames mapped quaternary terrace gravels alongside Coyote Creek in the canyons above Anderson reservoir ["lower Coyote Creek"]. He notes that: "The Coyote is at present incising these gravels, the present water level being 4 to 6 feet below the terrace level."	4-6 feet	Frames 1955:54

TABLE IV-2. HISTORICAL EVIDENCE FOR CHANNEL DEPTH.

Historical incision may, however, not be as extensive as assumed, because the channel was quite entrenched under natural conditions. Incision over the course of 75-125 years at these sites appears as great as 10 feet in the vicinity of Santa Clara and William Street (**FIGURE IV-22** through **IV-25**) , and negligible farther downstream in the vicinity of Highway 880 (**FIGURE IV-26**). This observation may be explained by the fact that Upper Penitencia Creek provides a substantial present-day sediment source to the lower reaches of the stream.

There does appear to be some consistent incision between 1969 and 2003 at these sites, on the order of 3 feet. Interestingly, this rate of ~1ft/10yrs is similar to the hypothesized long-term rate reported above (roughly 10 feet in 100 years). Comparison of cross-sections from the early 1980s for the Mid-Coyote reach shows a similar trend of approximately 2 feet of incision during 20 years (Sibley personal communication).

Comparison of longitudinal profiles suggests several observations. The profile based on Herrmann (1905), while generally following the modern profiles, does not appear sufficiently accurate for this use. While it shows a pronounced bulge in comparison to the modern profiles, as would be expected given subsequent subsidence, the location is too far upstream (given that subsidence was centered around downtown San Jose).

Even with the correction for subsidence since 1933, the Mid-Coyote reach between Highway 280 and the Upper Penitencia Creek confluence is notably flat. This may be the result of sediment input from Upper Penitencia Creek, which became a tributary to Coyote in 1852. In a stream now starved for upper watershed sediment, Upper Penitencia Creek has likely become an important sediment source for the lower reach. Alternatively, the gradient shift here could be related to the Silver Creek fault.

Given that stream bed erosion has been observed in the vicinity of Santa Clara and William Street since 1888-1925, it is likely that incision would have been even more extreme in the absence of subsidence, which was centered in this vicinity. The stream has been erosive despite a flattening of its gradient and reduced peak flows. Subsidence may have “protected” the reach from even worse incision.

Incision in other parts of the watershed may be more rapid and result from more recent activities. For example, bed erosion in the vicinity of Highway 101 in Coyote Valley has been suggested to result from quarrying activities during the mid-20th century (Reiller personal communication in Buchan and Randall 2003).

HYDROLOGY

This section discusses some of the significant changes affecting the hydrology of the Coyote Creek watershed, including the peak flows, summer flow, and monthly distribution of runoff.

INTERMITTENT VERSUS PERENNIAL FLOW

One of the important questions about the historical hydrology of streams in semiarid California is the

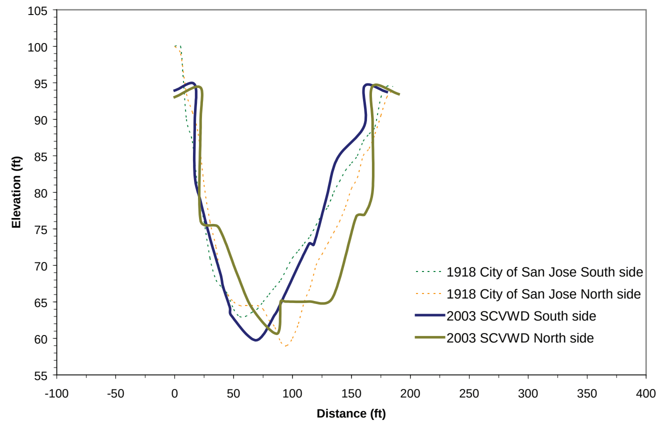


FIGURE IV-22. MEASURED CROSS-SECTIONS AT THE SANTA CLARA STREET BRIDGE. Note the South side cross-sections represent the channel surface on the upstream side of the bridge, while North side cross-sections represent the channel surface on the downstream side. 1918 data from the City of San Jose Department of Public Works. 2003 data from the Santa Clara Valley Water District.

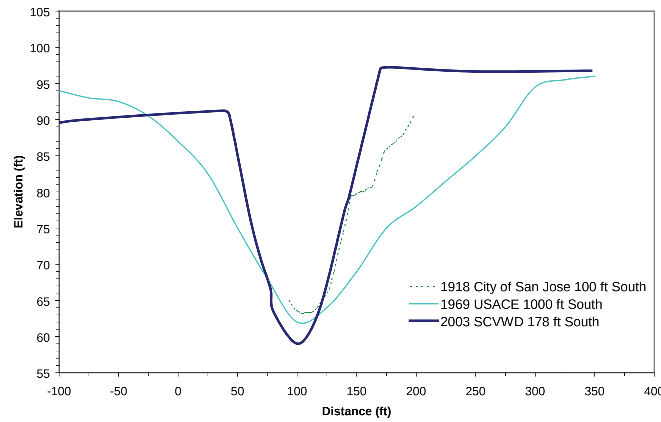


FIGURE IV-23. MEASURED CROSS-SECTIONS TAKEN UPSTREAM FROM THE SANTA CLARA STREET BRIDGE. Note that the three cross-sections represent different locations along the channel length. The 1918 data is from 100 ft south of the bridge (City of San Jose, Department of Public Works, 1918). The 1969 data is from 1000 ft south of the bridge (USACE [1969]1970). The 2003 data is from 178 ft south of the bridge (Santa Clara Valley Water District 2003).

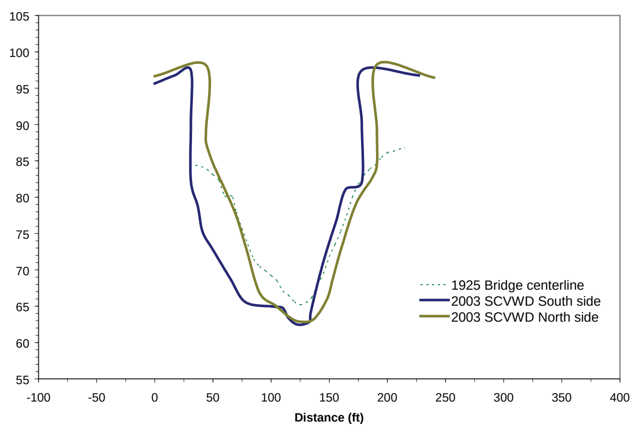


FIGURE IV-24. MEASURED CROSS-SECTIONS AT THE WILLIAM STREET BRIDGE. The 1925 cross-section represents the channel surface at the bridge centerline (City of San Jose, Department of Public Works, 1925). The 2003 South side data represents the channel surface on the upstream side of the bridge, while the 2003 North side data represents the channel surface on the downstream side of the bridge (Santa Clara Valley Water District 2003). We moved the 1925 data down 8 ft to match subsidence shown by Poland and Ireland (1988).

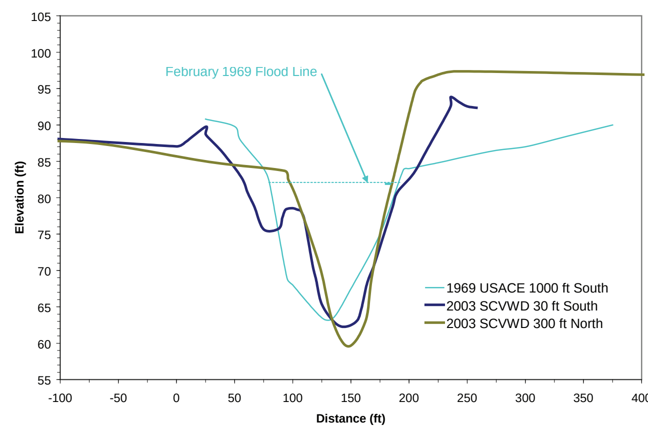


FIGURE IV-25. MEASURED CROSS-SECTIONS TAKEN UPSTREAM FROM THE WILLIAM STREET BRIDGE. Note that the three cross-sections are representing different locations along the channel length. The 1969 data is from 1000 ft south of the bridge, and also shows the flood peak elevation from the February 1969 flood (USACE [1969]1970). The 2003 South side data is from 30 ft upstream of the bridge, and the 2003 North side data is from 300 ft downstream of the bridge (Santa Clara Valley Water District 2003).

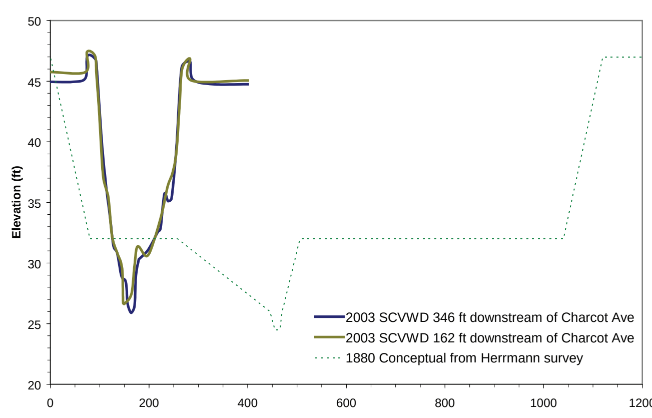


FIGURE IV-26. MEASURED AND CONCEPTUAL CROSS-SECTIONS FROM THE HIGHWAY 880/CHARCOT AVE AREA. Note that the three cross-sections are representing different locations along the channel length. The conceptual cross-section is taken from notes and maps from the circa 1874 survey by Herrmann (Herrmann 1874c). The 2003 data show cross-sections from 346 ft and 162 ft downstream from the Charcot Avenue bridge (Santa Clara Valley Water District 2003).

extent of summertime flow. Given the overall extent of water withdrawal and manipulation for human purposes, a major ecological concern is the maintenance of adequate base flows to support native fish and wildlife species. Relatively large local streams, such as Coyote, are often assumed to have been perennial.

In fact, a wide range of historical evidence confirms that, for most of its length, Coyote Creek was an intermittent stream under natural climatic conditions prior to regulation. As shown in **TABLE IV-3**, evidence for intermittence is reflected through a wide range of years, months, and observers. Accounts of the dry Coyote bed include one of the earliest Spanish explorations in the area and several mid-19th-century travelers' accounts. El Camino Real ran both along and through the creek, so Gold Rush-era visitors coming from the south often commented on stream conditions. An early Mexican map (US District Court 1834) actually incorporates the creek's seasonality into its name ("Arroyo del Coyote *que se seca annualmente*" or "creek that dries annually"), emphasizing this noteworthy condition on the largest stream in the area.

Evidence comes from a wide enough range of years to conclude that these data are not the result of spurious observations during particularly dry years. Intermittent conditions also clearly precede significant anthropogenic groundwater withdrawal. These data also support the finding of very little natural runoff during the months of November and December, as shown by USGS flow data for Coyote Creek near Madrone prior to dam construction, 1907-1935 (**FIGURE IV-27**).

Several explicit narrative descriptions, combined with illustrations of riparian and aquatic habitat, agree that perennial flow conditions on Coyote Creek were historically limited to the lowest reach of the alluvial plain — extending upstream from the tidal reach into the vicinity of present-day Oakland or Berryessa Roads — and the reach immediately downstream from the canyon mouth (present-day Anderson Dam site). Snyder (1905: 329) and Clark (1924: 51) affirm perennial conditions in the lower reach, as would be expected given groundwater emergence and a high water table. Graphic evidence such as willow thickets appearing along the channel in the vicinity of present-day Highway 880 (see **FIGURE II-19**) and evident water in photographs of the Oakland Road-Southern Pacific Railroad (see **FIGURE III-11**) reach also suggest summer flow in the lower reach. On the upper valley floor, early aerial photography shows a clear shift from dense riparian forest to largely unvegetated, gravelly channel between Highway 101 and Ogier Ponds, providing ecological corroboration of the statements by Snyder (1905) and Clark (1924) that summer flow did not extend far from the canyon mouth. Clark (1924: 19) explains the condition of Coyote and other large, episodic, sediment-rich channels of the southern part of the Bay Area: "The channels of Coyote Creek, San Benito River, and Alameda Creek have especially wide gravelly bottoms, which offer opportunity for rapid percolation of their waters into the ground." As a result, of Coyote's 26 mile valley floor length, no more than eight miles (31%) appears to have been perennial.

I= Intermittent; P= Perennial

STREAM(S)	REACH	YEAR	I/P	EVIDENCE	REFERENCE
Coyote Creek	Coyote Valley	1774	I	November 26: "we came to a large river channel, thickly grown with cottonwoods, sycamores, and willows, but without water"	Palou 1774 in Bolton 1930 : 406
Coyote Creek	Ogier Ponds area	1851	I	November 1: "a large creek in wet weather, now entirely dry"	Howe 1851: 89
Coyote Creek	Vicinity of Coyote Narrows (old Monterey Road crossed Coyote Creek at Coyote Narrows)	1849	I	September 1849:: "took the broad highway running southward, up the valley of San Jose. The mountains were barely visible on either side, and the road, perfectly level, now passed over wide reaches of grazing land, now crossed parklike tracts, studded with oaks and sycamores—a charming interchange of scenery. I crossed the dry bed of Coyote Creek several times, and reached Captain Fisher's Ranch as it was growing dusk."	Taylor [1850] 2000: 100-101
Coyote Creek	at The Narrows	1849	I	December 1849: "We then came to a point where the mountain reaches out almost across the valley to meet the mountain on the east side [The Narrows]. Here we found a gravelly creek with but little water, but as soon as we passed this point we saw the valley suddenly widening out."	Manley 1894: 383
Coyote Creek	just downstream of The Narrows	1929-1936	I	"Through most of the year the Coyote channels are dry and surfaced with stream gravel"	Pickwell and Smith 1938
Coyote Creek	between Edenvale and The Narrows	1834	I	Coyote Creek labeled "Arroyo del Coyote que se seca annualmente" [creek which dries annually]	US District Court 1834, 211 N.D., Map D-461
Coyote Creek	from Tully Road to The Narrows	1858	I	October: "It is run dry but during a wet season has an immense body of water flowing in it."	Wallace 1858: 428
Coyote Creek	general description	Summer 1849	I	"the dry bed of a winter stream"	Taylor *in* Carroll 1903: 185
Coyote Creek and other Santa Clara Valley streams	States that the lower fluvial reaches of all creeks, except Coyote, are seasonal. Coyote is mostly seasonal, with perennial reaches just below the canyon mouth and for the lower reach.	1905	I/P	"On the approach of the dry season all the streams of the region [the southern end of the Bay, i.e. Santa Clara Valley streams] rapidly shrink, both in volume and length, only one of them, Coyote Creek, discharging water into the Bay during the entire summer. Much of its bed is dry, however, for part of the year, the water sinking soon after leaving the mountains, and appearing about 2 miles above its mouth."	Snyder 1905: 329
Coyote Creek, Guadalupe River, Stevens Creek, and other Santa Clara Valley streams	Emphasizes that all streams in the Valley are intermittent and specifies some perennial reaches. Explains that lower reaches of streams extending to the Bay are perennial because they intercept the groundwater. Specifies Coyote and Guadalupe downstream of San Jose, and the lower reach of Stevens Creek as well as others, (some of the streams were extended across the valley floor by this time). Also notes that Coyote is perennial a short distance from the mouth of the Canyon (upper gorge).	1924	I/P	"All the streams in Santa Clara Valley are intermittent. Their courses through the valley are usually dry from four to eight months of the year, and occasionally water flows throughout their length for only a few days in the year or perhaps not at all." "Some of the stream channels have been cut down to the normal ground-water level in the lower lands and hence have practically perennial streams in their lower courses. Thus the lower stretches of Coyote Creek, Guadalupe Slough, Stevens Creek, and others carry water except in the very driest seasons. Coyote Creek and Guadalupe Slough may be considered perennial streams from San Jose to the bay. There is usually water flowing at the mouth of the upper gorge of Coyote Creek which disappears almost immediately on reaching the valley, but water reappears in the vicinity of San Jose."	Clark 1924: 51,18-19

TABLE IV-3. HISTORICAL EVIDENCE FOR PERENNIAL AND INTERMITTENT STREAM REACHES

Conditions have reversed today. Most of the stream exhibits perennial flow (Cloak and Buchan 2001). This change has resulted from at least three factors: summer releases from Coyote Reservoir, Anderson Reservoir, and smaller dams; urban runoff, which provides a new source of summer water through 68 storm drains emptying into the creek (Cloak and Buchan 2001); and the increased present-day connectivity of the watershed, which helps deliver urban runoff and shallow groundwater to the Coyote mainstem instead of percolating downward. Environmental improvement efforts have also focused on increasing perennial flow. A Cold Water and Fish Management Zone was recently established by the Fisheries and Aquatic Habitat Collaborative Effort to increase perennial flow below Anderson Dam. The zone largely matches the historically perennial reach, but does appear to extend a mile or more farther downstream. There is also consideration of extending perennial stream flow farther downstream, for the several additional miles through Coyote Valley (FAHCE 2003).

Direct evidence for other creeks in the watershed is less forthcoming, but Mexican-era maps indicate that both Silver and Thompson Creeks were considered "*Arroyo Seco*," indicating that they were seasonally dry. These data affirm the general pattern suggested by Snyder (1905) and Clark (1924), that most creeks were perennial only a short distance from their canyon mouth, at most (**TABLE IV-3**).

It should be noted, however, that intermittent stream reaches, observed to be "dry" or "*seco*" in the summer, can nevertheless maintain subsurface flow and pools with important ecological values. Stream reaches that were historically summer-dry can still become even drier, especially with decreased groundwater levels. In work on a subwatershed of Napa River, Sulphur Creek, we found strong evidence for decreased size and persistence of pools in recent decades, with fewer observed steelhead, even though the stream was historically intermittent (Grossinger et al. 2004). This evidence can often be obtained from interviews with local longtime residents, but because of the time-intensive aspect is most practical at the subwatershed scale.

SEASONAL DISTRIBUTION

The increase in summer flow, and a concurrent reduction in flow during the winter months, can be seen in the dramatically different monthly distribution of runoff before and after the construction of Coyote Reservoir in 1936 (**FIGURE IV-27**). For example, during 1936-1987 summer flow in October was nearly half (43%) the February flow, whereas during the previous three decades (prior to flow regulation), October flow averaged less than 1% of February. These data from the USGS gauging station near Madrone (near the Highway 101 crossing in Coyote Valley) reaffirm naturally intermittent conditions through most of Coyote Valley.

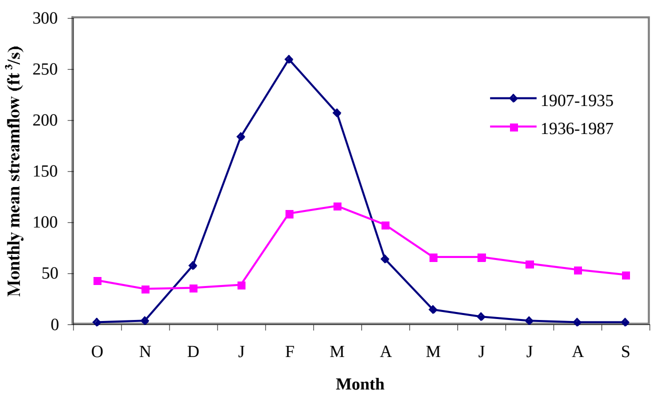


FIGURE IV-27. CHANGE IN MONTHLY RUNOFF DISTRIBUTION FOR COYOTE CREEK. Since the construction of Coyote Dam in 1936, the creek has received reduced winter flows and greatly increased summer flows. Gauge location approx. 1.2 mi. downstream of Anderson Dam and 1 mi. upstream of Highway 101 crossing.

HIGH FLOWS

As is standard in watersheds with significant water reservoirs, peak flows on Coyote Creek have been reduced significantly. For example, while flood flows of 25,000 cfs have been estimated in the past century (1911, Duryea, et al. 1977), the current "planning flood" is 14,500 cfs (Kevin Sibley, personal communication).

RIPARIAN HABITAT

Trends in riparian habitat along the alluvial stream reaches of the Coyote Creek watershed are diverse and spatially heterogeneous. In nearly all places, habitat character and extent has been dynamic under Euro-American management, primarily in response to changes in channel morphology and hydrology.

We observe five general types of change in riparian habitat:

- Complete loss of riparian habitat, where channels have been filled or replaced by artificial channels.
- Reduction in the lateral extent of riparian habitat area along many broad Coyote Creek channel reaches.
- Apparent recovery of narrow riparian forests from historical impacts, with some potential "overgrowth."
- Establishment of riparian tree cover along a few, but not most, engineered channels.
- Conversion of open riparian habitats (e.g. savanna, scrub, gravel bed) to dense forest.

In general, there has been a major expansion in the density of riparian trees in most persisting riparian areas during the second half of the 20th century. This trend, noted by Cloak and Buchan (2001), occurs in a variety of settings. In some places that had dense riparian forest under natural conditions, we may well be observing recovery to more natural habitat structure. But reduced disturbance by high flow events and increased summer stream flow is undoubtedly also causing excessive riparian growth in places. The expansion in riparian growth is particularly noteworthy in the broad riparian areas along Coyote Creek, where significant habitat conversion has taken place.

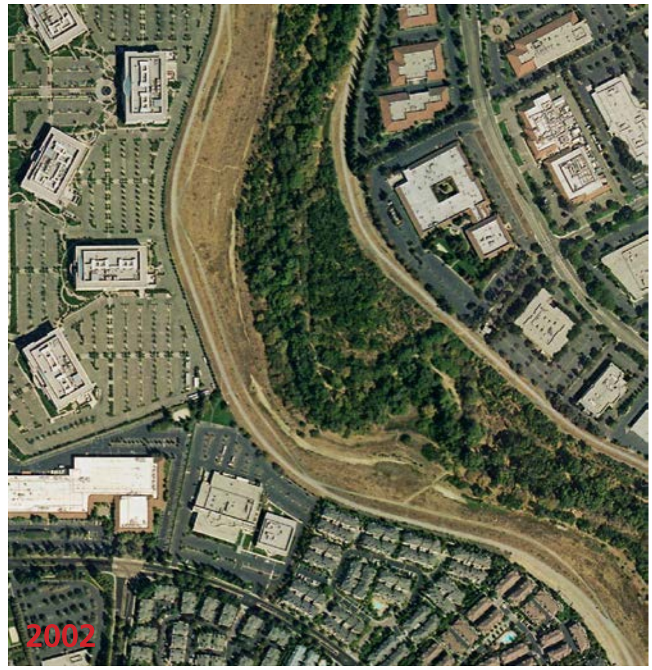


FIGURE IV-28. RIPARIAN RECOVERY ON LOWER COYOTE CREEK BETWEEN 1939 (LEFT) AND 2002 (RIGHT). Location immediately upstream of Tasman Drive (AAA 1939; 2002 Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

Coyote Creek has been considered to have one of the best-preserved riparian corridors in the region, with much of its riparian corridor "intact" (Cloak and Buchan 2001: 24). Along a significant portion of the creek this is true, and appears to result significantly from recovery in recent decades. On Lower Coyote Creek, where farmers willingly contributed streamside land for the SCVWD's 1996 flood protection project (Fiedler personal communication), there is, in fact, substantially more area dedicated to the stream in places than there was in 1939, and riparian forest has grown accordingly (**FIGURE IV-28**). At the same time, however, 20th-century changes in riparian habitat have greatly altered habitat values along much of the creek. Furthermore, these major ecological changes have not been well recognized because of the lack of historical analysis. As a result, there are a number of ecological functions that could be restored to benefit native species and habitats.

Because there is no existing map of present-day riparian habitat, this assessment must be qualitative. However, recent reports by the Santa Clara Valley Urban Runoff Pollution Prevention Program (Cloak and Buchan 2001, Buchan and Randall 2003) provide extensive and valuable information about present-day conditions. Now that historical riparian habitat patterns have been established, focused assessment to gage current conditions in the context of historical evidence, particularly age and species distribution, would be very useful for documenting trends and resulting management options.

RIPARIAN LOSS

Riparian habitat along the many creeks that have been filled or replaced by artificial channels has been lost. Nearly one quarter (22%) of the historical "tributary" (non-Coyote) streams of the valley floor no longer exist or have been converted to artificial channels. These creeks can be seen in the map of drainage change (see **FIGURES IV-7A** and **IV-7B**) and include a number of the smaller creeks of the watershed as well as some larger ones. Graphic examples are illustrated in **FIGURES II-13** and **II-20**. These smaller, discontinuous creeks may have had naturally sparse tree cover in places, but they were presumably lined by a distinctive herbaceous and shrub riparian plant community. Lower Penitencia Creek supported one of the few low gradient, sinuous,

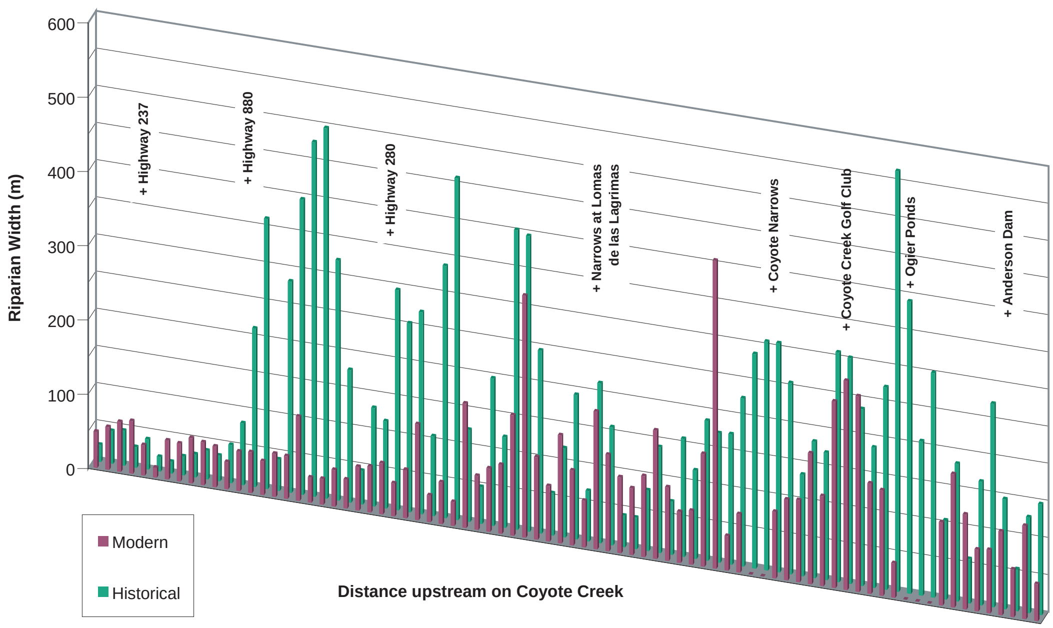


FIGURE IV-29. HISTORICAL CHANGE IN COYOTE CREEK RIPARIAN AREA WIDTH. This graph illustrates the variation between narrow and broad channel reaches along the creek under historical conditions (green bars). Comparison with the modern data (red bars) shows how streamside impacts also vary substantially along the creek. The Coyote Creek Golf Club area shows up as an important reach that has maintained broad riparian function. Reaches immediately above and below, where the channel flows through large ponds, have no effective riparian width and represent restoration opportunities.

dense riparian forests in the watershed — which was removed with conversion to an engineered channel.

Riparian habitat has also been lost along a significant portion of Coyote Creek. The creek's natural form, with a wide gravelly bed and broad benches deeply entrenched below the adjacent valley floor, has been remarkably effective at precluding immediate development, slowing adjacent land use enough to allow conservation of a substantial portion of the channel width. However, gravel ponds, percolation ponds, commercial development, freeway overpasses, city dumps, recreational park features, and housing have nevertheless encroached upon the channel in a number of places, reducing riparian habitat extent. The assessment in previous reports that Coyote Creek's "middle terrace has managed to survive, dominated by cottonwoods, with few remaining oak and sycamore trees" (Cloak and Buchan 2001:24, WMI 2003: 7-139) is substantially accurate in that riparian habitat has survived here more than in most places, but there has been significant reduction and extensive alteration to much of the surviving habitat. There does not appear to have been high terrace (valley floor) riparian forest in the mid-Coyote reach.

To assess this trend in the absence of present-day mapping, we compared the width of Coyote Creek's riparian area as mapped from historical data and present-day data at 2000 foot intervals along the creek (**FIGURE IV-29**). We used a variety of related indicators to define riparian extent, including riparian vegetation and evidence of recent channel scour, gravel deposition, or flooding from historical data and modern aerial photography. For the Mid-Coyote reach, we were able to use a survey of "top-of-bank," which corresponded closely to visible riparian habitat (SCVWD 2003). While this assessment is limited in precision by the lack of field verification, it provides a general illustration of the reduction of active riparian area along the creek. This reduction is most extreme closer to downtown San Jose and in certain Coyote Valley reaches heavily impacted by gravel or percolation ponds. The reaches upstream and downstream of Ogier Ponds stand out as maintaining historical riparian width. Lower Coyote Creek has maintained or expanded its immediate riparian habitat, although this does not include the reduction in frequently-accessed riparian habitat on former overflow channels, which was lost relatively early.

Conversely, the naturally narrow reaches of Coyote Creek have largely persisted, or recovered. The narrow riparian corridor observed along much of lower and middle Coyote Creek is thus not the result of loss due to urbanization (Buchan and Randall 2003: 46), but in fact reflective of natural condition.

RIPARIAN RECOVERY

Comparative photograph analysis — using both aerial and ground-based images — reveals a number of sites where riparian forest cover along narrow stream reaches has increased. In these places, a sparse corridor of scattered trees and shrubs observed in the late 19th century or first half of the 20th century has become much more dense and continuous tree cover. It is likely that at least some of this riparian expansion represents recovery to more natural conditions after historical impacts from grazing and agriculture, followed by more recent protection from these immediate land use effects. Also, the 1939 aerial photography reflects two decades of unusually low cumulative rainfall — the "Dust Bowl" conditions of the 1920s and 1930s — which may have exacerbated land use effects. Riparian expansion has probably been facilitated by the wetter winters of the last three decades of the 20th century (**FIGURE IV-30**; Poland and Ireland 1988:15-18, Millar and Woolfenden 1999, McKee et al. 2003), but does not appear to be purely a climatic response. For example, in **FIGURE IV-31**, obvious land use-caused gaps in riparian habitat visible in 1939 have filled in substantially since that time. SFEI (2001) observed similar urban riparian recovery during the second half of the 20th century along Wildcat Creek in Contra Costa County. These local examples fit the observation of Leopold (2004: 9) that the return of riparian vegetation helped initiate a "state of healing" on many channels in the western United States beginning in about 1950.

This trend on narrow stream reaches is illustrated in **FIGURE II-20** (right), **FIGURE III-3**, **FIGURE III-10** (left), **FIGURE II-14**, **FIGURE IV-14** and **FIGURE IV-32** (lower middle). Increased streamside land dedicated to riparian habitat since 1939, and associated riparian habitat expansion, can be seen in **FIGURES IV-28** and **IV-31**. **FIGURE IV-32**

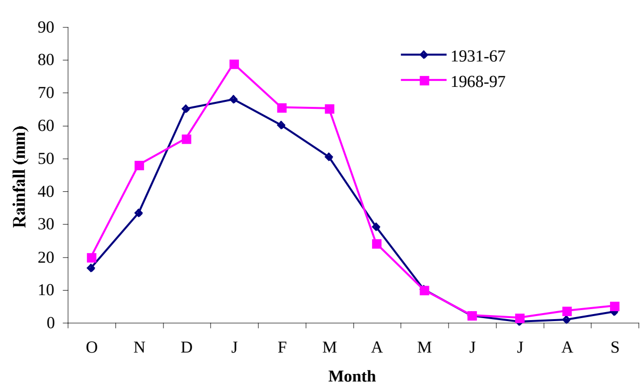


FIGURE IV-30. CHANGE IN MONTHLY RAINFALL DISTRIBUTION FOR SAN JOSE. Average rainfall in the last three decades of the 20th century was greater than the previous decades. Graph from McKee et al. (2003).

FIGURE IV-31. RIPARIAN RECOVERY ON UPPER PENITENCIA CREEK BETWEEN 1939 (LEFT) AND 2002 (RIGHT). The gaps in riparian forest visible in 1939 (AAA 1939), presumably the result of adjacent agricultural practice, have substantially filled in the subsequent years (2002 Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

shows a naturally narrow reach of Coyote Creek along Coyote Road in 1896, 1939, 2002, and 2005 with both aerial and landscape views. Riparian cover has clearly expanded, with mature native tree species, in comparison to the earlier images.

Since riparian habitat is not one of the features mapped precisely by most 19th-century maps, the assessment of pre-modification condition requires some inference and associated uncertainty. Based upon the local history, we would, however, expect to see some reduction in riparian tree cover during the 19th and early 20th centuries — as a result of wood cutting, unregulated grazing along streams and expansion of agriculture adjacent to streams. The impacts of these activities, while likely significant, do not appear to have been extreme. Extensive riparian forest can be seen adjacent to and contemporary with these land use practices throughout this time period — riparian trees were clearly not subject to wholesale clearcuts (see following section).

But many reaches do appear notably sparse in 1939 aerial photography, when compared to 19th-century descriptions, and there are some obvious gaps. So it is probable that the conversion of lands previously used for agriculture, grazing, firewood, and lumber to urban areas has (while having other, negative effects on streams) has effectively buffered the surviving stream reaches from direct impact. Similar "protection" of trees by urban growth has been noted for valley oaks because of reduced seed and seedling predation (Holstein 1999: 56-57).

Given the demonstrable conversion of open riparian habitat to dense cover discussed below, it should be considered to what extent the expansion of riparian cover has been excessive. Increased riparian tree density is a standard response to decreased scour by flows and increased summer water (Kondolf 1996, White & Greer 2006). Cloak and Buchan (2001: ES8) note that expansion of riparian vegetation can result in armored banks, reduced channel width, and channel incision. Excessive tree fall has been reported as a problem in some reaches (Anonymous, pers. comm.), a potential result of riparian overgrowth and incision.

FIGURE IV-32. CHANGES IN COYOTE CREEK RIPARIAN HABITAT ALONG COYOTE ROAD BETWEEN 1896 AND 2005. This set of photographs investigates riparian changes using both aerial and ground-based photographs. As shown in the 1939 photograph (upper left; AAA 1939), the northern half of this reach was broad and characterized by scattered trees. In the southern portion, lines of riparian trees followed a narrow channel, with some gaps. The 1896 photograph of the Swickard property (lower left; from Shortridge 1896, courtesy History San José) appears to have been taken at the point marked on the aerial photographs, looking south along the narrow channel reach. This view also shows gaps in riparian trees. The 2002 (upper right; Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved) and 2005 (lower right) views demonstrate increased riparian cover, and the expansion of dense riparian forest into the former open sycamore woodland habitat to the north.

However, the expansion of riparian trees along narrow channel courses has taken place along not only regulated streams such as Coyote, but also smaller creeks unaffected by dams and, in some cases, largely upstream of urbanization. **FIGURE II-14** shows expansion of riparian cover on unregulated Thompson Creek, while the lower portion of **FIGURE II-20** demonstrates riparian expansion on Quimby Creek clearly unrelated to flow regulation or hydromodification.

In light of the historical data and the functional importance of riparian habitat, some field assessment should be initiated to determine age class distribution and current trajectories of riparian habitat change. Selected sites should be assessed with more detailed sequential aerial photographic analysis and monitored for future change.

RIPARIAN CONVERSION

As discussed above, the observed expansion of riparian tree cover along narrow stream reaches in the watershed appears to be largely a natural adaptive phenomenon, based upon observation of unregulated streams and filling in of riparian gaps during the past 50-75 years. However, along the broad reaches of Coyote Creek, riparian expansion clearly represents the conversion of one type of riparian habitat to another, with a wide range of associated effects.

The development of dense riparian forest in reaches that had relatively little tree cover circa 1939 can be seen especially in **FIGURES II-19**, **III-12**, **III-20**, and **III-26**.

Similar riparian colonization of a constructed channel that replaced a naturally wide, braided channel with the open riparian canopy has been documented over the same general time period on Sulphur Creek in Napa County (Grossinger et al. 2004).

In **FIGURE II-19**, a broad channel area in 1874 supports large willow thickets on the left and several narrow, noncontinuous strands of riparian vegetation along the main channel. By 1939, the willow area has been reclaimed for agriculture (apparently with only marginal success) and riparian vegetation is beginning to closely follow the more confined channel. In 2002, the channel has been realigned and fully confined within levees; riparian trees have substantially colonized the altered channel.

As discussed in **PART II**, early aerial photography, mid-19th-century surveys, and extensive descriptive evidence confirm the open character of riparian habitat along the broad reaches of Coyote Creek, from approximately Tully Road to the upstream Highway 101 crossing. In those areas where there was not intensive manipulation, open riparian woodland/savanna conditions persisted through 1939. Most of the riparian conversion has taken place since then.

The expansion of riparian cover is probably mostly due to changes in hydrology, with the added effects of artificial channel confinement in some reaches. Increases in summer flow due to reservoir releases and urban runoff favor expanded riparian growth. Decreased winter high flows reduce disturbance and restrict natural riparian successional processes, favoring increased riparian recruitment and the persistence of older vegetation. Increased rainfall in the second half of the 20th century also favors the expansion of riparian vegetation.

A shift in dominant riparian tree species supports this interpretation. Historically, sycamores were widely noted along Coyote Creek while cottonwoods were barely mentioned. For example County Surveyor Charles Healy, in his descriptive report for the County to the Surveyor General (1857), writes that

> "The sycamore also grows to a great height along the banks of the creeks. The cotton-wood, willow, and other trees of like species, are found in wet places, and along the small streams."

While the intermittent conditions historically present along Coyote Creek supported sycamores, cottonwoods — previously limited to the few perennially wet reaches — dominate the channel today (Cloak and Buchan 2001: 24). Jepson (1910: 187, 249) notes that the two species occupy almost identical habitats — "the beds or on benches of flood streams" — but that Fremont cottonwood is restricted "almost exclusively [to] the beds or on the banks of ever-flowing streams." A shift from sycamore to cottonwood would be expected effect of the conversion of a semiarid, intermittent stream to perennial flow.

The least amount of riparian conversion has taken place in the historically intermittent reaches in Coyote Valley, north of the upstream Highway 101 crossing, specifically the few reaches that have not been impacted by gravel mining and percolation ponds. The reaches on either side of Ogier Ponds probably represent the closest present-day examples of Coyote Creek's predominant natural character (see **FIGURES III-25**, **III-26**, and **III-35**). The unvegetated gravel bed surfaces and widely spaced riparian trees, with occasional linear strands of dense riparian forest along one bank, are representative of former conditions along much of the creek and have been noted in statewide surveys for such sensitive or noteworthy habitats (see **PART II**).

Enhancement of this reach may be important, given continuing effects of flow regulation and gravel/percolation ponds. The reach is likely sediment starved and its long-term health may be affected by reduced high flows and increased summer flows. Sawyer and Keeler-Wolf (1995: 1) identify "intermittent flooding over broad floodplains and a stable subterranean water table during the dry summer months" as necessary conditions to perpetuate the sycamore alluvial woodland community. Restoration and enhancement goals should be calibrated with an understanding of these natural communities and processes.

Recent assessments of Coyote Creek have noted the challenge of evaluating conditions in the absence of historical analysis (Buchan and Randall 2003: 148). In fact, the historical analysis presented here does help explain the current conditions in new and significant ways. For example, the general decrease in riparian vegetation with upstream extent along Coyote noted by Cloak and Buchan (2001: 62) actually reflects that upstream conditions are closer to the natural, pre-modified state. Decreased canopy cover in Coyote Valley had been speculated to be the result of reduced stream flow caused by upstream water diversion. Accordingly, increased flows and canopy cover have been recommended (Buchan and Randall 2003: 106-

HABITAT	ACREAGE	ESTIMATED ACCURACY
Tidal Flat	1,300	H[1]
Tidal Marshland	10,000	H[1]
Wet Meadow[2]	7,500	H
Saltgrass-Alkali Meadow	4,000	H
Perennial Freshwater Wetlands, incl. Seasonal Lakes	800	M
Perennial Freshwater Ponds	20	M
Willow Groves	400	M
Sycamore Grove	200	M
Valley Oak Savanna	15,000	M
Dry Native Grasslands	29,000	M

[1] Measurement is precise, but boundary of marshland area associated with Coyote Creek could be defined differently. [2] Not including saltgrass-alkali meadows.

TABLE IV-4. ESTIMATED HISTORICAL HABITAT ACREAGES FOR THE COYOTE CREEK STUDY AREA. Areas based upon the GIS map describing the valley floor portion of the Coyote Creek watershed circa 1800. Certainty levels: H,+/-10%; M, +/-50%.

107). In the context of historical data, we might actually consider perennial flows to be a limiting factor to native habitat in this reach. The Coyote Diversion Dam, while having other negative impacts, appears to protect the northern Coyote Valley from excessive summer flows caused by reservoir releases.

This interpretation based upon historical analysis is supported by present-day assessment of fish assemblage. Buchan and Randall (2003: 106) found notably higher fisheries community function in this reach compared to downstream reaches. They hypothesized that the highly native community benefited from fewer pools and common summer dryback, conditions that favor native fish species over non-natives (which are generally less well-adapted to these local conditions). The cessation of diversions to the Coyote Canal since 1998, while generally assumed to have positive effects, should be considered for potentially negative effects on these native fish and riparian communities by increasing summer flow.

WETLAND HABITAT

The extent of native wetland habitats has been reduced in the extreme, primarily as result of increased drainage and urbanization. At the same time, however the bottomlands, where most wetlands were located, have been developed more slowly, because of their poor drainage. Furthermore, clay soils tend to persist (although buried in places). As a result, there are still significant opportunities for wetland restoration associated with some of the less intensively developed areas of the bottomlands. There remains potential to restore some of each of the Valley's native wetland habitat types, including wet meadow, alkali meadow, willow groves, perennial freshwater wetlands and ponds (**TABLES IV-4** and **IV-7**). There is also potential at several noteworthy sites to establish functional mosaics of these habitats, according to the templates described later in this chapter.

NATIVES SPECIES SUPPORT FUNCTIONS

The reconstruction of native habitat types, distribution, and abundance presented in this report provides an important element for prioritizing and designing projects to support native species (Collins and Montgomery 2002). Conservation plans are often hindered by lack of information about historical species distribution to guide the definition of "good habitat" and identification of opportunity zones for restoration. Native habitats, supported by natural hydrogeomorphic processes, often provide a wider range of required species support functions than the more artificial habitats currently available. Identifying "missing" habitat types thus can create previously-unrecognized environmental management opportunities.

This section discusses some of the implications of the historical landscape analysis on native species recovery efforts. It is not intended as an exhaustive assessment of the historical or present status of all species of concern within the watershed. Rather, this section highlights some of the opportunities suggested by the historical analysis. These implications provide a starting point; they should be reviewed, expanded, and adjusted by experienced local ecologists to integrate this information with understanding of present-day populations, non-native species, and other relevant data.

CALIFORNIA RED-LEGGED FROG

The historical landscape mapping may help explain the historical distribution of the California red-legged frog (*Rana aurora draytonii*) in the Santa Clara Valley. At the height of the California frog industry, Santa Clara County was the leading county for supplying red-legged frogs. In 1895, the popularity of red-legged frog legs in San Francisco cuisine drove a Santa Clara harvest of nearly 8000 kg, representing over 40,000 frogs (Jennings and Hayes 1985). However, to date, there has been no direct evidence of the specific habitats from which these large harvests were taken (Jennings personal communication).

The habitat type most widely recognized for red-legged frog harvest in California was the floodplain marshes of the Sacramento and San Joaquin Valleys (Chamberlain 1898 *in* Jennings and Hayes 1985). Santa Clara County, with mostly seasonal streams, did not have broad riverine floodplains with perennial ponds, but did have at least two types of functionally similar habitat. First, the freshwater and slightly brackish tidal marshlands along the Penitencia-Coyote-Guadalupe tidal interface would have provided surface waters likely suitable for breeding. Research at Pescadero Marsh has shown that the species can successfully reproduce with slight saline influences (Jennings personal communication). Secondly, the large freshwater wetland complexes at Laguna Socayre and Laguna Seca likely provided good-quality habitat. Photographs and written descriptions document perennial ponds at Laguna Seca, while Healy (1861) and Schneider (1893) describe similar small perennial water bodies in the Laguna Socayre complex. Surrounded by open grassland habitat, these were likely ideal red-legged frog habitat. Laguna Seca, with its potential for wetland restoration, may provide a significant opportunity for recovery of original habitat for the species.

FISH HABITAT AND ASSEMBLAGES

The restoration and conservation of native fish populations in the Santa Clara Valley is an important natural resource goal. Setting management targets for the restoration of native stream fishes requires an understanding of historical reference conditions. However, there remain

HABITAT	EXAMPLE (S)	PROBABLE FISH ASSEMBLAGE[1]
Fresh and brackish tidal channels	Tidal reaches of Lower Penitencia Creek, Coyote Creek, and artesian sloughs and the tidal marshlands downstream from these freshwater sources	White sturgeon, thicktail chub, Sacramento blackfish, Sacramento splittail, Sacramento sucker, longfin smelt, threespine stickleback, prickly sculpin, Pacific staghorn sculpin, Sacramento perch, tule perch, shiner perch, longjaw mudsucker, starry flounder
Shallow, sinuous, well-wooded perennial lowland stream reaches	Lower Coyote Creek, Lower Penitencia Creek (?)	Pacific lamprey, western brook lamprey, thicktail chub, Sacramento blackfish, hitch, Sacramento splittail, Sacramento pikeminnow, Sacramento sucker, Chinook salmon (?), threespine stickleback, prickly sculpin, tule perch
Well-wooded, perennial stream reaches immediately downstream from the canyon mouth	Coyote Creek immediately below Anderson Dam, Upper Penitencia Creek (?)	Pacific lamprey, thicktail chub, hitch, California roach, Sacramento pikeminnow, Sacramento sucker, Chinook salmon (?), rainbow trout/steelhead, threespine stickleback, prickly sculpin, Sacramento perch, tule perch,
Distributary streams terminating in seasonally flooded lowland habitats	Upper Penitencia Creek, Berryessa Creek	Rainbow trout/steelhead, Pacific lamprey, California roach, Sacramento sucker, threespine stickleback, prickly sculpin, riffle sculpin (Upper Penitencia Creek only)
Distributary streams terminating in relatively dry habitats a mile or more from a mainstem channel	Calera, Norwood, Babb Creeks	Resident rainbow trout, California roach, threespine stickleback, prickly sculpin
Seasonally-flooded bottomland habitats	Perennial ponds, seasonal lakes, freshwater marshes, and wet meadows throughout the valley floor; Laguna Seca	Thicktail chub, hitch, Sacramento blackfish, Sacramento pikeminnow, Sacramneto sucker, prickly sculpin, Sacramento perch, tule perch
Broad, seasonally dry channel beds with scattered persistent, shaded pools	Coyote Creek from ~Tully Road through Ogier Ponds	Thicktail chub, hitch, California roach, Sacramento blackfish, Sacramento pikeminnow, speckled dace, Sacramento sucker, prickly sculpin, threespine stickleback, Sacramento perch, tule perch
Perennial, shaded upper watershed riverine habitat	Arroyo Aguague, San Felipe Creek	Coho salmon (?), steelhead/rainbow trout, Pacific lamprey, California roach, Sacramento sucker, riffle sculpin

[1] the probable fish assemblages members could occur in any combination, not necessarily all members would be present at any given site.
Leidy et al. 2005a,b; Leidy 2004; Gobalet et al. 2004; Buchan et al. 1999

TABLE IV-5. PROBABLE HISTORICAL HABITAT-FISH RELATIONSHIPS IN THE COYOTE CREEK WATERSHED.

substantial questions about the distribution of fish species under natural conditions and therefore, about which species may be appropriate restoration targets (Leidy et al. 2005a,b, Buchan and Randall 2003).

WHICH SPECIES LIVED WHERE?

The diverse channel morphology and riparian habitat types within the Coyote Creek watershed historically provided habitat for a diverse array of fish species. Specific life history requirements limited each species to a distinct subset of the aquatic habitats within the watershed. The understanding of habitat characteristics developed in this study provides an environmental framework for predicting associated species assemblages. We developed a set of fish habitat relationships based on this information and the strong data set of historical records of fish in the watershed. Such an approach has been used to assess the historical distribution of native fishes in Estuary streams, including Coyote Creek (Leidy et al. 2005a,b, Gobalet et al. 2004, Leidy 2004, Buchan et al. 1999). Native fish assemblages associated with major habitat types in the watershed are summarized in **TABLES IV-5**. Supporting evidence is listed in **APPENDIX 1**.

In the lowest part of the watershed, perennial stream flows created freshwater-influenced tidal conditions similar to (albeit with lesser spatial extent) the northern San Francisco Estuary and Delta, and supporting many of the same fish species. Fresh-to-brackish conditions persisted in and along the tidal channel networks radiating from freshwater sources such as Penitencia Creek, Coyote Creek, and Guadalupe River, as well as the smaller, spring-fed sloughs between Coyote Creek and Guadalupe River. Freshwater tidal conditions also extended upstream along these few creeks that reached the Baylands interface. Thus the lowest reaches of Penitencia Creek, Coyote Creek, and the artesian sloughs also provided estuarine conditions with freshwater influence. These tidally-influenced areas offered shifting patches of habitat influenced by complex seasonal and annual changes in the salinity gradient, as affected by fluvial and spring discharges, tidal cycles, and total watershed outflow.

A number of species have been documented from these tidal freshwater environments on Coyote Creek, including Sacramento splittail, Sacramento perch, tule perch, white sturgeon, thicktail chub (now globally extinct), Sacramento sucker, longfin smelt, juvenile (rearing) and adult (migrating) salmonids, threespine stickleback, prickly sculpin, starry flounder, and staghorn sculpin. **APPENDIX 1** provides these references.

With planned tidal marsh restoration and significant present-day treated wastewater discharges near the mouth of Coyote Creek (and noting the challenges with native fish recovery in the Delta), restoring native brackish tidal marsh habitat and associated fish assemblages in the Coyote Creek delta would be a goal of regional significance.

The Coyote Creek watershed also had a lowland river component not dissimilar in microcosm to Central Valley streams. Downstream of approximately Trimble Road, Coyote Creek and probably Penitencia Creek were shallow, slow-moving perennial streams with mostly continuous riparian canopy (illustrated in **FIGURES III-4** and **III-11**). Lowland non-tidal riverine and brackish-tidal fish species occupied these sinuous, shaded reaches that comprised several miles of habitat. Species likely include Pacific lamprey, western brook lamprey, thicktail chub, Sacramento blackfish, hitch, threespine stickleback, Sacramento splittail, Sacramento pikeminnow, Sacramento sucker, prickly sculpin, Sacramento perch and tule perch. Based upon the habitat conditions, it is possible that Chinook salmon spawned in low-gradient riffle habitats here, although, to date, we have found no specific evidence for that historical use.

Coyote Creek also supported a perennial reach with relatively dense riparian canopy for several miles downstream from the canyon mouth (i.e. downstream of the present-day location of Anderson Dam). Species likely found in this reach include Pacific lamprey, thicktail chub, California roach, Sacramento pikeminnow, Sacramento sucker, rainbow trout, threespine stickleback, prickly sculpin, Sacramento perch, and tule perch. It is possible that this relatively small area may have had some value for Chinook in some years, although there is no specific evidence of this. Perennial, shaded reaches of the upper watershed, such as San Felipe Creek, likely provided high quality habitat for coho salmon and steelhead/rainbow trout.

We would not expect the braided reaches of Coyote

Creek — with intermittent flows and limited riparian cover (illustrated in **FIGURE III-22**), to have provided reliable habitat for salmonids except as a migratory corridor for juvenile and adult fish. However, it is likely that persistent pools of varying depths, partially maintained by zones of shallow groundwater discharge, were found at intervals along the creek (as noted by Day (1854: 514) near the present day Cottonwood Lake). These reaches had occasional dense riparian forest stands, as is affirmed by patches of willows and cottonwoods noted by expeditions in 1774 (Brown 2005: 17), and riparian forest stands visible in early aerial photography. These sites probably constituted important refugia for a distinctive fish assemblage of up to eleven species associated with braided channel streams. As stream reaches dried, fish would likely persist in the deeper, permanent pools. Fish species found within pool refugia may have included thicktail chub, hitch, California roach, Sacramento blackfish, Sacramento pikeminnow, speckled dace, Sacramento sucker, threespine stickleback, prickly sculpin, Sacramento perch, and tule perch (Leidy 2004).

The discontinuous nature of fluvial channels throughout much of the Valley may have precluded access by salmonids to some of the smallest creeks of the watershed during recent climatic regimes. Discontinuous creeks that terminated a mile or more from a mainstem channel or the Bay, with extensive dry land habitats in between, may not have supported consistent salmon or steelhead runs. These include many of the smaller creeks of the Diablo Range (e.g. Calera, Norwood, Babb). However, some of these creeks with suitable headwater habitat may have supported resident populations of rainbow trout that colonized during wetter epochs when fluvial connections to the mainstem channel or Bay may have been stronger.

Another class of streams had discontinuous channel connections to the Bay, but came farther down onto the valley floor. In these cases, the distributary point and the Coyote mainstem channel were separated only by a series of closely connected, occasionally flooded marshes and wet meadows. Streams entering the valley floor relatively close to the Bay, such as Penitencia Creek, Berryessa Creek, and perhaps Arroyo de los Coches, fit this category. The intervening wetland habitats probably provided little barrier to steelhead, which could persist in the upper watershed as resident rainbow trout in years when downstream flooding and ponding did not occur. These streams probably did not provide habitat suitable for coho and Chinook salmon.

In the case of historically discontinuous streams, recent human development of a continuous channel connection likely improved access to some streams for steelhead, Chinook salmon, and possibly coho salmon. For example, it is not unlikely that the 1852 diversion of Penitencia Creek into Coyote Creek while depriving the downstream freshwater wetlands and Lower Penitencia Creek of overflow, established a new corridor for salmon to reach the high-quality habitat on Upper Penitencia Creek. Thompson and Silver Creeks, with 8-10 miles of meadows between their distributaries and the initiation of the continuous Lower Penitencia Creek channel, probably supported only marginal steelhead runs and resident populations of rainbow trout. Smaller tributaries with discontinuous connections to the main channel and Bay likely also supported Pacific lamprey, California roach, Sacramento sucker, threespine stickleback, and prickly sculpin.

With more frequent connection historically between fluvial channels and their floodplains, a distinct fish assemblage would have followed spreading surface waters to forage in the bottomland floodplain habitats. Species such as thicktail chub, hitch, Sacramento blackfish, Sacramento splittail, Sacramento pikeminnow, Sacramento sucker, prickly sculpin, Sacramento perch, and tule perch would have benefited from seasonal access to the freshwater marshes, seasonal lakes, and wet meadows of the valley floor.

Native fishes also undoubtedly used Laguna Seca. The same assemblage described above for large lowland floodplain habitats would also likely have used the aquatic habitats available here at this wetland complex (illustrated in **FIGURES II-11** and **III-29**), especially tule perch, Sacramento perch, thicktail chub, Sacramento splittail, Sacramento blackfish, Sacramento pikeminnow, hitch, and prickly sculpin.

Given their threatened status, the societal focus on salmonid species for conservation actions is well-justified. However, much of the Coyote Creek watershed currently provides suitable habitat for a range of other important native species, and other stream reaches have the potential to be enhanced and restored to benefit native fishes other than salmonids. The habitat requirements for these lowland and estuarine species may be more sustainable restoration targets for much of the Coyote Creek channel than classic perennial, shaded river conditions typically favored by salmonids (that, in many places, may never have existed).

A vision for stream fish in the Coyote Creek watershed based on natural habitat support functions could include: (1) the restoration of brackish tidal sloughs; (2) restoration of several miles of shaded perennial riverine habitat at the top and bottom of the valley floor; and (3) the protection and management of scattered, large, persistent pool refugia with associated riparian forest segments along the remainder of Coyote Creek. Ironically, because of its rerouting into Lower Coyote Creek, Upper Penitencia Creek has probably increased in potential (over the discontinuous historical condition) as a resource for salmon and steelhead, with significant possibilities for improving access to habitat just downstream from the canyon mouth and upstream in the Arroyo Aguague subwatershed.

RESTORATION AND MANAGEMENT IMPLICATIONS

This section summarizes implications of the historical ecology study for restoration and management. First, we describe some of the ways that the historical analysis can be useful to management efforts. Then we briefly note several specific and noteworthy restoration opportunities. The final section summarizes key findings.

WAYS TO USE THE HISTORICAL ECOLOGY STUDY

Historical ecology often represents a new tool for environmental management, which, like any tool, can be misused or misapplied. When applied appropriately, interpretations of historical landscapes can be used in a number of different but related ways to advance environmental stewardship.

ESTABLISHMENT OF HISTORICAL LANDSCAPE CHARACTERISTICS AND REFERENCE CONDITION

This report has established historical landscape characteristics for the water-related features of the Santa Clara Valley draining to Coyote Creek, as well as initial information for some of the dry land features. Historical landscape conditions, when well understood, provide a technical basis for assessing the quality of present-day habitats and setting locally-calibrated restoration targets (National Research Council 1992, Hood and Hinton 2003). Without understanding the physical and ecological characteristics of fluvial features and habitats under relatively natural conditions, restoration has little technical basis. In the absence of a historical landscape perspective, restoration strategies and habitat goals are inevitably based only upon highly disturbed present-day conditions.

In highly modified landscapes like the Santa Clara Valley, a historical ecology study is important to establish reference conditions for monitoring and restoration. For example, the application of environmental indicators by the Santa Clara Valley Urban Runoff Pollution Prevention Program on Coyote Creek was limited by the lack of relatively natural, reference stream reaches downstream of Anderson Dam (Cloak and Buchan 2001). Similarly, a number of other recent studies have recognized the difficulty of interpreting present-day conditions without a well-developed historical data set. Recent reports on Santa Clara Valley streams calling for additional historical information to guide present-day technical assessment and recommendation include Buchan and Randall (2003), SCVURPPP (2003), PWA (2002), and GeoSyntec (2003).

FOUNDATION FOR A WATERSHED RESTORATION PLAN

Developing a picture of local historical conditions, and how they have changed through time, is a key element of creating region or watershed-scale restoration goals and strategies.

Regional historical analyses are increasingly being developed as foundation data sets for this kind of long-term environmental planning, including efforts for South Florida (McVoy 1996), Puget Sound rivers (Collins et al. 2003), Elkhorn Slough (Van Dyke and Wasson 2005), New England coastal marshes (Bromberg and Bertness 2005), and San Francisco Bay (Goals Project 1999). This historical ecology study establishes a foundation for integrated environmental management of the Coyote Creek watershed, addressing the interrelated processes of habitat creation and maintenance, flood protection, and water supply within a practical, local context.

The historical analysis establishes a framework upon which to set locally specific restoration goals. The identified restoration opportunities and landscape trajectories can now be evaluated in the context of local experience and expertise.

HISTORICAL LANDSCAPES PROVIDE NEW MANAGEMENT OPTIONS

Historical information does not mean that the historical condition is the way it has to be in the future. Historical landscape information provides a reference for interpreting present-day conditions and setting appropriate environmental goals. But it does not, by itself, dictate future scenarios. Changes in culture, land use, and climate mean that the historical landscape cannot be directly translated into the modern. Yet earlier landscapes coexisted with human activity for many centuries and were well-calibrated to local conditions, many of which persist or can be recovered. These landscapes can provide valuable lessons and inspiration for innovative environmental design today.

Living cultures continually incorporate elements of other cultures, including those of the past. Traditions, styles, and techniques of the past are reinterpreted as a source of both cultural innovation and constancy. Landscape history, when well-documented and broadly understood, can serve as a similar source of new ideas for the local landscape. Ecosystem components and management scenarios of the relatively recent past, now often forgotten, provide specific, local examples for present-day environmental challenges. These can come from any era in the local landscape history.

For example, the South Bay salt pond restoration effort is looking to the native-tended *salinas* of the tidal marshlands as natural analogues to the commercial salt ponds. Such features could potentially support some of the important native species now using the modern feature. Similarly, indigenous management of terrestrial fire regimes (with controlled burns) and willow groves (by coppicing), provide present-day stewardship models. Farmers' use of the constructed lower reaches of streams to strategically deliver sediment to the Baylands for reclamation constitutes a late 19th-century model for 21st-century wetlands restoration.

Historical analysis is also useful because it shows things we do not expect. For example, in a few places stream habitats appear to have improved or recovered during the past 75 years. These places should be recognized and studied for lessons that can be applied elsewhere. It is unlikely that we are going to reestablish the disconnected drainage system of the mid-19th century in full, but understanding the impacts of this change on downstream flood stage, groundwater recharge, sediment management, and channel stability leads us to look for places to strategically reintroduce elements of the natural function.

EXPANDED RESTORATION PALETTE

One of the results of aggressive management efforts of the 19th and 20th centuries has been the general homogenization of habitats (Collins and Montgomery 2002). Within a relatively small geography, Santa Clara Valley streams naturally exhibited a wide range of channel morphology, flow characteristics, riparian habitat, and wetland habitat. Today, much of that diversity has been lost. As a result, the apparent range of restoration alternatives has been reduced and replaced by "one-size-fits-all" models.

By identifying a wide range of native, local habitat types that were naturally present in different physical settings, the historical landscape offers managers an expanded "palette" for environmental restoration. This palette of ecological options often includes habitats – e.g. intermittent channels, sycamore alluvial woodland, alkali meadow – which may be more effectively sustained by current conditions than the previous, generalized targets of the past. It also includes unrecognized options for restoring threatened or endangered species. We can even see that some habitats in the watershed that have been considered artificially impacted (e.g. braided channel, brackish marsh), are actually closer to natural conditions than previously realized.

CONCEPTUAL FRAMEWORK OF LANDSCAPE TYPES

Landscape types provide a simple geographic framework for thinking about the spatial distribution of different watershed functions and the associated constraints and opportunities for environmental management. The framework integrates a range of complex physical and ecological factors – such as stream power, topography, soils, and groundwater interactions – in a relatively easy-to-understand concept. The five landscape types largely explain natural habitat distribution, landscape history, and current issues at a general planning scale, and provide a framework for understanding landscape patterns in more detail.

Some of the management strategies that can be targeted to different landscape types, or the interface between two types, are described in **TABLE IV-6**.

HABITAT REMNANTS

Initial fieldwork to test the historical mapping has revealed a surprising number of native habitat fragments within the watershed. These features, including remnants of the historical valley oak and sycamore groves, alkali meadow, riparian forest, and sycamore alluvial woodland have been sustained despite the surrounding land use changes. These fragments represent an important part of the natural and cultural heritage of the Valley. They also could be important places for habitat preservation and enhancement, as well as models for restoration of these habitats at other sites.

LANDSCAPE	ENVIRONMENTAL MANAGEMENT OPPORTUNITIES/CONSTRAINTS (SELECTED)
BAY	• maintenance of tidal channel capacity • Bay sediment supply • fluvial sediment supply
Interface	• tidal flat loss/development • shorebird habitat
BAYLANDS	• tidal marsh restoration • floodwater storage capacity • waterfowl habitat • endangered salt marsh species habitat • Bay and fluvial sediment supply
Interface	• fresh and brackish tidal marsh restoration • wet meadow and alkali meadow restoration • recovery of "delta" fish species • recovery of rare plant species in tidal marsh-saltgrass-alkali meadow ecotone • high tide refugia for salt marsh harvest mouse • salt water intrusion, sea level rise, and estuarine transgression
BOTTOMLANDS	• palustrine (freshwater, nontidal) wetland restoration • floodwater storage capacity • enhancement of artificial stream channels • excessive sedimentation in artificial channels
Interface	• drainage challenges associated with groundwater emergence • willow grove restoration
ALLUVIAL FANS	• restoration of natural stream channels • erosion/incision of natural stream channels with increased runoff • valley oak savanna preservation and restoration
Interface	• fish access to tributary habitat • excessive sediment storage behind dams • management of water releases for stream functions
HILLS	• hillslope management to decrease runoff, sediment erosion and drainage density increase • sediment and contaminant release from historical/current mining • preservation and restoration of wetland habitat in intermontane valleys

TABLE IV-6. **ENVIRONMENTAL MANAGEMENT OPPORTUNITIES AND CONSTRAINTS ASSOCIATED WITH DIFFERENT SANTA CLARA VALLEY LANDSCAPES.**

RESTORATION OPPORTUNITIES

HABITAT TEMPLATES

Historical analysis shows that fluvial and wetland habitats in the Coyote Creek watershed occurred in distinctive patterns involving multiple habitat types. We identified several of these habitat "templates." These templates describe the functional arrangement between different habitats and landscapes. They can serve as conceptual models for coordinated, multi-objective restoration planning.

Key elements of each template are described below. At this time a schematic diagram has been developed for the Riparian Tidal template; illustrations of the other templates will be developed as possible.

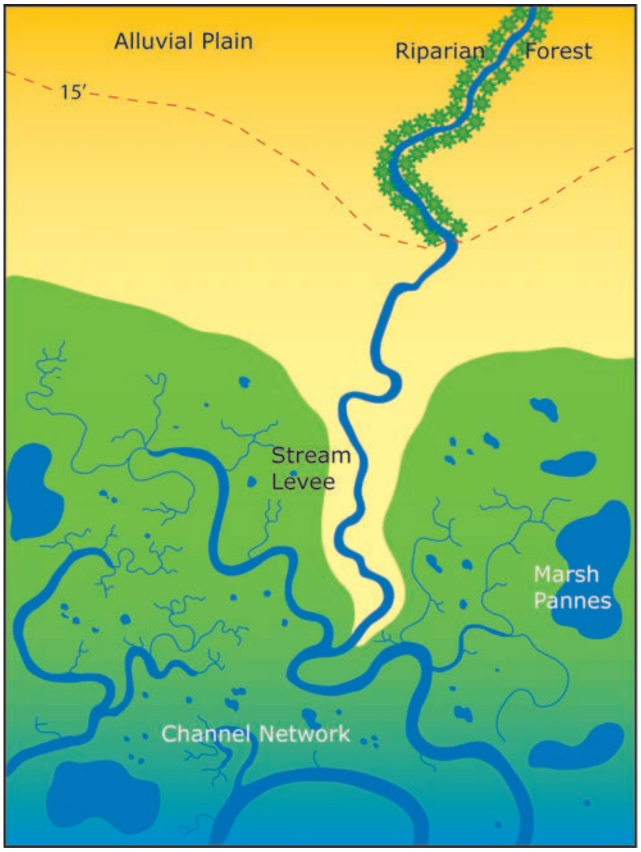


TABLE IV-33. **SCHEMATIC DIAGRAM OF THE RIPARIAN TIDAL TEMPLATE.**

RIPARIAN TIDAL TEMPLATE (FIGURE IV-33)

- fluvial channel directly joins tidal slough
- natural stream levee extends into tidal marshland along channel
- fresh and brackish tidal marsh extends from fluvial-tidal interface
- tule-lined channels
- tidal channel networks are less dense
- fewer and larger tidal marsh pannes
- dry grassland occupies alluvial fan-baylands interface

ARTESIAN SLOUGH TEMPLATE

- occurs at the baylands-bottomlands interface
- “spring runs” initiate from groundwater discharge in the bottomlands and join tidal sloughs
- may also serve as overflow channels
- fresh and brackish tidal marsh extends from fluvial-tidal interface
- tule-lined channels
- tidal marsh-saltgrass-alkali meadow ecotone

LAGUNA TEMPLATE

- mosaic of temporarily, seasonally, and perennially flooded wetlands
- substantial perennial freshwater wetland: tule marsh
- surrounding wet meadows and alkali meadows
- smaller perennial ponds supplied by groundwater emergence
- possible willow groves at outer margin of perennial wetland
- possible overflow channel but restricted fluvial connection
- distributary creeks contribute surface water directly to wet meadow areas or as groundwater reemergence

FIGURE IV-34. LAGUNA SECA 1919/2005. The area has changed relatively little since the reclamation for agriculture in the early part of the 20th century. Red circle shows location of **FIGURE III-30**. SCVWD Vault 1919: 169, courtesy Santa Clara Valley Water District.

REFERENCE SITES

Comparative, less-disturbed settings can probably be found in other parts of Central California that correspond closely to each of the habitat types historically found in the Coyote watershed. Identification of appropriate reference sites would help provide illustration for a restoration vision that includes habitats that have not been seen locally for some time, yet have significant restoration potential. Information about the characteristics of these sites will be useful for restoration project design and monitoring progress.

POTENTIAL OPPORTUNITIES AT LAGUNA SECA

The historical analysis identifies the Laguna Seca area at the north end of Coyote Valley as a site with unusual, multi-objective wetland restoration potential. The site has changed very little during the past 85 years (**FIGURE IV-34**) and appears to offer opportunities to reestablish significant natural hydrogeomorphic process, with benefits to floodwater attenuation and storage. It also could support a range of native species. Some of these considerations are discussed briefly below in a conceptual manner. Specific site assessments, hydrological modeling, and coordinated planning would be required to determine actual project opportunities.

Under natural conditions, Laguna Seca provided flood attenuation and storage because it could receive and store substantial amounts of water away from the Coyote Creek channel. It remains a topographic low point. The outlet channel, historically constructed for drainage purposes, could be managed or redesigned to reduce direct drainage to Coyote Creek. The system could provide some of the same flood protection benefits as the Soap Lake Floodplain Preservation Project proposed on the upper Pajaro River (RMC 2005).

The Fisher Creek drainage, which historically terminated in the Laguna Seca wetland complex, represents one of the few opportunities to reestablish a more discontinuous stream system, natural wetland storage capacity, and less flashy flood routing. Reducing the connectivity between Fisher Creek and Coyote Creek would help attenuate high flows before reaching Coyote Creek, provide surface water to Laguna Seca, and allow off-channel sediment retention.

Recharge of the Coyote Valley aquifer has been purposely limited in recent decades because of court-mandated diversion of Coyote Creek into the Coyote Canal. There was concern that summer discharges from the dam would raise groundwater levels to the detriment of local agriculture. However, because the site lies at the lowest portion of the valley, it may be possible to have some groundwater emergence at the site without adversely affecting drainage in the higher-lying parts of Coyote Valley. In fact, surface water can currently be found in the lowest part of the former lake bed during the summer, suggesting that natural hydrology is substantially intact. The bedrock barrier of the Santa Teresa Hills also effectively isolates Laguna Seca from the parts of San Jose to the north.

Reestablishment of the Laguna Seca wetlands is an opportunity to restore a regionally significant wetland mosaic. Large freshwater complexes such as Laguna Seca were not widely distributed in the semiarid Bay Area and opportunities for restoration are even less common. This array of habitats, described in the Laguna Habitat Template above, could support a number of locally important and/or special status species. These potentially include the red-legged frog, tiger salamander, rare plants, and waterfowl. The description of avian use of Laguna Socayre, presented in Part III, probably provides a good illustration of the diverse water birds that historically used Laguna Seca.

Laguna Seca also provides strong conservation benefit because it is contiguous to existing greenbelt. For example, The Silicon Valley Land Conservancy recently acquired portions of the adjacent Tulare Hill for a butterfly habitat preserve (San Jose Mercury News 2005). Wetland conservation and restoration at the site thus has the potential to contribute to an unusually functional preserve, including a mosaic of habitats from upland to lowland, within a relatively small space.

Wetland planning at the Laguna Seca site must be coordinated with adjacent development, emerging as part of the Coyote Valley Specific Plan, to address stormwater quality, recreational benefits, and other issues.

SYCAMORE ALLUVIAL WOODLAND AND STREAM HABITAT DIVERSITY

The open, sycamore-dominated riparian habitat of broad, intermittent streams was celebrated by the naturalist writers of the 19th century — from Sherman Day's "splendid groves of oaks and sycamores" found on Coyote Creek's braided channel, to Mary Carroll's "treasured" *Mentzelia* found in "sandy beds of the dry creeks." Author Bayard Taylor in particular described Coyote Creek's native beauty, lost in the 20th century but not unrecoverable, as a key component of the "dazzling" Santa Clara Valley landscape:

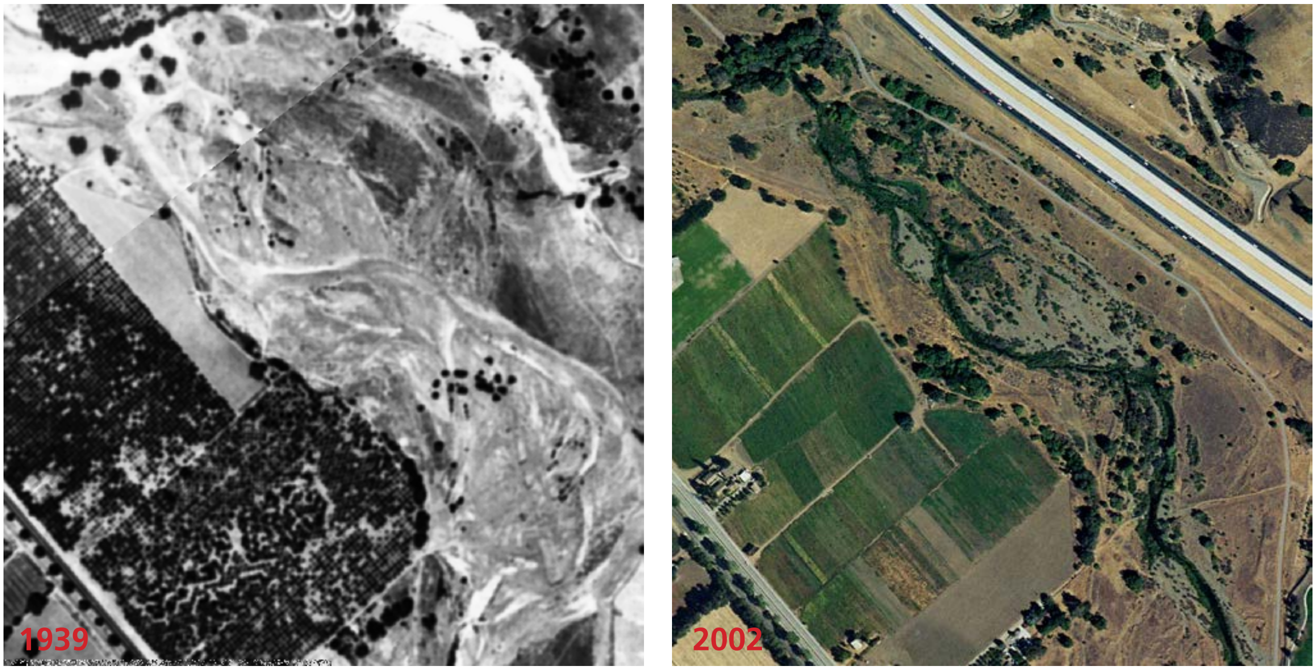


FIGURE IV-35. COYOTE CREEK IMMEDIATELY DOWNSTREAM OF THE COYOTE CREEK GOLF CLUB IN 1939 (LEFT) AND 2002 (RIGHT). Braided channel pattern with riparian scrub and occasional large trees can be seen in both images, but there is more riparian vegetation along the main channel in the recent image (AAA 1939; 2002 Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

> "A valley, ten miles wide, through the center of which winds the dry bed of a winter stream, whose course is marked with groups of giant sycamores, their trunks gleaming like silver through masses of glossy foliage" (Carroll 1903: 185).

One of the implications of the assessment of riparian habitat change is to recognize the value of Sycamore alluvial woodland as a major historical component of Coyote Creek. Given the substantial conversion of the habitat to more dense, cottonwood-dominated riparian habitat, existing remnants gain in significance.

In particular, the Coyote Valley reach from approximately Sycamore Lane to Highway 101 (where not removed by gravel quarrying) has unusually intact sycamore woodland and braided channel habitat (Keeler-Wolf et al. 1996). An important goal may be to preserve and enhance this open riparian habitat (**FIGURE IV-35**), rather than cause conversion to riparian forest. This goal would require maintaining broad, regularly flooded channel beds and would likely necessitate increased high flows, coarse sediment sources, and filling of former gravel ponds.

Target stream habitat for these riparian areas could involve a distinct suite of native species, including fish assemblages associated with braided channels (see Fish Assemblage section, **TABLE IV-5**), a distinct flora including California sycamores and smooth-stem blazing star (*Mentzelia sp.*), and nesting birds such as the lesser nighthawk.

At certain places within these larger reaches, short reaches with dense riparian canopy and persistent summer pools should be identified, preserved, and enhanced.

STREAM FLOW VARIABILITY

One component of stream restoration might involve manipulation of reservoir discharge to more closely mimic natural hydrology. The installation of Coyote and Anderson Reservoirs in the mid-20th century created a major and sustained impact on stream processes and habitat. However, the ability to control the timing and quantity of flows from 70% of the watershed does provide an opportunity to manage water releases strategically as part of habitat restoration and management strategies.

Habitat-oriented flow management presently focuses on summer releases to maintain cold water fish assemblages (FAHCE 2003). However, while maintaining minimum flow levels required by native species at appropriate sites, flow management should also consider the importance of flow variation and extremes for physical and ecological processes.

For example, the potential benefits of controlled, yet significant, high flow pulses to maintain or restore downstream habitat quality and improve native fish populations could be considered. Local native species and their habitats evolved with much higher peak flows than are currently observed on Coyote Creek. While extremely high flows must be avoided because of flood risk, managing the timing and frequency of moderately high pulses could have significant geomorphic and ecological benefits (e.g. USGS 2005). The proximity of relatively broad and buffered stream reaches to the Anderson Dam outlet might allow attenuation of a moderately "steep" discharge within the target area. Further study, including assessing sediment availability, would be needed to determine whether higher flows could potentially help reestablish active gravel bars and terraces to promote the continuation of the rare Sycamore alluvial woodland.

Higher flows might help maintain some of the surviving braided channel reaches that currently possess substantial residual value and potential for native fish habitat. Fish distribution studies before and after recent relatively high flows suggest that native fish are better adapted to the short duration, high flow events characteristic of historical conditions than their non-native competitors (Buchan and Randall 2003: 37). Significant, well timed late winter/early spring releases could potentially improve habitat for a range of native fish (Leidy personal communication).

Similarly, native fish tend to be more tolerant of the extreme summer-dry local conditions than most non-natives. Intermittent conditions might actually be an appropriate target for certain stream reaches, as some of the healthiest present-day native fish communities are observed in reaches with summer dryback (Buchan and Randall 2003: 106).

Higher flows could also remove short-lived woody vegetation that has expanded onto the former active channel in some areas since reservoir construction, in the absence of high flows. This might reduce tree fall hazards and trash jams, while increasing channel capacity and fish passage. Higher flows might thereby contribute large woody debris to the channel naturally.

DIVERSE URBAN RESTORATION OPPORTUNITIES

The historical analysis, combined with very preliminary fieldwork, also suggests a number of additional restoration "opportunity zones." These include freshwater

HABITAT	ECOLOGICAL VALUES	GENERAL VALUES	LANDSCAPE POSITION AND FUNCTIONAL REQUIREMENTS	RESTORATION OPPORTUNITIES (SELECTED)
Fresh and Brackish Tidal Marshland	• important component of tidal wetland mosaic • rare estuarine, "Delta" fish • anadromous fish corridor • red-legged frog	• navigable sloughs • public access to tidal channels	Tidal and fluvial water sources at the Baylands-Bottomlands interface.	• Salt ponds A15-23, integrated with fresh water drainage and treated effluent hydrology
Wet Meadow	• seasonal wetland values: rare wetland plants, waterfowl nesting and foraging habitat, tiger salamander	• low intensity agricultural vistas; open space • temporary flood storage	Clay soils with limited drainage, seasonal soil saturation, stream overflow and/or artesian springs, seeps	• Laguna Seca area in Coyote Valley • "buffer lands" of the San Jose-Santa Clara Water Pollution Control Plant
Salt grass-alkali meadow	• wet meadow values • rare alkali- and high marsh-associated plants • high tide refuge for salt marsh harvest mouse • future tidal marsh with sea level rise	• low intensity agricultural vistas; open space • temporary flood storage	Adobe, salt-affected soils with limited drainage, seasonal soil saturation, stream overflow and/or artesian springs, seeps	• Meadow lands at Lake Cunningham Regional Park
Valley Oak Savanna	rare and declining oak habitat	• "signature" habitat of Santa Clara Valley • shade tree • neighborhood stewardship opportunity	Coarse well-drained alluvial soils, access to groundwater via roots (<25 feet?)	• Full savanna habitat in urban parks and open spaces (e.g. Shady Oak Park), higher elevation Diablo Range valleys as potential climate change refugia • Valley oak component in roadsides, medians, yards, fencelines
Willow Grove	migratory and local songbird habitat, amphibians red-legged frog, tiger salamander	• habitat representation • evergreen, aesthetically pleasing	Alluvial fan-bottomland interface or tidal marsh-bottomland interface perennial water source (near surface groundwater, seeks or springs	• Laguna Seca area in Coyote Valley • "buffer lands" of the San Jose-Santa Clara Water Pollution Control Plant
Perennial freshwater marsh and ponds	red-legged frog, tiger salamander, waterfowl	• habitat representation: wetland aesthetics • temporary flood storage	Clay bottomland soils, groundwater emergence	Laguna Seca in Coyote Valley
Sycamore alluvial woodland	• significant, rare California habitat • lesser nighthawks and other birds • unique flora	signature habitat of Coyote Creek	Intermittent, high energy, seasonally flooded gravel substrate (groundwater at depth)	Coyote Creek from ~Sycamore Lane through Highway 101

TABLE IV-7. WATERSHED RESTORATION CONCEPTUAL FRAMEWORK. In addition to riparian and floodplain restoration opportunities, there are "opportunity zones" for restoring a range of other, related watershed components. Many of these habitats are linked to each other through hydrogeomorphic and groundwater processes; restoration of the watershed system should involve each component. Each habitat or watershed component offers distinct ecological/cultural benefits and has specific landscape requirements.

and brackish tidal marsh — which could support rare fish species associated with freshwater deltas — alkali meadows with a range of rare plants, and some of the grand valley oak trees of the alluvial fans. Some of these opportunities for the restoration of native habitats in their appropriate hydrogeomorphic settings are summarized in **TABLE IV-7**.

These habitat restoration opportunities range from sites with the potential to restore significant habitat mosaics following natural "templates" to more distributed opportunities for incremental habitat improvement. For example, while there are only a few possible places to restore a significant component of valley oak savanna, individual valley oak trees might be successfully nurtured at hundreds of sites throughout the Valley. Appropriate requirements could be identified by neighborhood, based upon historical distribution and present-day factors (depth to groundwater, limited summer watering, available space).

Given that most of the remaining valley oaks appear to be relatively old, it will be important to establish subsequent generations at suitable sites with local stewardship. The present-day persistence of many trees does suggest the potential for the continuation and even re-expansion of the Valley's grand oaks within the urban context.

Similarly, the Valley's sycamore trees have shown impressive persistence. The observation of sprouting trees from stumps 6 feet or more in diameter suggests substantial age. Given appropriate conditions, younger California Sycamores could be established alongside the heritage trees found fairly commonly at the edges of neighborhoods along streams. The historic sycamore grove area in San Jose appears to still be supporting sycamores with a range of ages.

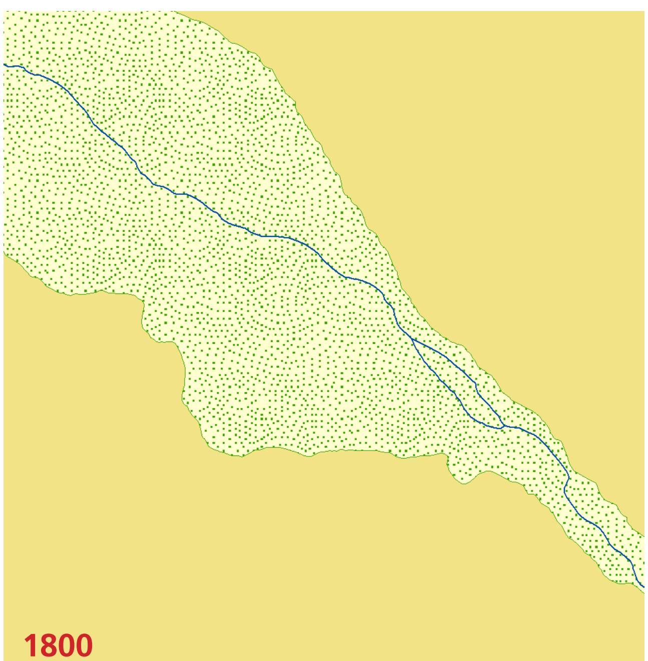


FIGURE IV-36. COYOTE CREEK CHANNEL AT HIGHWAY 880 CROSSING, CIRCA 1800 (LOWER LEFT), 1939 (UPPER LEFT), AND 2002 (RIGHT). The 1800 view identifies naturally broad and narrow channel reaches, which are not easily distinguished in the more recent aerial photography. Naturally wide reaches may have potential for floodplain restoration. For example, the undeveloped area in the center of the 2002 image is a former stream bench that remains flood-prone. Highway 880 runs north-south on the left side of the 2002 image. The *San Jose Mercury News* building can be seen at image bottom, immediately right of the highway. (AAA 1939; 2002 Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

SUMMARY OF KEY FINDINGS

This section provides brief summaries of some of the important products, findings, hypotheses, and management implications.

HISTORICAL ECOLOGY TOOLS

Historical data set. Through this project, thousands of historical documents have been examined for useful environmental data. The resulting project bibliography is a publicly-available tool for addressing future environmental questions in the watershed. This data set also provides a starting point for more detailed reach or sub-watershed investigations.

Georeferenced historical maps. Early maps and photography contain tremendous amounts of information, but are often difficult to use. We have georectified a number of important historical maps for the area, which will be available for convenient comparative use in GIS systems.

Early aerial photomosaic. We developed a composite, georectified image synthesizing over 80 of the earliest aerial photographs for the Coyote Creek valley floor. This data set will be useful for a range of engineering, research, planning and community purposes.

Historical landscape GIS. The GIS map of historical habitats and drainage patterns represents a new data set for restoration planning. Each feature is coded for certainty level, and supporting source materials.

Importance of early historical data for geomorphic assessment. Historical data are often used to determine pre-modification channel form but research efforts are sometimes limited to relatively late and/or coarse sources (e.g. Ouchi 1983 *in* Schumm et al. 2000), resulting in potential misinterpretation of channel processes. Earlier, pre-modification sources used in this project (particularly General Land Office surveys and land grant materials) can provide accurate and detailed baseline data.

The Historical Ecology Study provides a starting point for the development of a detailed vision for recovery and restoration in the Coyote Creek watershed. The Study constitutes the first step in the process of setting realistic, site-specific restoration targets. This "goals-setting" process — integrating the historical findings with modern assessment and local expertise — would produce a template for coordinating diverse restoration and management activities towards a healthy, sustainable watershed.

PRE-MODIFICATION CONDITIONS

Most stream channels did not cross the lower alluvial plain. Nearly 50% of the valley floor water courses draining today to Coyote Creek are constructed channels conveying runoff through areas that previously had no surface drainage. The natural drainage network was highly discontinuous, supporting groundwater recharge on the coarse alluvial fans and wetlands in the valley bottomlands.

Drainage density has increased dramatically. The construction of drainage channels, initially for agricultural drainage, increased the density of drainage to Coyote Creek by about 40%. Creation of the storm drain network during urbanization has resulted in a nearly tenfold increase in drainage density.

The functional watershed area has changed. Coyote Creek receives much more input of water and sediment from the lower part of the watershed than it did historically, when there were no tributaries downstream of Coyote Narrows. This results in a flashier hydrograph and many more sediment sources.

Coyote Creek displayed distinctly different channel morphology and riparian habitat along different reaches. We defined four distinct reaches; historical characteristics substantially explain present-day conditions.

Most of Coyote Creek was intermittent. There were important perennial reaches at the upper and lower ends of the valley and the balance of the mainstem was seasonally dry.

Coyote Creek maintained a regionally unusual broad channel area for much of its length, with interspersed narrow reaches. This pattern affected, and continues to affect, riparian habitat, fish habitat, and even urban transportation patterns.

Coyote Creek was naturally quite deep in the mid-Coyote reach. The system was substantially entrenched, with many broad, inset flood-prone benches.

Coyote Creek above Tully Road had strong braided channel character. Riparian habitat was an open savanna with riparian scrub and large unvegetated areas. Sycamore alluvial woodland was characteristic. There were occasional strands of linear riparian forest on the outer banks of the channel area.

Two major freshwater wetland complexes were found in the Coyote watershed, Laguna Seca and Laguna Socayre. A number of willow groves and other perennial freshwater wetlands provided additional important wetland habitat.

Wet meadows and saltgrass-alkali meadows occupied broad bottomlands. Poor drainage slowed agricultural and commercial development, leaving modern opportunities for both restoration and further urbanization.

Open grassland with valley oak savanna dominated the gently sloping alluvial fans. These were largely converted to orchards, then residential development.

NATURAL FLOOD PROTECTION.

Flood-prone areas have decreased greatly. Successful drainage and flood control projects have increased stream connectivity and decreased stream-floodplain connectivity.

Existing flood-prone benches provide potential flood capacity. In the Mid-Coyote reach, there are many large, broad stream benches still subject to flooding (**FIGURE IV-36**). A number of these areas remain in public ownership; some could potentially be designed to support and benefit from occasional flooding.

Strategic stream bench excavation could increase channel capacity and allow restoration of floodplain functions. Many of these areas have been filled, and the main channel has incised, reducing floodplain access. Recovery of even a small percentage of the historical stream floodplain could greatly increase habitat value.

There may be shared benefits with contaminant removal. Historical landfill on the Coyote Creek floodplain benches has become a contaminant concern at Watson Park. Soil removal at this and potentially other sites may be needed to reduce public exposure and prevent contaminant transport downstream to the Bay.

Historical and recent hydromodification has probably contributed to downstream flood potential by increasing connectivity to the Coyote mainstem. Reducing drainage connectivity through off-site storage, swales, and neighborhood-scale infiltration projects will be important especially given predicted climatic changes and increased impervious surfaces.

Laguna Seca and the Fisher Creek drainage network present an opportunity for significant off-site flood peak attenuation. Restoration of the natural hydrogeomorphology of the site could provide flood protection, wetland values, and habitat for a range of species.

Historical drainage patterns and wetland distribution help explain present-day flood-prone areas. Current locations of flooding appear often to be related to significant reduction in channel capacity or to the location of historical wetland complexes. This information may be useful to future flood protection planning.

CHANNEL STABILITY

Channel stability is highly variable within the watershed. We found stream reaches with substantial incision trends and reaches with no discernible change over a 150 year period.

Historical data indicate significant incision in the Mid-Coyote Reach. However, recent incision may not be as great as assumed because the channel was typically 20+ feet deep under historical conditions.

The timing and length of valley floor channel extension may help explain channel stability/instability. The historical data set, combined with field work, could provide a basis for testing this hypothesis, as also suggested by Jordan et al. (2005).

Substantial historical data are available to assess long-term rates of channel erosion. We identified a number of sources that can be integrated with strategic fieldwork to assess how much incision has been taking place where, over what time period.

Major lateral migration of the main channel has taken place during historical times. These changes appear to have been natural and were confined within the broader channel area defined by the outer banks, suggesting a practical buffer zone for land use planning.

STREAM RESTORATION

This natural bank erosion, also observed recently in Coyote Valley, combined with flood susceptibility, suggests that there is strong rationale for maintaining the broad, historical channel area as a stream buffer. Fortunately, much of the broad creek area has, in fact, been preserved as public space. However, there are numerous conflicting land uses within this area.

Coyote Creek's imposing natural morphology has led to unusually high present-day habitat value and restoration potential. Because of the flood risk on inset benches and braided reaches, much of the creek now lies within city and county parks, making it possible to consider a significant stream restoration vision.

Fresh and brackish tidal marsh gradients could be established at lower Coyote Creek. These should be designed to reestablish natural marshland patterns associated with freshwater influences.

Treated effluent inputs could be used to reestablish brackish tidal sloughs and the "Artesian Slough Habitat Template." Fresh and brackish tidal marsh gradients have been greatly lost within the region (Goals Project 1999).

Could the Coyote Creek delta be restored? A century ago the lower and tidal portions of the creek supported a fish assemblage largely similar to those found in the Sacramento-San Joaquin Delta. Restoration of some of these fish populations could be of regional significance.

While Coyote Creek has escaped major straightening by flood control projects, the channel has been severely modified by large artificial ponded areas. Separating the stream from Ogier Ponds and the Coyote Percolation Ponds would contribute greatly to restoring natural channel form.

Restoration of Coyote Creek at the Ogier Ponds complex would provide an opportunity to restore some of the creek's presently-rare native habitat. Based upon recent historical conditions, stream restoration at Ogier Ponds could consider a broad braided channel supporting Sycamore Alluvial Woodland and related habitats. The pre-modification main channel appears to correspond with the existing riparian forest strand.

RIPARIAN HABITAT RESTORATION

Riparian forest has been lost along some creeks, but also has recovered in places. Urbanization appears to have protected riparian forest from direct encroachment by agriculture and grazing in some cases. There are number of places where the creek now has more room for riparian habitat than it did in 1939.

Incision and excessive vegetation growth are a concern. While riparian habitat appears robust in many places, it should be evaluated to ensure its long-term viability.

Dense riparian forest has expanded into the relatively open native riparian woodland that characterized most of Coyote Creek historically. This riparian habitat conversion is likely due to reduced high flows and increased summer flows.

Preservation, enhancement, and restoration of braided channel habitats and California Sycamore Alluvial Woodland in Coyote Valley could be an important watershed goal. The reach between Sycamore Avenue and Highway 101 includes the best existing examples of the pre-modification habitat along most of Coyote Creek.

FLOW

Strategically modifying regulated flows to more closely mimic natural patterns could have significant benefit to native fishes and habitats. Environmental and groundwater recharge efforts have led to a flattening of the annual monthly distribution of streamflow. Greater variability could be important to stream health.

Controlled high flow releases could have some benefits. Modest but significant pulse flows, particularly with some augmented sediment and gravel supply, could have geomorphic benefit and select for native fishes over non-native species.

Perennial stream flows are not automatically good. The conversion of most of the stream to perennial flow has significantly altered riparian and aquatic habitats.

The braided channel habitats in the vicinity of the Coyote Creek Golf Club have probably maintained their relatively natural character partly because of the Coyote Diversion Canal. This portion of the stream has been excluded from strong summertime flow increases and has not converted to dense riparian forest. Future alterations to the flow regime should consider potential ecological effects within a temporal context.

Historical sites of perennial stream flow and groundwater discharge may be particularly important given future climate uncertainty. These sites, and their dependent native species, are more likely to persist than areas requiring supplemental water, particularly during extended drought and/or limited summer water supply periods.

RESTORATION OF WETLAND HABITATS

Laguna Seca represents a rare opportunity to restore natural hydrogeomorphic wetland functions and a diverse wetland mosaic. Laguna Seca restoration would link to existing buffers and would be regionally significant as a large, natural valley floor wetland.

Substantial historical documentation of Laguna Seca is available to establish natural hydrology and vegetation parameters. Much of this information has been preserved and recently scanned at the Santa Clara Valley Water District archives.

Successful wetland restoration at Laguna Seca could support a wide range of valued species, including rare plants, amphibians, and water birds. Many of these are documented by historical evidence for Laguna Seca and/or Laguna Socayre.

Some saltgrass-alkali meadow currently persists at Lake Cunningham Park. Strategic preservation and enhancement efforts could improve this rare habitat while coexisting with surrounding recreational activities. There may be other opportunities for similar restoration efforts in the vicinity of the historical Laguna Socayre.

Substantial restoration opportunities are also evident in the vicinity of the San Jose-Santa Clara Water Pollution Control Plant, where preservation of local agriculture by the City of San Jose has maintained relatively high habitat potential. Wet meadow and saltgrass-alkali meadows as part of the "Artesian Slough Habitat Template" could potentially be considered in this area.

RESTORATION OF DISTRIBUTED TREES IN PARKS AND NEIGHBORHOODS

Valley oak savanna, the signature habitat of the Santa Clara Valley, could be restored in elements through coordinated local stewardship. The naturally "scattered" distribution of valley oaks means that they can be relatively successfully integrated within the urban framework. Young trees need to be established to maintain this local habitat into the future.

The Valley's grand sycamore trees, found occasionally individually or in groves alongside stream channels, have also persisted to a surprising degree, apparently as descendents of the original trees. These heritage trees could be preserved and regenerated within the urban context.

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GLOSSARY OF TERMS

Aerial Photomosaic: A digital image made from multiple, adjacent, overlapping aerial photograph prints and/or negatives to seamlessly cover a large area.

Alluvial Fan: A body of alluvium whose surface forms a segment of a cone that radiates downslope from the point where the stream emerges from a narrow valley onto a less sloping surface (Grossman et al. 1998).

Alluvial: Deposited by a stream or running water (Bates and Jackson 1984).

Artesian: Pertaining to groundwater under sufficient hydrostatic pressure to rise above the aquifer containing it (Bates and Jackson 1984).

Bottomlands: Low-lying interfluvial flood basins.

Braided Channel: A channel or stream with multiple channels that interweave as a result of repeated bifurcation and convergence of flow around interchannel bars. Generally confined to broad, shallow streams of low sinuousity, high bedload, non-cohesive bank material, and steep gradient (Grossman et al. 1998).

Confined Groundwater: Groundwater that is under sufficient pressure to rise above the level at which it is encountered in a well; it may or may not flow to or above the ground surface. Its upper surface is the bottom of an impermeable bed. (Bates and Jackson 1984).

Distributary Creek: A stream with a discontinuous channel that, in the absence of a defined channel, distributed flow over a broad area; used to distinguish creeks directly tributary to a main stem channel from those that did not historically maintain a defined channel connection.

Entrenched: Entrenchment is defined by the elevation of the current floodplain relative to the elevation of the valley floor. A channel is entrenched when the floodplain is not coincident with the valley floor (Montgomery and MacDonald 2002).

Floodplain: A level area near a river channel, constructed by the river in the present climate and overflowed during moderate flow events (Leopold 1995).

Fluvial: Of or pertaining to rivers; produced by the action of a stream or river (Bates and Jackson 1984).

General Land Office (GLO): Federal agency that carried out the Public Land Survey, resulting in associated historical landscape information.

Georectification: To establish the relationship between page coordinates on a planar map and known real-world coordinates using elevation data to correct for topography. Often used interchangeably with the term 'georeference' (see below).

Georeference: To establish the relationship between page coordinates on a planar map and known real-world coordinates.

Habitat: The specific area or environment in which a particular type of plant or animal lives.

Hydrogeomorphic: Of or pertaining to a synthesis of the geomorphic setting, the water source and its transport, and hydrodynamics.

Hydrology: The branch of physical geography concerned with the behavior of water in the atmosphere, on the surface of the earth and underground. The science dealing with the properties, distribution and circulation of water

Intermittent Stream: A stream that flows only at certain times of the year (Bates and Jackson 1984).

Laguna: Lagoon or small lake (Spanish).

Levee: An artificial or natural embankment built along the margin of a water course or an arm of the sea. Constructed naturally by sediment deposition or artificially to protect land from inundation or to confine streamflow to its channel (Grossman et al. 1998).

Mean Lower Low Water (MLLW): The average height of the lower of the two daily low tide; zero tidal elevation.

Mean Tide Level (MTL): A tidal datum, or reference, which is midway between Mean High Water and Mean Low Water.

Palustrine Wetland: Palustrine wetlands are non-tidal wetlands that received most of their water by direct precipitation or surface runoff.

Perennial Stream: A perennial stream has flowing water year-round during a typical year.

Restoration: The reestablishment of the structure and function of ecosystems. Ecological restoration is the process of returning an ecosystem as closely as possible to appropriate sustainable conditions and functions which are defined based upon an understanding of past, present and predicted future conditions. Implicit in this definition is that ecosystems are naturally dynamic. It is therefore not possible to recreate a historical system exactly. The restoration process reestablishes the general structure, function, dynamic, and self-sustaining behavior of the ecosystem.

Rhizomatous: a plant having long, underground, horizontal stems capable of sprouting new growth.

Riparian Vegetation: Trees or shrubs that directly affect, or are affected by, the surface or subsurface hydrology of a river, stream, canal, ditch, lake, or reservoir.

Roblar: "The place where deciduous oaks grow" (Gudde 1998); commonly refers to groves of valley oaks (Spanish).

Salitroso: Descriptor of salt-affected lands with resulting limited agricultural value; literally, "saltpetrous" (Spanish).

Sausal: Willow grove (Spanish).

Tular: Place of the tules; indicative of perennial freshwater marsh (Spanish).

Unconfined Groundwater: Groundwater that has a free water table, i.e. is not confined under pressure beneath relatively impermeable rocks (Bates and Jackson 1984).

US Coast Survey (USCS): Federal agency established in 1807 to map the nation's shoreline. Produced maps well-recognized for their accuracy dating, in the Bay Area, to the 1850s.

US Department of Agriculture (USDA): Federal agency that has produced soil surveys and, since the 1930s, associated aerial photography of use in historical ecology research.

US Geological Survey (USGS): Federal agency established in 1879. Historical USGS quadrangles of the San Francisco Bay Area date to the late 1800s.

Vernal Pools: Ephemeral wetlands that form in shallow depressions underlain by an impervious, near-surface soil horizon, supporting distinct vernal pool plant and animal species.

HISTORICAL EVIDENCE FOR FISH ASSEMBLAGES IN THE COYOTE CREEK WATERSHED[1]

FAMILY/ SPECIES	ZOO-GEOGRAPHIC TYPE	LIFE HISTORY STATUS	DISTRI-BUTIONAL STATUS	PRIMARY HABITAT OCCURRENCE	NOTABLE EARLY RECORD(S) FROM THE WATERSHED (YEAR) (SOURCE)
PETROMYZONTIDAE/ LAMPREYS *Lampetra tridentata* Pacific lamprey	OBF-SD	M, AND, FWR	P, ?	LLR, MR, HSR	Coyote Creek, Santa Clara Co. (1898) (Snyder 1905)
Lampetra richardsoni western brook lamprey	OBF-SD	FWR	?	LLR, MR	Coyote Creek, Santa Clara Co. (1922) (Hubbs 1924, UMMZ 61003)
ACIPENSERIDAE/ STURGEONS *Acipenser transmontanus* white sturgeon	OBF-SD	M, AND, EST	UR	TER, L/OB	_
CYPRINIDAE/ MINNOWS *Gila crassicauda* thicktail chub	OBF-FD	FWR	EX	LLR, MR, FLP	Coyote Creek, Santa Clara Co. (1898) (Snyder 1905, SU 21031)
Lavinia exilicauda Hitch	OBF-FD	FWR	LC	LLR, MR, FLP	Coyote Creek, Santa Clara Co. (1897) (C. H. Gilbert, CAS 102562/SU2562, CAS104219/ SU 4219)
Lavinia symmetricus California roach	OBF-FD	FWR	LC	MR, HSR	Coyote Creek, Santa Clara Co. (1898) (Snyder 1905)
Orthodon microlepidotus Sacramento blackfish	OBF-FD	FWR	LC	LLR, FLP	Coyote Creek, Santa Clara Co. (1892) (C.H. Gilbert, CAS 111447) Coyote Creek, Santa Clara, Co. (1897, 1898) (C. H. Gilbert, CAS 101199/Snyder 1905) Coyote Creek, Santa Clara Co. (1922) (C. L. Hubbs, UMMZ 63411)
Pogonichthys macrolepidotus Sacramento splittail	OBF-FD	FWR, EST	EX	TER, LLR	Coyote Creek, Santa Clara Co. (1890s) (C.H. Gilbert, CAS 102537) Coyote Creek, Santa Clara Co. (1898) (Snyder 1905)
Ptychocheilus grandis Sacramento pikeminnow	OBF-FD	FWR	P	LLR, MR	Coyote Creek, Santa Clara Co. (1898) (Snyder 1905, CNHM 2574, USNM 75384) Coyote Creek, Santa Clara Co. (1922) (C. L. Hubbs, UMMZ 63410)
Rhinichthys osculus speckled dace	OBF-FD	FWR	EX	MR, HSR	Coyote Creek, Santa Clara Co. (1898) (Snyder 1905, SU 37823, 161721)
CATOSTOMIDAE/ SUCKERS *Catostomus occidentalis* Sacramento sucker	OBF-FD	FWR	W	LLR, MR, HSR, FLP	Coyote Creek, Santa Clara Co. (1898) (Snyder 1905) Coyote Creek, Santa Clara Co. (1922) (C. L. Hubbs, UMMZ 63399, 63400, 63401)
OSMERIDAE/ SMELTS *Spirinchus thaleichthys* longfin smelt	EM	M, AND, EST	P	TER, L/OB	_

[1]Table provided by Robert A. Leidy, US Environmental Protection Agency, San Francisco.

FAMILY/ SPECIES	ZOO-GEOGRAPHIC TYPE	LIFE HISTORY STATUS	DISTRI-BUTIONAL STATUS	PRIMARY HABITAT OCCURRENCE	NOTABLE EARLY RECORD(S) FROM THE WATERSHED (YEAR) (SOURCE)
SALMONIDAE/ SALMON AND TROUT *Oncorhynchus kisutch* coho/silver salmon	OBF-SD	M, AND, FWR	EX	MR, HSR	Coyote Creek, Santa Clara Co. (1950s) L. J. Hendricks, Emeritus, San Jose State University, pers. comm., as cited in Smith 1998
Oncorhynchus tshawytscha Chinook salmon	OBF-SD	M, AND, FWR	P, ?	LLR, MR, L/OB	_
Oncorhynchus mykiss resident rainbow trout/ steelhead	OBF-SD	M, AND, FWR	LC	MR, HSR, L/OB	Coyote Creek and San Jose, as "trout" (Hallock 1877) Coyote Creek, near mouth in San Jose and at Gilroy Hot Springs, Santa Clara Co. (1898) (SU 23657, USNM 75314, SCAS 123657, and Snyder 1905)
GASTEROSTEIDAE/ STICKLEBACKS *Gasterosteus aculeatus* threespine stickleback	OBF-SD	M, AND, EST, FWR	W	TER, LLR, MR, HSR, L/OB	San Jose [Coyote Creek] (1858 (Girard 1859, Stanford University 4444[2])
COTTIDAE/ SCULPINS *Cottus asper* prickly sculpin	OBF-SD	AMP, EST, FWR	W	TER, LLR, MR, HSR, L/OB	Coyote Creek, near mouth and San Jose (likely collected 1898) (Snyder 1905)
Cottus gulosus riffle sculpin	OBF-FD	FWR	LC	MR, HSR	Coyote Creek, Santa Clara Co. (1890s-early 1900s) (J. O. Snyder, USNM 75405) Coyote Creek, Santa Clara Co. (1922) (C. L. Hubbs, (UMMZ 63397)
Leptocottus armatus Pacific staghorn sculpin	EM	EST, AMP	LC	TER, LLR, L/OB	_
CENTRARCHIDAE/ SUNFISH *Archoplites interruptus* Sacramento perch	OBF-FD	EST?, FWR	EX	TER, LLR, MR, FLP	Coyote Creek., San Jose (inside City) (1922) (UMMZ 63336) Coyote Creek, "San Jose" (1922) (ANSP 85445) Coyote Creek, between Milpitas and Alviso (1922) (UMMZ 63335)
EMBIOTOCIDAE/ SURFPERCH *Hysterocarpus traskii* tule perch	OBF-SD/FD	EST, FWR	P, ?	TER, LLR, MR, FLP	Coyote Creek, Santa Clara Co. (1895) (Stanford University, 5007) Coyote Creek, Santa Clara Co. (1898) (Snyder 1905)
Cymatogaster aggregata shiner perch	EM	EST	LC	TER, L/OB	_
GOBIIDAE/ GOBIES *Gillichthys mirabilis* longjaw mudsucker	EM	M, EST	P, ?	TER	_
PLEURONECTIDAE/ RIGHTEYE FLOUNDERS *Platichthys stellatus* starry flounder	EM	M, EST	P	TER	_

Zoogeographic type: EM = euryhaline marine; OBF-FD = obligatory freshwater-freshwater dispersant; OBF-SD = obligatory freshwater-saltwater dispersant.
Life history status: M = marine; AND = anadromous; FWR = freshwater resident; EST = estuarine resident; AMP = amphidromous.
Current distributional status: LC = locally common; W = widespread; UR = uncommon/rare; P = present in watershed; EX = extinct in watershed; ? = current status and/or population abundance poorly documented or unknown.
Primary habitat occurrence: TER = tidal estuarine/riverine; LLR large lowland riverine; MR = mid-elevation riverine; HSR = headwater riverine; FLP = floodplain ponds; L/OB = lacustrine/open bay.

Source:
UMMZ = University of Michigan Museum of Vertebrate Zoology
SU = Stanford University Fish Collection (housed California Academy of Sciences, San Francisco)
CAS = California Academy of Sciences, San Francisco
USNM = United States National Museum (Smithsonian)
CNHM - Chicago Natural History Museum
SCAF - Southern California Academy of Sciences
ANSP - Academy of Natural Sciences in Philadelphia










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