Appendix A

Chronology of History of Arroyo Grande Creek Watershed

The following is a brief timeline of events in the Arroyo Grande Watershed:

	Chumash Indians are thought to have lived in the Lopez Valley as long ago as 2000 years. Four major villages were within the Lopez Valley, including the Chmoli and Chojuale villages.
1772	Canada del Trigo, now Lopez Canyon, supplied wheat to Mission San Luis Obispo.
	Soon after the mission's founding, the padres established a garden and plantation on the plain of Arroyo Grande Creek where they raised corn, beans, potatoes and other vegetables.
Early 1800's	First white settlers in valley. Branch family travels from New York to Lopez valley to farm. Joseph Jatta sails from Montreal, Canada to begin a dairy and prune orchard at the junction of Arroyo Grande and Lopez Creeks.
	The last grizzly bear in San Luis Obispo County was seen on Whittenburg Ranch where Lopez recreational area is today.
1862	Flood year. (Honeycutt)
1877	First Store. James Meacham at AG Creek planted the first fruit trees in the upper valley.
1883	Flood Year. Mr. Branch clear-cut his channel. Irrigation ditch from Strother Park to AG Village was constructed. At this time the creek had no channel, but usually flowed at the base of Newsome hills and down the valley where Pacific Coast Rail Road went (behind Valley Rd. campus of the high school). Dam in place to divert water flow to the irrigation ditch. At this time the creek was twenty miles long from source (Bald Mountain to ocean). Lopez Canyon Creek was fifteen miles from source to where it enters AG Creek at Santa Manuela schoolhouse (at Lopez Lake). Into AG Creek drains rainfall from Saucelito, Phoenix and Clapboard Canyons (all three miles long). Dry creek, Wittenberg Creek, drains all west and south mountain slopes of the high valley region, which is seven miles long. Tar Springs Canyon Creek is the same.
1895	Flood year. (Honeycutt)

1899	BorePorter Huasna ranch-Union Oil Company bored for oil. Phoenix Canyon on AG side, private company bored for oil and stopped. Late 1800's-Early 1900's-Trees and brush periodically clog sections of AG Creek. Huasna valley at Records Ranch and Rosa Porter Ranch were drilled several at several areas for oils with no success. West Huasna Oil Company drilled between Phoenix Canyon and Mrs. Flora Harloe Huasna Ranch. Many holes were drilled in the upper valleys and in the town of AG. Some were done with dynamite. Fourteen plus oil companies tried to drill oil.
1901	Santa Manuela schoolhouse was built at the junction of Arroyo Grande and Lopez Creeks. At that time schoolteachers earned approximately $65 a month. There were usually between 20 to 35 students enrolled at a time.
1909	Flood year. (Honeycutt)
1911	Flood year. Deposition and gullying require releveling of farmland from Hwy 1 to ocean. (Honeycutt)
1914	Flood year. Deposition and gullying require releveling of farmland from Hwy 1 to ocean. (Honeycutt)
1914	Flood Year. Tally Ho Creek crosses Branch St.
1926	Flood year. (Honeycutt)
1927	Flood year. (Honeycutt)
1929	Fire season burned thousands of acres of AG watershed in Lopez, Clapboard, Tar Springs, and Phoenix canyons. Canyons are loose with crumbly shale without the chaparral materials that cover them.
1930's	AG Village Stream Gage constructed. (Urban Streams Conference)
1930	Plowed Hillside Farms washed out with every heavy rain; Corralitas, Corbett, Carpenter, and Oak Park Canyons. Oak Park Canyon pea farmers have to build brush and straw dykes at the head of the slopes. Tried at Phoenix canyon to bore for oil and stopped. Civilian Conservation Corps (CCC) build drainage ditches and terraces to control runoff near Noyes Road and east of Printz Road. (Honeycutt)
1930	Dust Bowl. (Honeycutt) CCC stabilized hills in CarpenterCanyon-Poorman Canyon. (Honeycutt)
1936	Releveling portions of farmland from Hwy 1 to ocean. (Honeycutt)
1936-1938	Flood year. (Honeycutt)
1940	Before this time, 500-5000 steelhead were reported annually by sport fishermen in AG Creek. (CDFG)
1940-1941	3000-5000 steelhead reported by sport fishermen in AG Creek. (CDFG)

1941	Flood year. Re-leveling portions of farmland from Hwy 1 to ocean. (Honeycutt)
1942-1948	Less than 200 steelhead reported annually in AG Creek. (CDFG)
1942-1949	Flood year. (Honeycutt)
1943	Re-leveling portions of farmland from Hwy 1 to ocean. (Honeycutt)
1949-1950	200-300 steelhead reported by sport fishermen in AG Creek. (CDFG)
1950-1954	Less than 100 steelhead reported by sport fishermen annually in AG Creek. (CDFG)
1952	Flood destroys 450 acres of farmland leaving behind silt and debris.
	Re-leveling portions of farmland from Hwy 1 to ocean. (Honeycutt)
	Rainbow trout planting record, 1941-52. (CDFG)
1954	AGSCD holds first watershed meeting. (Honeycutt)
1954-1955	100-200 steelhead reported by sport fishermen in AG Creek. (CDFG)
1955-1956	300-500 steelhead reported by sport fishermen in AG Creek. (CDFG)
1956	Arroyo Grande Watershed 566 Project signed by AGSCD, San Luis Obispo Co. Flood Control and Water Conservation District, and State and Soil Conservation Service. (Honeycutt)
1957	US Forest Service Intensifies fire prevention steps in Los Padres National Service. (Honeycutt)
	Construction of channel begins. (Honeycutt)
1957-1958	100-300 steelhead reported by sport fishermen in AG Creek. (DFG)
1958-1960	Less than 100 steelhead found by sport fisherman in AG Creek. (DFG)
1959	Stream survey finds stickleback in AG Creek. (DFG/Smedley)
	Steelhead habitat survey from mouth to headwaters finds three-spine stickleback and steelhead in AG Creek. (CDFG)
	Steelhead observed in Lopez Canyon. (CDFG/Smedley)
1960	Stream survey finds stickleback, steelhead, and roach. In AG Creek. (CDFG/Schreiber)
	Steelhead observed in Lopez Canyon. (CDFG)
1961	Steelhead observed in AG Creek. (CDFG/Hinton)

Stickleback, roach, and Sacramento sucker observations in AG Creek. (Hinton)

Steelhead and stickleback observed in Lopez Canyon. (CDFG/Needham)

Construction of channel finished; two dikes built, stream bed deepened, rock rip rap at the Hwy 1 bridge, diversion of Los Berros Creek into AG Creek, inner banks planted to stop erosion, dunes planted with beach grass, levees and water flow-controls measures in, land treatment-crop cover, range fertilization, and pasture and range seeding, and heliports, firebreaks, roads and fire protection in LPNF. (Honeycutt)

No steelhead to date recorded by sport fisherman in AG Creek. (CDFG)

1968 Green sunfish, stickleback, steelhead, speckled dace, roach, and largemouth bass observed. (CDFG/Johnson)

Steelhead observed in Lopez Canyon. (CDFG)

1968 Lopez Dam completed; Dam filled to capacity and spills April 1969

1972 From Hwy 1 to Lopez dam, vegetation dense with predominantly willows, sycamores, cottonwoods and small shrubs. Water depth averages one foot (4 inches to 4 feet). Gravel makes up most of stream bottom. Few pools. Two barriers in creek. Four irrigation diversions. Three small pumps located near residential areas. Four roadways graded across creek (creek diverted into culvert pipes). Snail abundant. Sedges and bulrush at mouth of creek. Small amount of algae. Crusty scum at bottom of creek between Hwy 1 and ocean. Large amounts of junk. Upper sections of creek mildly turbid. Armoured three-spine stickleback found in city limits of creek. Creek runs through private land, residential areas, walnut orchards, and agriculture for grazing and row crops. (CDFG/Tartaglia)

1978 Four foot of silt removed from channel. (Honeycutt)

Stickleback, roach, and riffle sculpin observed in AG Creek. (CDFG/Stone)

1979 Stickleback observed in AG Creek. (CDFG/Schuler)

1983 12000 CY removed from AG channel. (Honeycutt)

1984 8640 CY removed from AG channel. (Honeycutt)

1984 County receives a Negative Declaration to clean out the sediment. EIR must now be written to clean channel.

1988 9830 CY removed from AG channel. (Honeycutt)

1989 16470 CY removed from AG channel. (Honeycutt)

1990 12875 CY removed from AG channel. (Honeycutt)

1996	Assessment of juvenile steelhead habitat and fish densities in Arroyo Grande Creek prepared by Donald W. Alley. Habitat listed as "below average to fair" in most cases with just one location being classified as "average." The results called the biggest limiting factors low pool habitat occurrence, poor spawning substrate, and a lack of suitable escape cover. Fish densities ranged from 0-22.5 fish/ 100 feet (young-of-the-year) and 0-8.3 fish/ 100 feet (yearlings).
1997	Arundo and willows removed from where they were growing in center of channel. (Honeycutt)
	South Central California Steelhead trout listed as threatened on the Endangered Species List.
1998	Two adult Steelhead trout killed in Arroyo Grande Creek due to insufficient releases from Lopez Dam.
1999	AG channel's capacity 15-25% of its original design. (Honeycutt)
2000	San Luis Obispo County Public Works Department begins Arroyo Grande Creek Habitat Conservation Plan for the Protection of Steelhead trout and Red-legged frog (HCP) to ensure safe yield conditions are maintained.
2001	San Luis Obispo County begins mandated earthquake retrofit of Lopez dam. Dam could only hold up to 80% of capacity. Potential threat of liquefaction of base soil under dam if at capacity and substantial earthquake were to occur.
2002-2003	Flood Zone 1/1A Advisory Committee convenes following March 2001 levee breach. County votes to relinquish flood channel maintenance to the State Department of Water Resources. Ad Hoc committee convenes under direction of County Supervisor to address on-going maintenance issues in the interim.
2004-2005	County of SLO and Coastal Conservancy fund Flood Alternatives Analysis. CSLRCD proceeds with Flood Alternatives Analysis contract. DWR initiates study for benefit assessment district. Ad Hoc committee convenes to develop strategy for a locally managed flood control channel.

Appendix B

Geomorphic and Hydrologic Conditions Assessment

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Final Technical Report

Arroyo Grande Creek Watershed Management Plan

Geomorphic and Hydrologic Conditions Assessment

for Central Coast Salmon Enhancement

December 8, 2004

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1. Introduction

1.1 Problem Statement

Arroyo Grande Creek is a 157 square mile coastal watershed located in west-central San Luis Obispo County (Figure 1). The mainstem of Arroyo Grande Creek flows through the cities of Arroyo Grande and Oceano and is an important regional waterway, providing agricultural and municipal water to the communities of Arroyo Grande, Grover Beach, Oceano, Pismo Beach, and Avila Beach by way of Lopez Reservoir located in the upper portion of the watershed. An expanding urban population and a desire to maintain the regions agricultural roots has resulted in an increasing demand on the natural and biological resources of the Arroyo Grande Creek watershed.

The debate on the future direction of the communities within the Arroyo Grande Creek watershed and the fate of Arroyo Grande Creek itself relates to several issues:

- Availability of water for agricultural and municipal uses,
- Protection of biological resources, such as steelhead and red -legged frog,
- Population growth and additional urban development,
- Protection of high quality agricultural lands, and
- Reducing flood risks on Lower Arroyo Grande Creek.

To provide direction on several of these issues, Central Coast Salmon Enhancement (CCSE) formed a Steering Committee and Technical Advisory Team consisting of representatives of stakeholder groups, landowners, and scientists, with the goal of assessing current and historic conditions within the lower Arroyo Grande Creek watershed and to provide preliminary recommendations for managing the watershed now and into the future.

In Spring of 2003, CCSE received funding from the California Department of Fish and Game to develop an Arroyo Grande Creek Watershed Management Plan (AGCWMP). One component of the AGCWMP is to assess geomorphic and hydrologic conditions within the Arroyo Grande Creek Watershed and develop management recommendations to enhance stream and habitat function, reduce fine sediment inputs, and identify opportunities for restoration actions in the watershed and site-specific treatments for restorations actions at high priority sites.

1.2 Study Goals and Objectives

CCSE subcontracted with Swanson Hydrology and Geomorphology (SH+G) to prepare a technical document describing geomorphic and hydrologic conditions in the watershed and to assist CCSE in developing management recommendation for the Arroyo Grande Creek Watershed within the context of these disciplines. The focus on this analysis is to assess the geomorphic health and proper functioning of Arroyo Grande Creek and its principle tributaries in relation to flood risk and habitat quality.

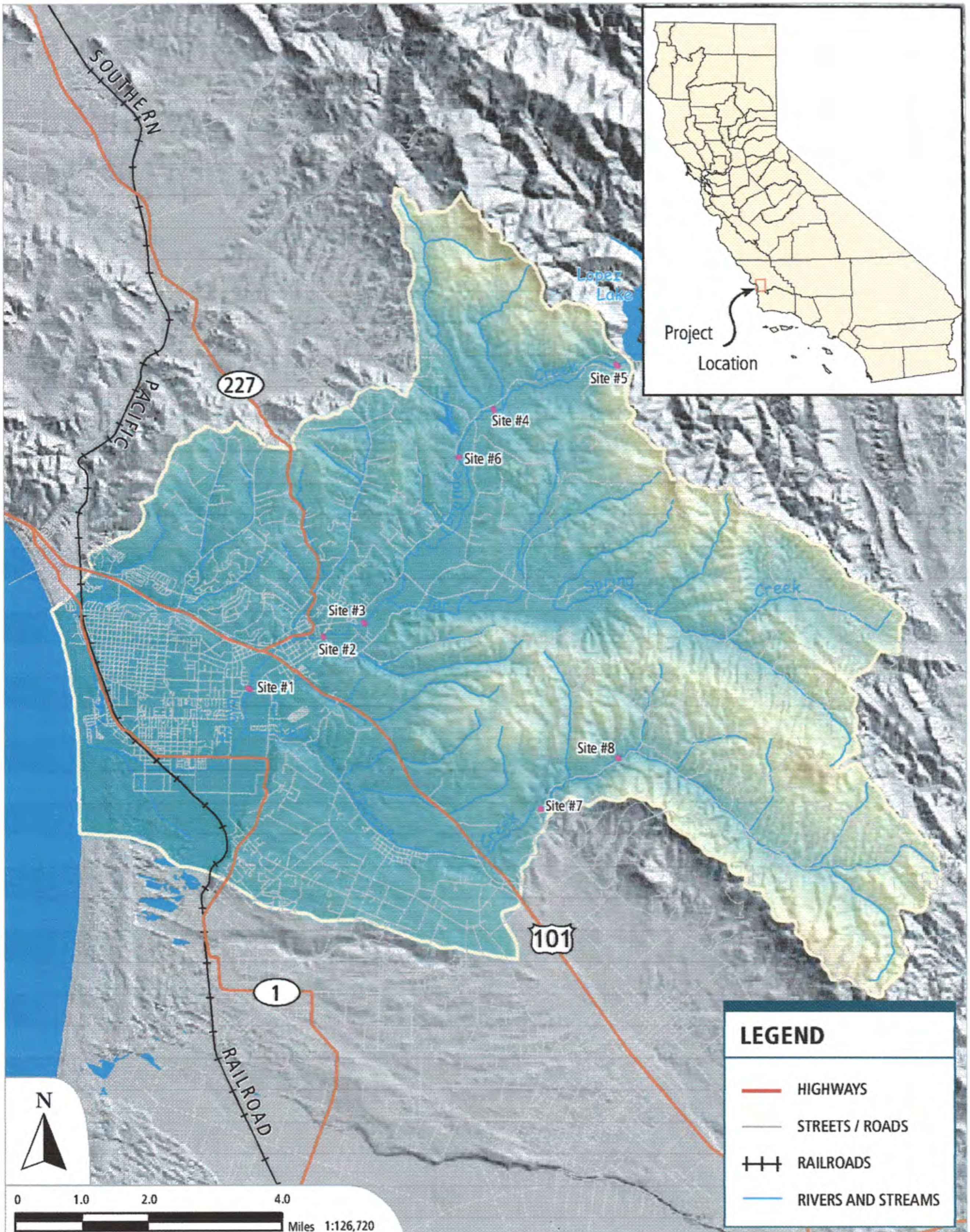

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FIGURE 1: Location map of the Arroyo Grande Creek Watershed below Lopez Dam in San Luis Obispo County, CA. Cross-section and pebble count location are also noted.

The tasks outlined by SH+G to prepare a comprehensive technical document are as follows:

- Review existing data and information related to hydrologic and geomorphic conditions,
- Compile and analyze data collected by the California Conservation Corps (CCC) Stream Inventory team members that are relevant to hydrologic and geomorphic conditions in the watershed,
- Identify key erosion processes and an order of magnitude understanding of sediment sources and their impact on channel stability, deposition within the lower watershed, and flooding,
- Obtain and analyze current and historic aerial photos to define historic channel function and the potential impact of channel modifications on erosion and sediment supply and sorting,
- Review and analyze current and historic flow records to assess timing and magnitude changes associated with land use impacts and their resulting effect on sediment conditions and flooding, and
- Identify future data collection efforts that would be required to address areas of interest identified through the stakeholder meeting process or through the watershed technical assessment.

2. Watershed Setting

2.1 Climate

The climate occurring within the Arroyo Grande Creek watershed can be characterized as Mediterranean with cool, wet winters and warm, dry summers. Due to the proximity of the lower watershed to the Pacific Ocean, coastal fog significantly reduces dry season temperatures, especially in late spring and early summer. Annual rainfall averages around 20 inches though rainfall totals can be much higher in the headwater regions where rainfall rates are increased through orographic uplift. Typically, 75% of the total average annual rainfall occurs between the months of December and March, producing a flashy hydrologic regime. Winter peak runoff can often be four to five orders of magnitude higher than summer baseflow. Such flashy flows are the result of meso-scale midlatitude cyclones, often invigorated by subtropical moisture during El Nino years.

2.2 Geology

The Arroyo Grande Creek watershed lies at a structural and geomorphic transition between the north-northwest trending Coast Ranges and the west trending Transverse Ranges and has been described by Nitchman (1988) and Namson and Davis (1990) as an active fold and thrust belt. The lower watershed occurs within a geomorphic province known as the Pismo Basin that is bound on the northeast by the West Huasna Fault Zone and on the southwest by the Santa Maria River Fault Zone. The Wilmar Avenue Faault Zone also dissects the lower watershed, running parallel to the Highway 101 corridor.

The lower watershed is primarily underlain by sedimentary and volcanic rocks from the Cenezoic age though portions of the watershed in the vicinity of Lopez Dam are mélange and serpentine rocks from the Franciscan Formation (Figure 2). The sedimentary or pyroclastic nature and relatively young age of much of the underlying bedrock material results in the presence of highly erodible, friable material that is unconconsolidated and easily weathered. Dune formations and extensive alluvial deposits in the valley floor of the mainstem and tributary channels also results in high erosion potentials. The alluvium primarily consist of unconsolidated, poorly bedded, poorly sorted to sorted sand, gravel, silt, and clay, with cobbles and boulders.

3. Channel Morphology

3.1 Background

Stream channels function in a physical sense to transport watershed products, including water, sediment, woody debris, and nutrients, to the lower end of the catchment. All of the fundamental characteristics of the channel, such as planform, capacity, and width-depth ratio, are reflective of the quantity and characteristics of watershed products supplied to the channel, and eventually transported through it. Changes in the quantity or characteristics of watershed products supplied to the channel are likely to result in changes in fundamental channel characteristics, although the link between the watershed and the channel is complex and specific channel response to watershed changes may be difficult to predict (Lisle 1999).

The supply of watershed products to the stream channel is to a great extent determined by geology and climate. Often termed independent variables in models of channel response, geology and climate do not respond to other factors governing channel behavior, and are not influenced by human management. The influence of these independent variables on channel behavior is felt across the entire watershed. Topography and watershed gradients, which sensitively control the rate of erosion, are dictated by tectonic activity and subsequent fluvial erosion. The quantity and size of bedload and suspended load sediments available for transport by the channel are a function of the erodibility of rocks in the watershed and their mode of transport from hillslope to stream channel. Climate-driven precipitation determines the amount and timing of water and sediment supplied to the channel. Geologic and climatic histories are also important influences on the delivery of watershed products; for example, the effects of higher past erosion rates, driven by a wetter climate, still influence how erosion occurs today.

The transport of watershed products through the stream system is also highly influenced by climate and geology. Large-scale geologic features such as faults, landslides or bedrock constrictions influence the stream profile gradient, the continuity of sediment transport down-valley during floods, and the storage of sediment and wood on the floodplain (Grant and Swanson, 1995; Benda, 1990; Miller, 1994), . The magnitude, timing and duration of floods have significant influence over rates of sediment transport.

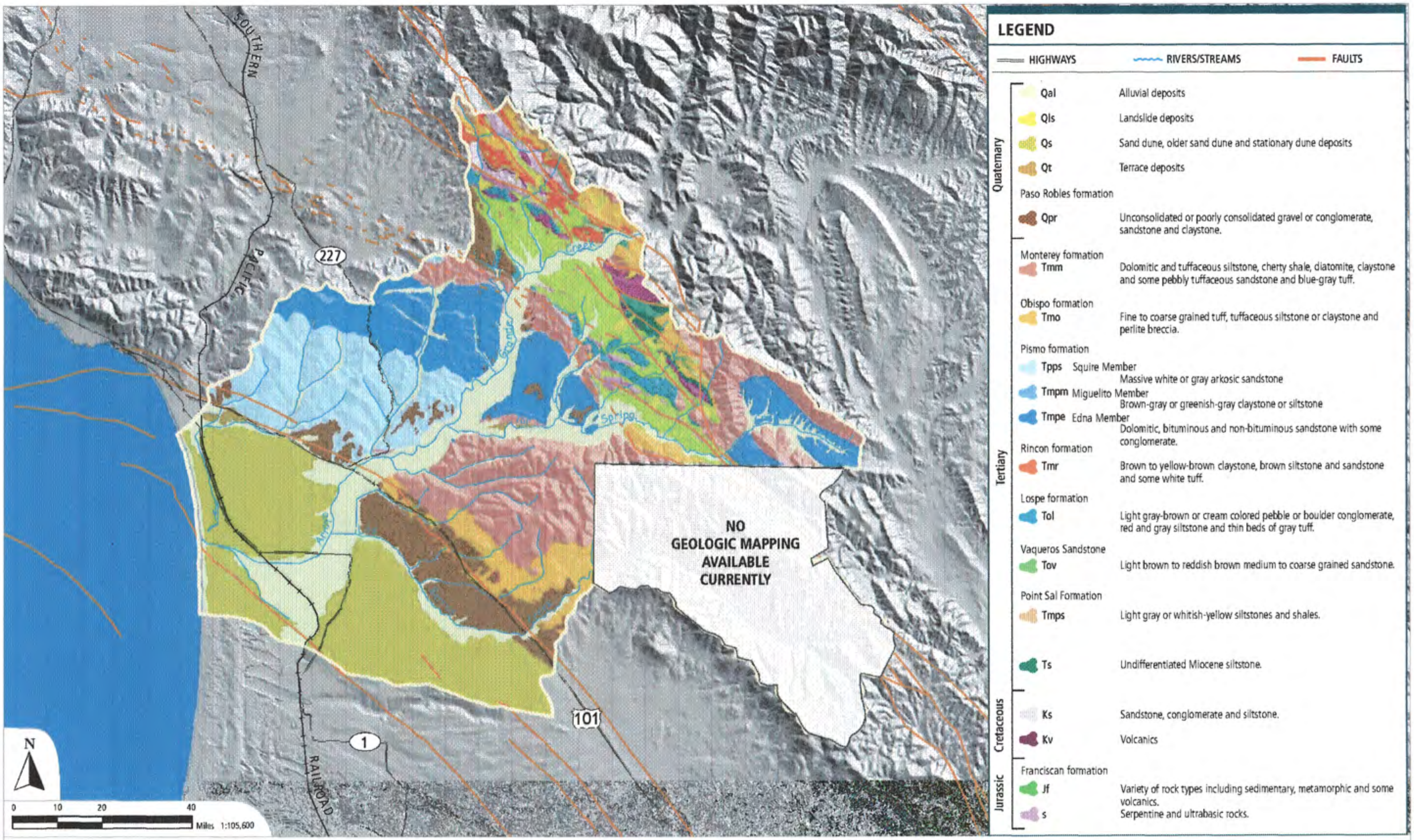

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FIGURE 2: Geologic map of Arroyo Grande Creek Watershed below Lopez Dam. Mapping data provided by County of San Luis Obispo, digitized from the Arroyo Grande 15' quad and the Tar Spring Ridge 7.5' quad.

Another important factor that influences the supply and transport of watershed products is fire. The combination of warm, dry summers and the dominant vegetation type present on the hillslope, referred to as chaparral, results in frequent wildfires within the Arroyo Grande watershed. Fire frequency on the southern Central Coast of California has been estimated to have a recurrence of approximately 40 to 50 years (Max Moritz, personal communication). The first rains following a fire result in supply and transport of large quantities of sediment that had been temporarily stored on the hillslope as colluvium in the intervening period (Keller, et. al. 1997). Much of this material is released from steeper tributaries and is delivered to mainstem channels. Channels and riparian vegetation can be buried during these depositional events with a slow recovery as the principal channel and associated floodplain is reformed.

Dunne and Leopold (1978) define the floodplain as the "flat area adjoining a river channel constructed by the river in the present climate and overflowed at times of high discharge". Again, although this appears to be a simple definition, on closer examination the reality is more complex. For example, the flat area in this definition is a landform constructed primarily by slow lateral migration and overbank deposition. In developing a technique for channel classification, Rosgen (1994), working from the Dunne and Leopold concepts of bankfull discharge and floodplain formation, notes that the active floodplain is the area of the valley flat above bankfull discharge and below a flood prone stage, twice the maximum bankfull flow depth (See the fish habitat assessment report for a description of Rosgen reaches observed in the lower Arroyo Grande Creek watershed). He notes that this may include both active flood plain and low terrace (a former floodplain abandoned due to climatic or other changes) (Rosgen, 1994).

During floods, localized erosion and deposition occurs on the floodplain, resulting in a highly varied microtopography. Sediment deposition on the floodplain is a key element in establishing new riparian vegetation, as is localized erosion, which provides growing areas in proximity to the water table. Also, log jams and woody debris act as hydraulic controls in the channel, and influence groundwater elevation throughout the floodplain, increasing the amount of time that soil moisture is available during the growing season, and increasing the overall density of vegetation. Woody debris also plays a key role in stabilizing the floodplain by providing resistance to erosion in flood channels, storing and sorting sediment in localized areas, and preventing widespread erosion by resisting the tendency of flood flows to concentrate. Individual trees or downed logs break up floodplain flow paths.

The heterogeneous nature of the floodplain due to these processes contributes to the future recruitment of large trees and woody debris. Recent deposits of flood sediment deliver nutrient rich deposits of fine sediment onto the floodplain and thus provide suitable establishment areas for riparian vegetation. Areas of nutrient rich soil in areas of high roughness become favorable for the regeneration of large trees, providing for the next generation of large woody debris. This, then, perpetuates the long-term supply of woody debris, and provides for a steady state with respect to the level of resilience within the system.

3.2 Historic Channel Conditions

Though it is difficult to definitively describe what Arroyo Grande Creek may have historically looked like, historical accounts from early settlers and an understanding of the physical setting provides a glimpse into the past and a picture of how the channel functioned.

The area of interest for this project is lower Arroyo Grande Creek from the downstream end of Lopez Dam to the mouth at the Pacific Ocean. Lopez Dam occurs at a point in the watershed where there is a transition from confined mountain valley to unconfined coastal plain. Many dams are placed at this location because they provide a convenient constriction point to place a dam with steep valley walls upstream to impound a large amount of water. Downstream of Lopez Dam the channel is much flatter, the valley much wider and historic floodplain deposits occur across the entire valley bottom (Figures 2 and 3). This area represents a depositional zone within the watershed where large quantities of water and sediment transported from the upper watershed spreads across the valley floor. Channels in steep, higher gradient valleys can transport more sediment than channels in lower gradient, wide valleys because the energy required to move the sediment is a function of an energy gradient that is related to surface water slope and depth. This is often referred to as the sediment transport competence of the flow. In the lower portions of the mainstem, near the City of Oceano, the floodplain deposits are extensive. Combined with the potential for sand berms to form at the mouth, high tides and storm surges during peak flow events, and the constricting presence of the sand dunes, this portion of the system can be classified as deltaic in nature.

The historic channel likely had a much wider active floodplain, as compared to the incised condition it is in today. The entire valley bottom (Figure 3) most likely consisted of a series of active channels, flood channels, and abandoned channels with backwater wetlands that all occurred at, or near, the elevation of the current valley floor. The active channel was likely to be an ephemeral feature, shifting from one location to another based on sediment deposition, debris jams, or other obstructions. In some areas the channel was likely braided, where the floodplain was wide, and a single thread channel where constrictions such as bedrock outcrops narrowed the floodplain.

Several lines of evidence suggest that the channel exhibited these characteristics including remnant channel and floodplain areas observed on historic aerial photos and historic accounts from early settlers. Figure 4a shows a historic aerial photo from 1939 depicting a remnant floodplain and channel occurring in the middle of a farm field. The photo displayed with it is a recent aerial photo from 2002. Historic accounts from early settlers, presented below, are taken from a book by Robert Brown, a local historian, entitled, "Story of the Arroyo Grande Creek", published in 2002:

> "..When Francisco and Manuela Branch came here in 1837 to establish their home, the valley was described as a 'thicket of swamp and willow and cottonwood, a monte, as it was called by the Spanish…"

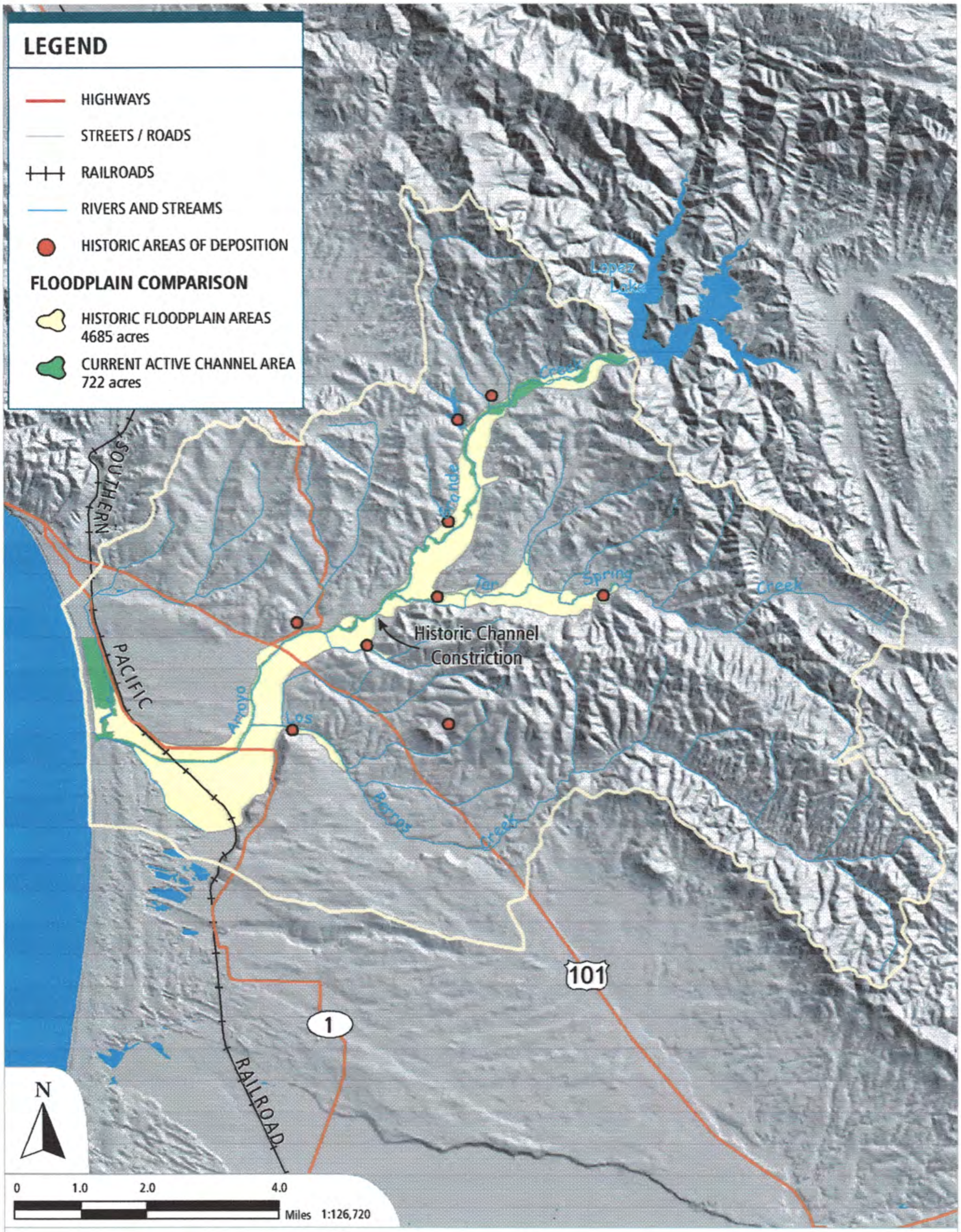

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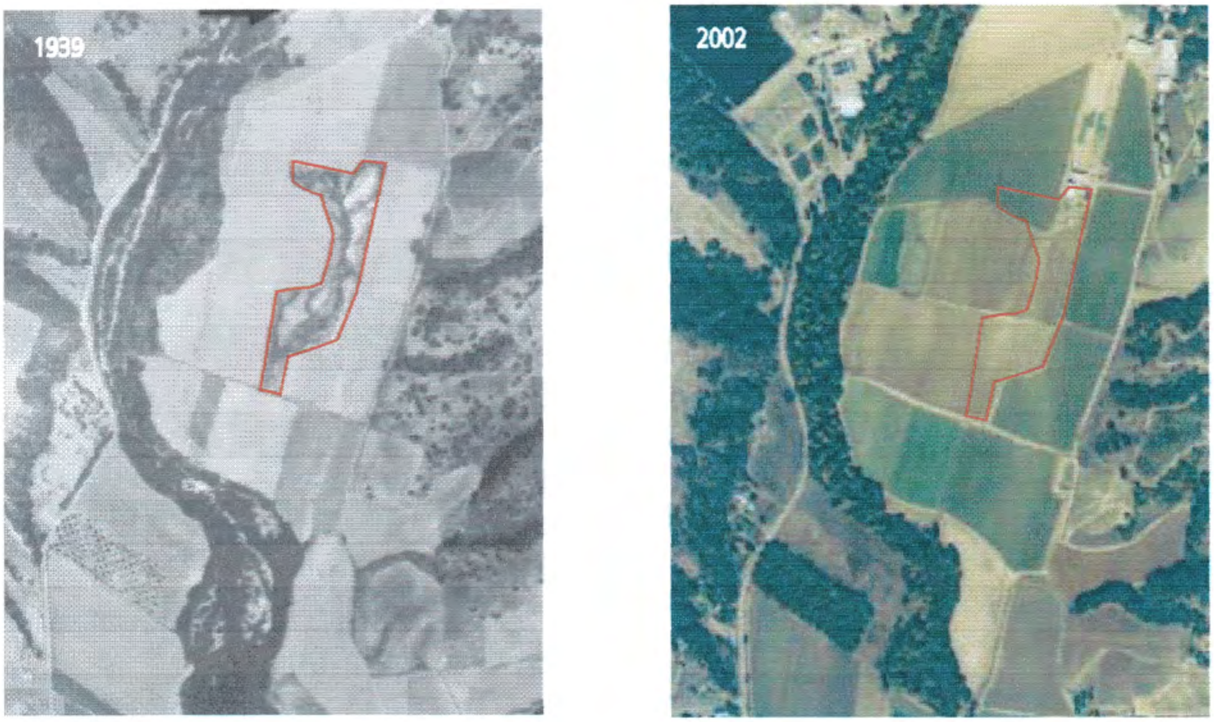
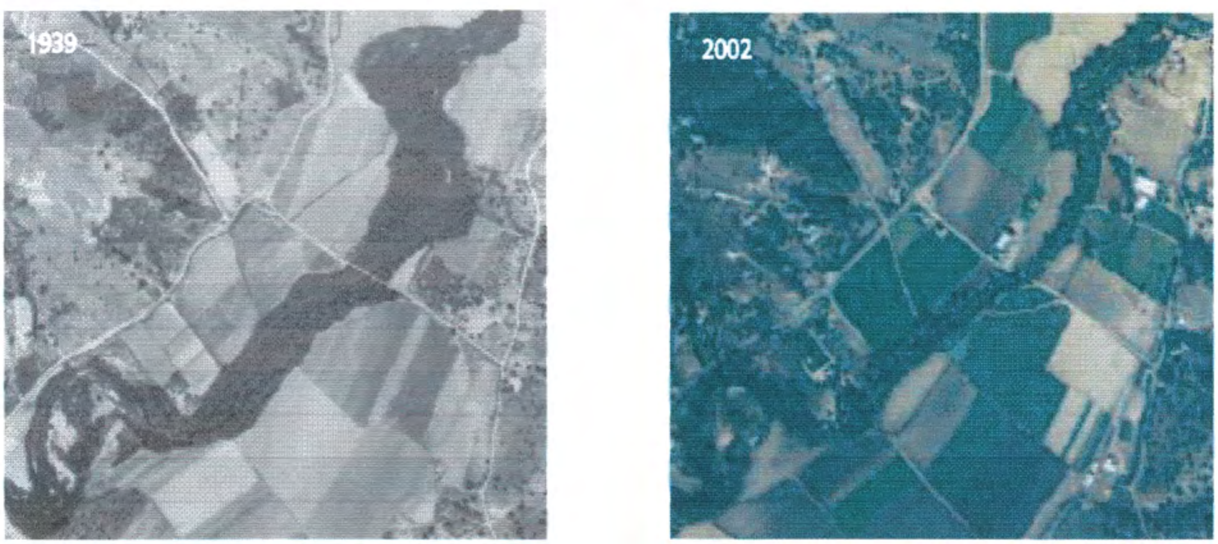
FIGURE 3: Map comparison of historic vs. present day available floodplain areas for valley floor areas of Arroyo Grande Creek and Tributaries. Only 15% of the available flood area remains. Historic depositional areas at tributary mouths are also shown.



A: Remnant riparian area evident in 1939 aerial photo, (highlighted in red), no longer exists in 2002 aerial photo.



B: Wide floodplain / riparian area evident in 1939 aerial photo, in 2002 aerial photo riparian area is confined by agricuctural fields.

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FIGURE 4: a) 1939 and 2003 comparison of aerial photos showing remnant floodplain and channel features. b) 1939 and 2002 comparison of aerial photos showing changes to riparian width.

"…The great adobe, built by Branch, was midway up the valley on a hill just below the present day Branch School. From that point on to the ocean the creek had no channel; it just spread out in the monte, creating bogs and ponds as it made its way to the sea."

"W. H. Findley, who came here in 1875 said in a speech delivered in 1911:'A large part of this beautiful valley was still covered with primeval forests through which the flood waters of the Arroyo Grande had been spreading for untold ages…we helped make the channel and reclaim the land. We felled the forests and built our homes…'"

"As far as the creek is concerned, the early settler, Branch, did some clearing of the monte when he first arrived, but it wasn't until 1863-64 that nature extended a hand and lent assistance by sending the Central Co ast a devastating drought. A lot of wetlands dried up and it was easier to channel the creek."

The tributaries entering the mainstem of the Arroyo Grande through the project reach respond to hydraulic and sediment transport conditions in a similar way. Many of the tributaries consist of relatively steep, confined valleys that have the competence to move a significant quantity of sediment. As these watershed products leave the confined valleys and enter the valley floor of the Arroyo Grande the grade shallows and the valley widens. Similar to the transition on the mainstem located near Lopez Dam, the sediment supplied by these tributaries would be deposited. Since the transition is so pronounced, an alluvial fan would likely have formed at the mouth of each of these tributaries (Figure 3). Alluvial fans can be described as fan shaped depositional features with poorly defined or ephemeral channel features. A channel may form during low flow events, but generally, any channel present is continually shifting in response to deposition of debris and sediment which continually builds the fan surface.

All of these lines of evidence point to the Arroyo Grande being a completely different channel than it is today. So several questions arise: How does the current channel and associated functions differ today than in the past, and; What were the primary influences that produced the current morphology that we see today?

3.3 Land Use Changes

Expansion of Farmland and the Taming of Arroyo Grande Creek

In general, the current morphology of the Arroyo Grande Creek channel consists of an incised, single thread channel from the confluence of Los Berros Creek upstream to Lopez Dam. Downstream of the Los Berros Creek confluence the channel is slightly incised and constrained by levees on both sides of the creek. There is quite a bit of variability in the level of incision but the current morphology does not resemble the historic condition. The degree of incision was estimated along most of the mainstem by a California Conservation Corps (CCC) stream inventory team (Figure 5). The CCC team members rated the degree of channel entrenchment based on a rating from 1 to 10, with 10 representing a highly incised/entrenched channel and 1 represent a channel where flood waters w ere unconfined and had access to an extensive floodplain surface. The survey was conducted to create a relative index of the degree of incision given the difficulties of measuring entrenchment directly (due to thick stands of blackberry and poison oak).

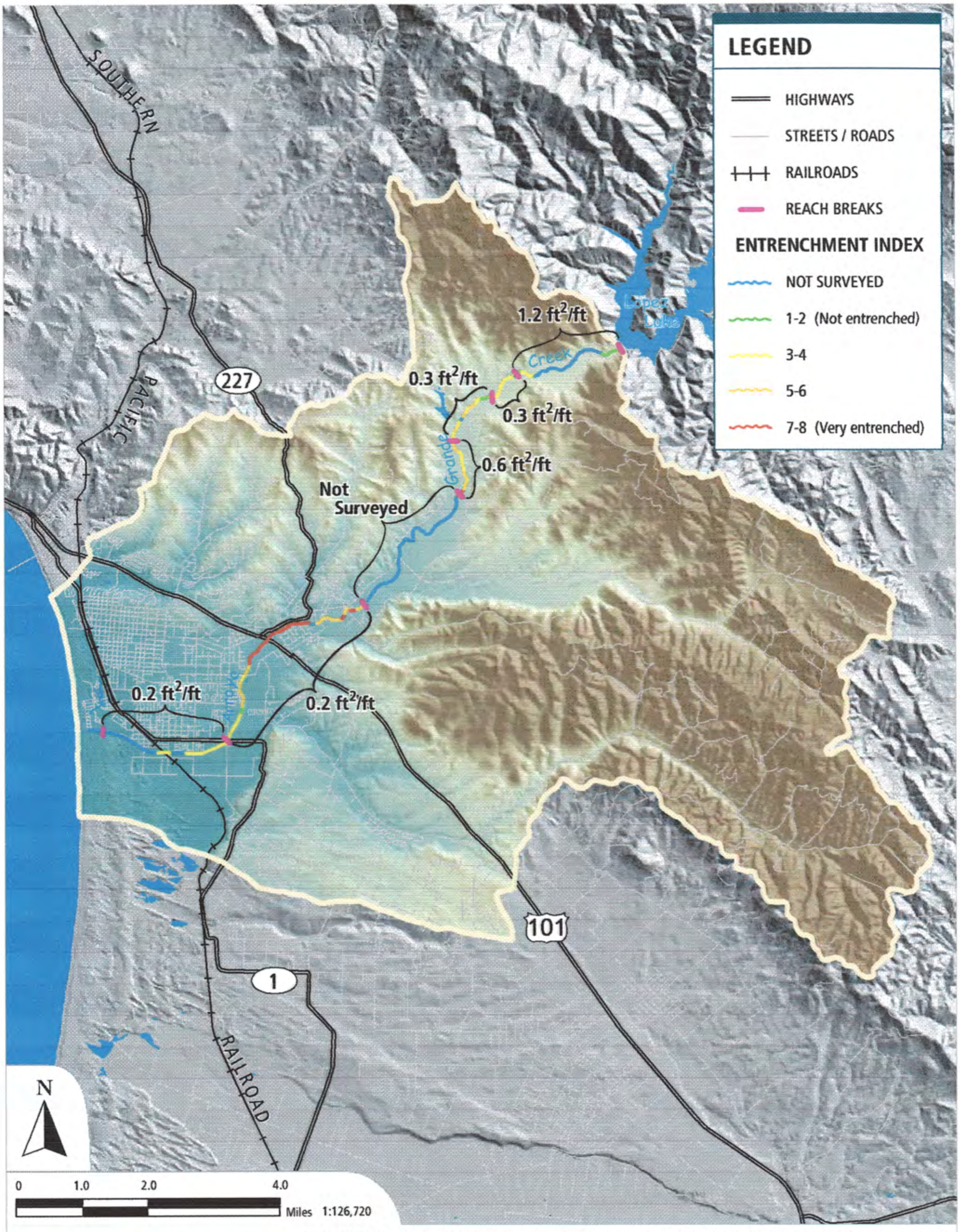

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FIGURE 5: Map of Arroyo Grande main channel divided into reaches according to channel type observed during summer 2004 field surveys. Rosgen channel types vary between F4 and F6. Channel entrenchment index displayed in various colors. Bank erosion area per length of channel called out for each reach.

Additionally, SH+G conducted a reconnaissance-level survey of channel conditions within the Arroyo Grande Creek watershed. Cross-section data, local channel slope, and grain size information was collected at 8 sites within the watershed, including 6 sites on the mainstem of Arroyo Grande Creek and 2 sites on Los Berros Creek (Figure 1). Figures 6 - 10 show the results of the cross-section survey and grain size sampling. Surface grain size was estimated at depositional features, such as bars, using the pebble count method (Wolman, 1954).

At each cross-section site we calculated bankfull width, floodprone width, and a width to depth ratio. In most cases, with the exception of Site #5, the channel was incised and lacked significant floodplain. There does not appear to be a pattern in the distribution of grain sizes in the mainstem of the lower Arroyo Grande channel. Grain size patterns are likely to be site dependent based on local hydraulics, channel geometry, and presence of channel obstructions such as woody material. Future analysis of these data will include estimates of shear at different discharges and associated levels of bed mobility.

Much of the existing channel has been straightened, confined, constricted, and deepened. Floodplain areas have been converted to agricultural fields and the associated riparian forests have been removed (Figure 4b). Many of these changes occurred in the late 1800's and early 1900's as evidenced in the historic accounts from Brown (2002):

> "...The Arroyo Grande Creek became used as a boundary line and it kept shifting, it made good business sense to get a fixed line somewhere. The way the creek shifted around and tore up the land when it flooded, it was necessary to create a definite channel on the south side of the valley."
>
> "'One of the interesting things about the Arroyo Grande Creek is that in the early days it flowed along the south side of the valley, but now it flows along the north side...'"
>
> "The channel formed by Francis Branch and others basically flowed along the south side of the valley...A second ditch brought the creek water down to a farm....This ditch had been extended down the north side of the valley to lands...To divert water into their ditch, Beckett and Young had put up a temporary dam across the main creek. The heavy rainfall in 1883-84 was early and was followed by additional rains in October and November, which coming before the temporary dam had been removed for the winter, resulting in a strong flow of water down the ditch on the north side of the valley. So heavy was the flow that the main channel of the creek swung to the north side of town, where it had remained ever since."
>
> "...The farmers all up and down the creek were working to straighten the creek and prevent further damage should another such flood ever come."
>
> "While the amount of damage done is great, including the loss of practically all bridges and the washing out of roads, it has some compensation. The channel of the Arroyo Grande Creek was never in better condition to carry future floods than it is now. The channel has been widened, many bad corners cut off and the creek bed is four to six feet deeper than it was..."
>
> "...In the winter of 1969, before the dam, it became furious and frothy to the belly of the Harris Bridge, 30 feet above the gorge that Mr. Harris and some engineers had dynamited in the early part of the century, for the creek had a lethal history."

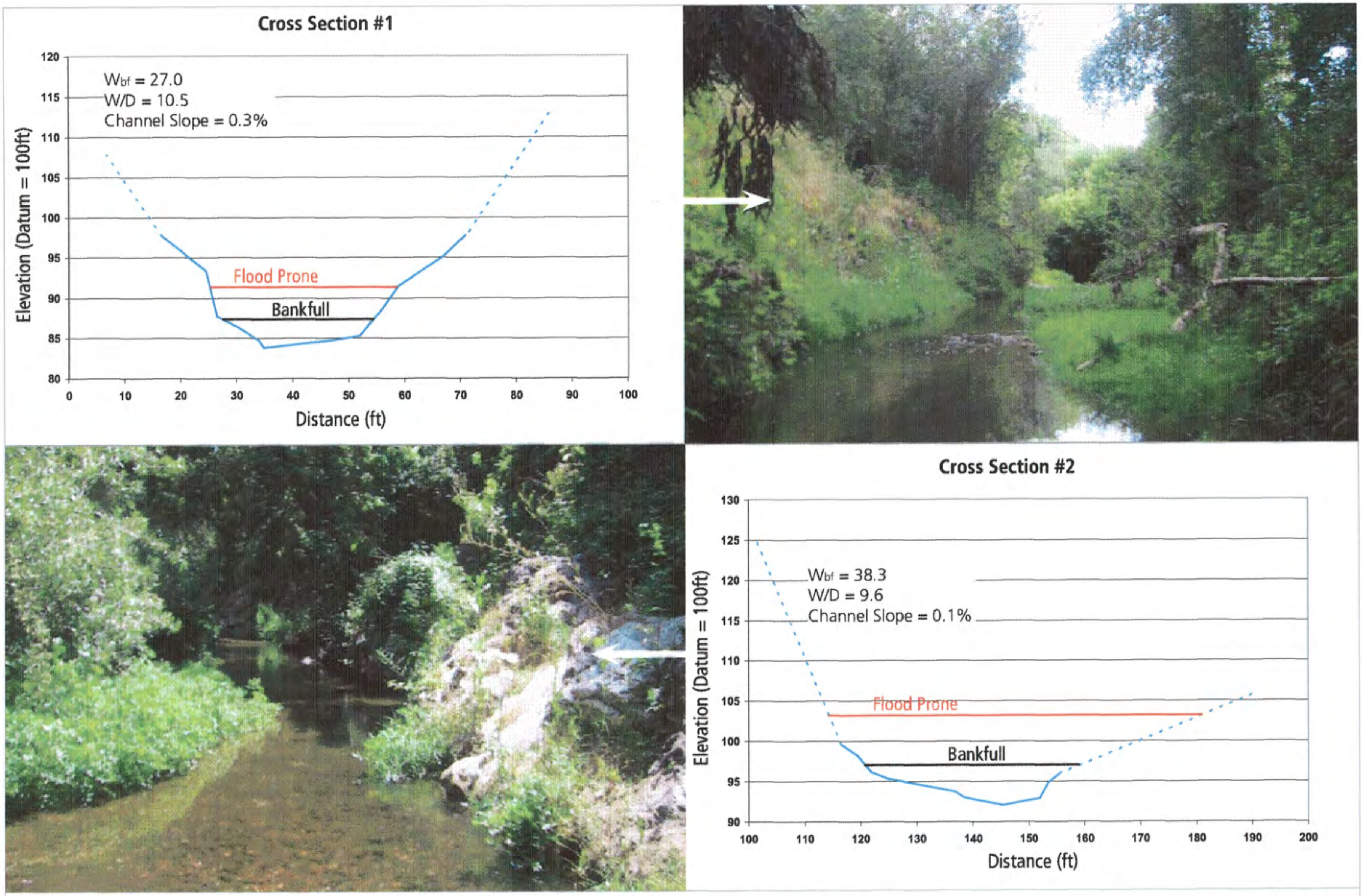

FIGURE 6: Cross-section and channel geometry results from survey conducted in Summer 2004. Bankfull was estimated from field indicators.

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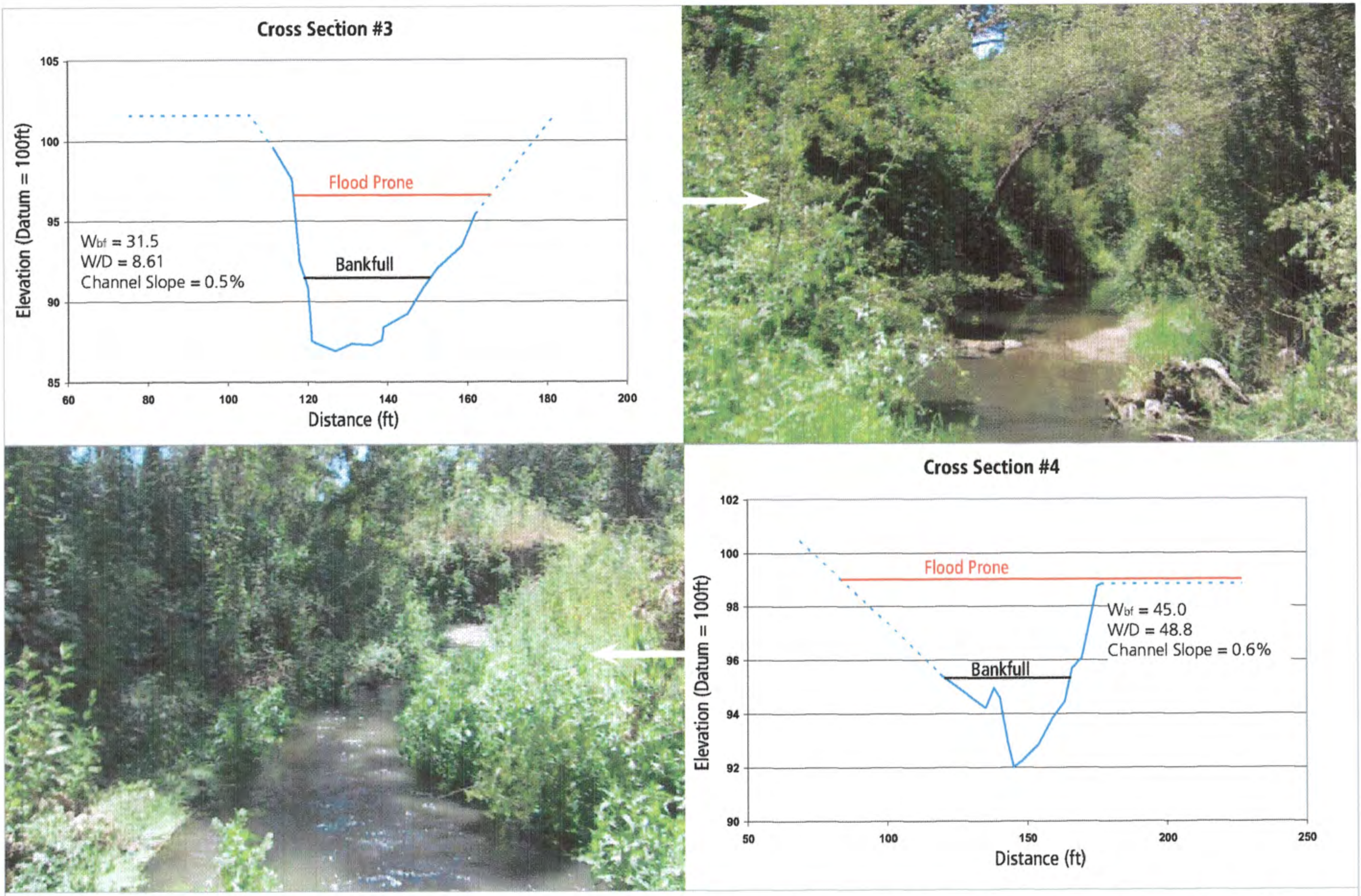

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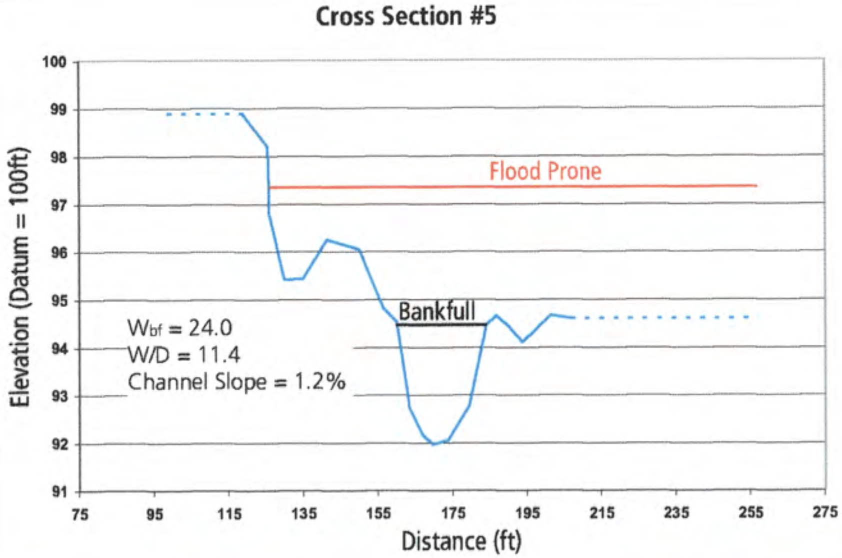
FIGURE 7: Cross-section and channel geometry results from survey conducted in Summer 2004. Bankfull was estimated from field indicators.



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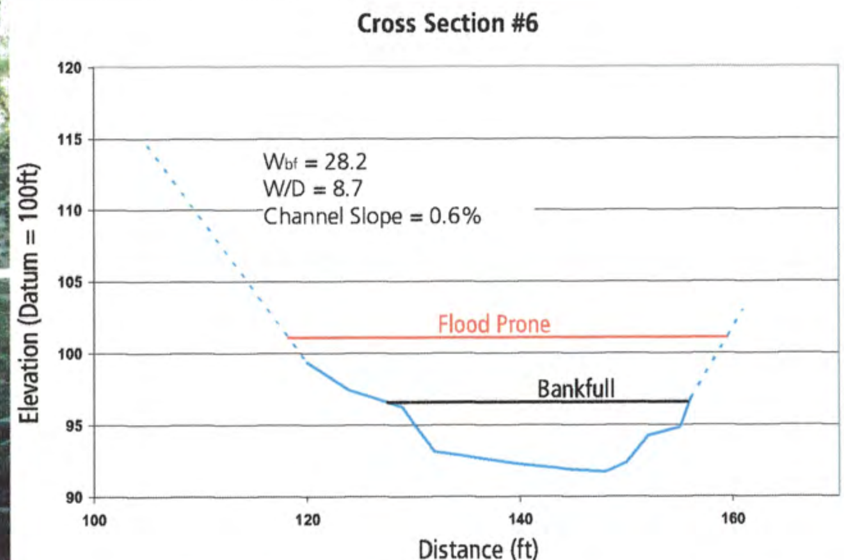

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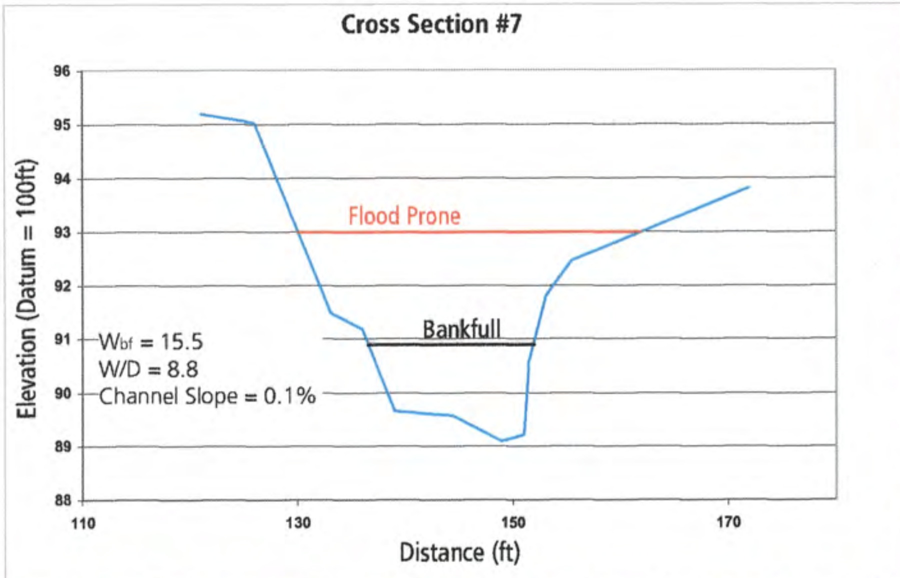
FIGURE 8: Cross-section and channel geometry results from survey conducted in Summer 2004. Bankfull was estimated from field indicators.



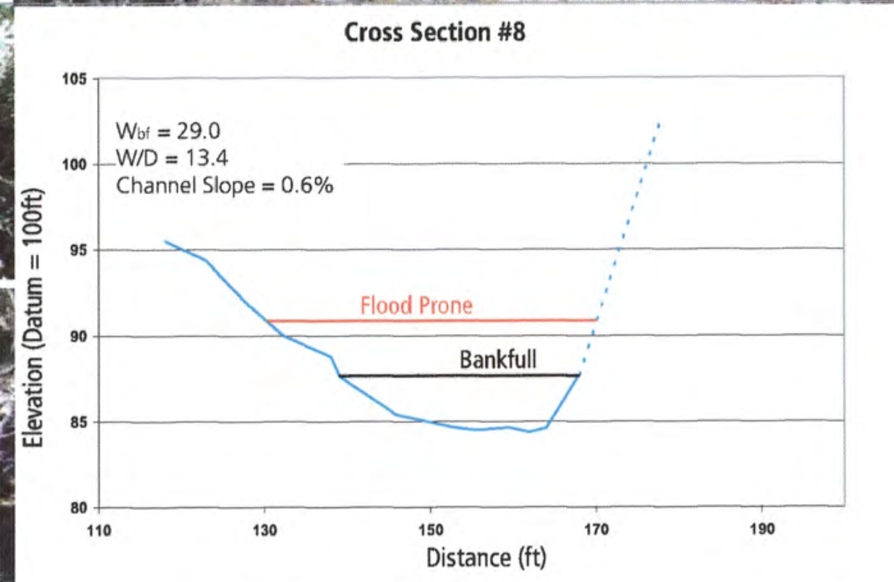


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FIGURE 9: Cross-section and channel geometry results from survey conducted in Summer 2004. Bankfull was estimated from field indicators.

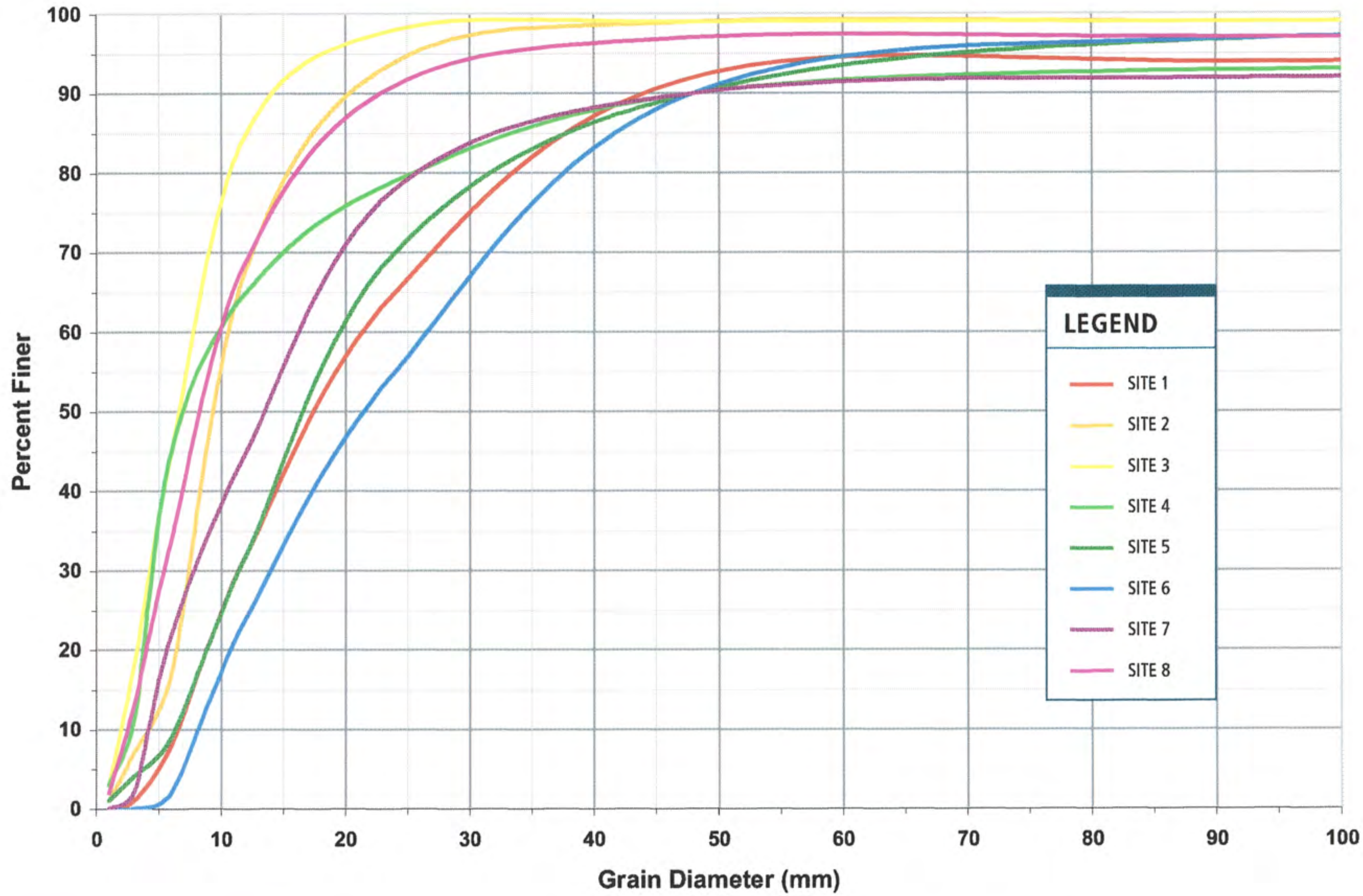

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FIGURE 10: Grain size analysis based on pebble counts for each cross-section site survyed in Summer 2004.

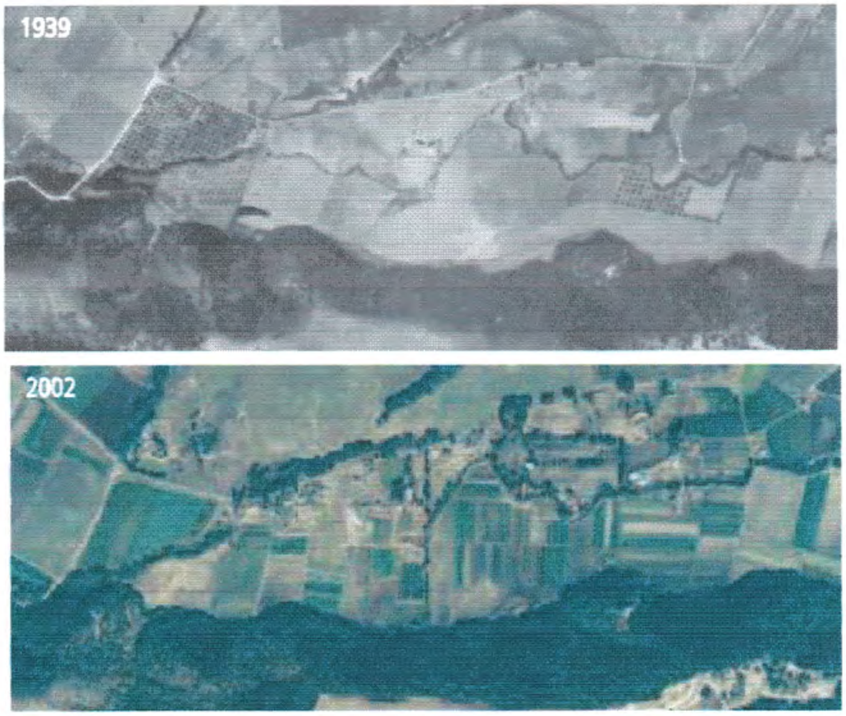
The late 1800's, early 1900's was also a time when significant modifications were occuring elsewhere in the watershed, affecting tributary channel and sediment supply. Alluvial valleys in the lower portions of some of the tributaries were being modified in similar ways to the Arroyo Grande mainstem. Figure 11a shows an example of channel modifications and straightening on Tar Springs Creek. The photos are from 1939 and 2002. It is likely that significant modifications to Tar Springs Creek occurred prior to 1939.

Conversion of the upland areas in the watershed was also occurring in the early 1900's. Hillslopes dominated by chaparral or oak woodland were being converted to grassland for grazing or to orchards. Figure 11b shows extensive hillslope erosion in the Corbett Canyon (Tally Ho) watershed associated with conversion of natural vegetation to agricultural or grazing land. The photos are from 1939 and 2002. Based on an assessment of the 1939 set, it appears that much of the sediment that was eroded from these hillslope was being stored in these tributary channels and/or increased the risk of flooding downstream within the Arroyo Grande mainstem.

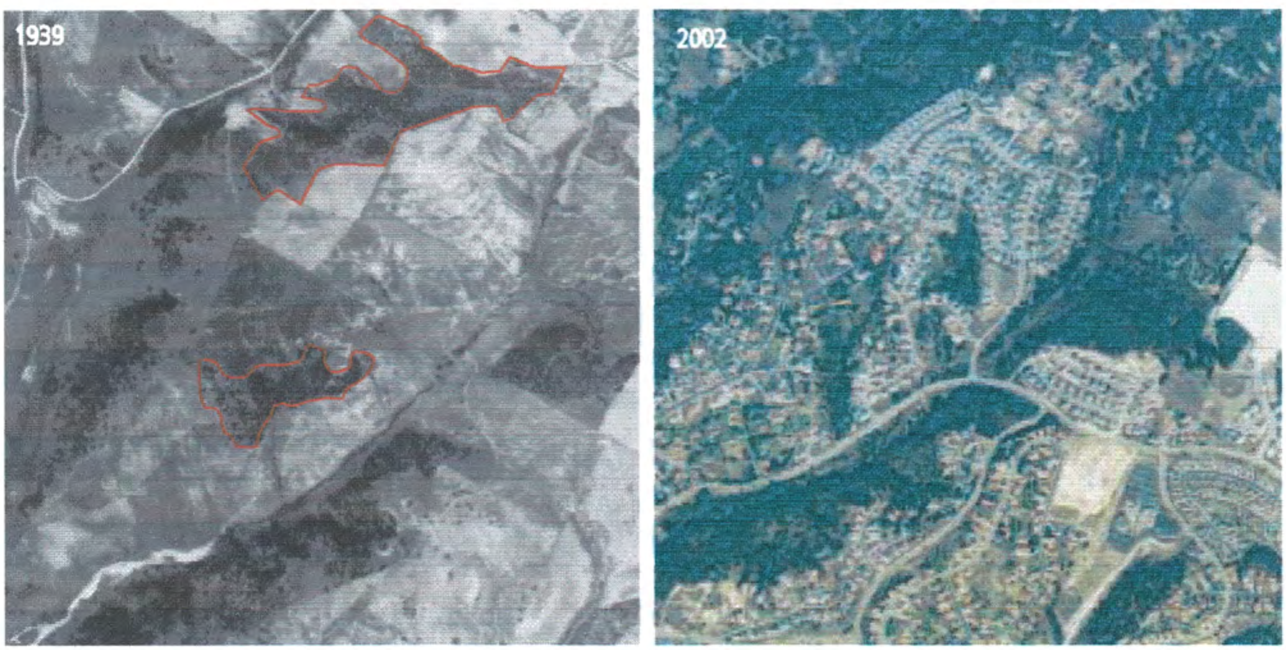
Urban Development

Beginning in the mid-1900's and accelerated in the late 1900's, urban development became an important influence for land use change in the Arroyo Grande Creek watershed. The communities comprising the Five Cities area began to grow and expand into agricultural lands within the Arroyo Grande valley and surrounding hills. Though many of the changes to the Arroyo Grande channel that we observe today had already occurred, the onset of urbanization within a watershed brings with it other impacts.

Several researchers have attempted to describe a predictable evolutionary sequence of channel response to urbanization (Simon, 1989; Arnold et al., 1982; Gregory et al., 1992; Park, 1997). One model, developed by Douglas (1985) describes a conceptual relationship between land use changes, relative sediment yield, and channel stability. At the onset of urban development, this model suggests the sediment yield would be very heavy due to increased runoff from impervious surfaces, resulting in increased gullying, undercutting, and bank erosion. The impact on channel stability would be rapid aggradation and some bank erosion. Assuming no net increase in urbanization, the Douglas model predicts that a watershed would proceed through a period of stabilization that would last on the order of 25 years. During this period sediment yields would be moderate as channels adjusted to the new hydrologic condition and readily available sediment supplies were exhausted. Reduced sediment yields during this transitional period would result in channel degradation and severe bank erosion. Eventually, the channel is expected to reach a stable urban condition with low to moderate sediment yields and a relatively stable channel. This whole channel evolutionary process is expected to take 50-75 years due to lags in land use change and channel response. The timing would be highly dependent upon the size of the watershed, the rate of urbanization, and the time it takes for land use conditions to stabilize.



A: Changes in channel location (Tar Spring Creek) to accomodate agricultural fields and homes.



B: 1939 aerial photo, (left), highlighted areas represent examples of areas with natural cover, surrounding areas have been converted from natural cover types to grazing land and orchards, evident rilling and erosion in disturbed areas. In 2002, (right), much of the general area has been developed with high increases in impervious cover.

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FIGURE 11: a) 1939 and 2002 comparison of aerial photos showing an example of channel modification on Tar Springs Creek. b) 1939 and 2002 comparison of aerial photos showing an example of vegetation conversion in tributary areas.

Due to continued urbanization of many of the tributaries within the Arroyo Grande Creek watershed, the area is likely to be somewhere in between the first and second stage with some subwatersheds experiencing gullying, undercutting, and bank erosion and others stabilizing. Much of the sediment that is being delivered to the mainstem of Arroyo Grande Creek, and specifically the flood control reach is derived from a combination of these sources and bank erosion in the mainstem of Arroyo Grande Creek. Tributary watersheds derive a significant source of erosion from headward expansion of the drainage network associated with an increase in impervious surfaces and reworking of sediment deposits associated with rilling and landslides during the early 1900's when the hillslopes were converted to grasslands and orchards.

Flood Control

Projects designed to reduce flood impacts on the Arroyo Grande mainstem include construction of the flood control channel on lower Arroyo Grande and Los Berros Creeks, completed in 1961, and completion of Lopez Dam in 1968. The impact of these projects on channel morphology are as follows:

- Lopez Dam: Though Lopez Dam does provide some level of flood protection for the flood control reach of lower Arroyo Grande Creek, it also allows for the release of sediment free water into the lower River. Sediment free water, or "hungry water" as it is sometimes referred to, can often contribute to channel incision and bank erosion. Since the water does not carry any sediment when it is released from the dam it is free to perform work on the bed and banks of the river downstream of the dam to reach its sediment carrying potential. This sediment is then efficiently carried to the lower portion of the watershed due to lack of extensive floodplains in the incised portions of the channel where sediment would historically be deposited. Deposition of this material will tend to occur in the flood control reach where the stream gradient is lower and constrictions occur (near bridges).
- Flood Control Channel: Straightening, narrowing, and construction of levees have obvious morphologic impacts on a channel. During moderate flow events, the flat bed configuration of the channel with lack of a bankfull channel may result in increased sediment deposition and increased flooding. The most significant problem with the flood control channel is the continued aggradation that has occurred, resulting in increased flooding. Much of this can be attributed to the lack of sediment deposition occurring elsewhere in the watershed due to incised channel conditions, and increased erosion from bed, banks, and gullying in tributary subwatersheds.

4. Watershed Hydrology

Winter peak flow events on Arroyo Grande Creek can be characterized as flashy and are tied closely to the duration and magnitude of winter rainfall and antecedent soil moisture conditions. In most years, the rainy season begins in October, but the soil moisture demand of the surrounding areas is not met until a significant amount of precipitation has occurred. Once the ground is saturated, a greater percentage of the precipitation is converted to stream flow during storm runoff and the continual contribution of groundwater and subsurface flow to the surface channel increases the winter baseflows. The precipitation is typically much lower during April, but the stream flows remain elevated as groundwater and subsurface flow continues to contribute water to the streams. By May, the water levels in the streams are typically low and relatively unresponsive to small spring thundershowers.

4.1 Pre- and Post-Lopez Dam

The current hydrology within lower Arroyo Grande Creek and major tributaries has been significantly altered through well pumping, direct diversions, changes to land use that have altered soil infiltration rates, and the construction of Lopez Dam in 1968. Lopez Dam impounds approximately 70 square miles of the upper watershed where rainfall intensities and the total volume of water is likely to be much higher than in the lower watershed, despite less drainage area (87 square miles of watershed below the dam).

Historically, Lopez Dam has been managed for water supply for both municipal and agricultural users. Water for municipal use is diverted directly from the dam to a small treatment reservoir located on a tributary to the lower mainstem of Arroyo Grande Creek, and then delivered through a series of pumps and pipes to the end user. To deliver water to agricultural users, water is released directly into Arroyo Grande Creek and passively recharged into local ground water basins. Agricultural users then pump from wells for irrigation. Historically, releases from Lopez for groundwater recharge were closely monitored to obtain maximum infiltration into the groundwater basin. Recent concerns over habitat quality in lower Arroyo Grande Creek for steelhead and red-legged frog have resulted in an interim program to provide enough water for both groundwater recharge and maintenance of natural systems.

Streamflow on Arroyo Grande Creek has only been gaged since 1940 (USGS Gage ID #11141500 – See Table 1) making it difficult to assess hydrologic conditions prior to intensive use of water resources within the watershed.

Table 1: Streamflow data available for Arroyo Grande Creek Watershed

Gage	Period of Record	USGS Station ID
Arroyo Grande above Phoenix Ck	1968-1992[1]	11141150
Wittenberg Ck nr Arroyo Grande	1968-1975[1]	11141160
Lopez Ck nr Arroyo Grande	1968 – present[2]	11141280
Arroyo Grande nr Arroyo Grande	1959-1966[1]	11141300
Tar Springs Ck nr Arroyo Grande	1968-1979[1]	11141400
Arroyo Grande at Arroyo Grande	1940 – present[2]	11141500
Los Berros Ck nr Nipomo	1968-1978[1]	11141600

1. Discontinued
2. Currently operated by San Luis Obispo County

A comprehensive analysis of the historic gaging record for Arroyo Grande Creek under both pre- and post-dam conditions were analyzed by Stetson Engineering, Inc during development of a Habitat Conservation Plan for San Luis Obispo County (Stetson, 2004) related to operations at Lopez Dam. Analysis of the hydrologic data for the HCP included the following:

- Historical streamflow in Arroyo Grande Creek,
- Pre- and post-dam hydrology,
- Lopez Reservoir release and diversion data,
- Reservoir inflow,
- Unregulated Arroyo Grande Creek flow,
- Comparison of unregulated and historical flow,
- Classification of hydrologic water year types,
- Comparison of flows for various hydrologic year types, and
- Lopez Reservoir operation model.

According to these data, the presence of the dam creates the most significant impact to streamflow in lower Arroyo Grande Creek. As is typically the case with large dams in semi-arid watersheds where water supply storage is the primary objective of reservoir operations, the presence of the dam reduces winter peak flow downstream and increases summer baseflow.

Based on data in the Stetson report, average annual inflow to the reservoir was estimated to be approximately 16,000 acre feet (ac-ft). The maximum storage volume based on a reservoir survey conducted in 2001 is approximately 49,400 ac-ft. This suggests that, on average, approximately three years of runoff can be stored in the reservoir. Given that the reservoir has only spilled 14 times in 28 years of operation (data only analyzed to 1998 in Stetson report), peak flow events have either been muted or attenuated since construction of the dam. Additionally, lower discharge events, such as those that occur during dry periods or channel maintenance events are muted completely. For example, Lopez Reservoir did not spill at all between 1986 and 1997 due to extended drought in the late 80's and early 90's.

Most recent estimates of peak flow hydrology for the Arroyo Grande Creek channel were conducted in 1998-99 the U.S. Army Corps of Engineers (USACE), Los Angeles District. Table 2 summarizes the results of the USACE study. These data show the effect of the dam on peak flow in lower Arroyo Grande Creek. Downstream of Lopez Dam, a 2-yr event is only 25% of what it would be if the dam were not present. During a 100 year event it is approximately half.

The opposite is true for summer baseflow conditions. Winter peak flow is stored in Lopez Reservoir for release in the dry summer months for groundwater recharge and municipal uses. Historically, those releases have been managed to maximize recharge and minimize the amount of water that reaches the Pacific Ocean. Therefore, higher base flows occur along lower Arroyo Grande Creek than under pre-dam conditions. The hydrologic record described in the HCP suggests that median summer baseflow conditions prior to construction of Lopez ranged between 1.5 to 2.5 cubic feet per second (cfs), as opposed to 3 to 4 cfs post-dam. During dry and drought years, the data suggest that the Creek would periodically dry up between July and October pre-dam but maintain flows between 0.5 and 2 cfs post-dam (Stetson, 2004).

Table 2: Flood frequency discharge estimates for Arroyo Grande Creek (USACE, 2001)

Location	DA (mi^2)	2-yr (cfs)	5-yr (cfs)	10-yr (cfs)	20-yr (cfs)	50-yr (cfs)	100-yr (cfs)
@ Lopez Dam	68	2000	5200	8100	11600	16800	21500
Outflow from Lopez	68	480	1200	2000	3100	5900	9000
Before the City of Arroyo Grande	103	300	1200	2600	4400	6900	10500
Near Pacific Ocean	145	800	2800	5400	8600	13600	19200
Los Berros Creek @ Arroyo Grande confluence	26.9	NA	NA	2400	NA	7700	11000

The potential impact of Lopez Dam on downstream hydrology is a bit more complicated when the mean daily flow record from the USGS gage is analyzed. Mean daily flow is an average of all instantaneous flow measurements taken at the gage using an automatic recorder. Consequently, the mean daily flow record does not capture the peak of a given storm event, especially in semi-arid watershed such as the Arroyo Grande where the hydrology is flashy. For the summer months, the mean daily flow record is a fairly indicative of an instantaneous measurement for the day.

Figure 12 summarizes mean daily flow data on Arroyo Grande Creek, by month, as observed at the USGS gage site (ID #11141500). The data are presented as an exceedance probability graph and are divided into pre- and post-dam conditions. Exceedance probability can be defined as the percentage of time a particular flow is exceeded. For example, in September, 2 cfs is only exceeded 25% of the time under pre-dam conditions but is exceeded 90% of the time under post-dam conditions. Several trends are revealed in Figure 12, including the following:

- Mean daily flow during the summer months is higher post-dam versus pre-dam,
- In dryer years (exceedance probabilities > 50%), mean daily flow in the winter months is higher pre-dam versus post-dam, and
- In wetter years (exceedance probabilities < 50%), mean daily flow in the winter months is lower pre-dam versus post-dam.

The last two bullet points requires some explanation as it appears these statements contradict previous arguments regarding peak flows being muted due to the presence of the dam. The difference lies in the type of data that are being analyzed and the influence of the dam on dry versus wet years. The data being analyzed are mean daily flow as opposed to instantaneous peak flow. The County of San Luis Obispo's HCP clearly argues that instantaneous peak flow is being reduced due to the presence of the dam. But the effect on mean daily flow is more complicated. During dry years, the dam is likely to have excess storage capacity, requiring less release from the dam to minimize the risk of flooding downstream. Conversely, during wet years, flood control operations at the dam allow for attenuation of the storm peak. Water is often released prior to the arrival of the storm peak, in excess of what is entering the dam, and extended releases afterwards, to restore flood control capacity following the storm event. The result is an extended period of moderated discharge from the dam as opposed to a more flashy natural hydrology.

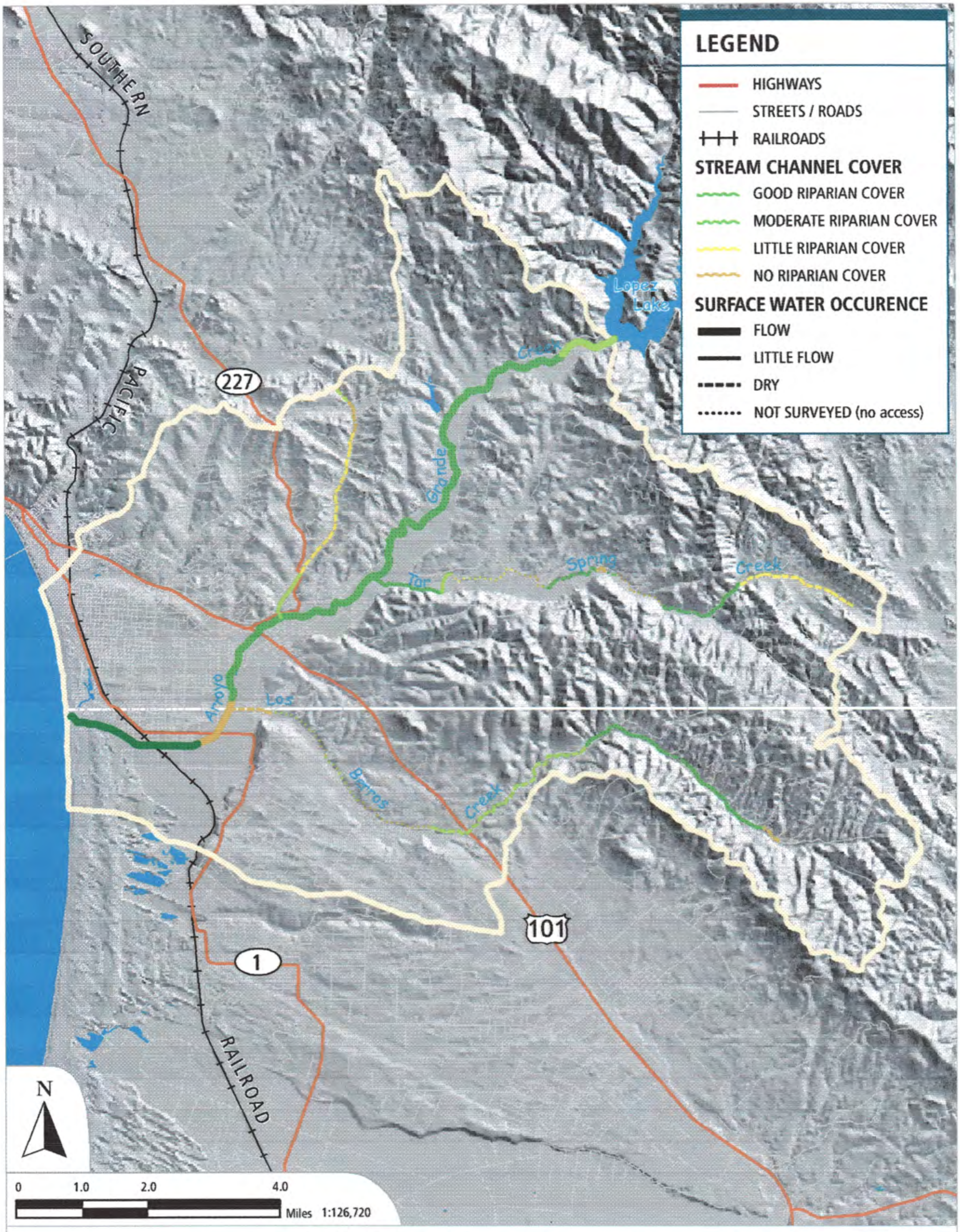

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FIGURE 13: Map of stream channel cover and occurence of surface water during field surveys conducted on June 2-4, 2004.

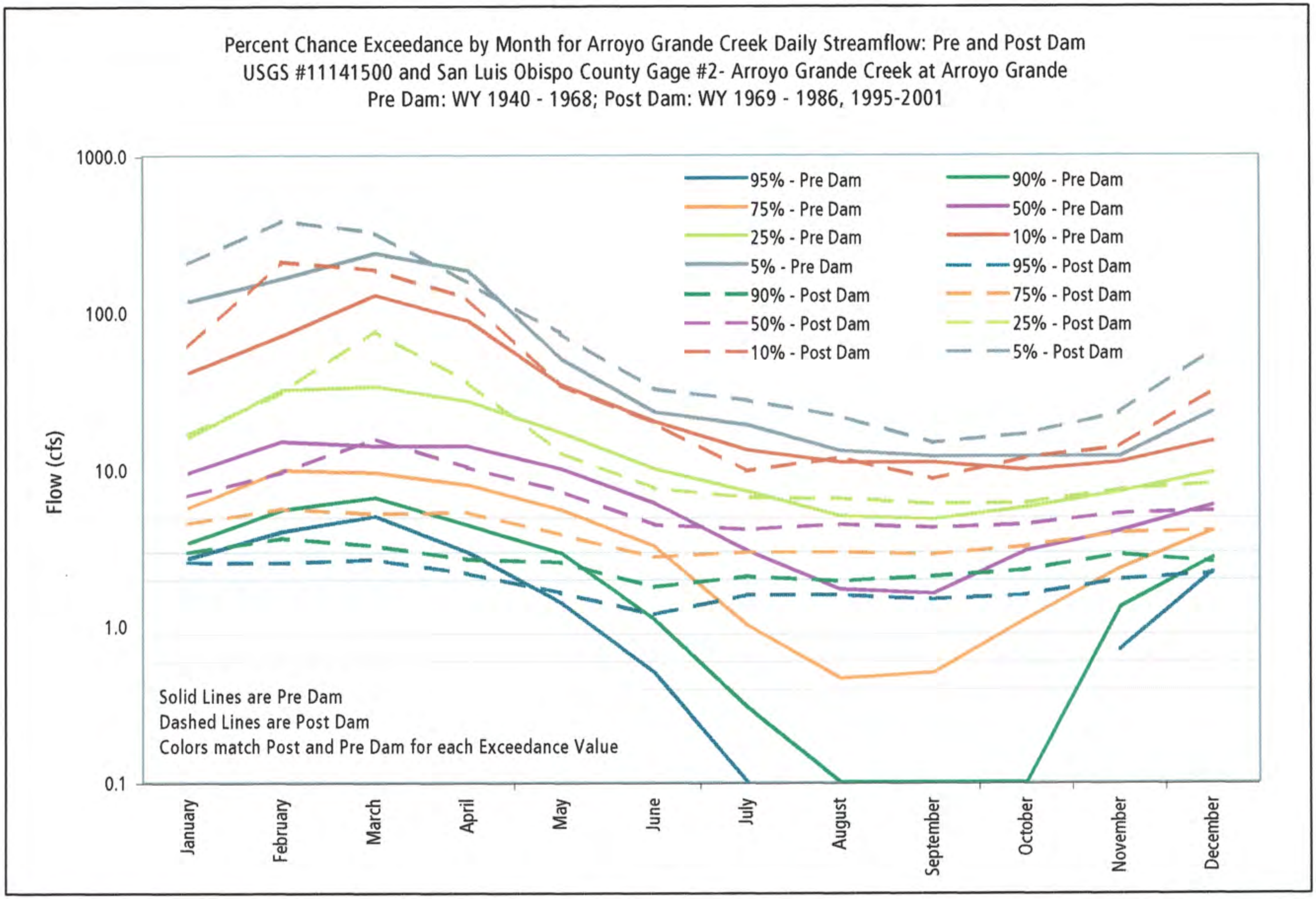

FIGURE 12: Exceedance probability plots for USGS Gage ID 11141500, Arroyo Grande @ Arroyo Grande for pre- and post-dam conditions.

As part of this study, we conducted a preliminary survey of the summer baseflow conditions on the Arroyo Grande mainstem and the primary tributaries (where public access was available). The purpose of this investigation was to assess where surface water persisted through the summer months. The results of this survey are shown in Figure13. As a result of releases from Lopez Reservoir, flow persisted through the summer months along the entire mainstem. In Los Berros and Tar Springs Creek, surface flow is intermittent with a pattern most likely associated with the depth of alluvium and bedrock outcrops. Corbett (Tally Ho), Carpenter, and Newsom Creeks are typically dry in the summer months.

4.2 Influence of Land Use Change on Hydrology

Roads have been shown to significantly alter the hydrology within a watershed (Wigmosta and Perkings, 2001; Bowling and Lettenmaier, 2001; Luce and Black, 2001). Roads increase the amount of impervious surface in a watershed. Roads also alter and concentrate flow paths, and depending on the quality of construction, can greatly increase sediment supply to the channel through road cut, fill, and outslope fill failures. Undersized culverts, built to handle water but not sediment and debris, can clog during peak events resulting in a complete washout of the road or gully formation when the flow path is altered.

Though road failures can often supply a mix of grain sizes to the channel which might not be entirely detrimental, their primary impact lies in the timing of sediment delivery. Most sediment is delivered to the channel during peak events when the stream flow is high and fine sediment can be transported downstream and coarse sediment can be sorted. This is the typical scenario for landslides, debris flows, and bank erosion, and in some cases, road fill failures. Unfortunately, sediment delivered from road surfaces, ditches, and cuts can be eroded from these features during most storm events due to their chronic nature. During low magnitude rainfall events, fine sediment from these features is being delivered and deposited in stream channels where the streamflow is too low to transport the supplied material. The result is pool filling and sedimentation of riffles with significant impact to macroinvertebrate production and habitat quality for fish populations.

As watersheds urbanize, an increasing percentage of the land surface becomes impervious to rainfall due to more roads, rooftops, and driveways. The increase in impervious surfaces creates a hydrologic regime that is flashier, with higher peak flow values. This is especially evident during low magnitude precipitation events. In undisturbed watersheds, low magnitude precipitation events produce very little runoff due to soil storage and percolation to groundwater. In urbanized watersheds, even small amounts of rainfall produce a significant amount of runoff from impervious surfaces that are delivered quickly to stream channels. This has been shown to increase bank erosion (Booth and Henshaw, 2001) and create unstable geomorphic conditions as the channel attempts to adjust to a new hydrologic regime. This process is magnified as the watershed becomes increasingly urbanized. There is little time for the channel to adjust to changing hydrologic conditions if those conditions are continually changing. When a channel is in a continual state of change, a massive episodic disturbance could result in catastrophic consequences.

Intensive grazing in a watershed can also create hydrologic and sediment supply impacts by reducing soil infiltration capacity due to compaction and denuding ground cover. The degree to which grazing is an impact relates directly to the density of the herd and how many grazers can safely be supported.

5. Sediment Source Analysis

5.1 Overview: What are the Primary Sources

There are a variety of erosional processes that contribute sediment to stream channels, including landsliding, slumping, rilling, debris flows, and bank failures. Each process differs by the quantity, timing and grain size of sediment delivered to stream channels that may act as impairing sediment to salmonid production and rearing. Each process can also be classified into sources that are natural and those that are a result of human land use impacts. Erosion sources can also be classified into those that are episodic and those that are chronic.

Landsliding results from weak geologic formations, steep topography caused by tectonic uplift, and occurrence of intense periods of rainfall and seismic forces. Landslides often terminate at and impinge upon stream channels, sometimes feeding a seemingly endless supply of fine material directly into the channels. In the worst cases, chronic sediment loading from landslides can eliminate pools, riffles and coarse substrate for hundreds of feet below the point of delivery. An important mechanism to store delivered sediment and attenuate sediment delivery downstream relates to the presence of large woody material and debris jams (Keller and Talley, 1979; Keller et al., 1981).

Steep slopes are an important factor in erosion in general and for landslides in particular. Figure 14 shows soil erodibility within the lower Arroyo Grande Creek watershed based on soil and slope properties. Weathered bedrock, soils and colluvium are subject to saturation by rainfall. Saturated conditions can produce a nearly instantaneous and deadly failure of a rapidly moving landslide called a *debris flow*. Debris flows occur during intense periods of rainfall after hundreds of years of persistent slope wash and colluvium accumulation in swales. The swales are often bedrock, which has a lower permeability than the overlying colluvium. When the rate of rainfall exceeds the rate that the colluvium and soil can drain water off, the saturated zone or water table above the less permeable bedrock deepens. When the saturated mass overcomes the resistance holding it on the hillslope, the mass liquefies instantly and moves down the hillslope carrying trees, soil, propane tanks and sometimes entire houses. In some cases, water separates from the debris flow mass as it reaches lower gradients and a debris torrent is unleashed - a wall of mud and debris that moves very fast and is extremely destructive. In the Arroyo Grande Creek watershed, debris flows are more common following fire events, which reduce the resisting forces on the colluvium.

Road building is a common and often dominant theme in land use disturbance. From farm road development to driveways and public thoroughfares, roads are required for access to nearly every land use. Roads are also by far the most destructive element in the landscape as far as excessive fine sediment generation per unit area. Roads constructed along canyon floors and steep inner gorge slopes cause channel realignment resulting in direct delivery of sediment to streams. Erosion from road surfaces, ditches, shoulders and other human-induced land clearing contribute mostly fine-grained sediment. Paved and unpaved roads modify local hillslope drainage patterns, concentrate flow and increase runoff rates. Runoff on roads concentrates over soils exposed on the roadbed and shoulder, drainage ditches, road cuts, sidecasts and fills. In terms of managing sediment loads to reduce aquatic habitat impairment, fine sediment source reduction from roads will be the most effective treatment.

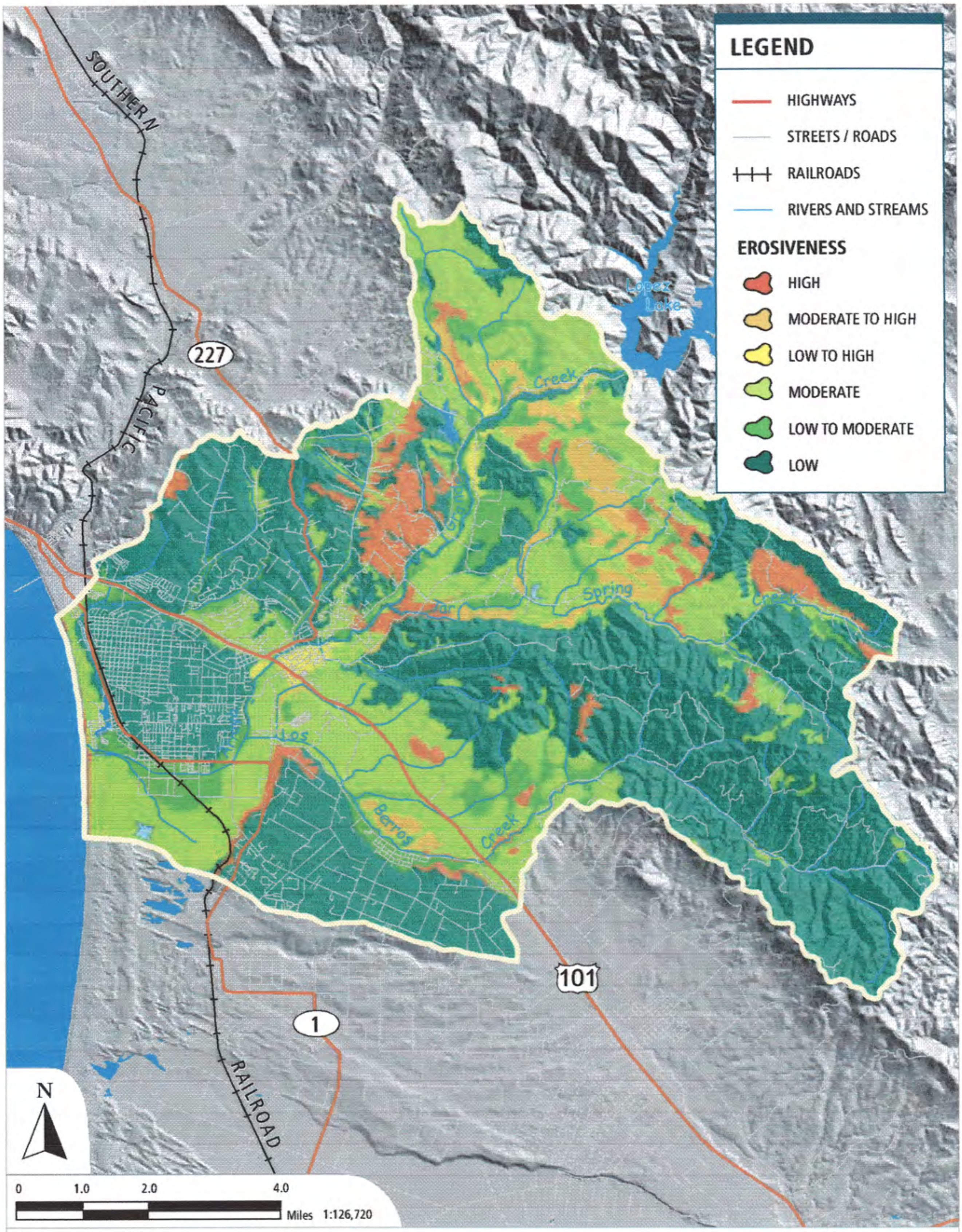

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FIGURE 14: Hillslope erosion potential in the Arroyo Grande Creek Watershed below Lopez Dam. Erosiveness ratings based on NRCS soil survey of San Luis Obispo County, incorporating both soils type and slope.

Bank erosion, reworking of old floodplain deposits, and drainage network expansion associated with gullying also contributes significantly to the amount of fine sediment in the channel. These sources contribute fine sediment directly to the channel and have a significant impact on aquatic habitat conditions. Reworking of old floodplain deposits that might have been delivered to the stream channel due to land use changes in the early 1900's may be especially important in the tributaries to Arroyo Grande Creek.

5.2 Identification of Dominant Erosion Processes

Development of a sediment budget is an approach that considers the erosion processes occurring in a particular study area and attempts to quantify the amount of material being delivered and transported past a specific point. If the amount of sediment being delivered exceeds the amount of sediment being transported, aggradation is the dominant process. If the amount of sediment being transported exceeds the amount being delivered, the stream channel is likely to be incising. If both delivery and transport of sediment are equal, the stream channel is said to be in equilibrium.

This simplified notion of a sediment budget is complicated because both sediment delivery and transport within a stream channel are stochastic processes (Benda and Dunne, 1997a; Benda and Dunne, 1997b). This means that sediment delivery to the channel occurs episodically through mast wasting events such as landslides, bank failure, or debris flows. Sediment transport is also a function of the magnitude, duration, and energy associated with streamflow, which has a significant range over time periods as short as a few hours. Sediment transport volumes during wet years can be orders of magnitude greater than those recorded in drought years. The same is true for sediment delivery. During wet years, a saturated hillslope in the steep inner gorge is much more likely to fail and deliver sediment to a stream channel than the same hillslope during a dry year. Over time, it is likely that episodic delivery and transport events even out, producing what is known as a system in dynamic equilibrium. The question often remains, over what time scale is the concept of dynamic equilibrium occurring within any given reach of stream.

The stochastic nature of sediment delivery and transport makes it very difficult to accurately estimate a sediment budget given limited data. Monitoring movement of suspended and bed load material passing a set location, such as a bridge, would require one to two decades of data to capture the range of flow and sediment events that characterize the stochastic nature of the process. It would not be uncommon for a single year, within a 20-year dataset, to represent over 50% of the total sediment load measured during that period. If that single year were removed, the average flux of sediment, per year, would be greatly underestimated.

There are also difficulties in estimating the supply side of the sediment budget equation that go beyond the stochastic nature of the process. In many cases it is very difficult to apply a rate to any particular erosion source. Sources of erosion can easily be identified in the field, and the volume of sediment being eroded and delivered to an adjacent stream channel can be estimated. The difficulty lies in estimating the rate at which the sediment is being delivered. Without information about how long ago a particular source began to erode, volume information becomes meaningless.

In some cases this problem has been overcome through the use of aerial photo series. Several photo dates can be examined to constrain the date at which a particular erosion feature, such as a landslide, began delivering sediment. By estimating sediment volumes from many landslides throughout a particular watershed from a series of aerial photos, a landslide rate for the landscape of interest can be estimated (Reid and Dunne, 1996). Unfortunately, aerial photo interpretation of erosion features becomes problematic in a landscape with dense tree cover. Features such as landslides, debris flows, or gullies are in most cases impossible to see, unless they are recent or very large. Mapping these features in a densely vegetated area with the intent of estimating a sediment budget can be very misleading.

The quality of the results generated from a sediment budget will ultimately be related to the quality of the input data and the amount of time and information that is available to accurately construct one (Reid and Dunne, 1996). To accurately quantify the rate at which sediment in being supplied to the channel would require years of intensive data collection and monitoring equipment, as well as access to all, or a statistically random subsample of potential sources. Since an intensive approach is not feasible, the best approach lies in identifying the most significant sources of sediment, obtaining as much information as possible about the physical setting of the landscape that might infer a certain rate of erosion, and applying published erosion rates from other watersheds that exhibit similar patterns of erosion.

Regardless of the difficulties in estimating sediment budgets, particularly in forested areas, the results can be a valuable dataset when attempting to understand the dominant erosion processes and the sources of sediment that may be impairing aquatic habitat. The exercise of estimating a sediment budget requires careful consideration of each potential source, the magnitude of delivery by that source, a description of the grain-sizes being delivered, and a comprehensive understanding of the transport hydraulics within a stream channel. Even though the final sediment budget numbers may contain a significant amount of error, there is much to be understood from them. The magnitude to which each source contributes to the overall sediment budget and the location of those sources within the watershed, as a whole, are valuable pieces of information that can guide current and future management.

For this study, we conducted an aerial photo analysis and made focused site visits to accessible points in the watershed to gain a general understanding of the dominant erosion processes that are occurring in the watershed. We present the following findings about each erosion process, which are listed in order of importance:

- *Headward expansion of drainage networks and associated gullying*: Any particular watershed or subwatershed can be defined in terms of the density of fluvial channels or how much drainage area is required to initiate a fluvial channel. This concept is referred to as a watersheds drainage density and is a function of physical variables such as steepness of slope, soil, geology, and base level elevation, vegetation characteristics, and climatic variables such as rainfall. In the Arroyo Grande watershed, two factors have combined to cause existing channels to expand further up into the watershed, (1) lowering of the base level of the mainstem of Arroyo Grande Creek, associated with downcutting, and (2) higher runoff, associated with an increase in impervious surfaces. These two factors have resulted in erosion of large quantities of sediment as channels widen, deepen, and expand towards the ridges. Though the amount of sediment in any particular drainage may seem small, this process is occurring in every part of the watershed.

- *Bank erosion:* Similar forces are at work on the mainstem of Arroyo Grande Creek as in the headwaters with the added factor of hungry water being present due to releases from Lopez Dam. Figure 5 shows relative quantities of bank erosion occurring along the mainstem of Arroyo Grande Creek as surveyed by the CCC's Stream Inventory Team. The CCC's identified discrete bank erosion sites and measured their height and length. What is shown in Figure 5 is the total amount of erosion in square feet normalized by the length of the reach. Though we are lacking an erosion rate, which would require a volume divided by the length of time over which the erosion occurred, the data presented in Figure 5 still provides an index of bank erosion on the mainstem.
- *Erosion from roads and farm fields:* The proximity of many roads, especially dirt roads, and the highly connected nature of the farm fields to the drainage network through agricultural ditch systems, makes them a significant source of fine sediment to Arroyo Grande Creek. The lack of vegetated buffer strips along roads, poor stream crossings, and unmaintained ditch and culvert systems present a significant erosion hazard during peak storm events. Farm fields, roads, and agricultural ditches also lack buffering vegetation, resulting in direct, unmanaged release of fine sediment to nearby stream channels.
- *Debris flows and landslides:* Though we did not observe this as an important source of erosion during our site assessments, the role of debris flows and landslides on the overall sediment budget of Arroyo Grande Creek becomes more important following large fires or during low frequency, high magnitude storm events.
- *Bare areas associated with urban development:* Development within urban areas results in a temporary release of fine sediment as the land surface is disturbed and laid bare for construction. Though these sources primarily consist of fine sediment and can have a significant impact locally, they are often short-term. The long-term impact of these sights is often associated with an increase in impervious surfaces.

5.3 Preliminary Analysis of Existing Sources

Though we did not have adequate resources as part of this project to develop a sediment budget for the lower Arroyo Grande Creek watershed, we did attempt to lay the groundwork for future studies. Through a combination of aerial photo analysis of the 2002 photo set and limited field verification in areas that were publicly accessible, we developed a preliminary list of erosion sources. The sites identified from aerial photos include bare areas, erosion associated with roads, areas of rilling or gullying, landslides, drainage ditches, and sites where potential erosion may exist due to the presence of bare, unvegetated surfaces. The list is preliminary and therefore not comprehensive. Since the survey is based on a single point in time it may include erosion sources that are temporary, such as those associated with new construction. The list also does not include bank erosion sites identified by the CCC Stream Inventory Team or a detailed examination of headward expansion of drainage networks by subwatershed. Descriptions of each site and a set of maps showing the location of each feature are presented in Appendix A.

Approximately 200 individual erosion sites were identified as part of the aerial photo analysis and limited ground reconnaissance. Since it would be cost prohibitive and infeasible to visit each of the sites on the list, we have conducted a preliminary filtering in order to prioritize which sites may be worth investigating as significant sources of sediment that would require remediation (Figure 15 and Table 3) . Our prioritization consists of a qualitative assessment of the likelihood that the identified source would have a potential impact on fisheries resources or flood control and is based on the following filtering criteria:

- *Confidence in the Observation:* Field identified sediment sources were given higher priority than aerial photo identified sources. Though this may introduce a bias based on the proximity of the site to public access routes, sites in areas with public access may also be more likely to receive attention.

- *Proximity to Stream Channels:* A higher priority was given to sources that are closer to stream channel. The assumption here is that sediment can only enter stream channels through direct flow paths that connect the hillslope to the channel. The closer a source is to a flow path or channel, the more significant the impairing impact. Channel proximity was determined within the GIS system by overlaying a 250 foot buffer around stream channels onto the mapped sedim ent sources. Sources that fell within the buffer were given higher priority over those that did not.

- Sediment Source Category: Sites were prioritized based on the type of source. The order of priority was road features, agricultural runoff, heavily grazed lands, general bare areas, and landslides. Road features are easily identifiable and are often directly connected to local stream channels through ditches. In addition, road features include crossings, are more impervious than other land uses, and are in some cases dirt. Similarly, runoff from agricultural lands and heavily grazed areas are directly are, in most cases, directly connected to stream channels through a network of swales and ditches. Roads, agricultural lands, and grazed areas have a well-documented body of literature that describe BMP's and other feasible approaches to reducing erosion. Bare areas were given low priority because they are often temporary (associated with development), tied to other land uses (e.g. – parking lot, road shoulder), and are a dispersed erosion source. Landslides were given the lowest priority because they are often part of the natural process of erosion and in most cases it is not feasible or cost effective to engineer a solution.

Further development and prioritization of these data along with construction of a detailed sediment budget for the lower watershed is planned as part of a future project.

5.4 Additional Data Requirements

Developing a reasonable estimate of erosion within a watershed and constructing a sediment budget requires high quality datasets and accurate estimates of erosion rates, as opposed to just the location of erosion sites and the total volume of material. Sediment budgets are based on estimating the rate of erosion which is the volume of sediment being delivered per unit time. Given limited time available to develop a sediment budget, the focus should be on significant sources and use of published erosion rates for similar landscapes that can be extended to the local watershed. It may be possible and prudent to begin addressing the well-known and more serious erosion sites prior to accomplishing additional data collection.

Priority Ranking	Sub-watershed ID	Site ID	Sediment Source Category	Proximity to the Channel	Method of Identification
1	2	F-10	Eroding Subwatershed	<= 250 Feet	Field Reconnaissance
1	3	F-3	Road Feature	<= 250 Feet	Field Reconnaissance
1	3	F-9	Agricultural Runoff	<= 250 Feet	Field Reconnaissance
2	3	F-5	Road Feature	> 250 Feet	Field Reconnaissance
2	3	F-6	Agricultural Runoff	> 250 Feet	Field Reconnaissance
2	3	F-11	Road Feature	> 250 Feet	Field Reconnaissance
3	1	81	Eroding Subwatershed	<= 250 Feet	Aerial Photos
3	2	50	Eroding Subwatershed	<= 250 Feet	Aerial Photos
3	3	8	Eroding Subwatershed	<= 250 Feet	Aerial Photos
3	3	9	Eroding Subwatershed	<= 250 Feet	Aerial Photos
3	3	F-7	Eroding Subwatershed	<= 250 Feet	Field Reconnaissance
3	3	F-13	Eroding Subwatershed	<= 250 Feet	Field Reconnaissance
3	4	99	Eroding Subwatershed	<= 250 Feet	Aerial Photos
3	4	F-14	Agricultural Runoff	<= 250 Feet	Field Reconnaissance
3	5	136	Eroding Subwatershed	<= 250 Feet	Aerial Photos
3	5	137	Eroding Subwatershed	<= 250 Feet	Aerial Photos
4	1	39	Road Feature	<= 250 Feet	Aerial Photos
4	1	41	Road Feature	<= 250 Feet	Aerial Photos
4	1	45	Road Feature	<= 250 Feet	Aerial Photos
4	1	46	Road Feature	<= 250 Feet	Aerial Photos
4	3	4	Road Feature	<= 250 Feet	Aerial Photos
4	3	6	Road Feature	<= 250 Feet	Aerial Photos
4	3	7	Road Feature	<= 250 Feet	Aerial Photos
4	3	10	Road Feature	<= 250 Feet	Aerial Photos
4	3	11	Road Feature	<= 250 Feet	Aerial Photos
4	3	15	Road Feature	<= 250 Feet	Aerial Photos
4	3	16	Road Feature	<= 250 Feet	Aerial Photos
4	3	24	Road Feature	<= 250 Feet	Aerial Photos
4	3	F-4	Road Feature	<= 250 Feet	Aerial Photos
4	3	F-8	Road Feature	<= 250 Feet	Aerial Photos
4	3	F-12	Road Feature	<= 250 Feet	Aerial Photos
4	4	83	Road Feature	<= 250 Feet	Aerial Photos
4	4	121	Road Feature	<= 250 Feet	Aerial Photos
4	5	128	Road Feature	<= 250 Feet	Aerial Photos
4	5	134	Road Feature	<= 250 Feet	Aerial Photos
4	5	135	Road Feature	<= 250 Feet	Aerial Photos
4	5	143	Road Feature	<= 250 Feet	Aerial Photos
4	5	172	Road Feature	<= 250 Feet	Aerial Photos
5	1	43	Road Feature	> 250 Feet	Aerial Photos
5	1	44	Road Feature	> 250 Feet	Aerial Photos
5	2	48	Road Feature	> 250 Feet	Aerial Photos

TABLE 3: Preliminary prioritization of sediment sources in the lower A.G. watershed.

Priority Ranking	Sub-watershed ID	Site ID	Sediment Source Category	Proximity to the Channel	Method of Identification
5	2	51	Road Feature	> 250 Feet	Aerial Photos
5	3	1	Road Feature	> 250 Feet	Aerial Photos
5	3	3	Road Feature	> 250 Feet	Aerial Photos
5	3	5	Road Feature	> 250 Feet	Aerial Photos
5	3	22	Road Feature	> 250 Feet	Aerial Photos
5	4	84	Road Feature	> 250 Feet	Aerial Photos
6	3	18	Heavy Grazing	<= 250 Feet	Aerial Photos
6	3	F-1	Heavy Grazing	<= 250 Feet	Field Reconnaissance
6	4	93	Heavy Grazing	<= 250 Feet	Aerial Photos
6	4	94	Heavy Grazing	<= 250 Feet	Aerial Photos
6	5	154	Agricultural Runoff	<= 250 Feet	Aerial Photos
6	5	155	Agricultural Runoff	<= 250 Feet	Aerial Photos
6	5	159	Agricultural Runoff	<= 250 Feet	Aerial Photos
6	5	165	Agricultural Runoff	<= 250 Feet	Aerial Photos
6	5	166	Agricultural Runoff	<= 250 Feet	Aerial Photos
6	5	169	Agricultural Runoff	<= 250 Feet	Aerial Photos
7	1	36	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	1	37	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	1	38	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	1	40	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	1	42	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	2	69	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	2	71	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	3	2	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	3	14	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	3	21	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	3	26	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	3	28	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	3	30	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	3	31	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	3	32	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	3	35	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	4	89	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	4	97	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	4	105	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	4	107	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	4	108	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	4	109	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	4	110	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	4	112	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos

TABLE 3 cont.: Preliminary prioritization of sediment sources in the lower A.G. watershed.

Priority Ranking	Sub-watershed ID	Site ID	Sediment Source Category	Proximity to the Channel	Method of Identification
7	4	113	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	4	114	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	4	115	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	4	116	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	4	117	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	4	122	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	4	123	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	4	124	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	4	126	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	5	129	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	5	133	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	5	140	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	5	147	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	5	150	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	5	156	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	5	157	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	5	158	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	5	168	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	5	170	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
7	5	171	Bare area susceptible to erosion	<= 250 Feet	Aerial Photos
8	3	12	Hillslope failure	> 250 Feet	Aerial Photos
8	3	13	Hillslope failure	> 250 Feet	Aerial Photos
8	3	F-2	Hillslope failure	> 250 Feet	Field Reconnaissance
8	4	82	Hillslope failure	> 250 Feet	Aerial Photos
8	4	85	Hillslope failure	> 250 Feet	Aerial Photos
8	4	86	Hillslope failure	> 250 Feet	Aerial Photos
8	4	87	Hillslope failure	> 250 Feet	Aerial Photos
8	4	88	Hillslope failure	> 250 Feet	Aerial Photos
8	4	90	Hillslope failure	> 250 Feet	Aerial Photos
8	4	91	Hillslope failure	> 250 Feet	Aerial Photos
8	4	92	Hillslope failure	> 250 Feet	Aerial Photos
8	4	95	Hillslope failure	> 250 Feet	Aerial Photos
8	4	96	Hillslope failure	> 250 Feet	Aerial Photos
8	4	98	Hillslope failure	> 250 Feet	Aerial Photos
8	4	111	Hillslope failure	> 250 Feet	Aerial Photos
8	4	173	Hillslope failure	> 250 Feet	Aerial Photos
8	4	176	Hillslope failure	> 250 Feet	Aerial Photos
8	4	178	Hillslope failure	> 250 Feet	Aerial Photos
9	2	49	Heavy Grazing	> 250 Feet	Aerial Photos
10	1	72	Bare area susceptible to erosion	> 250 Feet	Aerial Photos

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TABLE 3 cont.: Preliminary prioritization of sediment sources in the lower A.G. watershed.

Priority Ranking	Sub-watershed ID	Site ID	Sediment Source Category	Proximity to the Channel	Method of Identification
10	1	73	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	1	74	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	1	75	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	1	76	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	1	78	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	1	79	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	1	80	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	2	52	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	2	53	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	2	54	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	2	55	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	2	56	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	2	57	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	2	58	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	2	59	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	2	60	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	2	61	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	2	62	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	2	63	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	2	64	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	2	65	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	2	66	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	2	67	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	2	68	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	2	70	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	2	77	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	3	23	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	3	25	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	3	27	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	3	29	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	3	311	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	3	33	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	3	34	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	4	100	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	4	101	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	4	102	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	4	103	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	4	104	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	4	106	Bare area susceptible to erosion	> 250 Feet	Aerial Photos

TABLE 3 cont.: Preliminary prioritization of sediment sources in the lower A.G. watershed.

Priority Ranking	Sub-watershed ID	Site ID	Sediment Source Category	Proximity to the Channel	Method of Identification
10	4	118	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	4	119	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	4	120	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	4	125	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	4	127	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	4	174	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	4	175	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	4	177	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	4	179	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	5	47	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	5	130	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	5	131	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	5	132	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	5	138	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	5	139	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	5	141	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	5	142	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	5	144	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	5	145	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	5	146	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	5	148	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	5	149	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	5	151	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	5	152	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	5	153	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	5	160	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	5	161	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	5	162	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	5	163	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	5	164	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
10	5	167	Bare area susceptible to erosion	> 250 Feet	Aerial Photos
11	3	17	Bare areas associated w/ development	> 250 Feet	Aerial Photos
11	3	19	Bare areas associated w/ development	> 250 Feet	Aerial Photos
11	3	20	Bare areas associated w/ development	> 250 Feet	Aerial Photos

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TABLE 3 cont.: Preliminary prioritization of sediment sources in the lower A.G. watershed.

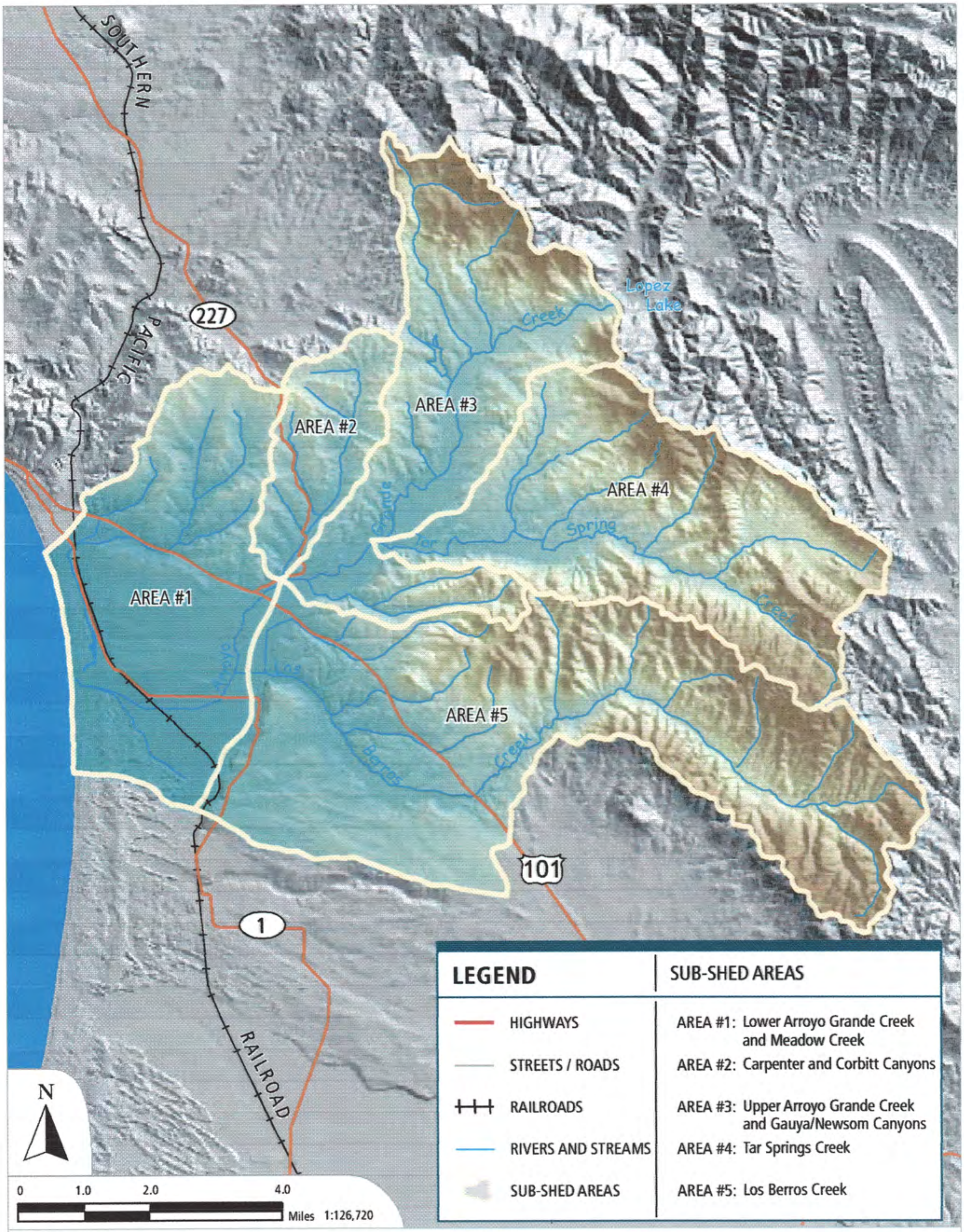

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FIGURE A-1: Vicinity map of the subwatersheds included in the preliminary erosion source assessment

The following list is a summary of additional data that would be required to develop a more complete sediment budget for lower Arroyo Grande Creek:

- Additional aerial photo sets to establish rates of erosion for sources such as landslides and gullies,
- A detailed road erosion survey on both public and private roads to estimate the quantity of material being delivered from these features. This would also require development of a comprehensive GIS database on roads in order to extrapolate survey results to areas that were not accessible,
- A comprehensive survey and GIS database of existing agricultural drainage ditches, their condition, and their connectedness to the stream network,
- A comprehensive bank erosion survey on tributaries to the Arroyo Grande including an investigation of the extent of headward migration of the drainage network,
- Estimates of sediment transport conditions in the watershed including suspended and bedload calculations at gaging sites within the watershed,
- Mapping of the quantity of sediment stored within the channel on both the mainstem and tributaries, the location and extent of floodplain storage features, and the quantity of sediment that would be available for transport during high flow events,
- Additional cross-section and grain size data would need to be collected in the watershed to define hydraulics and sediment transport conditions, and
- Calculation of hydrologic parameters, such as flood peaks, for ungaged subwatersheds.

Much of the additional work would be focused on developing quantities and rates of erosion in the watershed and understanding the sediment transport and storage dynamics. For the most part, the hydrology has already been developed, except within the ungaged tributaries.

6. Implications of Findings on Watershed Management

6.1 Key Issues Identified

The lower Arroyo Grande Creek channel looks vastly different today than it looked 200 years ago. A channel that once braided and meandered across a wide floodplain with extensive riparian forests that occurred at the same elevation as the existing valley floor is now deeply incised with a narrow riparian strip. The hydrology of the watershed has been changed significantly due to the presence of a large dam and lowering of groundwater tables which have dried up backwater wetlands and possibly reduced flow in tributary streams that once fed a lush riparian forest through the Arroyo Grande and Cienega Valleys.

Though these impacts have allowed humans to take advantage of the resources available in the Arroyo Grande valley through storage of water and development of agricultural, they have not come without consequences. For as long as modern humans have lived in the lower valley, flooding has been an issue (Brown, 2002). In the past, flood impacts were widespread and acute along the entire valley floor as humans encroached into the floodplain, built houses, and developed agricultural fields. Over time, through the process of ditching, rerouting, and deepening, the upper portion of the valley contained the river into a single, incised channel. Flooding in these areas is no longer a problem.

Unfortunately this approach to flood management has increased the risk of flooding in the lower portion of the valley. By ditching and channelizing the upper valley a system has been created that is more efficient at moving sediment (and water for that matter) that is eventually deposited in the lower portions of the valley. Through loss of floodplain and an increase in erosion from the mainstem and tributaries, natural sediment attenuation via floodplain buffering has been lost, with devastating flood impacts to the flood control reach.

6.2 Goals of Enhancement

Restoration of lower Arroyo Grande Creek to what it was 200 years ago is not a feasible, nor is it a reasonable alternative. The cost would be enormous and would require displacing significant numbers of people and removing thousands of acres of farmland from production. The goal, therefore, would be to enhance, rather than restore, function within the system, based on a set of goals defined by landowners, resource management agencies, and other watershed stakeholders. Such a set of goals should include:

- Reduction of flood impacts along the lower valley,
- Enhancement of habitat conditions within the mainstem for species such as steelhead and red-legged frog,
- Enhancement of floodplain and riparian areas within the lower watershed, and
- Improvements to water quality.

Specific projects proposed for the lower watershed would be evaluated, prioritized and funded based on its cost effectiveness and ability to achieve the stated goals. Meeting those goals will require cooperation from landowners and the local community and funding from local, state, and federal resource management agencies.

6.3 Preliminary Project Recommendations

The goals stated above are generalized and would require further discussion and analysis to establish sub-goals or a set of objectives that must be accomplished to reach those goals. This study is a preliminary attempt to identify those key objectives, define what existing data are available, identify data gaps, and set the stage for future project development and implementation. It is difficult, considering the level of analysis that has been completed to date, to develop a detailed project list. Instead, we are putting forth project concepts or programs that would allow for a more detailed assessment to identify and prioritize discrete project locations. We are providing limited recommendations within the flood control reach as a more detailed study of flood impacts and environmental benefits is in the process of being commissioned.

The following project areas are recommended:

- Where feasible, reduce runoff from impervious surfaces by developing detention basins and encouraging on site detention such as storm water ponds, cisterns, or rain barrels.
- Improve conditions for sediment storage in tributary drainages through restoration of floodplains in lower portions of subwatersheds and/or development of low maintenance sediment retention basins in non-fish bearing streams.
- Implement erosion control projects that focus on headward expansion of drainage networks such as gully erosion in headwater channels.
- Where feasible, bank erosion repair projects should include floodplain enhancement elements such as creating floodplain benches, laying back the slope to reduce future erosion, and planting of riparian vegetation.
- Vegetated buffer strips along farm roads and seeding of grass in agricultural ditches should be encouraged to reduce fine sediment erosion from these features.
- The riparian corridor through the flood control reach of the lower Arroyo Grande Creek mainstem should be managed to maximize channel shading and minimize overall channel roughness.
- Replace ford crossings within the watershed with culverts or bridges to reduce chronic sources of fine sediment.
- Update stream and road ditch culvert crossing throughout the watershed to improve flood capacity and allow for passage of debris and sediment.
- Where feasible, enhance floodplain area throughout the watershed through levee setbacks and laying back of slopes. Enhancement of the sediment storage and buffering capacity of the watershed will be a key component of any plan to reduce flood impacts in the flood control reach.
- Encourage adoption of design standards and guidelines for development in the watershed at the city and county level that result in no net increases in runoff from impervious surfaces. This includes runoff from residential, commercial, and industrial land uses as well as from transportation infrastructure.

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Appendix C

California Natural Diversity Database USGS Quads for Oceano and Arroyo Grande

Record	Quad Name	ELMCODE	Scientific Name	Common Name	Federal Status	California Satus	CDFG	CNPSLIST
1	Arroyo Grande NE	AAABH01022	*Rana aurora draytonii*	California red-legged frog	Threatened	None	SC	
2	Arroyo Grande NE	AFCHA0209H	*Oncorhynchus mykiss irideus*	steelhead - south/central California coast esu	Threatened	None		
3	Arroyo Grande NE	AMAJF04010	*Taxidea taxus*	American badger	None	None	SC	
4	Arroyo Grande NE	ARAAD02032	*Emys (=Clemmys) marmorata pallida*	southwestern pond turtle	None	None	SC	
5	Arroyo Grande NE	ARAAD02032	*Emys (=Clemmys) marmorata pallida*	southwestern pond turtle	None	None	SC	
6	Arroyo Grande NE	ARACF12022	*Phrynosoma coronatum (frontale)*	Coast (California) horned lizard	None	None	SC	
7	Arroyo Grande NE	CTT52410CA	Coastal and Valley Freshwater Marsh	Coastal and Valley Freshwater Marsh	None	None		
8	Arroyo Grande NE	PDAST2E2J0	*Cirsium rhothophilum*	Surf thistle	None	Threatened		1B
9	Arroyo Grande NE	PDAST4R0U4	*Deinandra increscens ssp. foliosa*	leafy tarplant	None	None		1B
10	Arroyo Grande NE	PDBRA10020	*Dithyrea maritima*	beach spectaclepod	None	Threatened		1B
11	Arroyo Grande NE	PDCAR040L0	*Arenaria paludicola*	marsh sandwort	Endangered	Endangered		1B
12	Arroyo Grande NE	PDCRA04012	*Dudleya abramsii ssp. murina*	San Luis Obispo dudleya	None	None		1B
13	Arroyo Grande NE	PDERI040N0	*Arctostaphylos luciana*	Santa Lucia manzanita	None	None		1B
14	Arroyo Grande NE	PDERI042B0	*Arctostaphylos wellsii*	Wells's manzanita	None	None		1B
15	Arroyo Grande NE	PDFAB2B2G0	*Lupinus ludovicianus*	San Luis Obispo County lupine	None	None		1B
16	Arroyo Grande NE	PDONA05111	*Clarkia speciosa ssp. immaculata*	Pismo clarkia	Endangered	Rare		1B
17	Arroyo Grande NE	PDPGN04050	*Chorizanthe breweri*	Brewer's spineflower	None	None		1B
18	Arroyo Grande NE	PDROS0W045	*Horkelia cuneata ssp. puberula*	mesa horkelia	None	None		1B
19	Arroyo Grande NE	PDSCR0D453	*Castilleja densiflora ssp. obispoensis*	Obispo Indian paintbrush	None	None		1B
20	Arroyo Grande NE	PDSCR1S010	*Scrophularia atrata*	black-flowered figwort	None	None		1B
21	Arroyo Grande NE	PMLIL0D110	*Calochortus obispoensis*	San Luis mariposa lily	None	None		1B
22	Arroyo Grande NE	PMPOA040M0	*Agrostis hooveri*	Hoover's bent grass	None	None		1B
1	Oceano	AAABH01022	*Rana aurora draytonii*	California red-legged frog	Threatened	None	SC	
2	Oceano	ABNKC12020	*Accipiter striatus*	sharp-shinned hawk	None	None	SC	
3	Oceano	ABNNB03031	*Charadrius alexandrinus*	western snowy plover	Threatened	None	SC	

			nivosus					
4	Oceano	ABNNM08103	*Sterna antillarum browni*	California least tern	Endangered	Endangered		
5	Oceano	AFCHA0209H	*Oncorhynchus mykiss irideus*	steelhead - south/central California coast esu	Threatened	None		
6	Oceano	ARAAD02032	*Emys (=Clemmys) marmorata pallida*	southwestern pond turtle	None	None	SC	
7	Oceano	CTT21220CA	Central Foredunes	Central Foredunes	None	None		
8	Oceano	CTT21320CA	Central Dune Scrub	Central Dune Scrub	None	None		
9	Oceano	CTT52410CA	Coastal and Valley Freshwater Marsh	Coastal and Valley Freshwater Marsh	None	None		
10	Oceano	IICOL67010	*Lichnanthe albipilosa*	white sand bear scarab beetle	None	None		
11	Oceano	IIDIP42010	*Ablautus schlingeri*	Oso Flaco robber fly	None	None		
12	Oceano	IILEG49010	*Areniscythris brachypteris*	Oso Flaco flightless moth	None	None		
13	Oceano	IILEPJA051	*Thessalia leanira elegans*	Oso Flaco patch butterfly	None	None		
14	Oceano	IILEPP2010	*Danaus plexippus*	monarch butterfly	None	None		
15	Oceano	IMGASJ7040	*Tryonia imitator*	mimic tryonia (=California brackishwater snail)	None	None		
16	Oceano	PDAST2E1N0	*Cirsium loncholepis*	La Graciosa thistle	Endangered	Threatened		1B
17	Oceano	PDAST2E2J0	*Cirsium rhothophilum*	Surf thistle	None	Threatened		1B
18	Oceano	PDAST3M5J0	*Erigeron blochmaniae*	Blochman's leafy daisy	None	None		1B
19	Oceano	PDBRA10020	*Dithyrea maritima*	beach spectaclepod	None	Threatened		1B
20	Oceano	PDBRA270V0	*Rorippa gambelii*	Gambel's water cress	Endangered	Threatened		1B
21	Oceano	PDCAR040L0	*Arenaria paludicola*	marsh sandwort	Endangered	Endangered		1B
22	Oceano	PDERI041E0	*Arctostaphylos rudis*	sand mesa manzanita	None	None		1B
23	Oceano	PDERI042B0	*Arctostaphylos wellsii*	Wells's manzanita	None	None		1B
24	Oceano	PDFAB2B111	*Lupinus nipomensis*	Nipomo Mesa lupine	Endangered	Endangered		1B
25	Oceano	PDLAM18070	*Monardella crispa*	crisp monardella	None	None		1B
26	Oceano	PDLAM180X0	*Monardella frutescens*	San Luis Obispo monardella	None	None		1B
27	Oceano	PDONA05111	*Clarkia speciosa ssp. immaculata*	Pismo clarkia	Endangered	Rare		1B
28	Oceano	PDRAN0B1B1	*Delphinium parryi ssp. blochmaniae*	dune larkspur	None	None		1B
29	Oceano	PDROS0W043	*Horkelia cuneata ssp. sericea*	Kellogg's horkelia	None	None		1B
30	Oceano	PMPOA040M0	*Agrostis hooveri*	Hoover's bent grass	None	None		1B

Appendix D

Stream Inventory for Arroyo Grande Creek

STREAM INVENTORY REPORT

ARROYO GRANDE CREEK
SUMMER 2004

PREPARED FOR:

CENTRAL COAST
SALMON ENHANCEMENT

PREPARED BY:

BOBBY JO CLOSE
INDEPENDENT CONTRACTOR
STACEY SMITH
CA CONSERVATION CORPS

FUNDING FOR THIS PROJECT HAS BEEN PROVIDED BY THE
CALIFORNIA DEPARTMENT OF FISH AND GAME
FISHERIES RESTORATION GRANT PROGRAM

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INTRODUCTION

A stream inventory was conducted from July 6, 2004 to August 16, 2004 on Arroyo Grande Creek. The survey began at the confluence with the Pacific Ocean and extended upstream 13.9 miles to Lopez Dam.

The objective of this habitat inventory was to document the habitat available to anadromous salmonids in Arroyo Grande Creek.

The objective of this report is to document the current habitat conditions and recommend options for the potential enhancement of habitat for steelhead trout. Recommendations for habitat improvement activities are based upon target habitat values suitable for salmonids in California's central coast streams.

WATERSHED OVERVIEW

Arroyo Grande Creek is located in San Luis Obispo County, California (Map 1). Arroyo Grande Creek's legal description at the confluence with the Pacific Ocean is T32S R12E. Its location is 35°06'04.0" North latitude and 120°37'48.0" West longitude, LLID number 1206299351011. Arroyo Grande Creek is a fourth order stream and has approximately 13.9 miles of blue line stream according to the USGS 7.5 minute quadrangle. Arroyo Grande Creek drains a watershed of approximately 153 square miles, approximately 86 square miles is below the Lopez Dam. Elevations in the watershed range from sea level at the mouth to approximately 520 feet at the Lopez Dam to 2,868 feet in the headwater areas. The watershed is dominated by willows, oaks and grass vegetation.

Approximately 72% of the 153 square mile watershed is privately owned and approximately 9.38 % of the privately owned land is managed for agriculture, including but not limited to row crops, orchards, greenhouses, and rangeland. The remaining portion of the privately owned land is managed for urban development, rangeland, and recreation. The remaining 28% of the Arroyo Grande Creek watershed is publicly owned by federal, state, and local agencies. These agencies include; Los Padres National Forest, which manages approximately 18%, County Regional Parks 6%, CA Dept. of Parks and Recreation 2%, US Bureau of Land Management 1% and CA Dept. of Fish and Game manages less than 1% of land in the watershed. These agencies manage the Arroyo Grande Creek watershed for preservation and recreation. (Percentages are approximate and provided through analysis of San Luis Obispo County GIS layers, crop2004 and ownership boundaries.) (Map 2)

METHODS

The habitat inventory conducted for Arroyo Grande Creek follows the methodology presented in Section III of the *California Salmonid Stream Habitat Restoration Manual* (Flosi et al, 1998). The California Conservation Corps (CCC) Technical Assistant and Independent Contractor that conducted this inventory were trained in standardized habitat inventory methods by DFG. This inventory was conducted by a two-person team. A CCC Specialist was employed to collect Global Positioning System (GPS) coordinates of the creek thalweg, erosion, exotic plant species and various other features in the creek that are listed and defined in Appendix A.

SAMPLING STRATEGY

The inventory uses a method that samples approximately 10% of the habitat units within the survey reach. All habitat units included in the survey are classified according to habitat type and their lengths are measured. All pool units are measured for mean and maximum depth, mean wetted width, depth of pool tail crest (measured in the thalweg), dominant substrate composing the pool tail crest, embeddedness, and shelter rating. Habitat unit types encountered for the first time in each reach are measured for all the parameters and characteristics on the field form. Additionally, one habitat unit is selected randomly from the ten habitat units on each page for complete measurement. The random unit is selected for each field data form prior to conducting the survey by using a 10-sided die.

HABITAT INVENTORY COMPONENTS

A standardized habitat inventory form has been developed for use in California stream surveys and can be viewed in Appendix G. This form was used in Arroyo Grande Creek to record measurements and observations. There are eleven components to the inventory form.

1. Flow:

Flow was measured in cubic feet per second (cfs) by Central Coast Salmon Enhancement staff by using the orange peel and stopwatch method. Additionally, ongoing average daily stream flows are measured at the San Luis Obispo County Stream Gage Station No. 2 along Arroyo Grande Creek at Latitude: 35°11'19" North, Longitude: 120°26'03" West.

2. Channel Type:

Channel typing is conducted according to the classification system developed and revised by David Rosgen (1994). This methodology is described in the *California Salmonid Stream Habitat Restoration Manual*. Channel typing is conducted simultaneously with habitat typing and follows a standard form to record measurements and observations. There are five measured parameters used to determine channel type: 1) water slope gradient, 2) entrenchment, 3) width/depth ratio, 4) substrate composition, and 5) sinuosity. Channel characteristics are measured using a clinometer, hand level, hip chain, tape measure, and a stadia rod.

3. Temperatures:

Both water and air temperatures are measured and recorded at every tenth habitat unit. The time of the measurement is also recorded. Both temperatures are taken in degrees Fahrenheit at the beginning of the habitat unit and within one foot of the water surface. Additionally, the water temperature is taken for all tributaries.

4. Habitat Type:

Habitat typing uses the 24 habitat classification types defined by McCain and others (1990). Habitat units are numbered sequentially and assigned a type identification number selected from a standard list of 24 habitat types. The standard list is provided in Appendix G. Dewatered units are labeled "dry". Arroyo Grande Creek habitat typing used standard basin level measurement criteria. These parameters require that the minimum length of a described habitat unit must be equal to or greater than the stream's mean wetted width. All measurements are in feet to the nearest tenth. Habitat characteristics are measured using a clinometer, hip chain, and stadia rod.

5. Embeddedness:

The depth of embeddedness of the gravels and cobbles in pool tail-out areas is measured by the percent of the rock that is surrounded or buried by fine sediment. In Arroyo Grande Creek, embeddedness was ocularly estimated. The values were recorded using the following ranges: 0 - 25% (value 1), 26 - 50% (value 2), 51 - 75% (value 3) and 76 - 100% (value 4). Additionally, a value of 5 was assigned to tail-outs deemed unsuitable for spawning due to inappropriate substrate like bedrock, log sills, boulders, beaver dams or tail-outs that are 100% silt.

6. Shelter Rating:
In-stream shelter is composed of those elements within a stream channel that provide juvenile salmonids protection from predation, reduce water velocities so fish can rest and conserve energy, and allow separation of territorial units to reduce density related competition for prey. The shelter rating is calculated for each fully described habitat unit and for all pool habitats by multiplying shelter value and percent cover. Using an overhead view, a quantitative estimate of the percentage of the habitat unit covered is made. All cover is then classified according to a list of nine cover types. In Arroyo Grande Creek, a standard qualitative shelter value of 0 (none), 1 (low), 2 (medium), or 3 (high) was assigned according to the complexity of the cover. Thus, shelter ratings can range from 0-300 and are expressed as mean values by habitat types within a stream (Table 10).

7. Substrate Composition:
Substrate composition ranges from silt/clay sized particles to boulders and bedrock elements. In all fully-described habitat units, dominant and sub-dominant substrate elements were ocularly estimated using a list of seven size classes and recorded as a one and two, respectively. In addition, the dominant substrate composing the pool tail-outs was recorded for each pool.

8. Canopy:
Stream canopy density was estimated using modified handheld spherical densiometers as described in the *California Salmonid Stream Habitat Restoration Manual.* Canopy density relates to the amount of stream shaded from the sun. In Arroyo Grande Creek, an estimate of the percentage of the habitat unit covered by canopy was made from the end of approximately every third unit in addition to every fully-described unit, giving an approximate 30% sub-sample. In addition, the area of canopy was estimated ocularly into percentages of evergreen or deciduous trees. Manmade structures such as bridges are considered evergreen because they provide canopy year-around.

9. Bank Composition and Vegetation:
Bank composition elements range from bedrock to bare soil. However, the stream banks are usually covered with grass, brush, or trees. These factors influence the ability of stream banks to withstand winter flows. In Arroyo Grande Creek, the dominant composition type and the dominant vegetation type of both the right and left banks for each fully-described unit were selected from the habitat inventory form. Additionally, the percent of each bank covered by vegetation (including downed trees, logs, and rootwads) was estimated and recorded.

10. Large Woody Debris Count:
Large woody debris (LWD) is an important component of fish habitat and an element in channel forming processes. In each habitat unit all pieces of LWD partially or entirely below the elevation of bankfull discharge are counted and recorded. The minimum size to be considered is twelve inches in diameter and six feet in length. The LWD count is presented by reach and is expressed as an average per 100 feet.

11. Average Bankfull Width:
Bankfull width can vary greatly in the course of a channel type stream reach. This is especially true in very long reaches. Bankfull width can be a factor in habitat components like canopy density, water temperature, and pool depths. Frequent measurements taken at riffle crests (velocity crossovers) are needed to accurately describe reach widths. At the first appropriate velocity crossover that occurs after the beginning of a new stream survey page (ten habitat units), bankfull width is measured and recorded in the appropriate header block of the page. These widths are presented as an average for the channel type reach. Additionally, a bankfull measurement is taken at the location of each Channel Type cross section.

12. GPS Data Collection:
In addition to the eleven components of the habitat inventory, a variety of other stream characteristics were mapped using GPS. Locations included: the creek thalweg, bank erosion sites, log jams, culverts, drain pipes, invasive plants, barriers to steelhead passage, and landmarks such as bridges, trails, and fences. A more detailed list of attributes to each layer is attached to the end of this report in Appendix A. A Trimble® Pathfinder Pro-XR GPS unit was used to record locations. Coordinate measurements recorded with this device are in WGS 1984 datum and are accurate to within one meter.

DATA ANALYSIS

Data from the habitat inventory form were entered into Stream Habitat, a Visual Basic data entry program developed by Karen Wilson, Pacific States Marine Fisheries Commission in conjunction with the California Department of Fish and Game. This program processes and summarizes the data, and produces the following ten tables (Appendix C):

1) Riffle, Flatwater, and Pool Habitat Types
2) Habitat Types and Measured Parameters
3) Pool Types
4) Maximum Residual Pool Depths by Habitat Types
5) Mean Percent Cover by Habitat Type
6) Dominant Substrates by Habitat Type
7) Mean Percent Vegetative Cover for Entire Stream
8) Fish Habitat Inventory Data Summary by Stream Reach
9) Mean Percent Dominant Substrate / Dominant Vegetation Type for Entire Stream
10) Mean Percent Shelter Cover Types for Entire Stream

Graphs were produced from the tables using Microsoft Excel. Graphs include (Appendix B):

1) Riffle, Flatwater, Pool Habitat Types by Percent Occurrence
2) Riffle, Flatwater, Pool Habitat Types by Percent Total Length
3) Habitat Types by Percent Occurrence
4) Pool Habitat Types by Percent Occurrence
5) Maximum Depth in Pools
6) Percent Embeddedness
7) Mean Percent Cover Types In Pools
8) Dominant Substrate in Pool Tail-outs
9) Percent Canopy
10) Dominant Bank Composition In Survey Reach
11) Dominant Bank Vegetation In Survey Reach

HABITAT INVENTORY RESULTS

The habitat inventory of Arroyo Grande Creek was conducted by Bobby Jo Close (Independent Contractor) and Stacey Smith (CCC). The GPS data collection was conducted by Brendan Banerdt (CCC). The total length of the stream surveyed from the Pacific Ocean to the Lopez Dam was 73,531.5 feet with an additional 823.8 feet of side channel.

Stream flow was measured in cubic feet per second (cfs) by Central Coast Salmon Enhancement staff Stephnie Wald and Freddy Otte by using the orange peel and stopwatch method. Flow measurements were taken on August 6, 2004 near the Fred Griebe Bridge (17682.5 feet upstream from Pacific Ocean) on Fair Oaks Boulivard in Arroyo Grande and at the culvert in Biddle Park (63136.5 feet up stream from the Pacific Ocean). The measurement at the Fred Griebe Bridge was 2.591cfs and the measurement at the Biddle Park culvert was 1.987cfs. Additionally, ongoing average daily stream flows are measured at the San Luis Obispo County Stream Gauge Station No. 2 along Arroyo Grande Creek at Latitude: 35°11'19" North, Longitude: 120°26'03" West. Release data from the Lopez Dam and flow data from the Gauge Station taken for the duration of this survey are provided in Appendix E.

Of the 73,531.5 feet (13.9 miles) surveyed, Arroyo Grande Creek was determined to be an F4 channel type for 32,413 feet (6.14 miles) of stream surveyed. F4 channels are entrenched, meandering, riffle/pool channels of low gradients with high width/depth ratios and gravel-dominant substrates. The majority of the creek channel that could be classified using Rosgen's classification (1994) was an F4 channel. Arroyo Grande Creek's substrate is largely composed of gravels. Entrenchment is high from channelization to protect urban and agricultural land uses on either side of the stream. Where open space exists, the stream reach becomes far less entrenched. Stream bank vegetation progresses as you move upstream from dense young willow growth throughout the flood-control channel to mature sycamores, willows, cottonwoods and oaks growing on the stream banks above Arroyo Grande city limits. Aquatic vegetation decreases and large woody debris becomes more prevalent as you move up the stream as well. Stream habitat complexity increases as you enter Arroyo Grande city limits above the Hwy 1 Bridge; runs begin to separate pool habitats.

Arroyo Grande Creek was determined to be an F6 channel type for 14,350.5 feet (2.72 miles). F6 channels are entrenched, meandering, riffle/pool channels of low gradients with high width/depth ratios and silt/clay-dominant substrates. The portion of the stream characterized as F6 was mostly located throughout the lower levee portion in the Arroyo Grande Valley. The stream is confined by the steep levee banks with minimal sinuosity. Stream habitat is mostly shallow mid-channel pools caused from young willow encroachment into the stream, dense aquatic vegetation growing throughout the stream's wetted width, and alterations due to land management and beaver activities. Most habitat shelter was provided by aquatic vegetation growth in the stream channel, sometimes covering over 90% of the wetted width of the stream, or by downed willows from the beavers.

10,455 feet (1.98 miles) of stream surveyed does not fit into the Rosgen channel typing method. The Rosgen channel classification system is used to characterize natural channels where the interaction between physical processes such and channel morphology, hydrology, and geology can be defined. In channels where significant modifications have occurred, it is difficult to apply the Rosgen system, primarily due to the lack of established geomorphic indicators (John Dvorsky, written communication).

The portion of the channel that could not be classified, can be separated into two geographic areas; the first located immediately below Lopez Dam; and the second located upstream of Biddle Park. Both channels lack habitat complexity; with consecutive fine substrate, mid-channel pools dominating stream habitats. The channel at both locations is highly impacted due to either man-made alterations or dispersed beaver dams.

The channel below Lopez Dam is a slightly entrenched, low gradient, meandering, narrow channel with eroding banks. Channel substrate is composed of depositional, silt/sand, soils. The channel is braided near the dam outflow where the stream connects to large marsh habitats tangent to stream. The large marsh/pool areas are classified as gravel pits in the County of San Luis Obispo Habitat Conservation Plan (2004). The floodplain is expansive with established forested vegetation below access area to dam.

The stream reach above Biddle Park is a slightly entrenched, low slope, wide, mid-channel pool stream; with eroding banks. Substrate consists of depositional soils; silt/sand channel. The channel is threaded connecting extremely large pools. Stream flow is dispersed throughout multiple side channels and large pool habitats. Emergent vegetation grows throughout the shallow portions of the main channel. Main channel lacks mature vegetation; side channels are dense with young willow growth.

The remaining portion of 16,316 feet (3.09 miles) was unsurveyed due to limited access on private property throughout the area. (Map 3)

Water temperatures taken during the survey period ranged from 59 to 74 degrees Fahrenheit. Air temperatures ranged from 59 to 82 degrees Fahrenheit. Although suitable water temperatures for steelhead in California are considered to range from 50 to 68 degrees Fahrenheit, southern steelhead have been observed in streams with water temperatures up to approximately 77.9 degrees Fahrenheit during summer and early fall (Arroyo Grande Creek HCP, 2004).

Table 1 summarizes the Level II riffle, flatwater, and pool habitat types. Based on frequency of occurrence, riffle habitat types occurred 1.7% of the time, flatwater 42.5% and pools 52.6% of the time. The remaining 3.2% of the creek habitat occurrence was either dry or not surveyed due lack of access or because the habitat type did not fit into the protocol, i.e., marsh (Figure 1). Based on total length of Level II habitat types, riffle habitat types occur 0.5% of the time (406 ft.), Pools 28.6% (21,230 ft.), and flatwater habitat types occur 35.2% (26,175 ft.) of the time. The remaining 35.7% (26,575 ft.) of the creek (below Lopez Dam) was either not surveyed or dry (Figure 2).

Twenty-two Level IV habitat types were identified (Table 2). The most frequent habitat types by percent occurrence were Mid-channel pools 41.6%, Runs 28.9% and Glides 13.2% (Figure 3). The most frequent habitat types based on percent total length were Mid-channel pools 20.6% (15,339 ft.), Runs 20% (14,892 ft.), and Glides 14.9% (11,051 ft.).

A total of 406 pools were identified (Table 3). Mid-channel pools were the most frequently encountered, and comprised 79.3% (15,406 ft.) of the total length of all pools (Figure 4).

Table 4 is a summary of maximum residual pool depths by pool habitat types. Pool quality for salmonids increases with depth. Fifty-five of the total 406 pools had a residual depth of two feet or greater (Figure 5).

The depth of cobble embeddedness was estimated at pool tail-outs. Of the 406 pool tail-outs measured, 27.3% had a value of 1, 9.3% a value of 2, 11.3% a value of 3, 27.5 % a value of 4 and 24.6% a value of 5 (Figure 6). On this scale, a value of 1 indicates the best spawning conditions and a value of 4 the worst. Additionally, a value of 5 was assigned to tail-outs deemed unsuitable for spawning due to inappropriate substrate like bedrock, log sills, boulders, beaver dams or tail-outs that are100% silt.

A shelter rating was calculated for all pools and fully measured habitat units and expressed as a mean value for each habitat type within the survey using a scale of 0-300. Riffle habitat types had a mean shelter rating of 78, flatwater habitat types had a mean shelter rating of 63, and pool habitats had a mean shelter rating of 58 (Table 1). Of the pool types, the mid-channel pools had a mean shelter rating of 61, the scour pools had a mean shelter rating of 51, and backwater pools had a mean shelter rating of 37 (Table 3).

Table 5 summarizes mean percent cover by habitat type. Terrestrial vegetation and small woody debris are the dominant cover types in Arroyo Grande Creek. Figure 7 describes the pool cover in Arroyo Grande Creek. Terrestrial vegetation, mostly in the form of young willows, occurs most frequently as pool cover dominating 30.5% of all pools. Small woody debris is the second dominant pool at 25.2%.

Table 6 summarizes the dominant substrate by habitat type. Figure 8 depicts the dominant substrate observed in pool tail-outs. Gravel and silt/sand/clay are the dominated substrates throughout the stream. Pool tail-outs are dominated by gravel substrate; however there was a significant amount of sand/silt/clay in addition to the gravel in the pool tail-outs.

Table 7 describes the mean percent canopy in Arroyo Grande Creek. The mean percent canopy density for the surveyed length of Arroyo Grande Creek was 79%. The mean percentages of deciduous canopy, evergreen canopy, and open canopy were 76.5%, 2.3% and 21.2% respectively (Figure 9).

For the entire stream surveyed, the mean percent right bank vegetated was 87%. The mean percent left bank vegetated was 87%. The dominant elements composing the structure of the stream banks consisted of 99% sand/silt/clay and 1% boulder (Figure 10). Deciduous trees were the dominant vegetation type observed in 72.7% of the units surveyed. Additionally, 18.7% of the units surveyed had grass as the dominant vegetation type, and 8.3% had brush as the dominant vegetation (Figure 11).

DISCUSSION

Arroyo Grande Creek is predominantly an F channel type with a short section below Lopez Dam that does not fit into the Rosgen Channel Typing classification. The table below summarizes the progressive series of channel types starting at the beginning of the survey, the Pacific Ocean, and following the creek upstream to the survey end, Lopez Dam.

Reach #	Channel Type	Steam Length (feet)
1	Tidal Influence (Flood Channel)	1,746
2	F6 (Flood Channel)	10,465.5
3	F4	20,391
4	No Access	14,567
5	F4	12,022
6	F6	3,885
7	NA*	1,420
8	NA*	9,035

** NA – Channel type does not fit into the Rosgen Channel Typing classification.*

The suitability of F channel types for fish habitat improvement structures is as follows: F channels are good for bank placed boulders, plunge weirs, single and opposing wing deflectors, channel constrictors and log cover.

The water temperatures recorded on the survey days, ranged from 59 to 74 degrees Fahrenheit. Air temperatures ranged from 59 to 82 degrees Fahrenheit. To make any further conclusions, temperatures would need to be monitored throughout the warm summer months, and more extensive biological sampling would need to be conducted.

Flatwater habitat types comprised 35.2% of the total length of this survey, riffles 0.5%, and pools 28.6%. The pools are relatively shallow, with only 55 of the total 406 pools having a maximum residual depth greater than 2 feet. In general, pool enhancement projects are considered when primary pools comprise less than 40% of the length of total stream habitat. In third and fourth order streams, a primary pool must be at least three feet deep. Installing structures that will increase or deepen pool habitat is recommended for locations where their installation will not be threatened by high stream energy, or where their installation will not conflict with the modification of the numerous log debris accumulations (LDA's) in the stream.

Cobble embeddedness measured to be 25% or less, a rating of 1, is considered to indicate good quality spawning substrate for salmon and steelhead. One hundred forty nine of the 406 pool tail-outs measured had embeddedness ratings of 1 or 2. One hundred fifty eight of the pool tail-outs had embeddedness ratings of 3 or 4. 100 of the pool tail-outs had a rating of 5, which is considered unsuitable for spawning. Sediment sources in Arroyo Grande Creek should be mapped and rated according to their potential sediment yields, and control measures should be taken. Locations of erosion visible from the stream channel were mapped during the survey (Maps 4-6).

Two hundred eighty four (70%) of the 406 pool tail-outs measured had gravel or small cobble as the dominant substrate. Gravel and small cobble is generally considered good for spawning salmonids.

The mean shelter rating for pools was 58. The shelter rating in the flatwater habitats was 63. A pool shelter rating of approximately 100 is desirable. The amount of cover that now exists is being provided primarily by overhanging terrestrial vegetation growing along Arroyo Grande Creek banks. Terrestrial vegetation is the dominant cover type in pools followed by small woody debris. Log and root wad cover structures in the pool and flatwater habitats would enhance both summer and winter salmonid habitat. Log cover structure provides rearing fry with protection from predation, rest from water velocity, and divides territorial units to reduce density related competition.

The mean percent canopy density for the stream was 79%. In general, revegetation projects are considered when canopy density is less than 80%.

The percentage of right and left bank covered with vegetation was high at 87% for both sides. In areas of stream bank erosion or where bank vegetation is sparse, planting endemic species of evergreen and deciduous trees, in conjunction with bank stabilization, is recommended.

RECOMMENDATIONS

1) Arroyo Grande Creek should be recognized as an anadromous, natural production stream.

2) The limited water temperature data available suggest that maximum temperatures are within the acceptable range for juvenile salmonids.

3) To establish more complete and meaningful temperature regime information, 24-hour monitoring during the July and August temperature extreme period should be performed for 3 to 5 years.

4) Where feasible, design and engineer pool enhancement structures to increase habitat complexity within existing pools. This must be done where the banks are stable or in conjunction with stream bank armor to prevent erosion.

5) Increase woody cover in the pools and flatwater habitat units. Most of the existing cover is from terrestrial vegetation. Adding high quality complexity with woody cover is desirable.

6) Inventory and map sources of stream bank erosion and prioritize them according to present and potential sediment yield. Identified sites should then be treated to reduce the amount of fine sediments entering the stream. Erosion locations on left and right banks of the stream were mapped using GPS in this study. Further analysis of these data is necessary.

7) Active and potential sediment sources need to be identified, mapped, and treated according to their potential for sediment yield to the stream and its tributaries.

8) Increase Riparian corridor buffer and plant diversity along Arroyo Grande Creek by planting a variety of appropriate native vegetation like willow, alder, sycamore and cottonwood along the stream where shade canopy is not at acceptable levels and where current vegetation dominated by one plant species.

9) Suitable size spawning substrate on Arroyo Grande Creek is limited to relatively few reaches. Projects should be designed at suitable sites to trap and sort spawning gravel.

10) There are several log debris accumulations present on Arroyo Grande Creek that are retaining moderate quantities of fine sediment. Many of these sites are a result of beaver inhabiting various locations throughout the stream. The modification of these debris accumulations is desirable, but must be done carefully, over time, to avoid excessive sediment loading in downstream reaches.

11) Additional studies should be done in locations where channel typing could not be completed to determine how entrenchment, slope, substrate composition, width/depth, etc., is affecting the channel processes at those locations.

12) Continuous flow data should be gathered to study the impacts that de-watering is having throughout the channel.

13) Additional studies should be done to determine the impacts beavers and non-native fish species, such as Sacramento pikeminnow, have on the stream.

14) Evaluation of fish migration barriers should be conducted. Possible fish migration barriers include road crossings, stream gauges, private dams, bedrock falls, etc.

15) Water quality monitoring should be conducted and analyzed throughout the stream in reaches where fish kills were present to identify any water quality issues such as low dissolved oxygen values.

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Flosi, G., Downie, S., Hopelain, J., Bird, M., Coey, R., and Collins, B. 1998. *California Salmonid Stream Habitat Restoration Manual*, 3rd edition. California Department of Fish and Game, Sacramento, California. Available at: http://www.dfg.ca.gov/nafwb/manual.html.

McCain, M., D. Fuller, L. Decker and K. Overton. 1990. Stream habitat classification and inventory procedures for northern California. FHC Currents. No.1. U.S. Department of Agriculture. Forest Service, Pacific Southwest Region.

Rosgen, D.L., 1994. A Classification of Natural Rivers. Catena, Vol 22: 169-199, Elsevier Science, B. V. Amsterdam.

PERSONAL COMMUNICATIONS

John Dvorsky, Swanson Hydrology and Geomorphology, channel type/geomorphology input

Meredith Hardy, California Conservation Corps, report review

Stephnie Wald, Central Coast Salmon Enhancement, stream flow and report review

Connie O'Henley, Central Coast Salmon Enhancement, report review

Freddy Otte, Central Coast Salmon Enhancement, stream flow

Thomas Gaffney, NOAA Fisheries, Lopez Dam release and creek flow data

John Kelly, San Luis Obispo County, Geographic Information Systems base layer data

APPENDICES

APPENDIX A – Habitat Typing GPS Data Collection

Information cataloged during survey using GPS

access point (line) This feature includes the type of access (trail or road), surface of the access (dirt, paved, or gravel), date, and comment.

bankfull (point) This feature includes the bankfull measurement taken at the first appropriate velocity crossover that occurs after the beginning of a new stream survey page (ten habitat units), bankfull width is measured and recorded.

bridge (point) This feature includes the name of the bridge, length, width, habitat unit, date and comment. A height was measured from the waters surface at thalweg to the bottom of bridge.

channel type change (point) The location of a potential channel change is recorded.

channel type cross section (point) The location of a channel type cross section and the channel type determined from the survey are recorded.

creek (line) This feature includes the creek name, date, and comment.

culvert (point) This feature includes the material the culvert is made out of, if it has baffles, if it has a fish barrier, length, width, the culvert's height, the habitat unit, date and comments.

drainpipe (point) This feature includes the material the drainpipe is made out of, the estimated height from bankfull to the bottom of the drainpipe, the diameter, habitat unit, date, and comment.

erosion end (point) This feature includes the length, height from bank full stage to top of erosion, total square footage, the habitat unit, which bank(s) the erosion is located on in respect to looking downstream, comment, and date.

exotics plants (point) This feature includes the species (castor bean, arundo, pampas grass, cape ivy, other), comment, and date.

fence (point) This feature includes the type of fence (for example, barbed wire, metal, etc. condition of fence (good, repair, remove), habitat unit, comment, and date.

fish barrier (point) This feature includes the type of barrier, length, width, and height measurements, the habitat unit, date and comment.

log jam (point) This feature includes the log jam type (log, debris, or both), if there is gravel retention, the length of the log jam in feet, width, the habitat unit, date, and comment.

modified bank (point) This feature includes the location of bank modifications that are visible from inside the creek channel. The habitat unit, which bank(s) the modification is located on in respect to looking downstream, comment, and date are also recorded.

new page (point) The habitat unit that is the first unit on a survey datasheet is recorded (every ten habitat units). The water temperature, air temperature, habitat unit and reach are recorded.

tributary (point) This feature includes the habitat unit, comment, and date.

APPENDIX B – Figures

HABITAT TYPES BY PERCENT OCCURRENCE

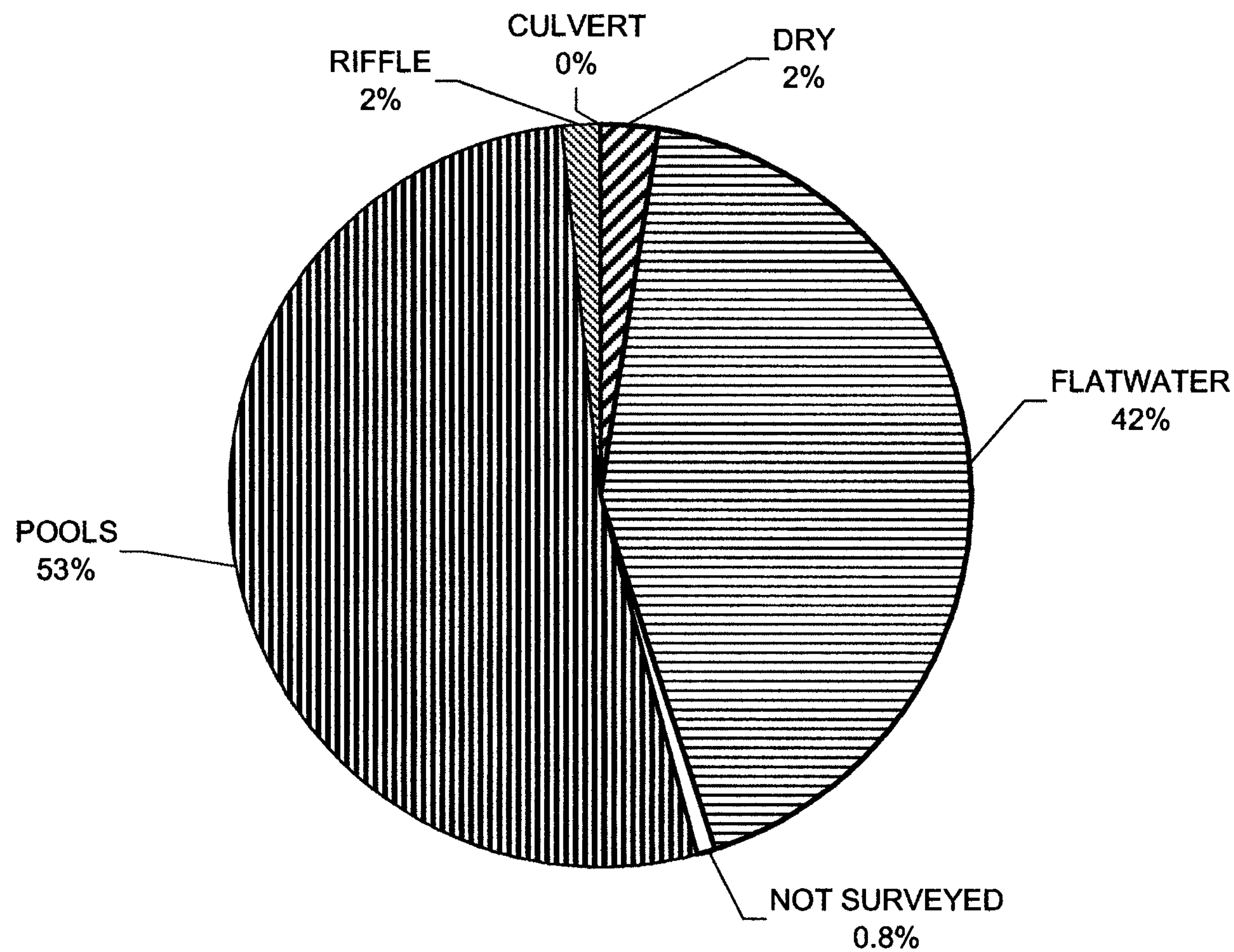


Figure 1

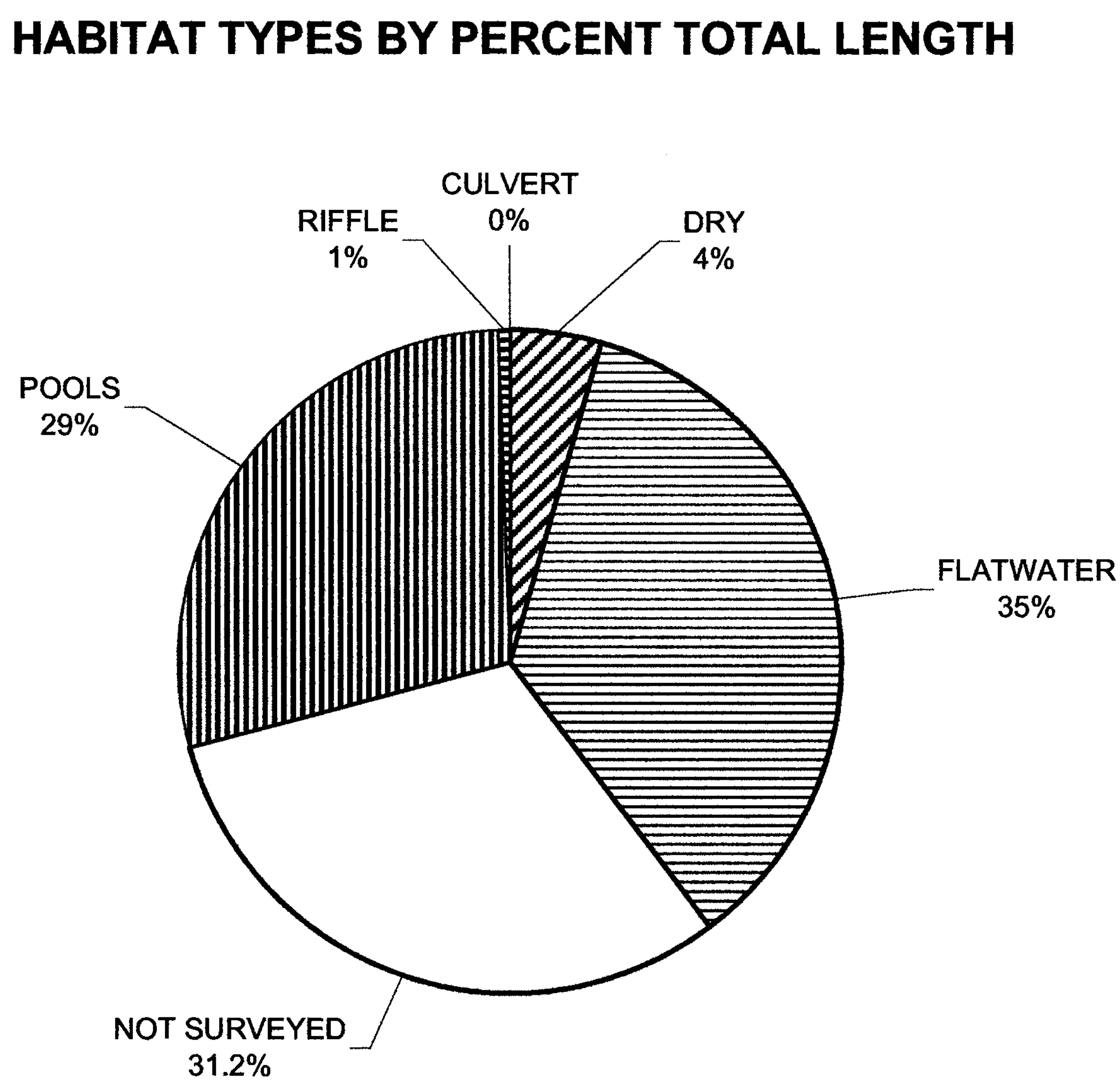

HABITAT TYPES BY PERCENT TOTAL LENGTH
RIFFLE 1%
CULVERT 0%
DRY 4%
POOLS 29%
FLATWATER 35%
NOT SURVEYED 31.2%

Figure 2

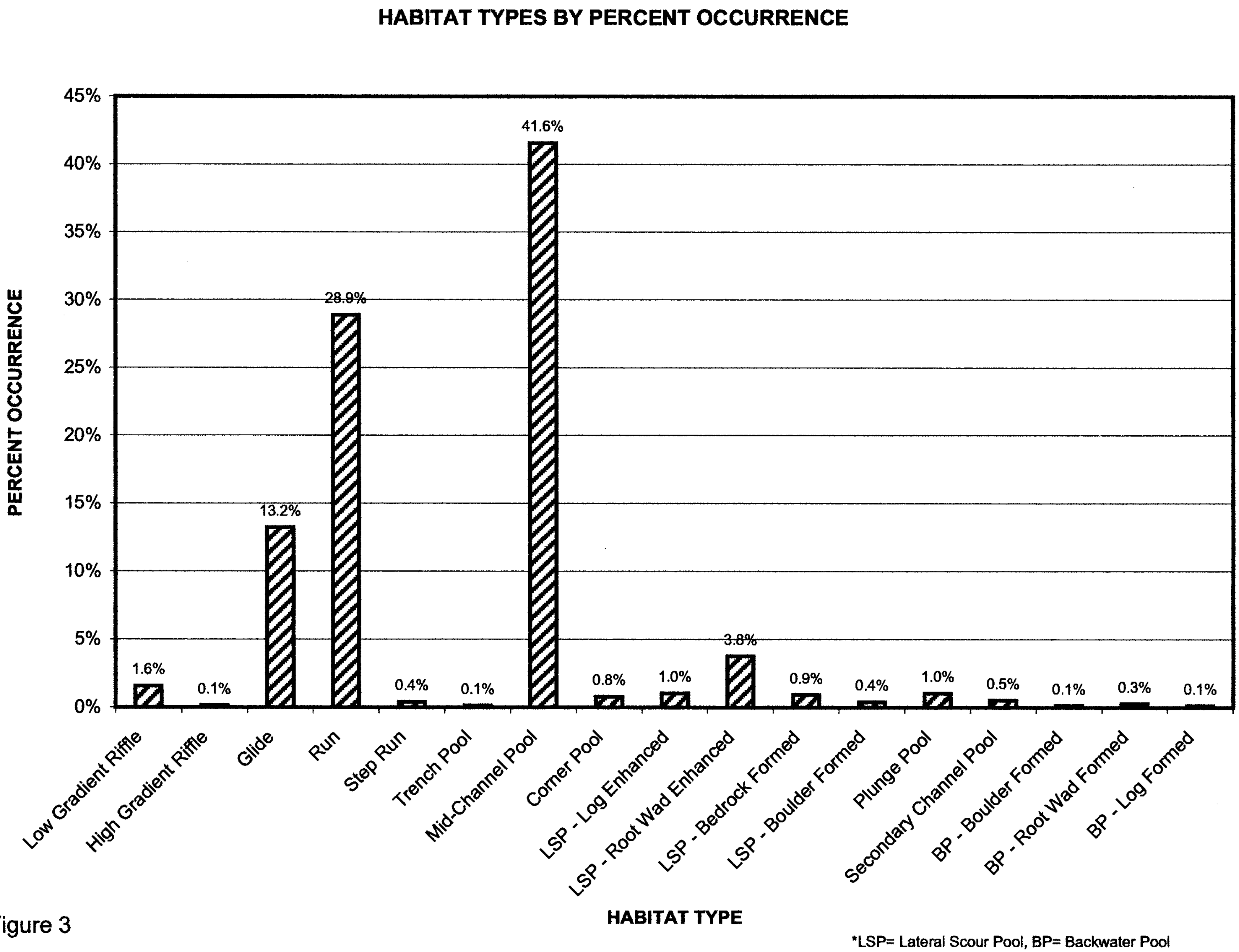

HABITAT TYPES BY PERCENT OCCURRENCE
PERCENT OCCURRENCE
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
1.6%
0.1%
13.2%
28.9%
0.4%
0.1%
41.6%
0.8%
1.0%
3.8%
0.9%
0.4%
1.0%
0.5%
0.1%
0.3%
0.1%
Low Gradient Riffle
High Gradient Riffle
Glide
Run
Step Run
Trench Pool
Mid-Channel Pool
Corner Pool
LSP - Log Enhanced
LSP - Root Wad Enhanced
LSP - Bedrock Formed
LSP - Boulder Formed
Plunge Pool
Secondary Channel Pool
BP - Boulder Formed
BP - Root Wad Formed
BP - Log Formed
HABITAT TYPE
*LSP= Lateral Scour Pool, BP= Backwater Pool

Figure 3

POOL TYPES BY PERCENT OCCURRENCE

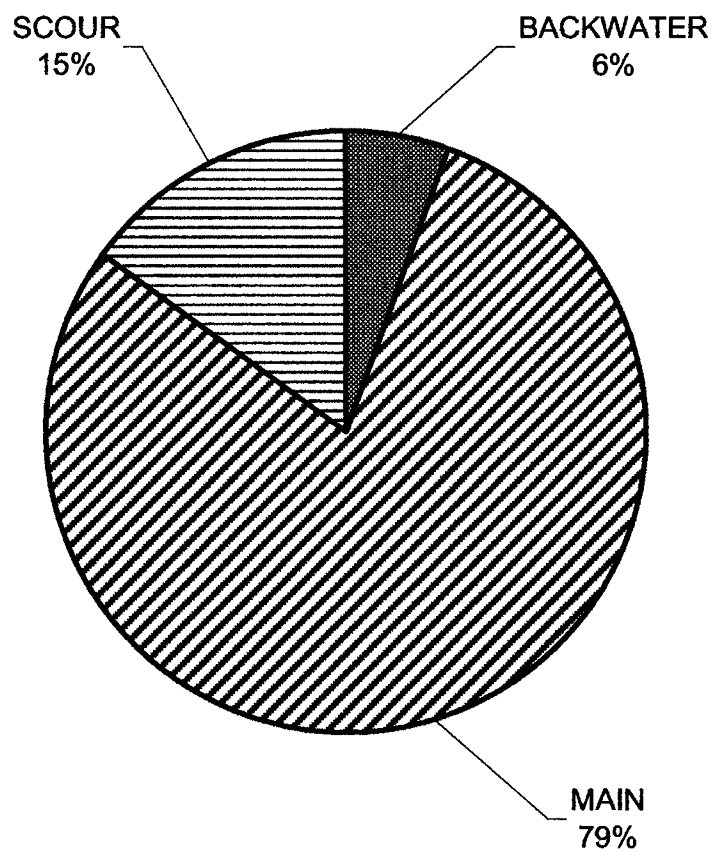


Figure 4

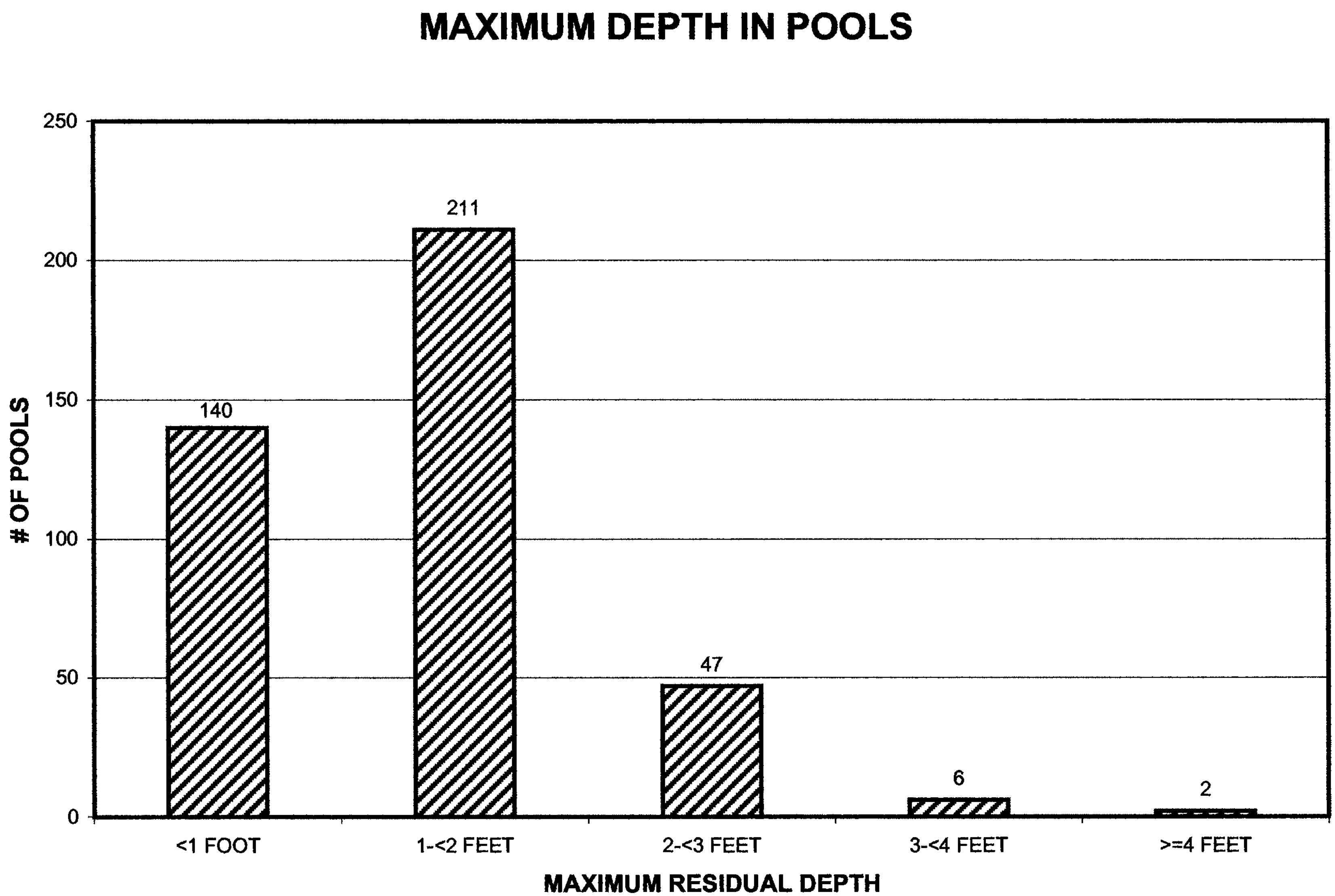

MAXIMUM DEPTH IN POOLS
OF POOLS
250
200
150
100
50
0
140
211
47
6
2
<1 FOOT
1-<2 FEET
2-<3 FEET
3-<4 FEET
>=4 FEET
MAXIMUM RESIDUAL DEPTH

Figure 5

PERCENT EMBEDDEDNESS

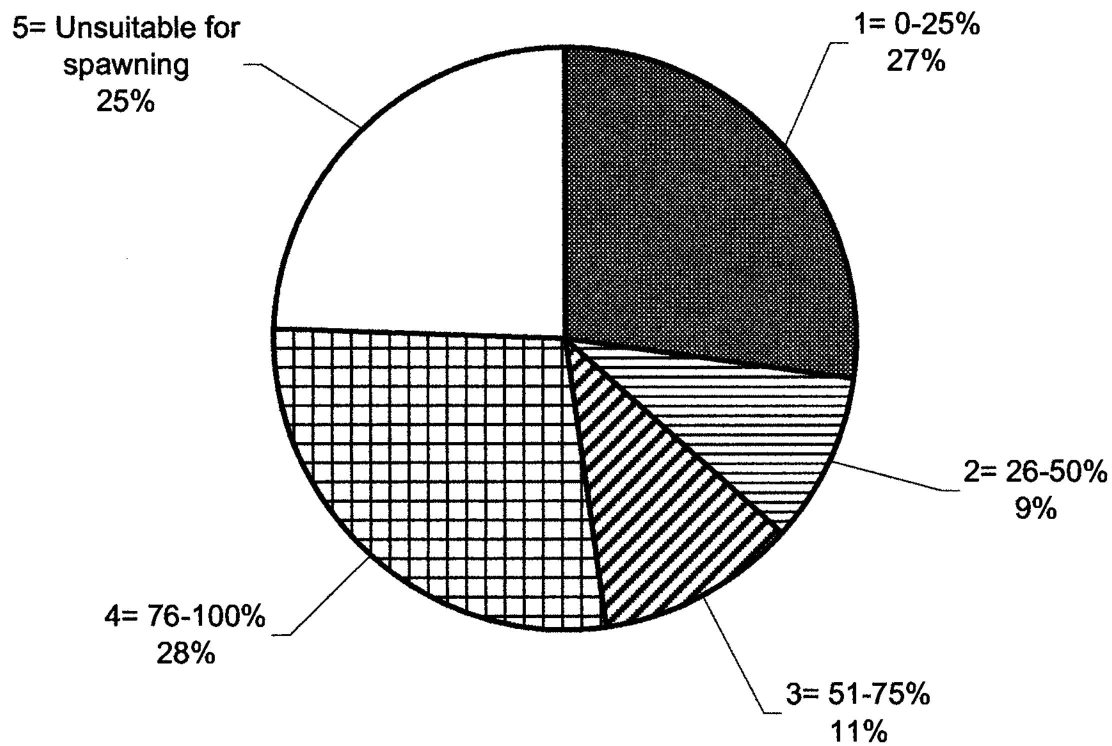


Figure 6

MEAN PERCENT COVER TYPES IN POOLS

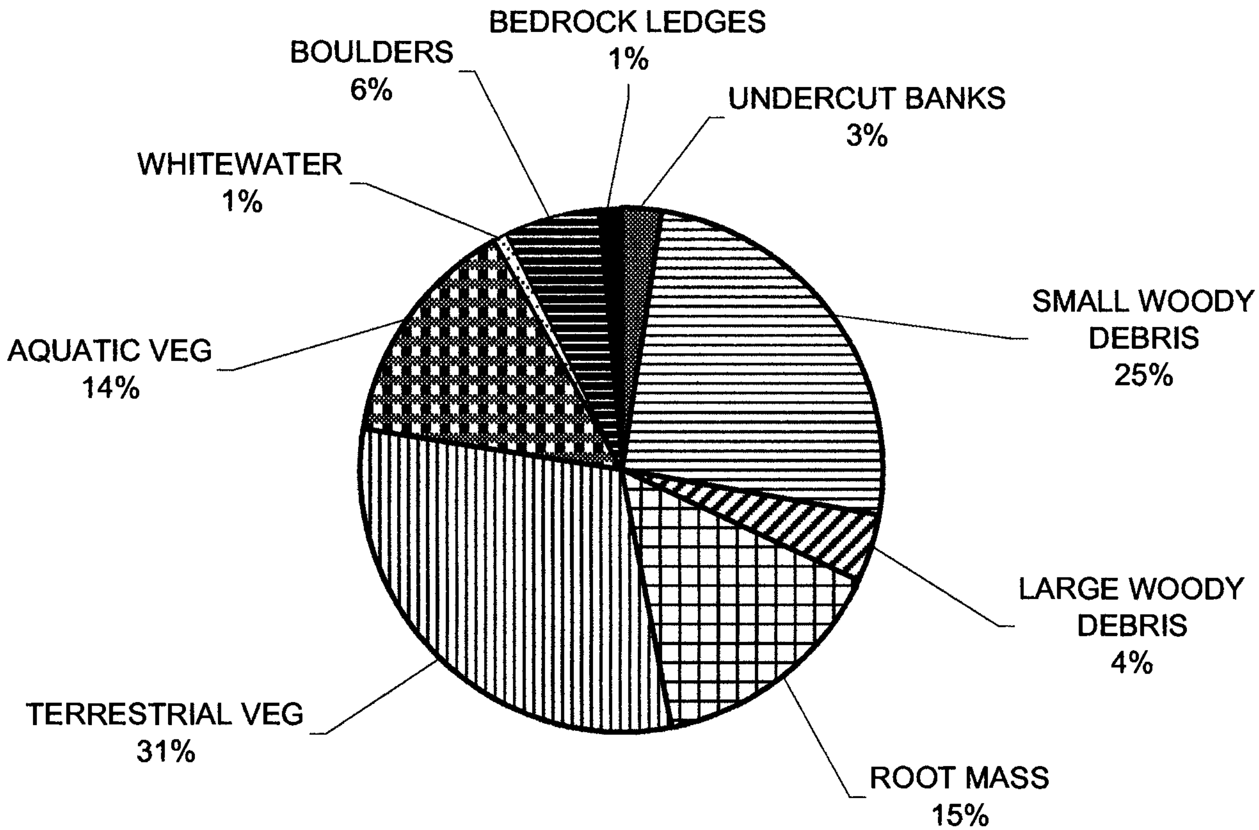


Figure 7

SUBSTRATE COMPOSITION IN POOL TAIL-OUTS

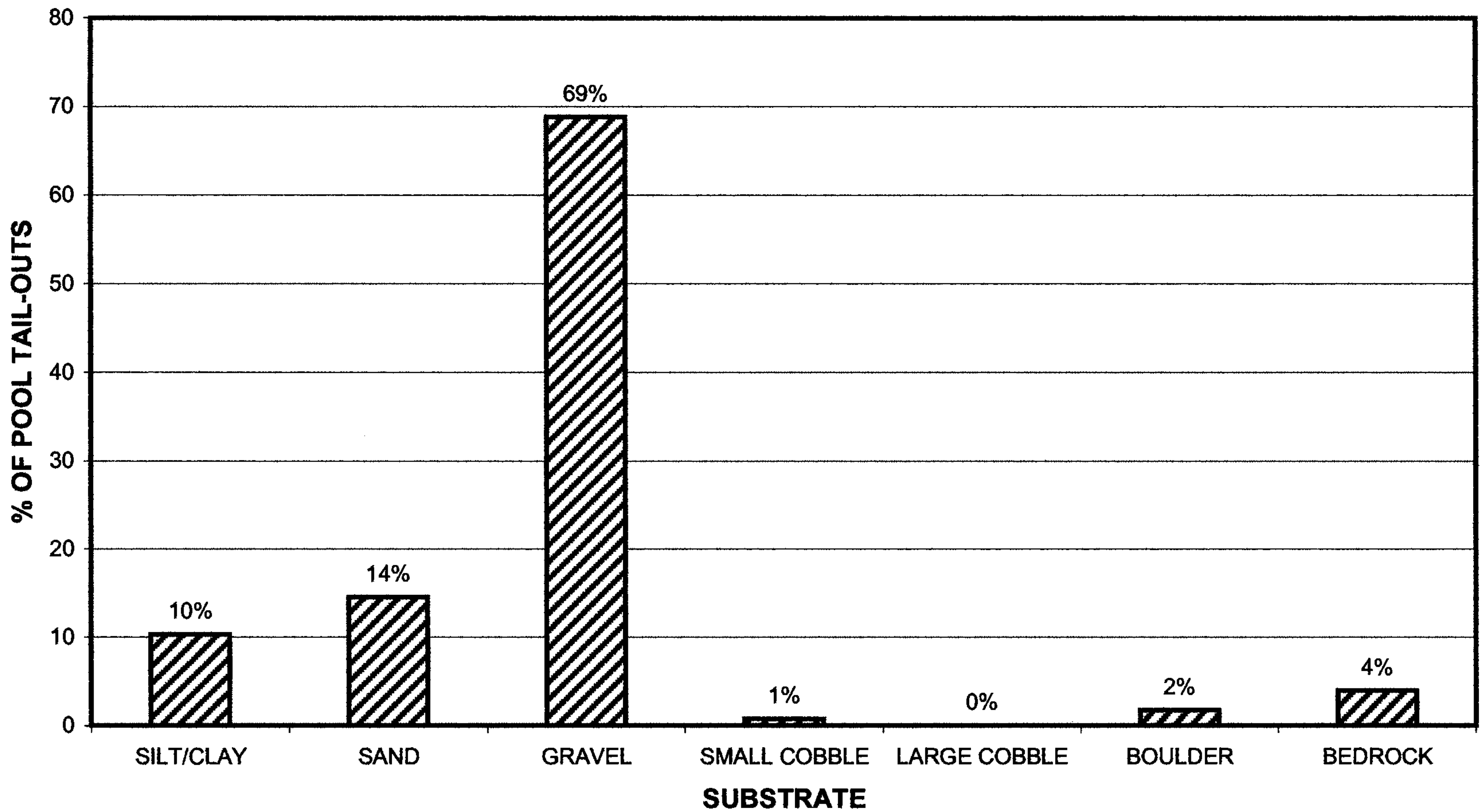


Figure 8

MEAN PERCENT CANOPY

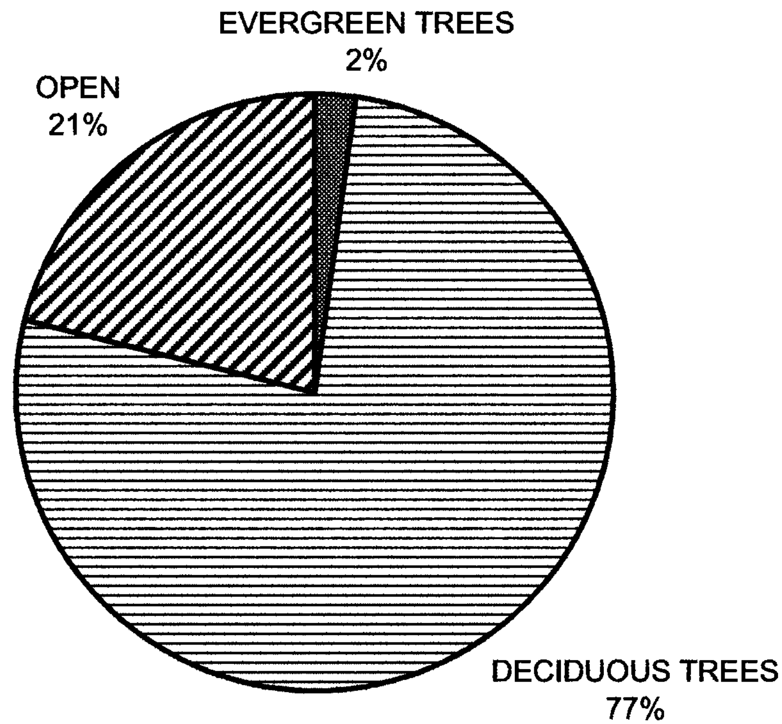


Figure 9

DOMINANT BANK COMPOSITION IN SURVEY REACH

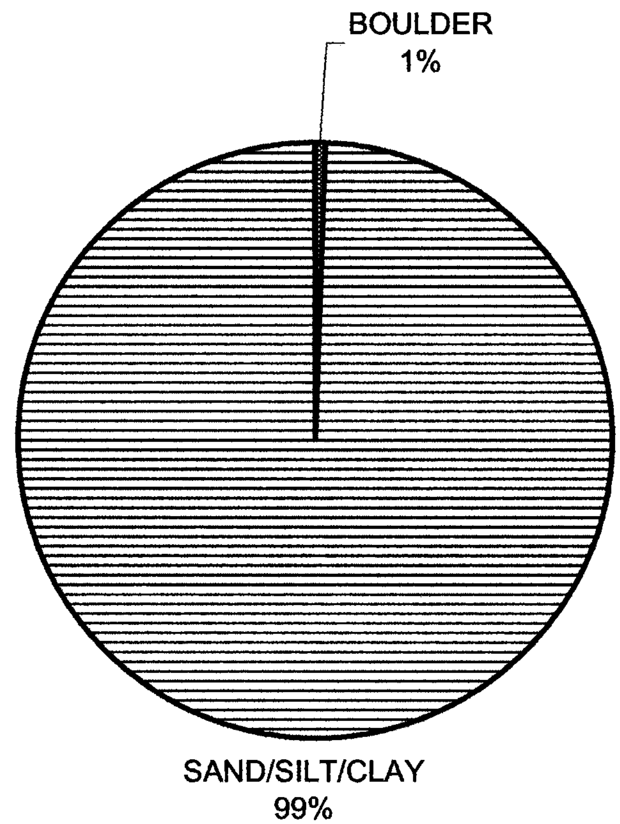


Figure 10

DOMINANT BANK VEGETATION IN SURVEY REACH

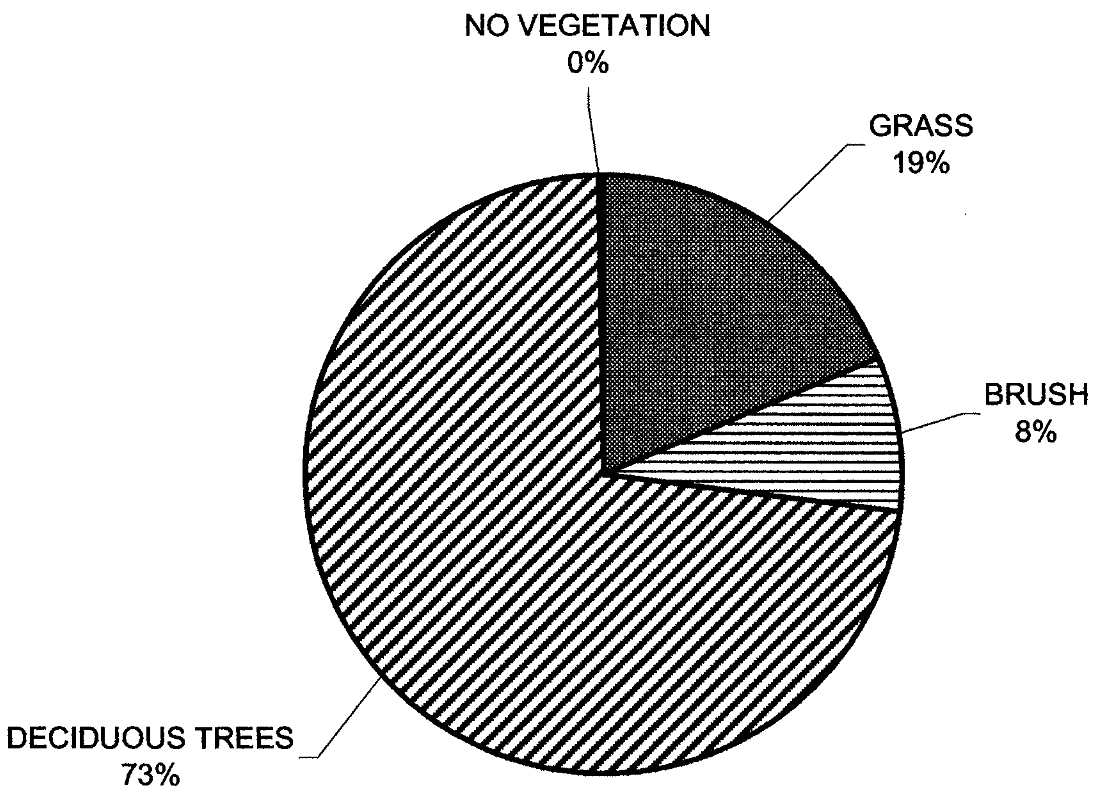


Figure 11

APPENDIX C – Tables

Table 1 - Summary of Riffle, Flatwater, and Pool Habitat Types

Stream Name: Arroyo Grande Creek　　LLID: 1206299351011　　Drainage: Arroyo Grande

Survey Dates: 7/6/2004 to 8/16/2004

Confluence Location: Quad: OCEANO　　Legal Description: T32SR13ES00　　Latitude: 35:06:04.0N　　Longitude: 120:37:48.0W

Habitat Units	Units Fully Measured	Habitat Type	Habitat Occurrence (%)	Mean Length (ft.)	Total Length (ft.)	Percent Total Length	Mean Width (ft.)	Mean Depth (ft.)	Mean Max Depth (ft.)	Mean Area (sq.ft.)	Estimated Total Area (sq.ft.)	Mean Volume (cu.ft.)	Estimated Total Volume (cu.ft.)	Mean Residual Pool Vol (cu.ft.)	Mean Shelter Rating
1	0	CULVERT	0.1	53	53	0.1									
18	0	DRY	2.3	182	3273	4.4									
328	54	FLATWATER	42.5	80	26175	35.2	11.9	0.6	0.9	1333	437175	932	305565		63
2	0	NOSURVEY	0.3	8156	16313	21.9									
4	0	NOSURVEY_	0.5	1726	6905	9.3									
406	405	POOL	52.6	52	21230.3	28.6	12.9	0.7	1.3	794	322165	1033	418349	754	58
13	8	RIFFLE	1.7	31	406	0.5	13.9	0.5	0.7	434	5645	237	3075		78

Total Units	Total Units Fully Measured	Total Length (ft.)	Total Area (sq.ft.)	Total Volume (cu.ft.)
772	467	74355.3	764985.3	726988

Table 2 - Summary of Habitat Types and Measured Parameters

Stream Name: Arroyo Grande Creek LLID: 1206299351011 Drainage: Arroyo Grande

Survey Dates: 7/6/2004 to 8/16/2004

Confluence Location: Quad: OCEANO Legal Description: T32SR13ES00 Latitude: 35:06:04.0N Longitude: 120:37:48.0W

Habitat Units	Units Fully Measured	Habitat Type	Habitat Occurrence (%)	Mean Length (ft.)	Total Length (ft.)	Total Length (%)	Mean Width (ft.)	Mean Depth (ft.)	Max Depth (ft.)	Mean Area (sq.ft.)	Estimated Total Area (sq.ft.)	Mean Volume (cu.ft.)	Estimated Total Volume (cu.ft.)	Mean Residual Pool Vol (cu.ft.)	Mean Shelter Rating	Mean Canopy (%)
12	7	LGR	1.6	31	373	0.5	13	0.4	1.3	409	4909	201	2406		59	65
1	1	HGR	0.1	33	33	0.0	18	0.8	1.2	611	611	488	488		210	86
102	18	GLD	13.2	108	11051	14.9	14	0.6	3.4	2268	231347	1829	186522		50	71
223	33	RUN	28.9	67	14892	20.0	11	0.5	1.7	860	191709	468	104417		66	87
3	3	SRN	0.4	77	232	0.3	13	0.6	1.3	926	2778	646	1939		100	91
1	1	TRP	0.1	67	67	0.1	6	1.6	2.5	402	402	804	804	643	20	71
321	320	MCP	41.6	48	15339	20.6	12	0.6	10.1	625	200564	705	226399	449	61	81
6	6	CRP	0.8	49	292	0.4	11	0.9	2.1	517	3100	634	3805	431	38	84
8	8	LSL	1.0	38	305	0.4	13	0.4	1.5	528	4222	494	3954	298	78	87
29	29	LSR	3.8	58	1673	2.3	13	0.5	3.2	810	23495	837	24274	452	42	79
7	7	LSBk	0.9	52	364	0.5	10	0.5	2.2	530	3713	597	4177	345	18	77
3	3	LSBo	0.4	41	122	0.2	10	0.4	1.2	425	1274	420	1259	156	93	83
8	8	PLP	1.0	67	533	0.7	17	1.7	7	1324	10593	3205	25638	3305	69	71
4	4	SCP	0.5	26	105	0.1	5	0.5	1.1	139	558	82	326	63	47	78
1	1	BPB	0.1	45	45	0.1	15	1.3	2.8	675	675	1013	1013	878	40	33
2	2	BPR	0.3	41	82	0.1	16	0.3	1.5	641	1283	406	811	113	20	18
1	1	BPL	0.1	32	32	0.0	22		2.9	704	704				80	75
15	15	DPL	1.9	151	2272	3.1	28	1.2	3.2	4761	71417	8371	125564	7341	34	65
18	0	DRY	2.3	182	3273	4.4										24
1	0	CUL	0.1	53	53	0.1										
2	0	NS	0.3	8156	16313	21.9										98
4	0	MAR	0.5	1726	6905	9.3										

Total Units	Total Units Fully Measured	Total Length (ft.)	Total Area (sq.ft.)	Total Volume (cu.ft.)
772	467	74355.3	753350.5	713796.2

Table 3 - Summary of Pool Types

Stream Name: Arroyo Grande Creek LLID: 1206299351011 Drainage: Arroyo Grande

Survey Dates: 7/6/2004 to 8/16/2004

Confluence Location: Quad: OCEANO Legal Description: T32SR13ES00 Latitude: 35:06:04.0N Longitude: 120:37:48.0W

Habitat Units	Units Fully Measured	Habitat Type	Habitat Occurrence (%)	Mean Length (ft.)	Total Length (ft.)	Total Length (%)	Mean Width (ft.)	Mean Residual Depth (ft.)	Mean Area (sq.ft.)	Estimated Total Area (sq.ft.)	Mean Residual Pool Vol (cu.ft.)	Estimated Total Resid.Vol. (cu.ft.)	Mean Shelter Rating
322	321	MAIN	79	48	15406	73	12.3	0.6	624	200965	450	141175	61
61	61	SCOUR	15	54	3289	15	13.0	0.7	761	46394	753	42903	51
23	23	BACKWATER	6	110	2535	12	21.9	1.0	3245	74636	5303	111357	37

Total Units	Total Units Fully Measured	Total Length (ft.)	Total Area (sq.ft.)	Total Volume (cu.ft.)
406	405	21230.3	321996	295435.9

Table 4 - Summary of Maximum Residual Pool Depths By Pool Habitat Types

Stream Name: Arroyo Grande Creek LLID: 1206299351011 Drainage: Arroyo Grande

Survey Dates: 7/6/2004 to 8/16/2004

Confluence Location: Quad: OCEANO Legal Description: T32SR13ES00 Latitude: 35:06:04.0N Longitude: 120:37:48.0W

Habitat Units	Habitat Type	Habitat Occurrence (%)	< 1 Foot Maximum Residual Depth	< 1 Foot Percent Occurrence	1 < 2 Feet Maximum Residual Depth	1 < 2 Feet Percent Occurrence	2 < 3 Feet Maximum Residual Depth	2 < 3 Feet Percent Occurrence	3 < 4 Feet Maximum Residual Depth	3 < 4 Feet Percent Occurrence	>= 4 Feet Maximum Residual Depth	>= 4 Feet Percent Occurrence
1	TRP	0	0	0	0	0	1	100	0	0	0	0
321	MCP	79	117	36	169	53	32	10	2	1	1	0
6	CRP	1	0	0	4	67	2	33	0	0	0	0
8	LSL	2	7	88	1	13	0	0	0	0	0	0
29	LSR	7	11	38	16	55	1	3	1	3	0	0
7	LSBk	2	0	0	6	86	1	14	0	0	0	0
3	LSBo	1	0	0	3	100	0	0	0	0	0	0
8	PLP	2	2	25	1	13	3	38	1	13	1	13
4	SCP	1	2	50	2	50	0	0	0	0	0	0
1	BPB	0	0	0	0	0	1	100	0	0	0	0
2	BPR	0	0	0	2	100	0	0	0	0	0	0
1	BPL	0	0	0	0	0	1	100	0	0	0	0
15	DPL	4	1	7	7	47	5	33	2	13	0	0

Total Units			Total < 1 Foot Max Resid. Depth	Total < 1 Foot % Occurrence	Total 1< 2 Foot Max Resid. Depth	Total 1< 2 Foot % Occurrence	Total 2< 3 Foot Max Resid. Depth	Total 2< 3 Foot % Occurrence	Total 3< 4 Foot Max Resid. Depth	Total 3< 4 Foot % Occurrence	Total >= 4 Foot Max Resid. Depth	Total >= 4 Foot % Occurrence
406			140	34	211	52	47	12	6	1	2	0

Mean Maximum Residual Pool Depth (ft.): 1.3

Table 5 - Summary of Mean Percent Cover By Habitat Type

Stream Name: Arroyo Grande Creek LLID: 1206299351011 Drainage: Arroyo Grande

Survey Dates: 7/6/2004 to 8/16/2004 Dry Units: 18

Confluence Location: Quad: OCEANO Legal Description: T32SR13ES00 Latitude: 35:06:04.0N Longitude: 120:37:48.0W

Habitat Units	Units Fully Measured	Habitat Type	Mean % Undercut Banks	Mean % SWD	Mean % LWD	Mean % Root Mass	Mean % Terr. Vegetation	Mean % Aquatic Vegetation	Mean % White Water	Mean % Boulders	Mean % Bedrock Ledges
12	7	LGR	0	3	0	1	23	27	8	39	0
1	1	HGR	0	5	0	5	5	0	35	50	0
13	8	TOTAL RIFFLE	0	3	0	1	21	24	11	40	0
102	17	GLD	0	16	1	10	44	29	0	1	0
223	33	RUN	0	15	1	9	34	28	1	12	0
3	3	SRN	22	20	3	3	13	2	18	18	0
328	53	TOTAL FLAT	1	16	1	9	36	26	2	9	0
1	1	TRP	0	0	0	0	0	20	0	0	80
321	301	MCP	2	29	4	13	33	13	0	6	1
6	6	CRP	10	9	0	23	4	23	0	21	10
8	8	LSL	4	45	18	5	28	1	0	1	0
29	23	LSR	4	3	2	47	24	19	0	1	0
7	6	LSBk	11	1	0	12	8	50	0	2	17
3	3	LSBo	0	15	0	5	7	40	0	10	23
8	8	PLP	3	14	6	8	15	8	31	16	0
4	3	SCP	0	3	0	67	25	5	0	0	0
1	1	BPB	30	0	0	0	10	60	0	0	0
2	1	BPR	0	10	0	0	45	45	0	0	0
1	1	BPL	0	25	50	5	10	5	0	5	0
15	15	DPL	5	15	0	9	40	21	0	9	0
406	377	TOTAL POOL	3	25	4	15	31	14	1	6	1
1	0	CUL									
2	0	NS									
4	0	MAR									
772	438	TOTAL	2	24	4	14	31	16	1	7	1

Table 6 - Summary of Dominant Substrates By Habitat Type

Stream Name: Arroyo Grande Creek | LLID: 1206299351011 | Drainage: Arroyo Grande

Survey Dates: 7/6/2004 to 8/16/2004 | Dry Units: 18

Confluence Location: Quad: OCEANO | Legal Description: T32SR13ES00 | Latitude: 35:06:04.0N | Longitude: 120:37:48.0W

Habitat Units	Units Fully Measured	Habitat Type	% Total Silt/Clay Dominant	% Total Sand Dominant	% Total Gravel Dominant	% Total Small Cobble Dominant	% Total Large Cobble Dominant	% Total Boulder Dominant	% Total Bedrock Dominant
12	7	LGR	0	29	43	14	0	0	14
1	1	HGR	0	0	0	0	0	100	0
102	17	GLD	53	6	41	0	0	0	0
223	33	RUN	12	0	85	3	0	0	0
3	3	SRN	33	0	67	0	0	0	0
1	1	TRP	0	0	100	0	0	0	0
321	48	MCP	52	17	31	0	0	0	0
6	4	CRP	25	0	50	0	0	25	0
8	4	LSL	25	25	50	0	0	0	0
29	12	LSR	25	8	67	0	0	0	0
7	2	LSBk	0	0	50	50	0	0	0
3	2	LSBo	0	50	50	0	0	0	0
8	4	PLP	0	50	50	0	0	0	0
4	2	SCP	100	0	0	0	0	0	0
1	1	BPB	0	100	0	0	0	0	0
2	1	BPR	100	0	0	0	0	0	0
1	1	BPL	100	0	0	0	0	0	0
15	5	DPL	40	20	40	0	0	0	0

Table 7 - Summary of Mean Percent Canopy for Entire Stream

Stream Name: Arroyo Grande Creek LLID: 1206299351011 Drainage: Arroyo Grande

Survey Dates: 7/6/2004 to 8/16/2004

Confluence Location: Quad: OCEANO Legal Description: T32SR13ES00 Latitude: 35:06:04.0N Longitude: 120:37:48.0W

Mean Percent Canopy	Mean Percent Conifer	Mean Percent Deciduous	Mean Percent Open Units	Mean Right Bank % Cover	Mean Left Bank % Cover
79	3	97	1	87	87

Note: Mean percent evergreen and deciduous for the entire reach are means of canopy components from units with canopy values greater than zero.

Open units represent habitat units with zero canopy cover.

Table 8 - Fish Habitat Inventory Data Summary

Stream Name: Arroyo Grande Creek | LLID: 1206299351011 | Drainage: Arroyo Grande

Survey Dates: 7/6/2004 to 8/16/2004 | Survey Length (ft.): 74355.3 | Main Channel (ft.): 73531.5 | Side Channel (ft.): 823.8

Confluence Location: Quad: OCEANO | Legal Description: T32SR13ES00 | Latitude: 35:06:04.0N | Longitude: 120:37:48.0W

Summary of Fish Habitat Elements By Stream Reach

STREAM REACH: 1

Channel Type: NA	Canopy Density (%):	Pools by Stream Length (%): 0
Reach Length (ft.): 1746	Coniferous Component (%):	Pool Frequency (%): 0
Riffle/Flatwater Mean Width (ft.):	Deciduous Component (%):	Residual Pool Depth (%):
BFW:	Dominant Bank Vegetation:	< 2 Feet Deep:
Range (ft.): to	Vegetative Cover (%): 0	2 to 2.9 Feet Deep:
Mean (ft.):	Dominant Shelter:	3 to 3.9 Feet Deep:
Std. Dev.:	Dominant Bank Substrate Type:	>= 4 Feet Deep:
Base Flow (cfs.): 0.0	Occurrence of LWD (%):	Mean Max Residual Pool Depth (ft.):
Water (F): 64 - 64 Air (F): 59 - 59	LWD per 100 ft.:	Mean Pool Shelter Rating:
Dry Channel (ft): 0	Riffles:	
	Pools:	
	Flat:	

Pool Tail Substrate (%): Silt/Clay: Sand: Gravel: Sm Cobble: Lg Cobble: Boulder: Bedrock:

Embeddedness Values (%): 1. 2. 3. 4. 5. 0

STREAM REACH: 2

Channel Type: F6	Canopy Density (%): 41	Pools by Stream Length (%): 32
Reach Length (ft.): 10465.5	Coniferous Component (%): 3	Pool Frequency (%): 45
Riffle/Flatwater Mean Width (ft.): 15.4	Deciduous Component (%): 97	Residual Pool Depth (%):
BFW:	Dominant Bank Vegetation: Deciduous Trees	< 2 Feet Deep: 88
Range (ft.): 16 to 45	Vegetative Cover (%): 94	2 to 2.9 Feet Deep: 12
Mean (ft.): 30	Dominant Shelter: Terrestrial Veg.	3 to 3.9 Feet Deep: 0
Std. Dev.: 8	Dominant Bank Substrate Type: Sand/Silt/Clay	>= 4 Feet Deep: 0
Base Flow (cfs.): 0.0	Occurrence of LWD (%): 0	Mean Max Residual Pool Depth (ft.): 1.4
Water (F): 60 - 68 Air (F): 59 - 78	LWD per 100 ft.:	Mean Pool Shelter Rating: 74
Dry Channel (ft): 3273	Riffles: 0	
	Pools: 0	
	Flat: 0	

Pool Tail Substrate (%): Silt/Clay: 23 Sand: 34 Gravel: 36 Sm Cobble: 0 Lg Cobble: 0 Boulder: 0 Bedrock: 7

Embeddedness Values (%): 1. 14 2. 7 3. 23 4. 16 5. 41

Summary of Fish Habitat Elements By Stream Reach

STREAM REACH: 3

Channel Type: F4	Canopy Density (%): 73	Pools by Stream Length (%): 38
Reach Length (ft.): 20391	Coniferous Component (%): 6	Pool Frequency (%): 50
Riffle/Flatwater Mean Width (ft.): 13.5	Deciduous Component (%): 94	Residual Pool Depth (%):
BFW:	Dominant Bank Vegetation: Deciduous Trees	< 2 Feet Deep: 86
Range (ft.): 13 to 39	Vegetative Cover (%): 84	2 to 2.9 Feet Deep: 12
Mean (ft.): 25	Dominant Shelter: Aquatic Vegetation	3 to 3.9 Feet Deep: 1
Std. Dev.: 6	Dominant Bank Substrate Type: Sand/Silt/Clay	>= 4 Feet Deep: 1
Base Flow (cfs.): 2.6	Occurrence of LWD (%): 1	Mean Max Residual Pool Depth (ft.): 1.3
Water (F): 59 - 72 Air (F): 59 - 82	LWD per 100 ft.:	Mean Pool Shelter Rating: 48
Dry Channel (ft): 0	Riffles: 0	
	Pools: 0	
	Flat: 0	

Pool Tail Substrate (%):	Silt/Clay: 4	Sand: 15	Gravel: 72	Sm Cobble: 1	Lg Cobble: 0	Boulder: 4	Bedrock: 5
Embeddedness Values (%):	1. 33	2. 7	3. 9	4. 26	5. 25		

STREAM REACH: 4

Channel Type: NA	Canopy Density (%): 98	Pools by Stream Length (%): 0
Reach Length (ft.): 14567	Coniferous Component (%): 0	Pool Frequency (%): 0
Riffle/Flatwater Mean Width (ft.):	Deciduous Component (%): 100	Residual Pool Depth (%):
BFW:	Dominant Bank Vegetation:	< 2 Feet Deep:
Range (ft.): to	Vegetative Cover (%): 0	2 to 2.9 Feet Deep:
Mean (ft.):	Dominant Shelter:	3 to 3.9 Feet Deep:
Std. Dev.:	Dominant Bank Substrate Type:	>= 4 Feet Deep:
Base Flow (cfs.): 2.6	Occurrence of LWD (%):	Mean Max Residual Pool Depth (ft.):
Water (F): 68 - 68 Air (F): 72 - 72	LWD per 100 ft.:	Mean Pool Shelter Rating:
Dry Channel (ft): 0	Riffles:	
	Pools:	
	Flat:	

Pool Tail Substrate (%):	Silt/Clay:	Sand:	Gravel:	Sm Cobble:	Lg Cobble:	Boulder:	Bedrock:
Embeddedness Values (%):	1.	2.	3.	4.	5. 0		

Summary of Fish Habitat Elements By Stream Reach

STREAM REACH: 5

Channel Type: F4
Reach Length (ft.): 12022
Riffle/Flatwater Mean Width (ft.): 11.0
BFW:
Range (ft.): 16 to 29
Mean (ft.): 22
Std. Dev.: 3
Base Flow (cfs.): 2.0
Water (F): 60 - 66 Air (F): 62 - 75
Dry Channel (ft): 0

Canopy Density (%): 94
Coniferous Component (%): 1
Deciduous Component (%): 99
Dominant Bank Vegetation: Deciduous Trees
Vegetative Cover (%): 87
Dominant Shelter: Small Woody Debris
Dominant Bank Substrate Type: Sand/Silt/Clay
Occurrence of LWD (%): 6
LWD per 100 ft.:
Riffles: 0
Pools: 1
Flat: 0

Pools by Stream Length (%): 50
Pool Frequency (%): 56
Residual Pool Depth (%):
< 2 Feet Deep: 82
2 to 2.9 Feet Deep: 15
3 to 3.9 Feet Deep: 2
>= 4 Feet Deep: 1
Mean Max Residual Pool Depth (ft.): 1.4
Mean Pool Shelter Rating: 57

Pool Tail Substrate (%): Silt/Clay: 2 Sand: 8 Gravel: 86 Sm Cobble: 2 Lg Cobble: 0 Boulder: 1 Bedrock: 2
Embeddedness Values (%): 1. 34 2. 17 3. 13 4. 27 5. 10

STREAM REACH: 6

Channel Type: F6
Reach Length (ft.): 3885
Riffle/Flatwater Mean Width (ft.): 9.3
BFW:
Range (ft.): 15 to 54
Mean (ft.): 28
Std. Dev.: 8
Base Flow (cfs.): 2.0
Water (F): 64 - 66 Air (F): 59 - 81
Dry Channel (ft): 0

Canopy Density (%): 94
Coniferous Component (%): 0
Deciduous Component (%): 100
Dominant Bank Vegetation: Deciduous Trees
Vegetative Cover (%): 86
Dominant Shelter: Terrestrial Veg.
Dominant Bank Substrate Type: Sand/Silt/Clay
Occurrence of LWD (%): 6
LWD per 100 ft.:
Riffles:
Pools: 1
Flat: 0

Pools by Stream Length (%): 47
Pool Frequency (%): 58
Residual Pool Depth (%):
< 2 Feet Deep: 98
2 to 2.9 Feet Deep: 2
3 to 3.9 Feet Deep: 0
>= 4 Feet Deep: 0
Mean Max Residual Pool Depth (ft.): 1.0
Mean Pool Shelter Rating: 76

Pool Tail Substrate (%): Silt/Clay: 19 Sand: 26 Gravel: 50 Sm Cobble: 0 Lg Cobble: 0 Boulder: 0 Bedrock: 5
Embeddedness Values (%): 1. 7 2. 5 3. 10 4. 33 5. 45

Summary of Fish Habitat Elements By Stream Reach

STREAM REACH: 7

Channel Type: NA	Canopy Density (%): 97	Pools by Stream Length (%): 45
Reach Length (ft.): 1420	Coniferous Component (%): 1	Pool Frequency (%): 57
Riffle/Flatwater Mean Width (ft.): 7.6	Deciduous Component (%): 99	Residual Pool Depth (%):
BFW:	Dominant Bank Vegetation: Deciduous Trees	< 2 Feet Deep: 100
Range (ft.): 20 to 54	Vegetative Cover (%): 86	2 to 2.9 Feet Deep: 0
Mean (ft.): 30	Dominant Shelter: Small Woody Debris	3 to 3.9 Feet Deep: 0
Std. Dev.: 13	Dominant Bank Substrate Type: Sand/Silt/Clay	>= 4 Feet Deep: 0
Base Flow (cfs.): 2.0	Occurrence of LWD (%): 11	Mean Max Residual Pool Depth (ft.): 1.0
Water (F): 64 - 74 Air (F): 59 - 75	LWD per 100 ft.:	Mean Pool Shelter Rating: 42
Dry Channel (ft): 0	Riffles:	
	Pools: 1	
	Flat: 1	

Pool Tail Substrate (%): Silt/Clay: 40 Sand: 5 Gravel: 55 Sm Cobble: 0 Lg Cobble: 0 Boulder: 0 Bedrock: 0

Embeddedness Values (%): 1. 10 2. 0 3. 5 4. 55 5. 30

STREAM REACH: 8

Channel Type: NA	Canopy Density (%): 85	Pools by Stream Length (%): 17
Reach Length (ft.): 9035	Coniferous Component (%): 0	Pool Frequency (%): 48
Riffle/Flatwater Mean Width (ft.): 16.0	Deciduous Component (%): 100	Residual Pool Depth (%):
BFW:	Dominant Bank Vegetation: Deciduous Trees	< 2 Feet Deep: 75
Range (ft.): 15 to 26	Vegetative Cover (%): 81	2 to 2.9 Feet Deep: 19
Mean (ft.): 22	Dominant Shelter: Terrestrial Veg.	3 to 3.9 Feet Deep: 6
Std. Dev.: 4	Dominant Bank Substrate Type: Sand/Silt/Clay	>= 4 Feet Deep: 0
Base Flow (cfs.): 2.0	Occurrence of LWD (%): 2	Mean Max Residual Pool Depth (ft.): 1.6
Water (F): 69 - 74 Air (F): 70 - 82	LWD per 100 ft.:	Mean Pool Shelter Rating: 81
Dry Channel (ft): 0	Riffles:	
	Pools: 0	
	Flat: 0	

Pool Tail Substrate (%): Silt/Clay: 39 Sand: 0 Gravel: 56 Sm Cobble: 0 Lg Cobble: 0 Boulder: 0 Bedrock: 6

Embeddedness Values (%): 1. 28 2. 0 3. 6 4. 28 5. 39

Table 9 - Mean Percentage of Dominant Substrate and Vegetation

Stream Name: Arroyo Grande Creek LLID: 1206299351011 Drainage: Arroyo Grande

Survey Dates: 7/6/2004 to 8/16/2004

Confluence Location: Quad: OCEANO Legal Description: T32SR13ES00 Latitude: 35:06:04.0N Longitude: 120:37:48.0W

Mean Percentage of Dominant Stream Bank Substrate

Dominant Class of Substrate	Number of Units Right Bank	Number of Units Left Bank	Total Mean Percent (%)
Bedrock	0	0	0.00
Boulder	1	1	0.67
Cobble / Gravel	0	0	0.00
Sand / Silt / Clay	149	149	99.33

Mean Percentage of Dominant Stream Bank Vegetation

Dominant Class of Vegetation	Number of Units Right Bank	Number of Units Left Bank	Total Mean Percent (%)
Grass	35	21	18.67
Brush	14	11	8.33
Deciduous Trees	100	118	72.67
Coniferous Trees	0	0	0.00
No Vegetation	1	0	0.33

Total Stream Cobble Embeddedness Values: 3

Table 10 - Mean Percent of Shelter Cover Types For Entire Stream

StreamName: Arroyo Grande Creek LLID: 1206299351011 Drainage: Arroyo Grande

Survey Dates: 7/6/2004 to 8/16/2004

Confluence Location: Quad: OCEANO Legal Description: T32SR13ES00 Latitude: 35:06:04.0N Longitude: 120:37:48.0W

	Riffles	Flatwater	Pools
UNDERCUT BANKS (%)	0	1	3
SMALL WOODY DEBRIS (%)	3	16	25
LARGE WOODY DEBRIS (%)	0	1	4
ROOT MASS (%)	1	9	15
TERRESTRIAL VEGETATION (%)	21	36	31
AQUATIC VEGETATION (%)	24	26	14
WHITEWATER (%)	11	2	1
BOULDERS (%)	40	9	6
BEDROCK LEDGES (%)	0	0	1

APPENDIX D – Maps

MAP 1 – Overview

MAP 2 – Ownership and Agriculture

MAP 3 – Channel Types

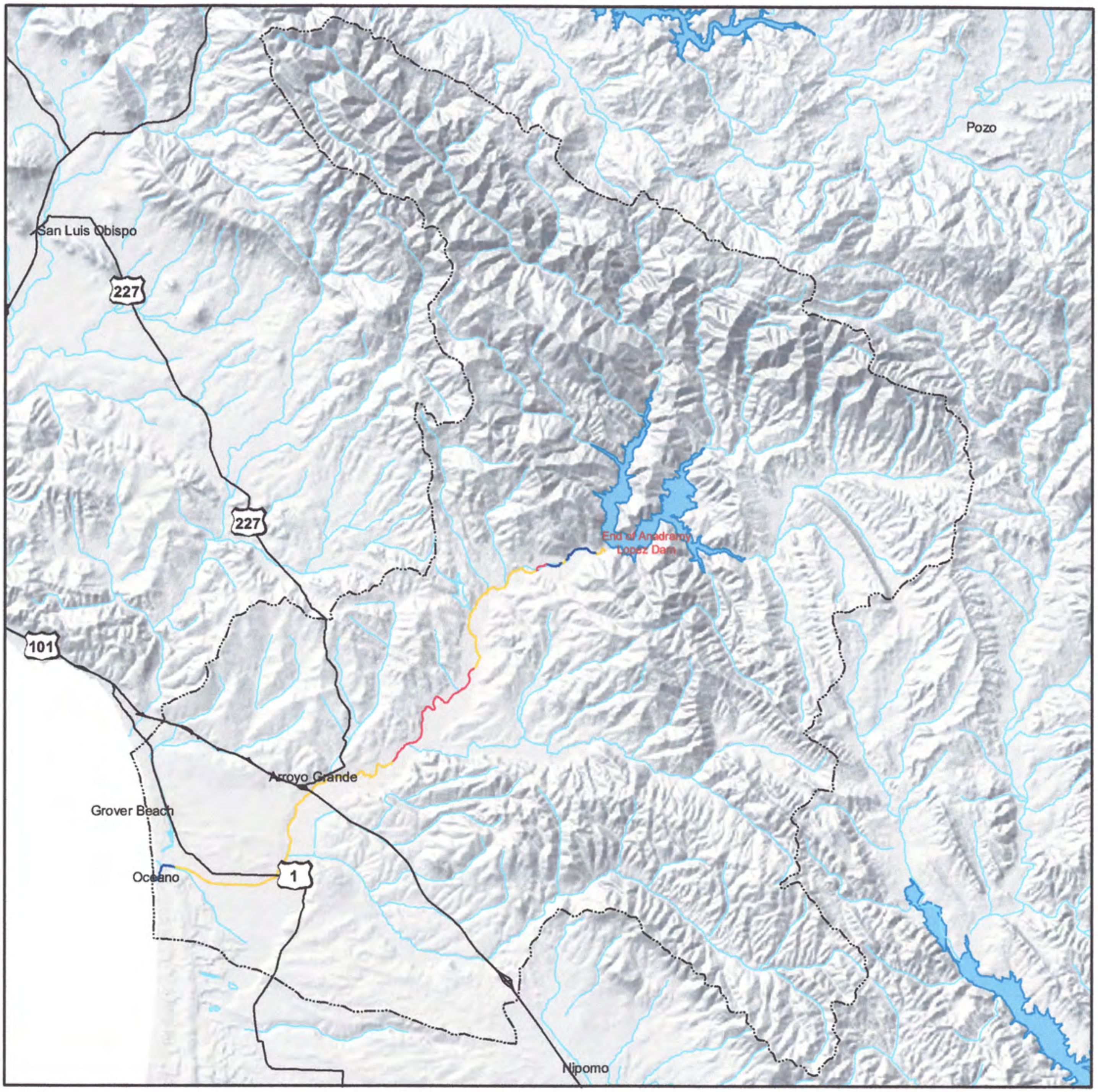
MAP 4 – Erosion Sites Overview

MAP 5 – Erosion Sites - Lower Section

MAP 6 – Erosion Sites - Upper Section

Arroyo Grande Creek Overview

Map 1



Legend

Highways

Arroyo Grande Creek 13.9 miles

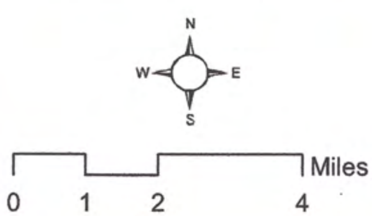
Surveyed Area = 9 mi.

No Access = 3 mi.

Unsurveyable = 2 mi.

Lakes

Watershed Boundary

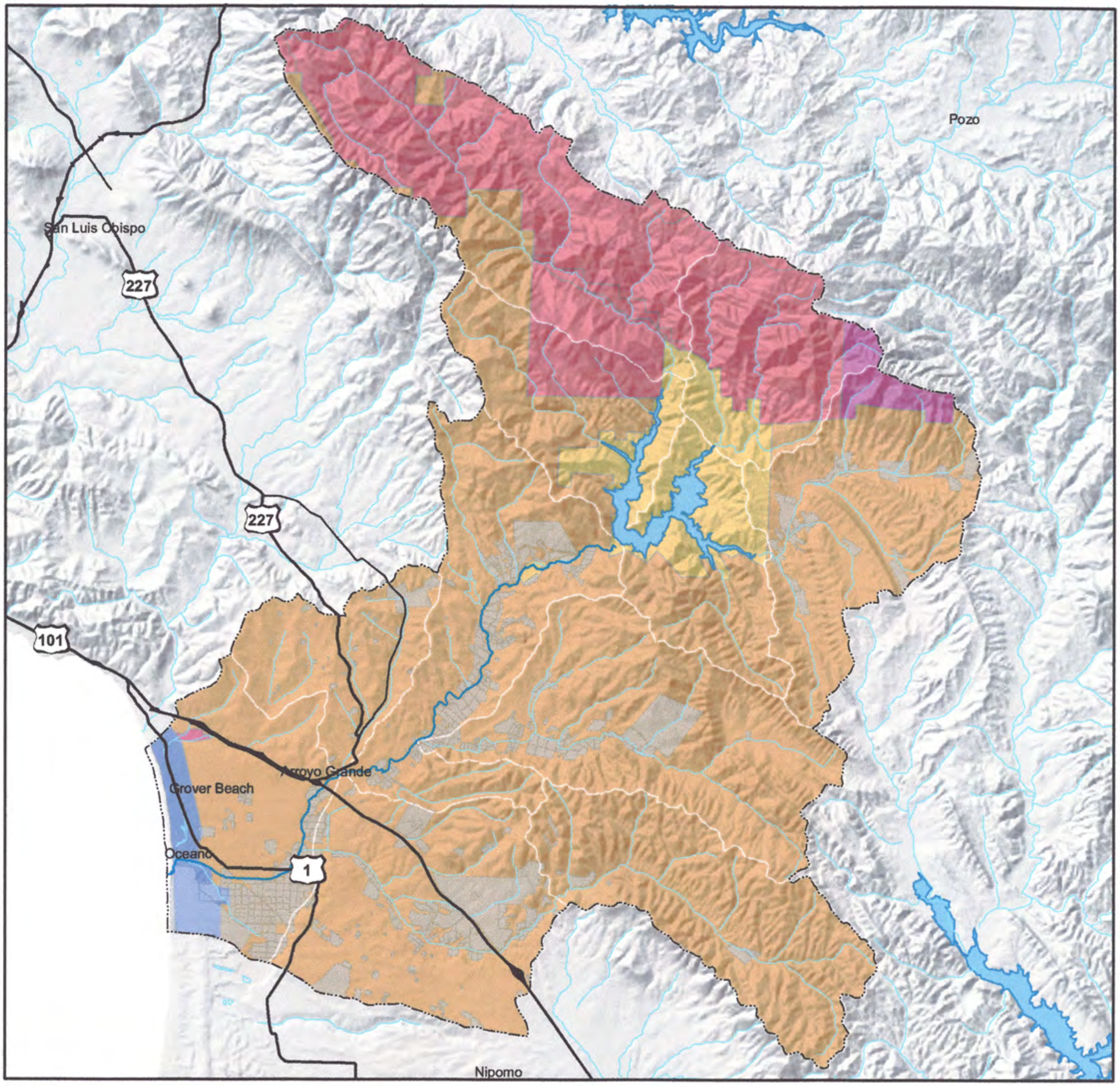


Watershed = 153 square miles
Below Lopez Dam = 86 square miles

San Luis Obispo County

Arroyo Grande Creek Watershed Ownership and Agriculture

Map 2



Legend

- Major Roads
- Arroyo Grande Creek
- Streams
- Lakes
- Watershed
- Drainage Watersheds
- Agriculture

Ownership

- CDFG
- State Parks
- County Parks
- National Forest
- Private
- BLM

N W E S

0 1 2 4 Miles

Land Owner	square miles	% of total area
BLM	1.78	1.17%
CDFG	0.10	0.07%
County-Regional Parks	9.58	6.29%
National Forest	27.72	18.19%
State Parks	2.34	1.54%
*Public - Agriculture	1.45	0.95%
Private	95.13	62.42%
*Private - Agriculture	14.30	9.38%

San Luis Obispo County

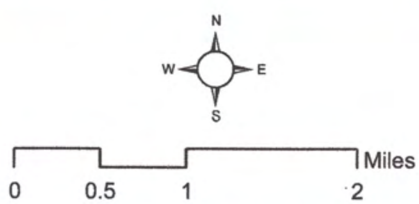
Arroyo Grande Creek Channel Changes

Map 3

Legend

Arroyo Grande Creek

- Surveyed Area
- Not Surveyed, No Access
- Not Surveyed, Unsurveyable
- Channel Changes
- Watershed

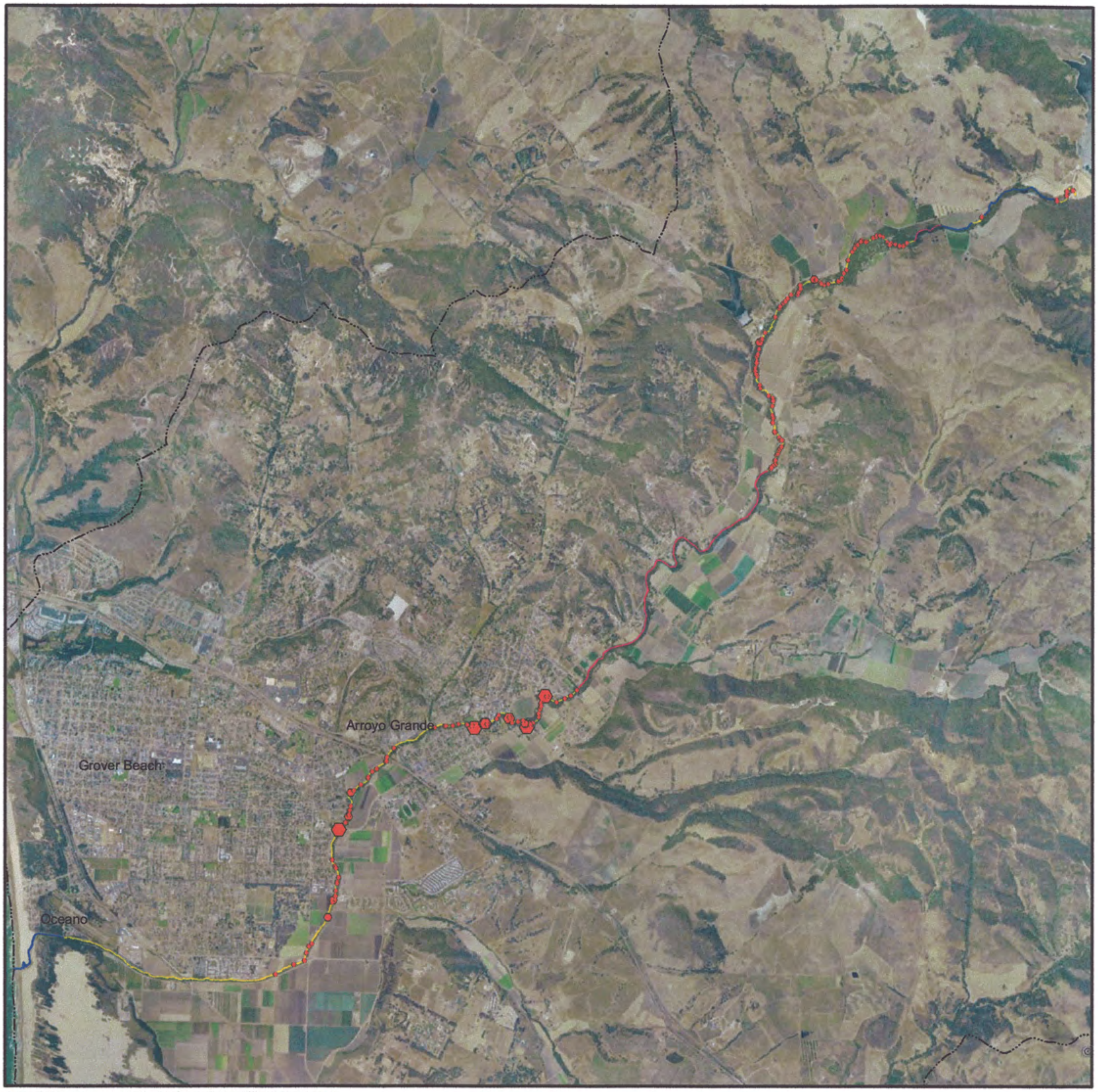


Total Survey Mileage: 13.9 mi.
F4 Channel Type: 6.14 F6 Channel Type: 2.72
Not Classifiable: 1.98 Unsurveyed: 3.09

Arroyo Grande Creek Watershed

Arroyo Grande Creek Erosion Sites Overview

Map 4



Area of Erosion (sq. ft.)
- 18 - 1994
- 1995 - 3969
- 3990 - 5945
- 6776 - 7920

Arroyo Grande Creek
- Surveyed Area
- No Access
- Unsurveyable
- Watershed

N
W E
S

0 0.5 1 2 Miles

Erosion Sites along 13.9 miles of creek = 179
Erosion Statistics (area measured in square feet)
Min: 18 Max: 7920
Sum: 140,151 Mean: 783

San Luis Obispo County

Map 5

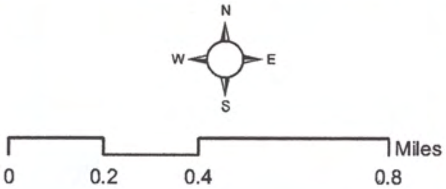
Arroyo Grande Creek Erosion Sites - Lower Section

Area of Erosion (square feet)

- 18 - 1000
- 1001 - 3000
- 3001 - 5500
- 5501 - 8000

Arroyo Grande Creek

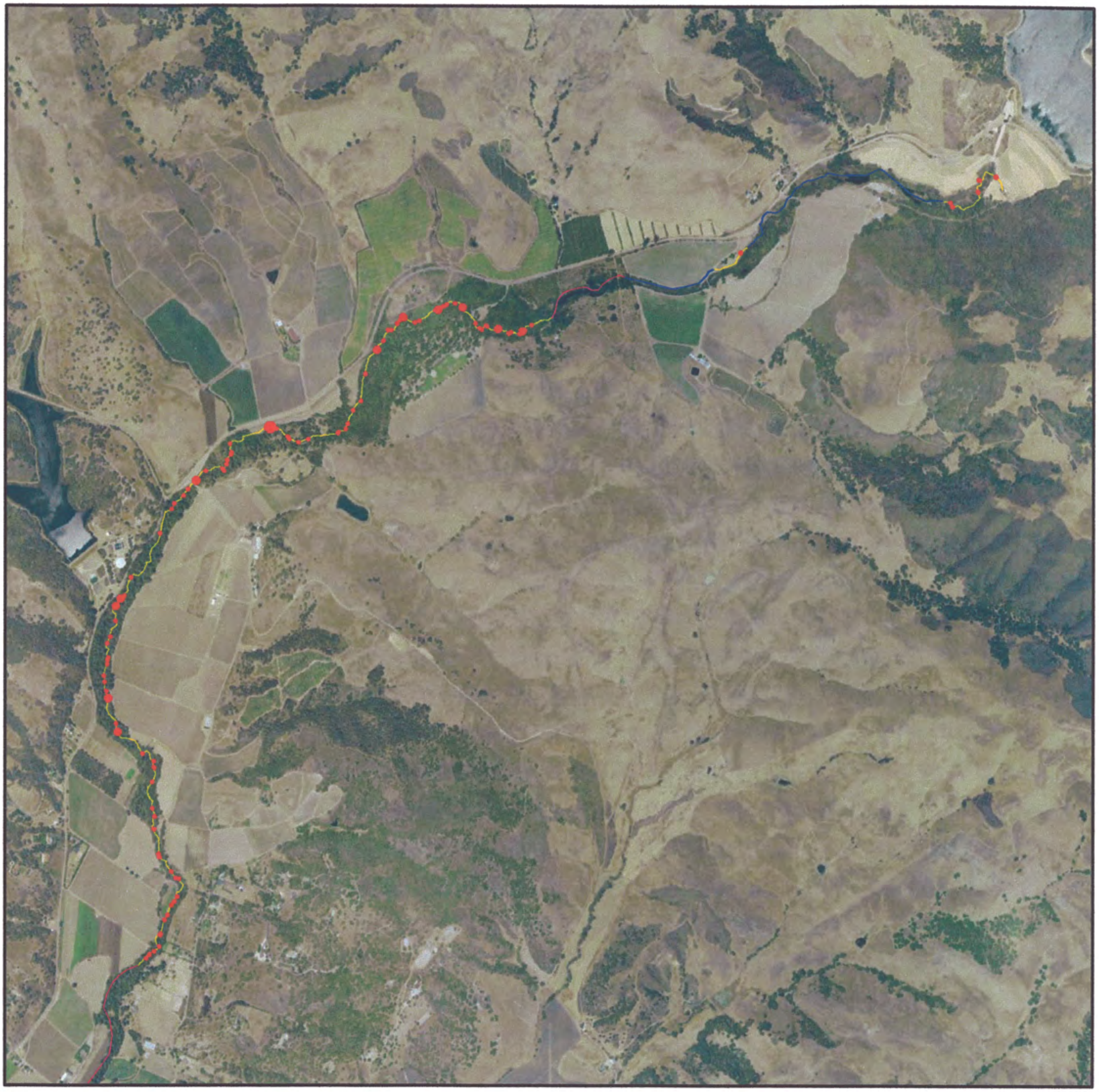
- Surveyed Area
- No Access
- Unsurveyable
- Watershed



Number of Erosion Sites in Lower Section= 74
Erosion Statistics (area measured in square feet)
Min: 18 Max: 7920
Sum: 94,508 Mean: 1277

Arroyo Grande Watershed

Arroyo Grande Creek Erosion Sites - Upper Section

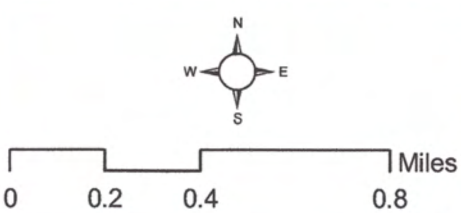


Area of Erosion (sq. ft.)

- 18 - 1000
- 1001 - 3000
- 3001 - 5500
- 5501 - 8000

Arroyo Grande Creek

- Surveyed Area
- No Access
- Unsurveyable
- Arroyo Grande Creek Watershed

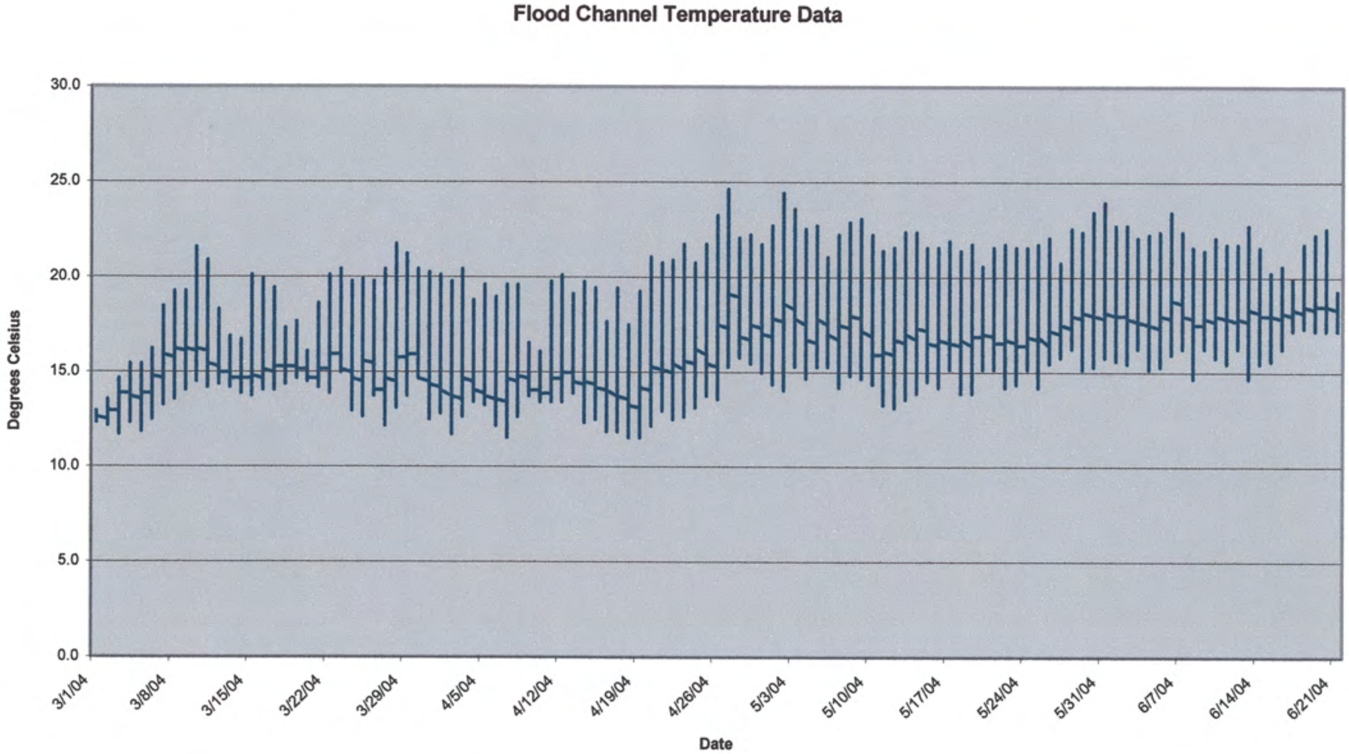


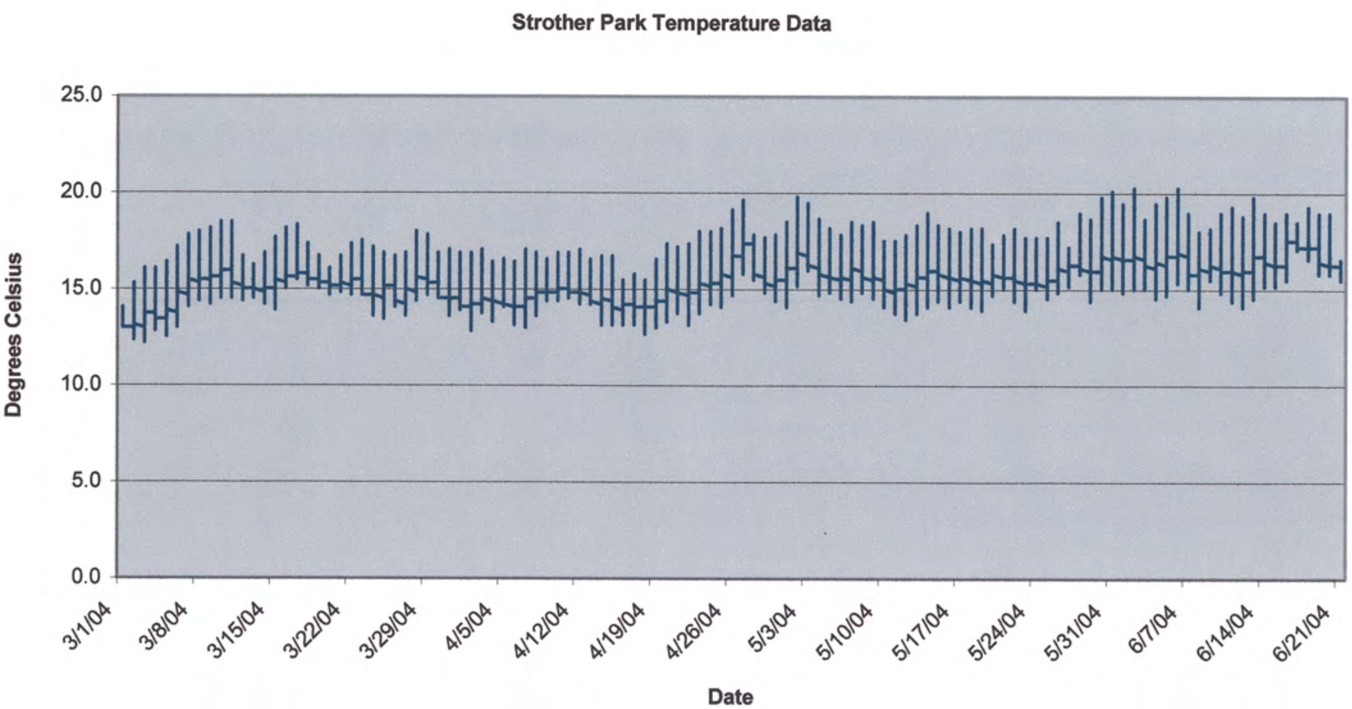
Number of Erosion Sites in Upper Section= 105
Erosion Statistics (area measured in square feet)
Min: 18 Max: 3,230
Sum: 45,643 Mean: 435

Arroyo Grande Creek Watershed

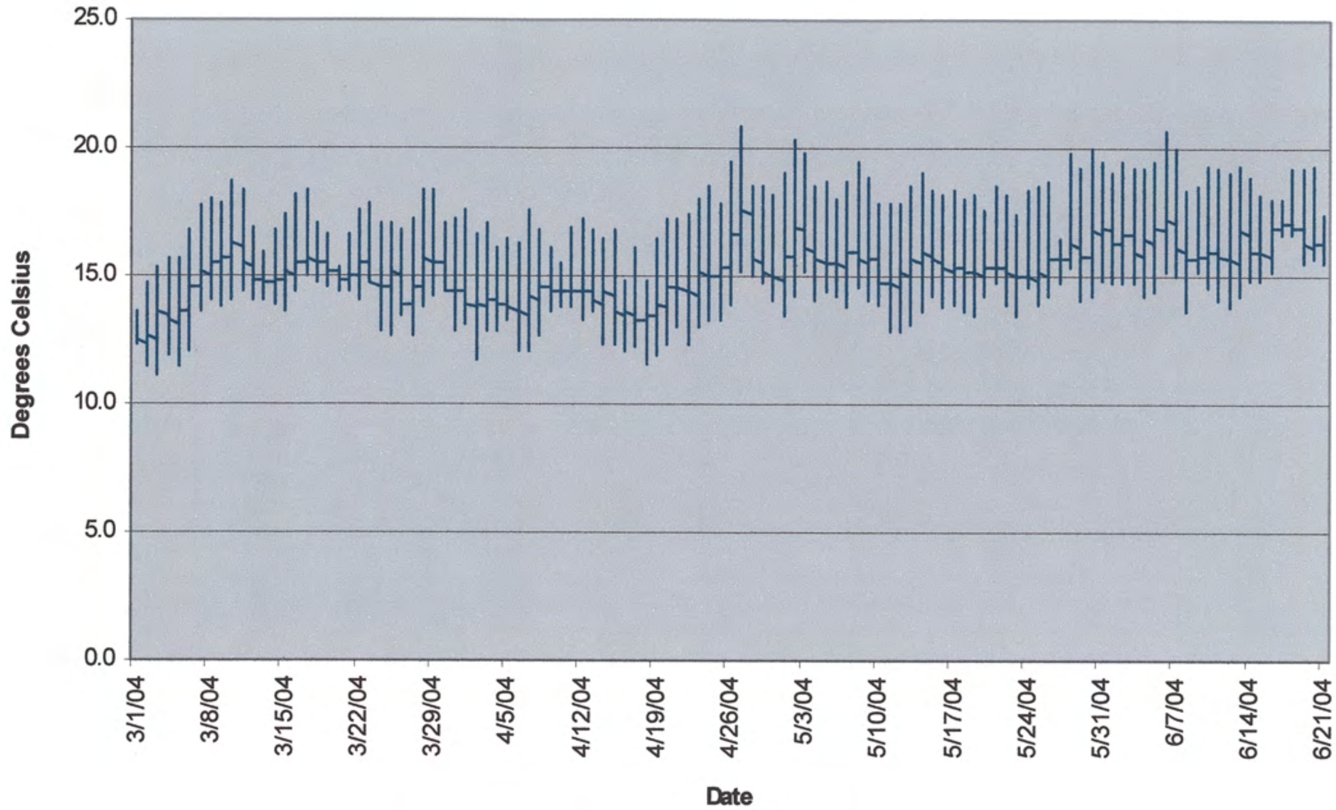
Appendix E

Volunteer Water Quality Monitoring Results

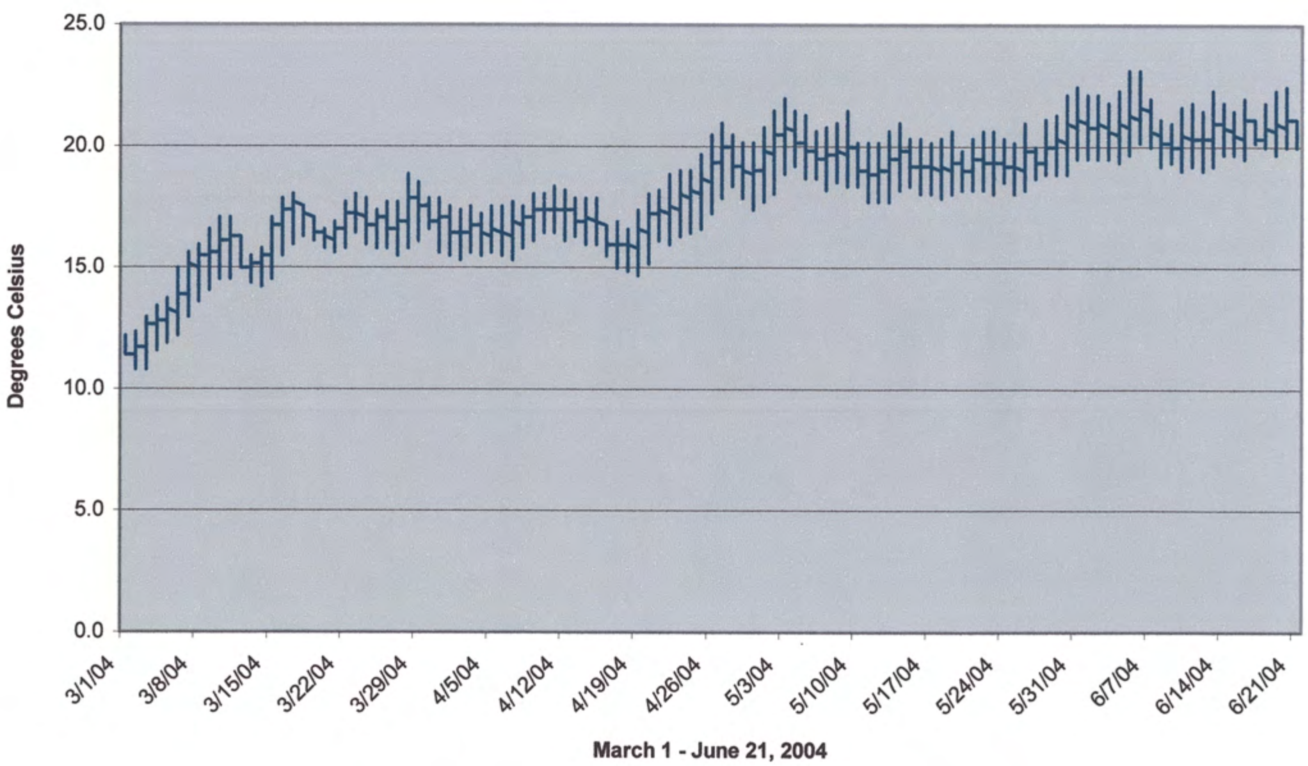




Johnson Property Temperature Data



Upper Arroyo Grande Creek Temperature Data



Appendix F

CCAMP Coastal Confluences Results

CCAMP Site: Arroyo Grande Creek @ 22nd Street

SWRCB Geotracker

USEPA Enviromapper for water

USEPA Surf Your Watershed

US Census Bureau Tiger

Microsoft Terraserver

Analyte	Max	Min	Mean	GeoMean	Samples	Hits	%	First	Last	Crit.	Ref
% algal Cover, filamentous	95	2	44.1	26.9	23			04/2001	03/2003		
% algal Cover, periphyton	100	10	41	32	21			04/2001	02/2003		
Air Temperature	29	15	20.1	19.7	7			04/2001	10/2002		
Air Temperature(F)	70	16	58.6	56	14			07/2001	03/2003		
Ammonia as N, Total	0.1	0.005	0.033	0.024	23		00%	04/2001	03/2003	2.4	Calif. Ocean Plan Daily Maximum
Ammonia as N,	0.006	0	0.001	0.001	22		00%	04/2001	03/2003	0.025	Basin Plan General

Unionized											Objective
Bank Plant Cover	100	50	89	87	23			04/2001	03/2003		
Boron, dissolved	0.21	0.086	0.159	0.154	16		00%	04/2001	06/2002	0.75	Basin Plan Agriculture (Irrigation)
Calcium	130	99	117	116	21			04/2001	03/2003		
Chloride	48	34	40.5	40.2	16		00%	04/2001	06/2002	50	Waterbody Specific Objective
Chlorophyll a	2.9	0.05	0.944	0.487	24		00%	04/2001	03/2003	15	North Carolina DENR, 2002 - Objective in streams
Coliform, Fecal	2400	40	606	354	18	9	50%	04/2001	09/2002	400	Basin Plan Water Body Contact Recreation
Coliform, Total	90000	800	10572	4478	18	4	22%	04/2001	09/2002	10000	Basin Plan Marine Water Contact Recreation
Conductivity(Us)	1278	806	1041	1037	26		00%	04/2001	03/2003	3000	Basin Plan Severe Problems for Ag
Dissolved Solids, Fixed	1500	443	581	561	22			04/2001	03/2003		
Dissolved Solids, Total	1830	571	762	740	23	3	13%	04/2001	03/2003	800	Waterbody Specific Objective
Dissolved Solids, volatile	330	109	181	177	22			04/2001	03/2003		
Hardness as CaCO3	585	326	513	510	23			04/2001	03/2003		
Magnesium	63	51	56.4	56.3	21			04/2001	03/2003		
Nitrate as N	7.8	0.074	2.176	1.439	23		00%	04/2001	03/2003	10	Basin Plan Municipal and Domestic Supply
Nitrate as NO3	34.7	0.3	9.7	6.4	23		00%	04/2001	03/2003	45	Basin Plan Municipal and Domestic Supply
Nitrite as N	0.066	0.005	0.021	0.016	23		00%	04/2001	03/2003	1	EPA Primary Max. Contaminant Level
Nitrogen, Total	7.8	0.7	4.25	2.337	2			08/2002	09/2002		
Nitrogen, Total Kjeldahl	0.6	0.2	0.442	0.426	22			04/2001	03/2003		
Nitrogen, Total NO3 + NO2 + NH3	7.89	0.155	2.229	1.582	23			04/2001	03/2003		
OrthoPhosphate as P	0.4	0.16	0.27	0.263	23			04/2001	03/2003		
OrthoPhosphate as PO4	1.212	0.485	0.818	0.798	23			04/2001	03/2003		
Oxygen, Dissolved	16.1	3.3	10.6	9.8	26	4	15%	04/2001	03/2003	7	Basin Plan Cold Water Fish Habitat
Oxygen, Saturation	170	34	105	97	26	7	27%	04/2001	03/2003	85	Basin Plan General
pH	8.71	7.2	8.066	8.056	26	6	23%	04/2001	03/2003	6.5	Basin Plan Cold Water Fish Habitat
Phosphate, total as P	1.12	0.18	0.478	0.416	17			04/2001	03/2003		
Phosphorus, total	0.32	0.25	0.292	0.291	5			11/2001	10/2002		
Plant Cover	90	5	29.5	17.5	21			05/2001	03/2003		
Salinity	0.67	0.42	0.546	0.544	26			04/2001	03/2003		
Sodium	50	40	43.8	43.7	16		00%	04/2001	06/2002	50	Waterbody Specific Objective
Sulfate	260	190	222	221	16	15	94%	04/2001	06/2002	200	Waterbody Specific Objective
Suspended Solids, Fixed	8.6	0.5	2.624	1.661	21			04/2001	03/2003		
Suspended Solids, Total	14	0.5	4.4	3	21			04/2001	03/2003		

Suspended Solids, Volatile	5.4	0.5	1.957	1.526	21			04/2001	03/2003		
Turbidity(NTU)	15.4	0.1	4.4	1.5	26			04/2001	03/2003		
Water Temperature	18.7	9.1	14.8	14.5	26			04/2001	03/2003		
Antimony in Sediment	0.2	0.2	0.2	0.2	1		00%	06/2002	06/2002	25	NOAA Effects Range Median
Arsenic in Sediment	1	1	1	1	1		00%	06/2002	06/2002	70	NOAA Effects Range Median
Barium in Sediment	44	44	44	44	1			06/2002	06/2002		
Beryllium in Sediment	0.22	0.22	0.22	0.22	1			06/2002	06/2002		
Cadmium in Sediment	1.5	1.5	1.5	1.5	1		00%	06/2002	06/2002	9.6	NOAA Effects Range Median
Chromium in Sediment	18	18	18	18	1		00%	06/2002	06/2002	370	NOAA Effects Range Median
Cobalt in Sediment	2.2	2.2	2.2	2.2	1			06/2002	06/2002		
Copper in Sediment	8.5	8.5	8.5	8.5	1		00%	06/2002	06/2002	270	NOAA Effects Range Median
Lead in Sediment	2	2	2	2	1		00%	06/2002	06/2002	218	NOAA Effects Range Median
Mercury in Sediment	0.029	0.029	0.029	0.029	1		00%	06/2002	06/2002	0.71	NOAA Effects Range Median
Molybdenum in Sediment	1	1	1	1	1			06/2002	06/2002		
Nickel in Sediment	19	19	19	19	1		00%	06/2002	06/2002	51.6	NOAA Effects Range Median
Selenium in Sediment	1	1	1	1	1			06/2002	06/2002		
Silver in Sediment	0.028	0.028	0.028	0.028	1		00%	06/2002	06/2002	3.7	NOAA Effects Range Median
Thallium in Sediment	0.4	0.4	0.4	0.4	1			06/2002	06/2002		
Vanadium in Sediment	18	18	18	18	1			06/2002	06/2002		
Zinc in Sediment	39	39	39	39	1		00%	06/2002	06/2002	410	NOAA Effects Range Median
Aldrin in Sediment	0	0	0	0	1			06/2002	06/2002		
Azinphos methyl in Sediment	0	0	0	0	1			06/2002	06/2002		
BHC, alpha in Sediment	0	0	0	0	1			06/2002	06/2002		
BHC, beta in Sediment	0.001	0.001	0.001	0.001	1			06/2002	06/2002		
BHC, delta in Sediment	0	0	0	0	1			06/2002	06/2002		
BHC, gamma(Lindane) in Sediment	0	0	0	0	1			06/2002	06/2002		
Bolstar in Sediment	0.001	0.001	0.001	0.001	1			06/2002	06/2002		
Chlordane, Total in Sediment	0.003	0.003	0.003	0.002	1		00%	06/2002	06/2002	6	NOAA Effects Range Median
Chlorpyrifos in Sediment	0.001	0.001	0.001	0.001	1			06/2002	06/2002		
Coumaphos in Sediment	0	0	0	0	1			06/2002	06/2002		
Demeton in Sediment	0	0	0	0	1			06/2002	06/2002		
Diazinon in Sediment	0.001	0.001	0.001	0.001	1			06/2002	06/2002		
Dichlorvos in Sediment	0.002	0.002	0.002	0.002	1			06/2002	06/2002		

Dieldrin in Sediment	0	0	0	0	1		00%	06/2002	06/2002	8	NOAA Effects Range Median
Disulfoton in Sediment	0	0	0	0	1			06/2002	06/2002		
Endosulfan I in Sediment	0	0	0	0	1			06/2002	06/2002		
Endosulfan II in Sediment	0	0	0	0	1			06/2002	06/2002		
Endosulfan Sulfate in Sediment	0	0	0	0	1			06/2002	06/2002		
Endrin in Sediment	0	0	0	0	1		00%	06/2002	06/2002	45	NOAA Effects Range Median
Endrin Aldehyde in Sediment	0	0	0	0	1			06/2002	06/2002		
Ethoprop in Sediment	0.001	0.001	0.001	0.001	1			06/2002	06/2002		
Fensulfothion in Sediment	0	0	0	0	1			06/2002	06/2002		
Fenthion in Sediment	0.001	0.001	0.001	0.001	1			06/2002	06/2002		
Heptachlor in Sediment	0	0	0	0	1			06/2002	06/2002		
Heptachlor Epoxide in Sediment	0	0	0	0	1			06/2002	06/2002		
Merphos in Sediment	0.001	0.001	0.001	0.001	1			06/2002	06/2002		
Methoxychlor in Sediment	0	0	0	0	1			06/2002	06/2002		
Mevinphos in Sediment	0.001	0.001	0.001	0.001	1			06/2002	06/2002		
Naled(Dibrom) in Sediment	0.002	0.002	0.002	0.002	1			06/2002	06/2002		
Parathion, methyl in Sediment	0.001	0.001	0.001	0.001	1			06/2002	06/2002		
Ronnel(Fenchlorphos) in Sediment	0.001	0.001	0.001	0.001	1			06/2002	06/2002		
Stirophos(Tetrachlorvinphos) in Sediment	0	0	0	0	1			06/2002	06/2002		
Total Organic Carbon in Sediment	170	170	170	170	1			06/2002	06/2002		
Toxaphene in Sediment	0.025	0.025	0.025	0.025	1			06/2002	06/2002		
Acenaphthene in Sediment	0.025	0.025	0.025	0.025	1		00%	06/2002	06/2002	500	NOAA Effects Range Median
Acenaphthylene in Sediment	0.015	0.015	0.015	0.015	1		00%	06/2002	06/2002	640	NOAA Effects Range Median
Anthracene in Sediment	0	0	0	0	1		00%	06/2002	06/2002	1100	NOAA Effects Range Median
Benzo(a)anthracene in Sediment	0.001	0.001	0.001	0.001	1		00%	06/2002	06/2002	1600	NOAA Effects Range Median
Benzo(a)Pyrene in Sediment	0.001	0.001	0.001	0.001	1		00%	06/2002	06/2002	1600	NOAA Effects Range Median
Benzo(b)flouranthene in Sediment	0.001	0.001	0.001	0.001	1			06/2002	06/2002		
Benzo(g, h, i)Perylene in Sediment	0.003	0.003	0.003	0.003	1			06/2002	06/2002		
Benzo(k)Fluoranthene in Sediment	0.002	0.002	0.002	0.002	1			06/2002	06/2002		
C1 - Naphthalenes in	0.001	0.001	0.001	0.001	1			06/2002	06/2002		

Sediment											
C2 - Dibenzothiophenes in Sediment	0.001	0.001	0.001	0.001	1			06/2002	06/2002		
C3 - Chrysenes in Sediment	0	0	0	0	1			06/2002	06/2002		
Chrysene in Sediment	0.001	0.001	0.001	0.001	1		00%	06/2002	06/2002	2800	NOAA Effects Range Median
Dibenzo(a, h)anthracene in Sediment	0.012	0.012	0.012	0.011	1		00%	06/2002	06/2002	260	NOAA Effects Range Median
Fluoranthene in Sediment	0.003	0.003	0.003	0.003	1		00%	06/2002	06/2002	5100	NOAA Effects Range Median
Fluorene in Sediment	0.001	0.001	0.001	0.001	1		00%	06/2002	06/2002	540	NOAA Effects Range Median
Indeno(1, 2, 3-C, D)Pyrene in Sediment	0.001	0.001	0.001	0.001	1			06/2002	06/2002		
Naphthalene in Sediment	0.005	0.005	0.005	0.005	1		00%	06/2002	06/2002	2100	NOAA Effects Range Median
Phenanthrene in Sediment	0.001	0.001	0.001	0.001	1		00%	06/2002	06/2002	1500	NOAA Effects Range Median
Pyrene in Sediment	0.003	0.003	0.003	0.003	1		00%	06/2002	06/2002	2600	NOAA Effects Range Median
% Collectors	99.3	46.4	83.8	82.6	15			09/1999	03/2003		
% Dominant Taxon	97.8	28.8	61.2	57	15			09/1999	03/2003		
% Filterers	29.5	0.7	10.9	6.5	11			09/1999	03/2003		
% Grazers	2.712	2.712	2.712	2.712	1			04/2002	04/2002		
% Predators	10.2	1.5	4.9	4.1	14			09/1999	03/2003		
% Shredders	1.342	1.342	1.342	1.342	1			04/2002	04/2002		
% Tolerant Species	99.3	3.3	46.8	27.9	15			09/1999	03/2003		
Average riffle depth	1	0.3	0.673	0.62	6			04/2001	04/2002		
Average riffle width	9.3	2.743	4.96	4.472	6			04/2001	04/2002		
Bank Stability	16	10	13	12.6	6			04/2001	04/2002		
Ccamp-IBI	5.786	0.001	1.959	1.028	15	13	87%	09/1999	03/2003	3	CCAMP screening
Channel Alteration	8	6	7	6.928	6			04/2001	04/2002		
Channel Flow	15	8	13	12.7	6			04/2001	04/2002		
Embeddedness	16	14	15.3	15.3	6			04/2001	04/2002		
Ephemeroptera Taxa	3	1	1.727	1.613	11			09/1999	03/2003		
Epifaunal Substrate	11	5	7	6.8	6			04/2001	04/2002		
Ept Index(%)	66.8	0.3	22	6.1	12			09/1999	03/2003		
Ept Taxa	7	1	2.167	1.762	12			09/1999	03/2003		
Habitat Score	117	104	107	107	6			04/2001	04/2002		
Index of Instream Habitat Quality	11	8.8	9.3	9.3	6			04/2001	04/2002		
Index of Riparian Health	13.3	7.7	10.5	10.1	6			04/2001	04/2002		
Index of Sediment Impact	16.7	10	12.8	12.5	6			04/2001	04/2002		
Intolerant Individual Count	8.136	8.136	8.136	8.136	1			04/2002	04/2002		
Plecoptera Taxa	1	1	1	1	1			04/2002	04/2002		
Riffle Velocity	2.4	0.75	1.604	1.424	6			04/2001	04/2002		
Riparian Zone Width	10	7	8.5	8.4	6			04/2001	04/2002		

Sediment Deposition	18	8	11	10.4	6			04/2001	04/2002		
Taxa Diversity(count)	20	3	12.9	11.9	15			09/1999	03/2003		
ToleranceValue	2309	529	1733	1641	15			09/1999	03/2003		
Tolerant Individual Count	9	2	5.067	4.668	15			09/1999	03/2003		
Total Organisms	326	92	268	258	15			09/1999	03/2003		
Tricoptera Taxa	4	1	2	1.587	3			09/1999	04/2002		
Vegetation Protection	14	6	10	9.2	6			04/2001	04/2002		
Velocity/Depth	13	9	10.2	10.1	6			04/2001	04/2002		

Appendix G

Census Trend 1970 to 2000 Summary Report and General Summary Report for Demographics of Zip Codes 93420 and 93445

Date: November 30, 2004
Current Geography Selection: ZIP Codes by County (Q3 2003): 93420 Arroyo Grande, 93445 Oceano
Your title for this geography: AG Creek demographics

General Summary Report

US Census 2000 Basic Variables

2000 Educational Attainment		**2000 Marital Status**	
College: Associates Degree	8.65%	Divorced	11.51%
College: Bachelor's Degree	18.02%	Never Married	20.72%
College: Graduate Degree	9.07%	Now Married	57.14%
College: Some College, No Degree	26.96%	Separated	3.54%
School: 9th to 11th grade no diploma	8.31%	Widowed	7.08%
School: Grade K - 9	6.22%		
School: High School Graduate	22.77%		

The 2000 Census Median Household Income for this geography was $ 47,297. The Median Family Income was $ 53,698, and the Average Non-family Income was $ 40,768. The Per Capita Income revealed in the 2000 Census for this geography was $ 23,436.

This geography included a total of 13,221 Housing Units in 2000, of which 64% were Owner Occupied, 29% were Renter Occupied, 6% were vacant, and 38% were mortgaged.

The Median Cash Rent for occupied rental units in 2000 was $ 645, and a total of 430 Rental Housing Units had a rent in excess of $1,000 monthly. The Median Housing Value for owner occupied housing in this geography in 2000 was $ 230,831, and a total of 765 homes were valued at $500,000 or more.

US Census 2000 Race and Ethnicity

Total Population		Hispanic Ethinicity: Race	
American Indian, Eskimo, Aleut Population	0.8%	American Indian/Alaska Native Alone	1.0%
Asian	2.5%	Asian Alone	0.7%
Black Population	0.7%	Black Alone	0.6%
Hispanic Ethnicity	18.7%	Native Hawaiian/Other Pacific Islander Alone	0.0%
Native Hawaiian and Other Pacific Islander Alone	0.1%	Some Other Race	41.7%
Not or Latino	81.3%	Two or More races	8.0%
Other Population	8.0%	White Alone	48.0%
Two or More Races	3.8%	**Hispanic Ethnicity Population**	6,059
White Population	84.3%		

US Census 2000 Occupation and Employment

2000 Means of Transportation to Work		2000 Travel Time to Work in Minutes	
Bicycle	0.79%	Median Travel Time To Work	20.0
Bus or trolley bus	0.6%	0 to 5	3.0%
Carpooled	13.0%	5 to 9	15.7%
Drove alone	76.4%	10 to 14	16.0%
Ferryboat	0.0%	15 to 19	13.0%

Motorcycle	0.4%	20 to 24	16.5%
Other means	1.0%	25 to 29	7.6%
Railroad	0.0%	30 to 34	12.5%
Streetcar or trolley car (p·bli	0.0%	35 to 39	1.1%
Subway or elevated	0.0%	40 to 44	1.2%
Taxicab	0.0%	45 to 59	2.6%
Walked	1.8%	60 to 89	2.3%
Worked at home	6.2%	90 or more	2.3%
Workers Age 16+	14,578	Worked at home	6.2%

US Census 2000 Family Status: Family Households

Family Households	8,704	Male Householder	421
Natural Born or Adopted Children in Family Households	8,791	Male HHldr, no wife present, own children < 18	238
Grandchildren in Family Households	574	Female Householder	323
Step Children in Family Households	442	Female HHldr, no husband present, own children < 18	681
Married Couple Family	7,067		
Married Couple Family with Children under 18	2,892		
Married Couple Family with no own Children under 18	4,174		

Date: November 30, 2004
Current Geography Selection: ZIP Codes by County (Q3 2003): 93420 Arroyo Grande, 93445 Oceano
Your title for this geography: AG Creek demographics

Census Trend 1970 to 2000 Summary Report

Basic Variables

	1970	1980	Percent Change 1970 to 1980	1990	Percent Change 1980 to 1990	2000	Percent Change 1990 to 2000
Population	17,580	28,051	59.6%	28,126	0.3%	32,327	14.9%
Percent Female	50.5%	50.9%	60.9%	51.0%	0.4%	51.7%	16.6%
Percent Male	49.5%	49.1%	58.2%	49.0%	0.2%	48.3%	13.3%
Total Households	5,535	10,359	87.2%	10,564	2.0%	12,375	17.1%
Average Household Size	3.11	2.71	-12.9%	2.65	-2.2%	2.61	2.3%
Family Population	16,072	24,775	54.2%	23,521	-5.1%	27,412	16.5%
Group Quarters Population	414	184	-55.7%	237	29.4%	251	5.7%

Household Income

	1970	1980	Percent Change 1970 to 1980	1990	Percent Change 1980 to 1990	2000	Percent Change 1990 to 2000
Median Household Income	$8,190	$14,917	82.1%	$33,866	127.0%	$47,297	39.7%
Average Household Income	$8,429	$19,111	126.7%	$41,961	119.6%	$61,222	45.9%
Per Capita Income	$2,634	$6,983	2.7%	$15,629	123.8%	$23,654	51.3%
$ 0 - $9,999	3,384	3,344	-1.2%	1,202	-64.0%	877	-27.1%
$ 10,000 - $14,999	1,362	1,866	36.9%	817	-56.2%	694	-15.0%
$ 15,000 - $19,999	548	1,465	167.2%	979	-33.2%	657	-32.9%
$ 20,000 - $29,999	186	1,173	528.7%	1,713	46.1%	1,487	15.2%
$ 30,000 - $39,999	24	1,450	5,895.1%	1,530	5.5%	1,559	1.9%
$ 40,000 - $49,999	7	349	4,665.2%	1,317	276.8%	1,318	0.1%
$ 50,000 - $74,999	10	426	4,225.5%	1,857	335.6%	2,557	37.7%
$ 75,000 +	2	289	12,224.1%	1,142	294.8%	3,226	182.5%
$ 75,000 - $99,999		203		661	224.8%	1,408	113.2%
$100,000 +		86		481	460.7%	1,818	277.7%
$100,000 - $124,999				248		756	204.7%
$125,000 - $149,999				81		381	372.2%
$150,000 +				153		682	346.2%

Race and Ethnicity

	1970	1980	Percent Change 1970 to 1980	1990	Percent Change 1980 to 1990	2000	Percent Change 1990 to 2000
American Indian, Eskimo, Aleut		350		283	-19.3%	243	-13.9%
Asian		949		836	-11.9%	833	-0.3%
Other	1,032	2,179	111.2%	1,196	-45.1%	2,572	115.1%
Black	135	134	-0.4%	184	36.9%	214	16.5%
White	16,413	24,429	48.8%	25,623	4.9%	27,250	6.4%
Hispanic Ethnicity	2,541	4,071	60.2%	4,378	7.5%	6,059	38.4%

Housing Units

	1970	1980	Percent Change 1970 to 1980	1990	Percent Change 1980 to 1990	2000	Percent Change 1990 to 2000
Owner Occupied Housing	1,950	6,747	246.0%	7,127	5.6%	8,498	19.2%
Renter Occupied Housing	3,587	3,612	0.7%	3,440	-4.7%	3,877	12.7%

Date: November 30, 2004
Current Geography Selection: ZIP Codes by County (Q3 2003): 93420 Arroyo Grande, 93445 Oceano
Your title for this geography: AG Creek demographics

Race, Ethnicity, and Ancestry Summary Report

Ancestry: Total Population Tallied	
Acadian/Cajun	0
Afghan	0
African	24
Albanian	0
Alsatian	0
Arab	92
Arab/Arabic	7
Armenian	46
Assyrian/Chaldean/Syriac	0
Australian	7
Austrian	99
Bahamian	0
Barbadian	0
Basque	87
Belgian	22
Belizean	0
Bermudan	0

Race & Ethnicity Percents	
American Indian, Eskimo, Aleut Population	0.75%
Asian	2.46%
Black Population	0.66%
Native Hawaiian and Other Pacific Islander Alone	0.12%
Other Population	7.96%
White Population	84.30%
Two or More Races	3.76%
Hispanic Ethnicity	18.74%
Not Hispanic or Latino	81.26%

Race & Ethnicity: Hispanic Detail	
All other Hispanic or Latino	650
Argentinean	8
Bolivian	3
Central American	53
Chilean	13

Brazilian	9	Colombian	11
British	240	Costa Rican	2
British West Indian	0	Cuban	7
Bulgarian	0	Dominican Republic	1
Canadian	117	Ecuadorian	1
Cape Verdean	0	Guatemalan	15
Carpatho Rusyn	0	Hispanic or Latino	6,141
Celtic	18	Honduran	1
Croatian	34	Mexican	5,161
Cypriot	0	Nicaraguan	4
Czech	194	Not Hispanic or Latino	26,183
Czechoslovakian	60	Other Central American	6
Danish	493	Other Hispanic or Latino	828
Dutch	582	Other South American	2
Dutch West Indian	0	Panamanian	0
Eastern European	37	Paraguayan	0
Egyptian	1	Peruvian	3
English	4,178	Puerto Rican	50
Estonian	14	Salvadoran	17
Ethiopian	0	South American	47
European	351	Spaniard	13
Finnish	134	Spanish	146
French (except Basque)	1,065	Spanish American	14
French Canadian	192	Total	32,327
German	5,525	Uruguayan	0

Sudanese	0
Swedish	663
Swiss	252
Syrian	12
Total specified ancestries tallied	35,749
Trinidadian and Tobagonian	0
Turkish	9
U.S. Virgin Islander	0
Ugandan	0
Ukrainian	43
United States or American	1,688
Welsh	316
West Indian	0
West Indian (excluding Hispanic groups)	9
Yugoslavian	26
Zairian	0
Zimbabwean	0
Total specified ancestries tallied	35,749

Appendix H

Community Questions and Answers for Critical Issues

Arroyo Grande Watershed Forum
May 30th meeting
Input to Questions

Question: What are your concerns and/or issues about the creek and watershed?

Answers:

Written Answer	Category
The creek and watershed is filled with many non-native invasive pest plants (NNIPP).	Vegetation
Significant threat of flooding in Oceano area.	Flooding
Pollutants: chemicals and pesticides contaminating the creek. Erosion and animal habitat-mammals and aquatic life. Drinking water.	Pollution, Erosion, Habitat, Drinking Water
Excessive pesticide runoff. Erosion.	Pollution, Erosion
Rate of development (land use). Habitat connectivity from headwaters to the ocean (terrestrial and aquatic). Rate of water use (extraction)-urban and agricultural uses. Is grazing negatively impacting the riparian areas and aquatic systems? Riparian areas. Water quality parameters. Aquatic life forms. Water quantity (timing, magnitude and duration, watershed stability of flows). Open areas (% developed/used US open areas for wildlife and humans)	Development, Habitat, Water use, Grazing, Riparian Zones, Water quality and quantity, Open Space.
Development around the creek causing sediment, pollution and erosion.	Development, Sedimentation, Pollution, Erosion
Erosion (bank stabilization), silt from farms, and fish habitat.	Erosion, Sedimentation, Habitat
Is the creek in good enough condition for steelhead and trout reproduction? Is there sufficient water flow?	Habitat, Water quantity.
The need to remove excess water in heavy rain years. Use of the water for irrigation.	Flooding, Water Use.

I don't want to see it controlled by the public and government agencies. It would be nice for some type of erosion, cleaning and maintenance program to take place without affecting adjacent property owners rights.	Control, Maintenance, Property Rights.
We farm along the creek and use the water to irrigate our vegetables. We feel the creek water helps replenish our well water supply. The channel in lower AG valley should be cleared. It was built (man made) to protect the prime farmland in the case of a flood. Right now I don't think it would do what it was built for. The farming community and the cities have some sort of "gentleman's agreement." It seems to be working. The cities are allowed to pump a certain amount of ground water and there is water guaranteed for the downstream release.	Water quantity, Flooding.
The creek recharges the aquifer, as farmers we depend on an adequate supply of water. Erosion is a concern in extremely wet years.	Water quantity, Erosion.
Invasive, non-native plant species are threatening and overtaking riparian species (e.g.-ivy climbing and killing cottonwoods). Need to balance landowner rights, conservation, restoration and access. Would like to see more passive access to creek. Concerned about AG creek being engineered. Restore creek down to Ocean.	Vegetation, Property owner rights, Engineering, Conservation and Restoration
Habitat and recreational issues.	Habitat, Recreation.
Educating the ignorant. Getting vegetation/habitat on the reach through Oceano.	Education, Vegetation, Habitat.
There is a lot of litter in the creek! The trees DWR planted were mostly lost. Replant? Re-establish as a fishery for trout/steelhead.	Litter, Vegetation, Fisheries.
Amount of water flow. Fish habitat.	Water quantity, Habitat.
Balance the water available in the creek with needs of the viability of the lake as a fishery.	Water quantity, Fishery.
We are concerned about the stream ecology and the environment of AG creek.	Ecology, Environment.
I'm concerned about how much pollution is going into the runoff. I	Pollution.

want to see the watershed healthy and safe.	
Keeping from pollution. Supporting others, organizing support groups. Current ranch practices. Erosion.	Pollution, Support, Land Use, Erosion.
Creek litter is a problem-old car parts, tires, etc..	Litter.
Overall management. Erosion controll. TMDL process. Salting and pesticides. Maintaining adequate Q. GWISW interaction.	Management, Erosion, Pollution.
Steelhead and riparian habitat	Fishery, Habitat
Litter in creek and overgrowth	Litter, Vegetation.
Remove litter.	Litter.
Is the creek going to be overgrown with vegetation to the point of blocking the flow of water?	Vegetation, Water Flow.
Preservation of all life forms. Danger of pollution.	Ecology, Pollution.
For over 50 years I have been using a dry crossing to serve my business and my family home. During the few times it was impassible I had an alternate route which precluded business use. At low flow I adjusted a culvert system. Now with Lopez releases I have been faced with an impossible permit process with 7 agencies.	Property rights.
Pollution. Agricultural runoff. Illegal dumping. Invasive plants. Urbanization. Potential problems with new Lopez Lake dam.	Pollution, Runoff, Litter, Vegetation, Development, Regulation.
Too much plastic in Arroyo Grande Creek and little effort to clean it up.	Litter.
Property rights. Over population. Garbage in creek. Pollution in creek.	Property rights, Urbanization, Litter, Pollution.
The creek runs through my farming operation. I need minimal restrictions to continue farming.	Property rights.

There is litter in the creek and erosion is taking my land.	Litter, Erosion.
I want the creek left natural-keep development away from the creek.	Development.

Question: Why do you care about the creek and watershed?

Answers:

Written Answer	Category
All watersheds should be preserved. Good timing.	Interested Party.
My home is on the creek.	Landowner.
I'm a Central Coast resident since 1959. If let go it will only get worse with time.	Community Member.
I care because the water source effects many people who live in and around the watershed. I'm also concerned about the wildlife around the watershed.	Water user. Interested Party.
Because it was here before me and I don't want to see things like pollution.	Interested party.
My business relates to the whole watershed. Also how can we get more people involved?	Business owner.
Would like to see the creek open for more fishing.	Fisherman.
It is in our community-not elsewhere. We like to explore, both below and above Lopez Lake.	Community member, Recreational user.
I teach Environmental Science at Arroyo Grande High school. I care about stewardship.	Teacher.
The Central Coasts is fortunate to have creeks which are largely natural. I want to see a cooperative effort to restore and preserve this resource. The effort must be a win-win for conservationist, landowners, farmers and the entire community.	Interested Party.
Our property fronts the creek for over a mile. The recharge of the aquifer is extremely important to our business.	Landowner, Business owner/Agriculturist Water user.

My business relies on the water in that creek for irrigation.	Business owner/ Agriculturist, Water user.
We farm along creeks and are concerned about regulations being placed on the water.	Agriculturist.
Because it's there.	Interested Party.
Ranch and home along creek.	Landowner, Business owner.
My students live in watershed and the creek is important to their access to wildlife and natural beauty.	Teacher.
The creek is important habitat to wild animals.	Interested party.
I love the creek and I do not want to see the environment get to the point of no return (we are almost there).	Interested party.
Should be conserved as a natural/multi-use habitat compatible for steelhead and salmon as well as recreational use.	Interested party.
I would like to se a healthy riparian habitat and wise land-use to maintain a healthy environment.	Interested party.
My home is about ten feet from the edge of the creek and I enjoy watching and hearing the variety of birds that it attracts.	Land owner.
Life saving elements and energy needed for all life.	Interested party.
My crossing is in a section of Arroyo Grande Creek that was designed and built as a flood protection project. This has deteriorated in recent years from lack of routing maintenance. This part of the creek must be restored first for its purpose as a flood protection device, secondly as a riparian corridor.	Interested party.
I live near it, walk along it, and am concerned about the changes over the last decades. Wildlife is dwindling, litter is multiplying and I want to participate in positive changes.	Community member.
Want the general public to be able to enjoy a clear, clean creek.	Interested party.
Property owner.	Property owner.
My business is along the creek and it is not an attraction to customers.	Business owner.

I live there-we own land to the center of the creek.	Landowner.
I border Los Berros creek and want to keep waterway clean and full of fish.	Landowner.

Question: With respect to living and working in the watershed, what would you like to learn more about?

Answers:

Written Answers	Category
What are exotics? More important, how to provide money incentive to manage on a basin-wide scale?	Funding, Management.
What are the long-term plans for the creek-restore fishing to the creek?	Planning.
What I can do to help as an individual. Erosion. What is being done now?	Planning, Erosion.
The economic effects of the watershed. The wildlife effected by the watershed.	Funding, Ecology.
How we can help the creek.	Planning.
Effect of run-off from fields. What the main problems are on a watershed level. What does a healthy creek look like compared to what we have?	Run-off, Indicators, Current condition.
The fishery and habitat.	Fishery, Habitat.
What are the politics involved? What is the difference between a steelhead and a rainbow? What are the chances of a hatchery?	Politics, Fishery.
Funding for restoration. Why was vegetation cleared in the lower creek but not in the upper and middle reaches? Can restoration occur in the lower reaches without endangering farmland?	Funding, Management, Property owner rights.
The county trail proposal-we are concerned that the county may create a trail adjacent to the creek on our property. States of the California Sport Fisherman's Lawsuit against SLO county.	County project, Politics.

I would like to learn the objective of these meetings. My concerns: The more agencies involved the more regulations, paperwork, restrictions,etc. The word monitoring scares me. Is this whole process going to end up making some lawyers a lot of money? This was all written before the start of the meeting. I like fish as much as the next person, but this whole process is going to (or has the potential to) have a big effect on my livelihood. I love Arroyo Grande creek, but don't see that it needs to be changed (or my business changed).	Politics, Management, Property owner rights.
How to educate students about the impacts of "everyday life" on the health of a watershed and the significance of our daily activities.	Education.
Release flow requirements from Lopez Lake. Environmental Education programs available for landowners and schools. What natural resources are in the watershed and where are they located? Good maps depicting the watershed.	Lopez Lake, Education, Current condition, Maps.
Creek restoration technique (low budget). What is being done?	Restoration, Current condition.
Alternative methods of fertilizers and community pollutants. Ways to help solve problems with erosion and pollution through education.	Fertilizers, Pollution, Erosion, Education.
Proper removal of exotics. Maintain habitat for special status species.	Exotic removal, Habitat.
What are the plans for the future planning? Is the creek going to be a concrete channel? I shudder to think of that! What will keep the creek flowing toward the ocean instead of blocking the flow and cause flooding of my yard and home?	Planning, Flooding, Channel.
Conservation and preservation of all life forms. Creek restoration. River restoration. How to deal with building and construction along creeks and rivers? Strip mining and sand stripping. How to deal with people dumping construction trash?	Conservation, Restoration, Development, Pollution.
Invasive vs. native plants. Proper control/removal of invasive plants. Regular maintenance techniques for creek banks.	Exotic species, Maintenance.
Would like to know how to maintain the watershed without imposing on surrounding businesses.	Maintenance, Property owner rights.
Steelhead life cycle and condition of habitat in the creek.	Fisheries, Habitat.

Appendix I

Information on Types of Easements

Ohio State University Fact Sheet

Community Development

700 Ackerman Road, Columbus, OH 43202-1578

What is a conservation easement?
A conservation easement is a restriction placed on a piece of property to protect the resources (natural or man-made) associated with the parcel. The easement is either voluntarily sold or donated by the landowner, and constitutes a legally binding agreement that prohibits certain types of development (i.e. residential or commercial) from taking place on the land.
Ownership of a piece of property may best be described as a "bundle of rights." These rights include the right to occupy, use, lease, sell, and develop the land. An easement involves the exchange of one or more of these rights from the landowner to someone who does not own the land. An easement permits the holder certain rights regarding the land for specified purposes while the ownership of the land remains with the private property owner.
A conservation easement is designed to exclude certain activities on private land, such as commercial development or residential subdivisions. Its primary purpose is to conserve natural or man-made resources on the land. The easement itself is typically described in terms of the resource it is designed to protect (e.g., agricultural, forest, historic, or open space easements).
The easement is a legally binding covenant that is publicly recorded and runs with the property deed for a specified time or in perpetuity. It gives the holder the responsibility to monitor and enforce the property restrictions imposed by the easement for as long as it is designed to run. An easement does not grant ownership nor does it absolve the property owner from traditional owner responsibilities, i.e. property tax, upkeep, maintenance, or improvements.

What is an agricultural easement?

An agricultural easement is a specific type of conservation easement, designed to protect land from development and insure that the use of the land will remain conducive to agriculture in the future. Agricultural easements are designed to meet the needs of the property owner. They may include provisions for limited development for buildings such as barns, and housing for children and grandchildren who wish to stay on the farm. They may exclude certain sections of the farm from the easement entirely. As with other types of conservation easements, agricultural easements basically limit or prohibit the land from being developed for residential or industrial purposes regardless of who owns the land in the future.

What are the tax implications of conservation easements?

If an easement is granted in perpetuity as a charitable gift, some federal income and estate tax advantages usually accrue. These tax savings may be substantial, and are often cited as a major factor in landowners' decisions to donate easements. The 1997 federal tax law specifies estate easement donation options for farms within 25 miles of a metropolitan area. Property tax benefits are state and locally determined and may vary. Contact an attorney knowledgeable about land-use law for specific tax implications.

Who can grant a conservation easement?

The owner of the property is the only one who can decide to place a conservation easement on his or her property. When a property is owned by several individuals, all owners must agree to place the easement. If the property is mortgaged, the mortgage holder must also be in agreement for the easement to be placed. A conservation easement is a voluntary land-protection tool that is privately initiated.

Who holds the easement?

A conservation easement is designed to protect a property according to the owner's wishes. Since the easement is generally granted in perpetuity, it is necessary for an outside party to be responsible for the monitoring and maintenance of the easement. The outside party "holds" the easement and is required to monitor and enforce the adherence of current and future property owners to the terms of the easement.

Typically, easements are held by local government agencies, land trusts (see OSU Extension Fact Sheet, Land Trusts, CDFS-1262-98) or other nonprofit organizations designed to hold them. Since the monitoring and maintenance of easements requires personnel inputs in perpetuity, easement donors often are required to provide financial support for the easement if it is held by a nonprofit organization. Designating both a government agency and a nonprofit or land trust as co-holders of the easement is an alternative selected in many easements and may be required in certain public programs wherein the easements are purchased by a government preservation program or organization.

Is land under a conservation easement considered public property?

The easement can restrict or permit certain public uses of the land. An easement does not have to permit public access at all. The decision to allow public access is left to the individual property owner who places the easement on the property. It is important to emphasize that land covered by a conservation easement is still privately held land, with the only restrictions on land use being those desired by the owner who places the easement on the property.

Certain government initiated easement programs may require some public accessibility in order to meet tax requirements so it is necessary to investigate the public access requirements before writing the easement.

What are the responsibilities of the easement holder?

Whether the easement holder is a public or nonprofit organization, the holder has the responsibility to enforce the requirements stipulated in the easement. This responsibility generally includes:

a. Establishing baseline documentation through ensuring that the language of the easement is clear and enforceable, developing maps, property descriptions and baseline documentation of the property's characteristics.

b. Monitoring the use of the land on a regular basis. This may require personal visits to the property to ensure that easement restrictions are being upheld.

c. Providing information and background data regarding the easement to new or prospective property owners.

d. Establishing a review and approval process for land activities stipulated in easement.

e. Enforcing the restrictions of the easement through the legal system if necessary.

f. Maintaining property/easement related records.

Where can I get more information about conservation easements?

American Farmland Trust, 1920 N St. NW, Suite 400, Washington, DC 20036 phone 202-659-5170
Land Trust Alliance, 1319 F St. NW, Suite 501, Washington, DC 20004 phone 202-638-4725
Trust for Public Land, 116 New Montgomery St., 4th Floor, San Francisco, CA 94105 phone 415-495-4014

Where can I read about conservation easements on the World Wide Web?

http://www.farmland.org
http://www.olympus.net/community/saveland/qanda.html

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Appendix J

Master Plan

Arroyo Grande Watershed Forum
Steering Committee
February 2001

Purpose Statement Categories:

1. **Master Plan Development and Project Permitting**
   a. Should identify areas of concern and coordinate/establish a watershed management plan.
   b. Draft and adopt a watershed plan that represents the community needs
   c. To make a plan for AG Creek that protects its resources and protects the uses of the creek.
   d. Establish the criteria for the creek and its maintenance.
   e. Work with all of the agencies that are part of sustaining a complete ecosystem.
   f. Help facilitate permitting process.
   g. To create a plan of action for management of the watershed and creek
   h. Establish a group to address individuals who have concerns regarding their property.
   i. Aid community in navigation permitting requirements for creek projects by compliance with a watershed master plan.
   j. Validate the blue print for a healthy creek that others can copy.

2. **Recreation**
   a. Help maintain access to creek and watershed
   b. To encourage limited access and provide education about the watershed and creek
   c. Re-establish fishing in the creek
   d. Be able to fish the creek again

3. **Watershed Function**
   a. To support and encourage the elimination of exotic plant species within the creek
   b. Develop exotic plant species eradication task force.
   c. Develop committees to implement on the ground restoration activities in the watershed.
   d. To enhance the natural functions of the creek
   e. Identify opportunities for listed species habitat enhancement in the watershed.
   f. Enhance/restore natural habitat for animals and plants
   g. Identify opportunities for bank stabilization
   h. Assessment of current conditions
   i. To protect steelhead trout with community education and restoration projects

j. Make sure the creek is able to release excess water into the ocean with minimal damage to property
k. Help reestablish the natural spawning of fish in the creek
l. Habitat restoration

4. Communication / Education

a. Get out information
b. Bring the citizens into the fold so everyone becomes an environmentally concerned citizen.
c. Maintain open dialog with all concerned parties
d. Increase public enjoyment/knowledge of the creek as an asset/resource
e. To educate stakeholders on watershed issues.
f. Help encourage community participation in our goals, people cannot be excluded from recreation
g. So all facets of the watershed have the understanding needed for success
h. Total community satisfaction
i. To reach common ground with stakeholders
j. Community education
k. Educate the public
l. Establish a task force to inform the entire community of the biological aspects of the watershed.

5. Protection of Property Rights

a. Existing riparian and water rights
b. Protect property rights
c. Investigate landowner interest in exotic species control and other restoration opportunities on private lands
d. Protect farm land
e. To preserve and protect sustainable agriculture
f. Protect property

6. Funding for Projects

a. Project sustainability
b. Help secure funding for projects
c. Obtain funding for watershed master plan projects that are under funded

7. Monitoring of Current Conditions

a. Monitor what is the condition of the creek
b. Be as scientific as possible
c. Monitor the release of tail water

Appendix K

Lower AG Creek and Lagoon Fishery and Aquatic Resources Summary Monitoring Report

Lower Arroyo Grande Creek and Lagoon
Fishery and Aquatic Resources
Summary Monitoring Report

Oceano Dunes State Vehicular Recreation Area

Pismo State Beach Dune Preserve

by
Douglas Rischbieter
Associate State Park Resource Ecologist
Central Valley District

December 2004

ABSTRACT

The lowest half-mile of Arroyo Grande Creek, including a periodically-closed euryhaline lagoon, is within or adjacent to Oceano Dunes State Vehicular Recreation Area (SVRA) and Pismo State Beach (SB) Dune Preserve (San Luis Obispo County, California). Qualitative sampling of the fishery in this area was conducted a total of seven times between August, 2003, and November, 2004. Purposes of sampling included gathering information about various species' use of the habitats within the State Park, and gaging the degree to which Park activities may be impacting the fishery and aquatic habitat. We used a generally-consistent regime of electrofishing, seining, dipnetting, and direct observation during each survey episode. A total of 15 fish species were collected during the duration of the study, including eight species native to lower Arroyo Grande Creek and two other native California species. Among the latter were Sacramento sucker, an extension of the known range of this species. Noteworthy among the native fish collected were steelhead, a federally-listed Threatened species, regularly present in the study reach in low numbers. Non-native fish appeared present irregularly and also in low numbers. Though Park activities appeared to have little impact on the fishery or habitat, much of the study reach dried up for about 3 months in 2004 and decimated the fishery of the lower creek and lagoon. Future sampling and monitoring could document the recovery of this fishery following resumption of surface flow, as well as document the impacts of likely future disturbances. This dynamic habitat is also within the documented range of several additional native and introduced species, some of which could be expected to be collected in the future.

INTRODUCTION

Arroyo Grande Creek arises from the mountains of San Luis Obispo County and flows to the Pacific Ocean. Within the watershed is one major reservoir, Lopez Lake storing up to 52,000 acre-feet, that is situated about 15 miles upstream from the ocean. Within the last few miles to the ocean, a low-gradient reach of stream flows through an alluvial valley and then forms a lagoon behind the beach. The lagoon is closed by a sandbar in some summers, but otherwise flows over the beach to the sea. The terminal half-mile of Arroyo Grande Creek, and the aforementioned lagoon, are part of Oceano Dunes SVRA and Pismo SB Dune Preserve. Adjacent to the Park reach of stream are a municipal airport and a wastewater treatment plant.

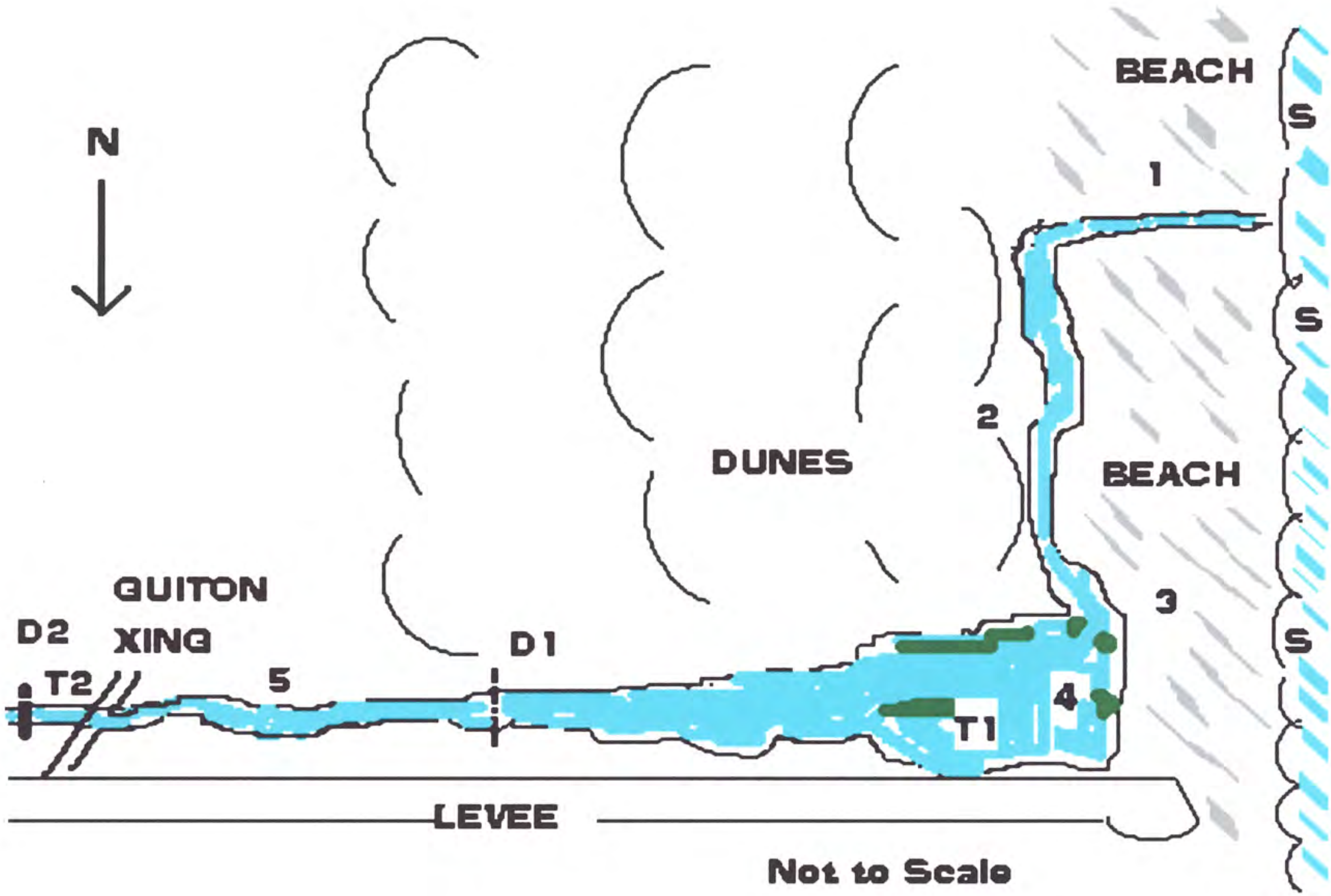
Study Area

Arroyo Grande Creek in and adjacent to Oceano Dunes SVRA and Pismo Dunes SR typically consists of three distinct aquatic habitats: up to a few hundred yards of low-complexity, relatively shallow (maximum depth <1.5 feet) channel that proceeds up from the surf line and is characterized by sand banks and substrate; a several-acre elongate lagoon behind the back-beach that has maximum depths of about 4 feet and varies slightly in extent depending on tides, characterized by patches of submerged and emergent aquatic vegetation and a substrate of mud and silt; and a lotic environment upstream of the lagoon characterized by a series of short low gradient riffles and shallow (maximum depth <3 feet) pools, runs, and glides. This upper reach is characterized by dense riparian vegetation on and overhanging the banks, and predominantly small-gravel substrate with sparse distribution of large woody debris fragments. The north side of the lagoon and both sides of the upstream reach are confined by levees.

Figure 1 shows the lower half-mile of Arroyo Grande Creek and the relative locations of the habitats described above. "Guiton Crossing" is the approximate upstream limit of State Park ownership.

FIGURE 1. Relative locations of zones of Study Area, lower Arroyo Grande Creek and Lagoon, San Luis Obispo County.

1 - Surf-line Outlet Reach; **2** - Back-beach Reach (occasionally discontiguous); **3** - Lagoon-tail Outlet Area; **4** - Lagoon Pool; **5** - Upstream of Lagoon Head
D1/D2 - Beaver Dams; **T1/T2** - Temperature Datalogger Placements; **S** - Normal Surf Zone



Streamflow was cursorily estimated to be between 0-5 cfs in the lotic areas during all survey periods. Often, surface inflow to the lagoon appeared to slightly exceed surface outflow. Water quality flowing into the lagoon appeared good; water quality within the lagoon appeared to vary over the period of surveys (but was not measured except for temperature). Periodic disturbances to these habitats during the survey period included short-duration floods and construction and removal of beaver dams. The depth of the lagoon varied from time to time, sometimes more than one foot, depending on the dynamics of sandbar formation, inflow, outflow, and occasionally tidal wash.

Purpose and Scope

This study was conducted for two primary purposes: 1) to evaluate the composition and significance of the fishery in Arroyo Grande Creek associated with State Park habitat, and 2) to gage the impact (if any) of SVRA vehicle traffic on these aquatic resources, especially in an area (beach) where vehicles traverse the wetted stream. Most information sought was qualitative; quantitative evaluation of the fishery was beyond the scope of this study. Towards these goals, aquatic sampling was generally limited to the Park reach of Arroyo Grande Creek, plus about 500 feet upstream, as described above. Visual observation of habitat and stream conditions further upstream were made on two or three occasions. Select historical and contemporary literature describing the watershed and fishery were reviewed.

MONITORING PROCEDURES

We typically used dipnets, beach seine, direct observation, and electrofishing to observe, collect, and identify fish in each of the three habitat zones described above. Each of these methods had some shortcomings in various areas from time to time, but generally a similar degree and type of effort was expended on each survey date. More detailed description of activities pursued during each of the seven surveys can be found within the summary reports prepared for each individual fish-sampling survey (Rischbieter, various dates). However, the following discussion recaps typical procedures conducted over the study period.

A seine or dipnets were used on several occasions to strain the outflow of the creek immediately above the surf line. A narrow segment of channel was chosen so that all or almost all streamflow passed through the 3/16" mesh nets. Sometimes the stream channel upstream from the nets was purposely disturbed by foot or with a vehicle, in order to dislocate any organisms that might be holding in the surf-line outlet reach. After 10-20 minutes, the nets were checked for organisms.

The back-beach reach, lagoon-tail outlet area, and west end of the lagoon were usually subject to 4-6 seine hauls using a 4' x 50' beach seine with 3/16" mesh. The seine was typically swept in an arc, with a set pivot-point on shore, and closed and dragged ashore. After each haul the seine was checked for organisms and, if any were present, they were removed and identified and released. Sometimes algae and other vegetation in the lagoon prevented effective sampling in the main lagoon pool (area 4, Figure 1).

If underwater visibility was good, direct observation and a dipnet were used to observe and collect fish in portions of the back-beach reach not seined. In addition, a Smith-Root Type 12 backpack electroshocker was usually used through this reach, in an upstream direction, in areas unsuitable for seining (for example, in sections too narrow or vegetated for the seine). Electrofishing usually continued up to the lagoon-tail with occasional probing among the nearby *Scirpus* stands.

Electrofishing was also conducted above the head of the lagoon. Effort was usually continuous from a relatively easy access point about 1,000 feet downstream of Guiton Crossing upstream to a point 100-500 feet above Guiton Crossing. Termination of this effort usually depended on the location of a beaver dam at the latter location; the base of the beaver dam was electrofished and a brief effort was also made on the upstream side of the dam, if present. The electrofisher was accompanied by two netters, using dipnets, who netted immobilized fish and placed noteworthy or representative specimens into a bucket for recovery, identification, and release. Between 1,000 and 1,500 seconds of electrofishing current was usually applied during the collective efforts above and below the lagoon; settings were normally 60 Hertz at 200 Volts DC (though sometimes varied for brief periods to gage effectiveness of alternate settings).

On December 12, 2003, two Onset Tidbit temperature dataloggers were placed within the survey area. One was placed in the lagoon at the west ("downstream") end of a mid-water *Scirpus* stand (location T1, Figure 1) at a depth that was about 6-12 inches off the bottom. Depth from surface varied depending on changes in lagoon conditions, but datalogger T1 was usually 1-2 feet below the surface. A second datalogger was placed in a narrow, shaded run of Arroyo Grande Creek about 200 feet upstream from Guiton Crossing (location T2, Figure 1). Location T2 later became alternately upstream and downstream of beaver dams, but good flow velocity persisted through the datalogger location. This logger was suspended from a submerged willow branch about 6" above the streambed and was immersed in between 6-18 inches of water, depending on flow conditions. Dataloggers were programmed to record temperature hourly; data was off-loaded, using an Onset Optical Shuttle, at each successive survey date until the dataloggers were removed on August 9, 2004. On that date, they had been dewatered for at least several days, perhaps weeks.

RESULTS

Fifteen species of fish were collected over the seven survey dates. Species collected, relative locations of collection for each species, general relative maturity of each species collected, and survey dates are summarized in Table 1. Virtually all fish collected were returned alive to the approximate location of capture. Exceptions to the preceding statement include: two minnows (roach, dace) taken for identification in August, 2003; Centrarchids captured beginning in and after December, 2003; and about 6-8 striped mullet taken for identification in November, 2004.

Temperature data for about seven months were reported in the individual survey reports prepared for the February, April, June, and August sampling dates (Rischbieter, various dates). A chart showing typical daily temperature ranges is reproduced for the period December 16, 2003, through April 7, 2004, in Figure 2. In the following 2-3 months (not shown), temperature extremes (daily highs and lows) trended between 5° and 10° Fahrenheit higher. Lagoon temperature peaked in late June at well over 80°F, when stream temperature (datalogger location T2, Figure 1) only rarely exceeded 70°F, but by early July temperature data became unreliable as dewatering of dataloggers may have begun so later data are not reproduced here. The lagoon (datalogger location T1) regularly warmed to higher temperatures than the flowing creek each day, and generally remained slightly warmer overnight.

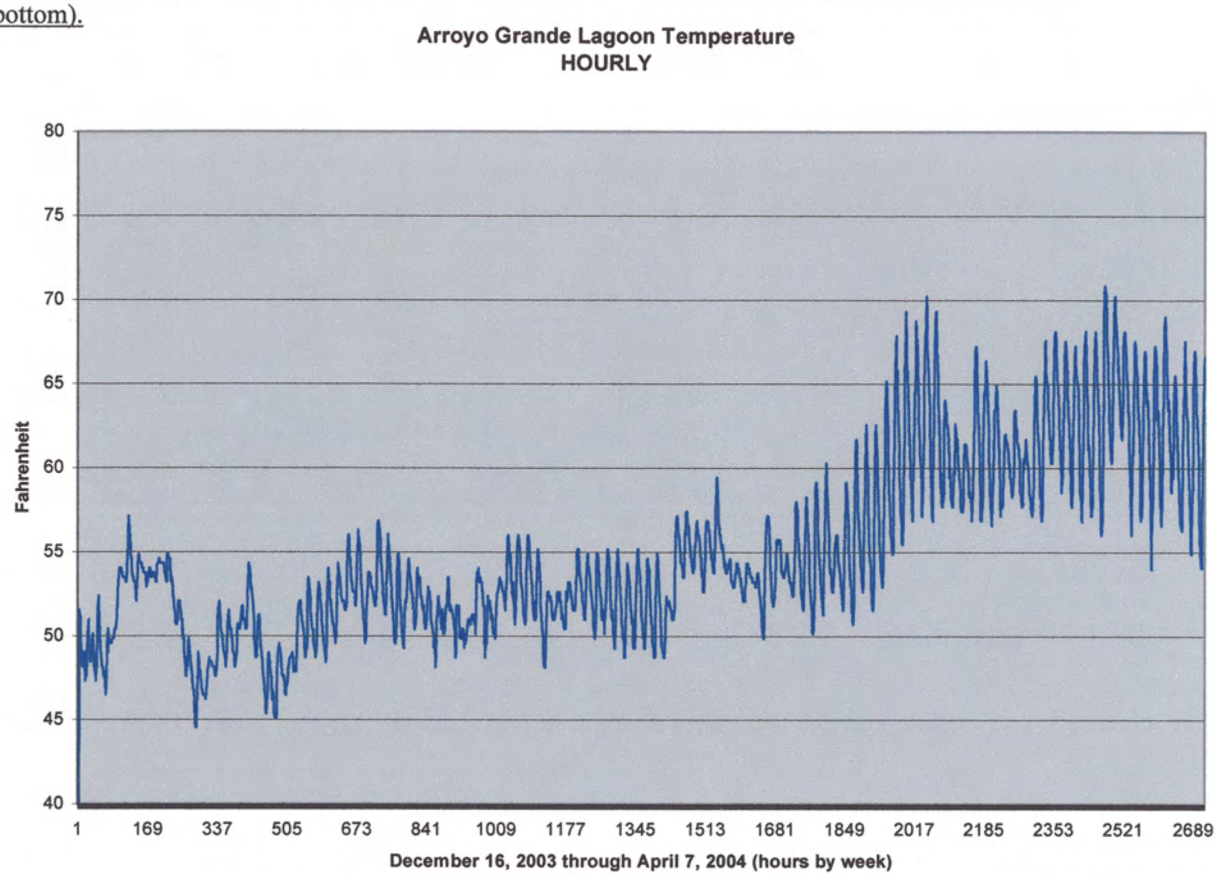
Few reptiles, amphibians, or large invertebrates were observed during any of the surveys. Anecdotal observations included one pond turtle collected and released immediately upstream from Guiton Crossing (April, 2004); an unidentified frog or toad (not collected), downstream from Guiton Crossing

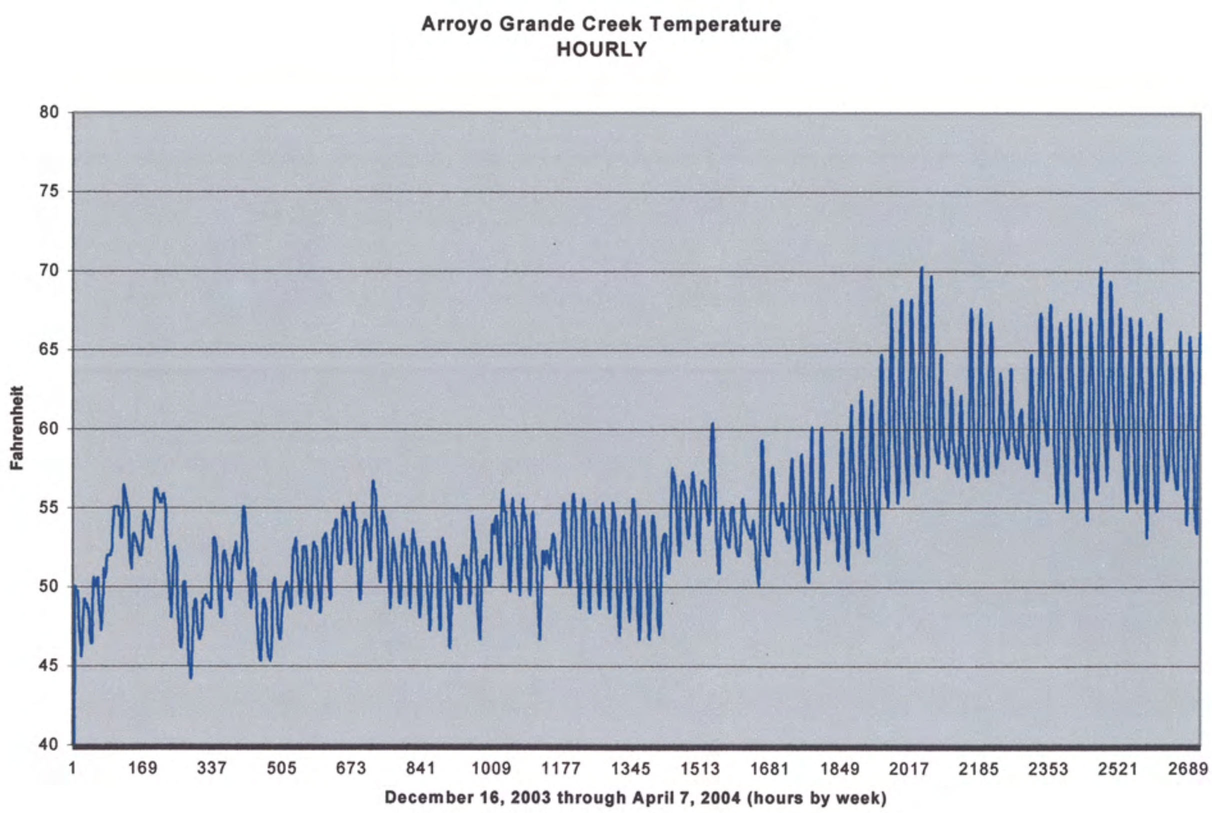
TABLE 1. Fish of lower Arroyo Grande Creek and Lagoon: species collected, status, collection dates, approximate collection locations, and life history stages observed.

SPECIES	STATUS	AUG 4, 2003*	DEC 16, 2003*	FEB 13, 2004	APR 8, 2004	JUN 16, 2004*	AUG 10, 2004	NOV 18, 2004	COMMENTS
California roach *Lavinia symmetricus*	n	Oo: 2,3,5	Oo5	--	Aa4,Aa5	Aa5	o5	o4,U5	April: peak spawning activity
speckled dace *Rhinichthys osculus*	N	Oo5	--	--	U5	--	--	--	
Sacramento sucker *Catostomus occidentalis*	n	a5,U5	o5	O5	Oo5	Oa5	a5	u5	February: spawning pairs on nests
steelhead *Oncorhynchus mykiss*	N	o5	u5	u5	u4	u5	--	--	1 stranded adult on beach@ 12/03,3/04
mosquitofish *Gambusia affinis*	I	--	--	--	--	u3,U5	o3,o4,u5	Uu4	
topsmelt *Antherinops affinis*	N	--	--	--	o2(?)	U2	--	--	(?)4/8(9) tentative identification
threespine stickleback *Gasterosteus aculeatus*	N	a1,a2,Aa5	a2,o3,o5	Oo3,o4,o5	U2,u3,u4, Oo5	u3,Aa5	o5	U5	
black crappie *Pomoxis nigromaculatus*	I	--	u4	--	--	--	--	--	
green sunfish *Lepomis cyanellus*	I	--	--	--	u4	--	--	--	
bluegill *Lepomis cyanellus*	I	--	--	--	--	--	--	u5	YOY, tentative identification
largemouth bass *Micropterus salmoides*	I	u5	--	--	o4	o3,u5	--	--	
prickly sculpin *Cottus asper*	N	u2,Aa5	Oo5	o4,o5	Aa5	Aa5	o5	U5	2/13 identification tentative in Zone 4
staghorn sculpin *Leptocottus armatus*	N	--	--	a3,o4(?)	Aa: 2,3,4; U5	O2,Aa3,U5	--	--	(?)2/13 tentative identification
striped mullet *Mugil cephalus*	N	--	--	--	--	--	--	2a,4o,5u	
starry flounder *Platyichthys stellatus*	N	u2	--	--	--	o3	--	--	

KEY Status: **N** = Native to watershed; **n** = Native to California, but likely introduced to watershed; **I** = Introduced to California; ***** = limited or no sampling in Zone 4
Zones Where Found (Figure 1): **1** - Surf-line Outlet Reach; **2** - Back-beach Reach; **3** - Lagoon-tail Outlet Area; **4** - Lagoon Pool; **5** - Upstream of Lagoon Head
Abundance (UPPER CASE = Adults; lower case = Young-of-Year): **A/a** - Abundant or Common; **O/o** - Occasionally Collected; **U/u** - Infrequently Collected

FIGURE 2. Sixteen weeks of temperature data recorded from locations (see Figure 1) T1 (top) and T2 (bottom).





(August, 2004); and a crayfish observed in the back-beach reach (April and June, 2004) and one upstream from Guiton Crossing (April, 2004). Benthic and other aquatic invertebrates appeared varied and abundant, in wetted areas, during all surveys except November, 2004. Freshwater leeches and horsehair worms were observed on one or two occasions.

The location and impoundment effect of beaver dams varied significantly over the series of observations, affecting the amount of stream that could be effectively electrofished. No dams were present in August, 2003. In December, one had been erected at location D1 (just above head of lagoon, Figure 1). In February, a second appeared near location D2 (about 100 feet upstream from Guiton Crossing) and D1 had been heightened. By April, D1 was gone and D2 had been heightened and moved upstream (about 500 feet upstream from Guiton Crossing); D2 persisted throughout the rest of the survey period. No beavers were seen, but numerous small lodges, "tunnels," and other habitats were seen dewatered in August, 2004.

The lagoon and creek also support substantial numbers of migratory waterfowl. Wading shorebirds, both predators and scavengers, were frequently observed both resting and stalking in the lagoon, in back-beach pools, and in the surf zone outlet reach. Predators were not observed successfully feeding, but are assumed responsible for the overnight disappearance of about a half-dozen adult topsmelt observed trapped in an isolated back-beach pool on June 15, 2004.

DISCUSSION

No known previous study of Arroyo Grande Creek has collected as many species as observed within the Park reach. In contrast, the first known published survey of San Luis Obispo County streams (including Arroyo Grande Creek) described County fish fauna in these terms: "In no other stream of the United States in which an equal amount of water flows has so short a list [of fishes] been recorded" (Jordan 1895). However, readily evident by the range of hydrologic conditions observed in 2004, the lower reaches of Arroyo Grande are potentially subject to severe disturbance with commensurate impact to the fishery. While additional information and discussion related to each of the seven surveys can be found within the summary reports prepared for each individual fish-sampling survey (Rischbieter, various dates), the following discussion recaps the most significant observations and recommendations compiled over the study period.

Evaluation

With the exception of occasional Centrarchids and the ubiquitous mosquitofish, the fishes of lower Arroyo Grande Creek represent a rather remarkable assemblage of California native fish (though California roach and Sacramento sucker are not native to this watershed). Some species' use of the lagoon and adjacent habitat appears seasonal, and some are permanent residents. Hydrologic and other impacts to this dynamic fishery are discussed below.

One purpose of this monitoring was to gage the degree to which high traffic volume in the SVRA (including vehicles fording the seasonal lagoon outlet) affects fish or their habitat; no significant vehicle impacts to fish or their habitat were observed. However, a seasonal vehicle closure of most of the back-beach reach was probably partly responsible for minimizing impacts. When allowed, vehicle traffic may disturb several common species' rearing habitat in the back-beach reach: staghorn sculpin, threespine stickleback, and striped mullet appear the species most likely subject to this periodic disturbance. In comparison, fish typically do not use the surf-line outlet reach, where vehicles most frequently and efficiently ford the stream. Furthermore, the quality of habitat in this lowest reach (sand banks, sandy channel) does not appear to be significantly altered by vehicle traffic, owing largely to the naturally transitory and dynamic nature of sandy features near the surf line and through the beach.

It appears the most significant potential impact to the fishery, including sensitive species such as steelhead, relates to the seasonality of surface flow. Cessation of flow across the beach area (lagoon closure) is a frequent but not necessarily annual occurrence. Lagoon water quality usually degrades during closed periods, especially if inflow is low, and poor water quality and lack of access to and from the ocean can impact steelhead. Even more severe, complete loss of inflow to the lagoon has occurred over a dozen times since 1940, though less frequently (if at all) since completion of Lopez Dam in 1969 (Stetson Engineers et al. 2004). In 2004, severe dewatering was likely due to local agricultural groundwater pumping that exceeded the recharge available from the creek. Future dewatering of this reach of stream is to be expected; the degree to which the fishery reestablishes itself will likely depend upon the number of years between such disturbances. However, recolonization by fishes can be expected to occur by both freshwater (from upstream) and marine (from ocean) species because of the normally-rich resources afforded by the lagoon environment.

The relationship between success of steelhead in Arroyo Grande Creek and variations in flow regime was documented decades ago. Hinton (1961) deduced that adult run size varied between wet and dry years and numbered in the hundreds, and occasionally thousands, up until about 1940. A series of dry years thereafter substantially reduced that fishery, and the construction of Lopez Dam in 1969 and "deteriorating" conditions downstream were believed to have further reduced runs (Schuler 1972). Indeed, noteworthy spawning and rearing habitat was observed to be in a tributary upstream of where Lopez Dam is now situated (Jordan 1895). Nevertheless, steelhead persist throughout much of the 15 miles of Arroyo Grande Creek below the dam (Stetson Engineers et al. 2004) and appear to use the Park reach in low numbers for late-stage rearing (smoltification). Current adult runs may only number in the dozens, perhaps occasionally low-hundreds in wetter years, but in any case all successful steelhead use the Park reach for migration. Adult runs should be expected annually unless low streamflow causes the lagoon to close for unusually-long winter periods.

The presence of Sacramento sucker is noteworthy because Arroyo Grande Creek is south of the expected range of this species. Some species not observed during this study may also be expected to occur periodically: introduced species such as catfish *Ictalurus sp.* and bullheads *Ameiurus sp.* and others are known to occur upstream in Lopez Lake (Stetson Engineers et al. 2004). It would be unusual not to find golden shiner *Notemigonus crysoleucas*, a widespread bait-bucket introduction common in many reservoirs that support Centrarchids, in the watershed. In the creek, native species such as tidewater goby *Eucyclogobius newberryii* and even Chinook salmon *Oncorhynchus tschawytscha* (both federally-listed under the Endangered Species Act) have been reported in the past (Jordan 1895). Jordan (1895) also claimed to have identified riffle sculpin *Cottus gulosus* in San Luis Obispo County streams, but the southernmost coastal extent of the current known range is San Benito County (Moyle 2002; Rischbieter 2004). However, San Luis Obispo County is within the documented range of the coastrange sculpin *Cottus aleuticus* (Moyle 2002). Some other marine species may periodically occur in the Arroyo Grande Creek lagoon, depending on ocean conditions. Relatively warm ocean conditions may explain the appearance of striped mullet at the end of this study. California grunion *Leuresthes tenuis* are also known to run on the SVRA's beach, and may briefly use the lagoon, and jacksmelt *Antherinopsis californiensis* are often found with topsmelt (Moyle 2002). Just as striped mullet's range is typically further south unless warmer ocean conditions predominate (Moyle 2002), so instead might Chinook salmon stray into San Luis Obispo County streams during colder ocean conditions.

Recommendations

In general, the primary objectives of this study were accomplished. However, additional or continued sampling may serve to identify the periodic presence of the aforementioned species in the future. Additional periodic fishery monitoring in this reach could provide additional useful information for resource managers, related to any future impacts from vehicle traffic that may arise. It is probably not necessary to continue the bimonthly frequency scheduled in 2004, but two to four surveys during 2005 may be sufficient to document significant progress in the reestablishment of the lower Arroyo Grande Creek fishery. Possible benefits of more frequent sampling should be reevaluated when the fishery in the study reach is restored to a significant degree towards its former quality.

Future objectives should include an attempt to sample and observe fish that periodically may reside in the area subject to regular vehicle traffic. Practically, this should usually be limited to the surf-line outlet reach; however, the back-beach reach of the creek is dynamic and occasionally is outside the vehicle closure zone. There may be future opportunities to conduct observations of the behavior and fate of fish in trafficked areas, so the failed attempts to do so during 2004 should not deter this objective. Even in the absence of evidence of direct or indirect impacts attributable to vehicle traffic upon fish of any species, the closure zone should generally be aligned so as to include as much length and area of active streambed as reasonably possible, to the degree practicable and consistent with necessary Park operations.

Future survey dates should be scheduled as hydrologic and other resource conditions warrant and allow. This should also include consideration of the desirability of trying to sample during times when species of special concern (e.g., steelhead) are more likely to be present, such as during changes in hydrologic conditions that might be expected to induce migration. However, it must be remembered that quantitative sampling in the vicinity of the lagoon is difficult and effective techniques limited. If a better assessment of the steelhead population in the watershed is desired, and especially to gage reproductive success, fall sampling should be periodically undertaken higher in the watershed (in the few miles below Lopez Dam).

Park staff can provide useful information by remaining observant and recording unusual biological sightings and changes in hydrologic conditions. At a minimum: photographs should be taken of unusual, large, or abundant fish observed (such as fish occasionally found dead) and representative specimens preserved by freezing[1]; the dates of significant floods, lagoon closing and breach, and cessation and restoration of stream surface flow (into the lagoon) should be recorded; any other natural or man-made disturbances to water quality or aquatic habitat should be cursorily documented (fuel or sewage spills, flood channel maintenance or vegetation removal, etc.). These activities can help ensure the continued effective management and protection of the aquatic resources of Arroyo Grande Creek and Oceano Dunes SVRA.

[1] Handling and storage of listed species, such as steelhead, legally requires coordination with NOAA Fisheries and/or the California Department of Fish and Game.

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