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Upper Pajaro River Watershed Condition Assessment 2015

Report prepared for the Santa Clara Valley Water District
Safe, Clean Water and Natural Flood Protection Program
Ecological Data Collection and Analysis Project (Priority D5)

SCVWD Agreement #A3765F

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Submitted by
San Francisco Estuary Institute

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Executive Summary

The Santa Clara Valley Water District's (District) Safe, Clean Water and Natural Flood Protection Program has multiple priorities including Priority D for restoring and protecting vital wildlife habitat, and providing opportunities for increased access to trails and open space. Project D5 focuses on ecological data collection and analysis. Since 2010, the D5 Project has developed and implemented a watershed approach to environmental monitoring and assessment using the Wetland and Riparian Area Monitoring Plan (WRAMP) endorsed by the California Wetland Monitoring Workgroup (CWMW 2010) of the California Water Quality Monitoring Council (CWQMC) as a preferred strategy to assess the extent and health of California's wetland and stream resources (also see EOA and SFEI 2011). WRAMP incorporates the 3-Level data classification system recommended by United States Environmental Protection Agency (USEPA). The D5 Project has been conducting watershed-wide Level-1 (Geographic Information System (GIS) based) and Level 2 (rapid field based) assessments of streams and their riparian areas in five major watersheds of Santa Clara County, namely: Coyote Creek, Guadalupe, upper Pajaro River, Lower Peninsula, and West Valley watersheds. The five watersheds will be re-assessed by the District on a rotational basis to evaluate temporal and spatial changes in stream condition. This watershed assessment is for the upper Pajaro River located within Santa Clara County.

A fundamental purpose of the D5 Project is to align the collection and analysis of ecological data with the needs of water resource decision-makers. This is achieved by carefully developing management questions or concerns that the data should directly address for each watershed. The data collected by the D5 Project support the District and other agencies and organizations in evaluating and tracking the overall abundance, distribution, diversity, and condition of aquatic resources in the County, which in-turn informs watershed- or landscape-based natural resource management.

The upper Pajaro River watershed is the third watershed and stream assessment completed by the D5 Project. This report describes baseline information about the upper Pajaro River watershed and addresses specific management questions provided by the District. It also discusses potential ecological risks to streams in general.

For the purposes of this report, the portion of the Pajaro River watershed within Santa Clara Country, and therefore within the purview of the District, is termed the upper Pajaro River watershed. It is the northern extent of the Pajaro River, which flows south, then west to the Pacific Ocean at Monterey Bay. The Pajaro River watershed covers approximately 1,300 square miles across four counties with just over 60% of its area in San Benito County. The upper Pajaro River watershed covers approximately 360 square miles in Santa Clara County, comprising about 35% of the County, and includes about 40% of the County's total miles of streams. It has three main sub-watersheds: Pacheco Creek, Llagas Creek, and Uvas Creek. The District regards each of these tributary watersheds as a Primary Area of Interest (PAI). Llagas Creek has the greatest percentage of urban or agricultural development, and therefore also has the greatest extent of unnatural channel.

There is a total of 1,472 miles of stream and 2,106 acres of non-riverine wetland within the upper Pajaro River watershed study area. The stream network supports many miles of riparian area, of varying functional riparian width classes. Compared to the historical conditions, the total length of channels has increased, due to the construction of unnatural channels. There has only been a slight decrease in the total length of natural channels. The District owns 3% of the total

stream length within the upper watershed, mostly along the valley bottom of the Llagas Creek sub-watershed.

Figure 1 compares the upper Pajaro River watershed to other Santa Clara County watersheds surveyed by the District's D5 Project, two San Francisco Bay area ecoregions, and statewide based on steam conditions assessed using CRAM. In each case, the figure shows the relative proportions of stream miles in poor, fair, and good ecological health corresponding to three equal-intervals of the full range of possible CRAM Index Scores (≤50, 51-75, and >75 respectively). More than half of the streams in the upper Pajaro River watershed are in fair ecological condition, based on the Level 2 CRAM assessment. About 40% are in good condition and only about 8% are in poor condition.

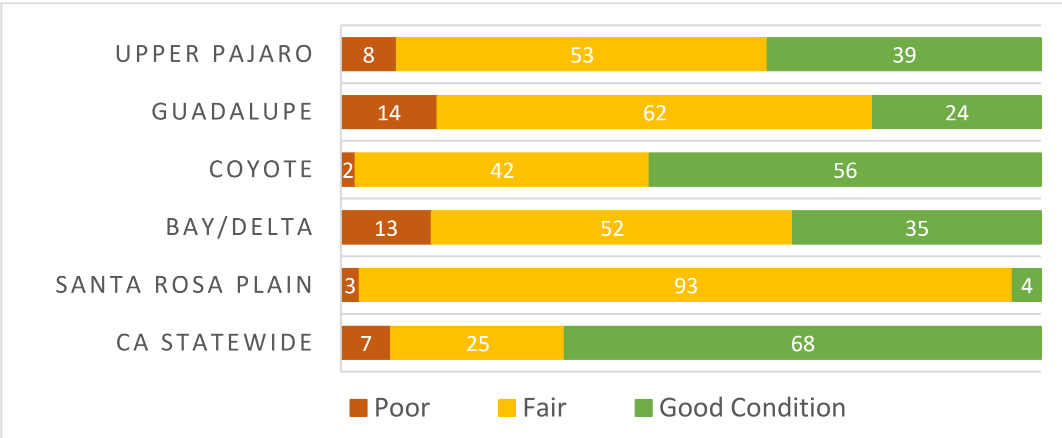

Figure 1. Comparison of watersheds based on probabilistic surveys of stream condition using CRAM.

The District developed the Ecological Service Index (ESI) for the Coyote Creek watershed assessment (EOA and SFEI 2011), which represents the sample-weighted average CRAM Score for a watershed or PAI based on the probability survey's cumulative distribution function estimates (CDFs). The ESI could be used to compare stream condition between District watersheds and to track change over time. The ESI represents a watershed's ecological level of service bases on conditions during the season that the CRAM field assessments were conducted.

The ESI for the upper Pajaro River watershed assessment (in 2015) was 70 (with a 95% confidence interval of 63-77), which is between the ESIs for Coyote Creek and Guadalupe River watershed assessments conducted in 2010 and 2012 respectively. Table 1 compares the ESIs of the District's three completed watershed-wide stream condition assessments and their respective Primary Areas of Interest (PAIs).

Table 1. Comparison of the Ecological Service Indices (ESIs) for the three major watersheds assessed by the District based on the CRAM Index Score CDFs.

<table>
<tr><th>Watershed</th><th>ESI (95% CI)</th><th colspan="3">ESI (95% CI) for PAIs</th></tr>
<tr><td>Pajaro Watershed (2015)</td><td>70 (63-77)</td><td>Pacheco = 75 (70-80)</td><td>Llagas = 60 (56-65)</td><td>Uvas = 62 (49-75)</td></tr>
<tr><td>Coyote Creek (2010)</td><td>75 (72-78)</td><td colspan="3">Upper Penitencia = 73 (70-75)</td></tr>
<tr><td>Guadalupe River (2012)</td><td>68 (65-71)</td><td>Non-urban = 72 (70-75)</td><td colspan="2">Urban = 63 (57-68)</td></tr>
</table>

Results of the stressor analysis reflect the rural and remote nature of the middle and upper reaches of the Pajaro River watershed, compared to developed or intensively farmed lower reaches. Much of the riparian areas have been invaded by non-native vegetation and lack of its effective treatment is the leading source of stream stress. Other stressors associated urban development and intensive agriculture, especially truck crops, effect the lower reaches of the watershed. Much of the middle and lower reaches of the mainstem creeks, and Pajaro River are bounded by roadways, as reflected by the predominance of the transportation stressors. Many publically accessible areas are intensively utilized. As a consequence, the stressors associated with human visitation, such as trash and passive recreation, impact creek and river conditions.

Any efforts to restore the health of upper Pajaro River watershed streams, such as improvements to the form or structure of channels, wetlands, or their riparian areas should reflect the best available information on likely future changes in rainfall and temperature regimes (climate change, droughts, storm and flood frequency and intensity). The success of restoration efforts will also depend on partnerships between the District and other entities that are collectively responsible for the condition of most of the stream system.

List of Abbreviations

BAARI	Bay Area Aquatic Resources Inventory v2.0 (GIS data)
CARI	California Aquatic Resources Inventory v0.2 (GIS data)
CPAD	California Protected Areas Database from the GreenInfo Netowork (GIS data)
CRAM	California Rapid Assesment Method for wetlands
CWMW	California Wetland Monitoring Workgroup
CWQMC	California Water Quality Monitoring Council
DEM	Digital Elevation Model (this project employed a 10-meter DEM from the USGS National Elevation Dataset)
District	Santa Clara Valley Water District
EMAF	Environmental Monitoring and Assessment Framework for the District
ESI	Ecological Service Index
GIS	Geographic Information System
HCP	Habitat Conservation Plan
HUC 10	USGS watershed boundary - Hydrologic Unit Code 10
LOS	Level of Service defined by the District
NHD	National Hydrography Database (GIS data)
NWI	National Wetlands Inventory 2008-2011(GIS data)
PAI	Primary Area of Interest defined by the District
RipZET	Riparian Zone Estimation Tool v2.0
SMP	District's Stream Maintenance Program
USEPA	United States Environmental Protection Agency
WRAMP	Wetland and Riparian Area Monitoring Plan 2010, endorsed by the CWMW

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Introduction

The District's Safe, Clean Water and Natural Flood Protection Program has many priorities including restoring and protecting vital wildlife habitat and providing opportunities for increased access to trails and open space. This Program pays for projects that control non-native invasive plants, revegetate native species, and maintain previously revegetated areas. Other projects include removal of fish barriers, improvement of steelhead habitat and stabilization of eroded creek banks. The Priority D5 Project supports Ecological Data Collection and Analysis. Since 2010 the D5 Project has developed and implemented an environmental monitoring and assessment framework (EMAF; see EOA and SFEI 2011), and is conducting watershed-wide GIS and field-based assessments to characterize and track aquatic resources, and overall stream condition in five major watersheds of Santa Clara County. The data collected by the D5 Project helps the District, other agencies, and organizations evaluate and track the overall abundance, distribution, diversity, and condition of aquatic resources in the County, as necessary to inform watershed- or landscape-based natural resource management decisions.

The D5 Project employs a watershed approach and 3-level framework that organizes data and information into: 1) landscape level, map-based assessments that can be evaluated using GIS; 2) rapid condition assessments conducted in the field (primarily the California Rapid Assessment Method or CRAM); and 3) intensive field study to further investigate causes of poor condition, or address other specific ecological management and regulatory questions (Figure 2).

The 3-Level Framework for Aligning Monitoring Data to Management Questions

The 3-level framework is a data and information organizational format, recommended by WRAMP and the USEPA for wetland and stream monitoring and assessment. It is supported by EcoAtlas tools, and was adopted by the District's D5 Project's EMAF. The framework classifies management questions based on the kinds of data required to answer them.

Level 1 questions are best answered by map-based inventories of aquatic resources plus maps of on-the-ground projects that have a direct effect on the distribution, abundance, diversity, or condition of aquatic resources. A Level 1 map may serve as a spatial framework for Level 2 and 3 assessments.

Level 2 questions are best addressed by rapid, field-based, semi-quantitative evaluations of the overall condition or stress of aquatic resources. In California, the California Rapid Assessment Method (CRAM) is the most common Level 2 assessment method.

Level 3 questions are best answered with field-based, quantitative measures of specific aspects of condition or stress. Plant species composition, nesting bird surveys, counts of spawning salmon, and measures of groundwater recharge rates are examples of Level 3 data. The D5 Project does not currently include Level 3 assessments.

Figure 2. Definitions of Level 1-3 data according to WRAMP.

The D5 Project employs standardized, repeatable, and defensible monitoring methods that are consistent with the California Wetland and Riparian Area Monitoring Plan (WRAMP) of the California Water Quality Monitoring Council (CWQMC) developed to support the Wetland Protection Policy for California. The methods are supported by online resources including a statewide aquatic resource base map called the California Aquatic Resources Inventory (CARI), the California Rapid Assessment Method (CRAM), and data management tools (EcoAtlas and eCRAM) coupled with statistically based, random sampling design methodology to survey streams and their riparian areas within a watershed or other landscape context.

By using these methods and tools, the D5 Project enables a broad community of environmental regulators, managers, scientists, and the public to access the assessment data. The overall condition of the streams within Santa Clara County can also be compared to the condition of streams in the Bay-Delta ecoregion, other ecoregions, or statewide. The D5 Project supports the District by 1) evaluating and setting asset management priorities on a watershed basis, and 2) tracking the overall ecological condition of streams and their riparian areas over time. Some expected benefits of the D5 Project include:

- Improving watershed and asset management decisions;
- Supporting ecologically beneficial design options for capital projects; and
- Maximizing the positive impacts of investment in ecological restoration.

This first assessment of stream and riparian condition for the upper Pajaro River watershed was conducted in 2015 by the District and its consultants. The D5 Project team began the assessment by defining the management questions that would drive the assessment. It then compiled the best available (most complete and accurate) digital aquatic resource base map to serve the Level 1 and Level 2 analyses. After the Level 2 stream condition assessment sites had been identified, the District led the CRAM field survey throughout the upper Pajaro River watershed.

This report summarizes the abundance, distribution, and diversity of aquatic resources in the upper Pajaro watershed study area (Level 1 analyses) and condition of streams (Level 2 analyses). To further understand relative stream condition in the upper Pajaro River watershed, results were compared to baseline assessments conducted by the District for the Guadalupe and Coyote Creek watersheds, and to the Bay-Delta ecoregion and statewide assessments conducted by other interests.

Management Questions

A fundamental purpose of EMAF is to align the collection and analysis of ecological data with the needs of water resource decision-makers. This is achieved by carefully developing management questions or concerns that the data should directly address. Management questions can be overarching or specific, and can evolve over time based on monitoring findings and management needs. This report addresses the following Management Questions, as provided by the District.

Level 1 Management Questions

1. What are the distribution, quantity, and diversity of aquatic resources in the watershed and Primary Areas of Interest (PAIs)?
    a. How many miles of streams exist (including natural and unnatural stream channels, if they can be distinguished)?
    b. What are the extent and distribution of non-riverine wetlands?
2. What are the extent and distribution of stream riparian areas?
3. How does the extent of modern-day aquatic resources compare to their historical extent, especially within the low-lying, valley floor areas for which there is historical ecology information?
4. Other landscape level questions about streams and stream condition:
    a. What amount / percent of streams are within the Stream Maintenance Program (SMP**)** 1,000 foot elevation boundary?
    b. What amount and proportion of the streams are District-owned (designated as District fee / ownership); and
    c. What proportion of the streams are publicly owned, based on the California Protected Areas Database (CPAD)?

Level 2: Management Questions

1. What are the overall ecological conditions of streams based on CRAM?
2. What are the likely stressors impacting stream condition?
3. What are the Ecological Service Indices (ESIs) for stream ecosystem resources?

Stream Ecosystem Risks

1. What are the likely sources of risk to stream ecosystems?
2. What is the likelihood that sources of risk may impact stream ecosystems?
3. What are the likely consequences of these risks to stream ecosystem conditions?

D5 Project Overview

The D5 Project creates a comprehensive watershed database that tracks stream ecosystem conditions to help the District and other county agencies and organizations make informed watershed and asset management decisions. The District's five major watersheds within Santa Clara County are assessed, namely: Coyote Creek, Guadalupe, upper Pajaro River, Lower Peninsula, and West Valley (Figure 3 and Table 2). Ecological monitoring and assessment is conducted on an ongoing basis, and results shared with land use agencies, environmental resource groups and the public. Baseline assessments began with the Coyote Creek watershed in 2010 and since then proceeded to the Guadalupe, upper Pajaro River, Lower Peninsula, and scheduled for 2017, the West Valley watershed assessment. Key performance indicators of the D5 Project are to establish new or track existing ecological levels of service (potentially measured as ESIs) for streams in the five watersheds, then reassess streams in the five watersheds to determine if ecological levels of service are maintained or improved.

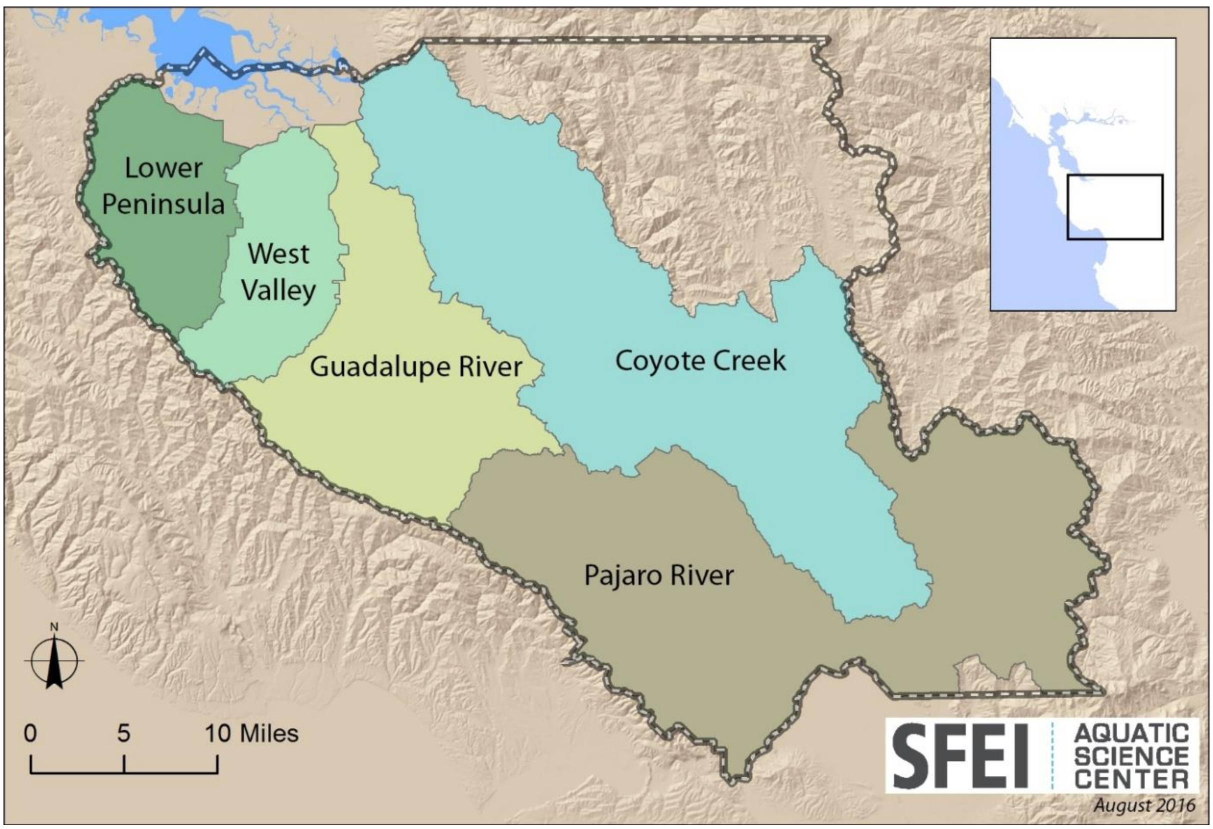

Figure 3. Map of the District's five watersheds being assessed by the D5 Project using the Environmental Monitoring and Assessment Framework (EMAF) based on WRAMP: Coyote Creek (2010), Guadalupe River (2012), upper Pajaro River (2015), Lower Peninsula (2016), and West Valley (2017). The study areas include the freshwater extents of each watershed located within Santa Clara County.

Table 2. Estimated watershed areas and number of non-tidal stream miles in the five major Santa Clara County watersheds assessed by the D5 Project (see Figure 3 above). Please note that these areas are estimates of the watershed study area extents and do not include the San Francisco Baylands within Santa Clara County.

Watershed Name	Total Watershed Area			Total Length of Streams		
	Square Miles	Acres	% Total Area	Length* (Miles)	% Total Miles*	Additional Miles of 1st Order Channels
Coyote Creek	350	224,228	34%	1,245	35%	1,615
Guadalupe River	170	108,694	16%	464	13%	589
Upper Pajaro River	361	230,922	35%	1,472	41%	NA*
Lower Peninsula	85	54,144	8%	244	7%	279
West Valley	76	48,757	7%	139	4%	112
Totals	**1,042**	**666,745**		**3,563**		**2,595**

* Length and % Total Miles of streams does not include the 1st order channels because comparable data for 1st order streams were not available for the upper Pajaro River watershed.

Watershed Setting

The upper Pajaro River watershed is the southernmost watershed in Santa Clara County, encompassing some 35% of the total area of the District's five major watersheds (about 231,000 acres). It is comprised of three major creek drainages; Uvas, Llagas, and Pacheco creeks, plus the uppermost reaches of the Pajaro River itself, and Pescadero Creek on the southwest corner of the County (Figure 4). This is the northern extent of the entire Pajaro River watershed, which covers four counties, mostly San Benito County. Streams in the watershed do not flow to San Francisco Bay, like the other four District watersheds in Santa Clara County, but instead, the Pajaro River flows to Monterey Bay, defining the border of Santa Cruz and Monterey counties.

The District selected three PAIs; Pacheco, Llagas, and Uvas Creek watersheds where individual ESIs could be calculated (Figure 5). An ESI was determined for the entire upper Pajaro River watershed study area within Santa Clara County as well. The District's SMP service area covers below the 1,000-ft elevation contour throughout the watershed. The ambient stream survey characterizes overall ecological condition of streams in the upper Pajaro River watershed study area (Santa Clara County), each of the three PAIs, as well as Strahler stream orders 3-7 (Strahler 1952, 1957) within each PAI.

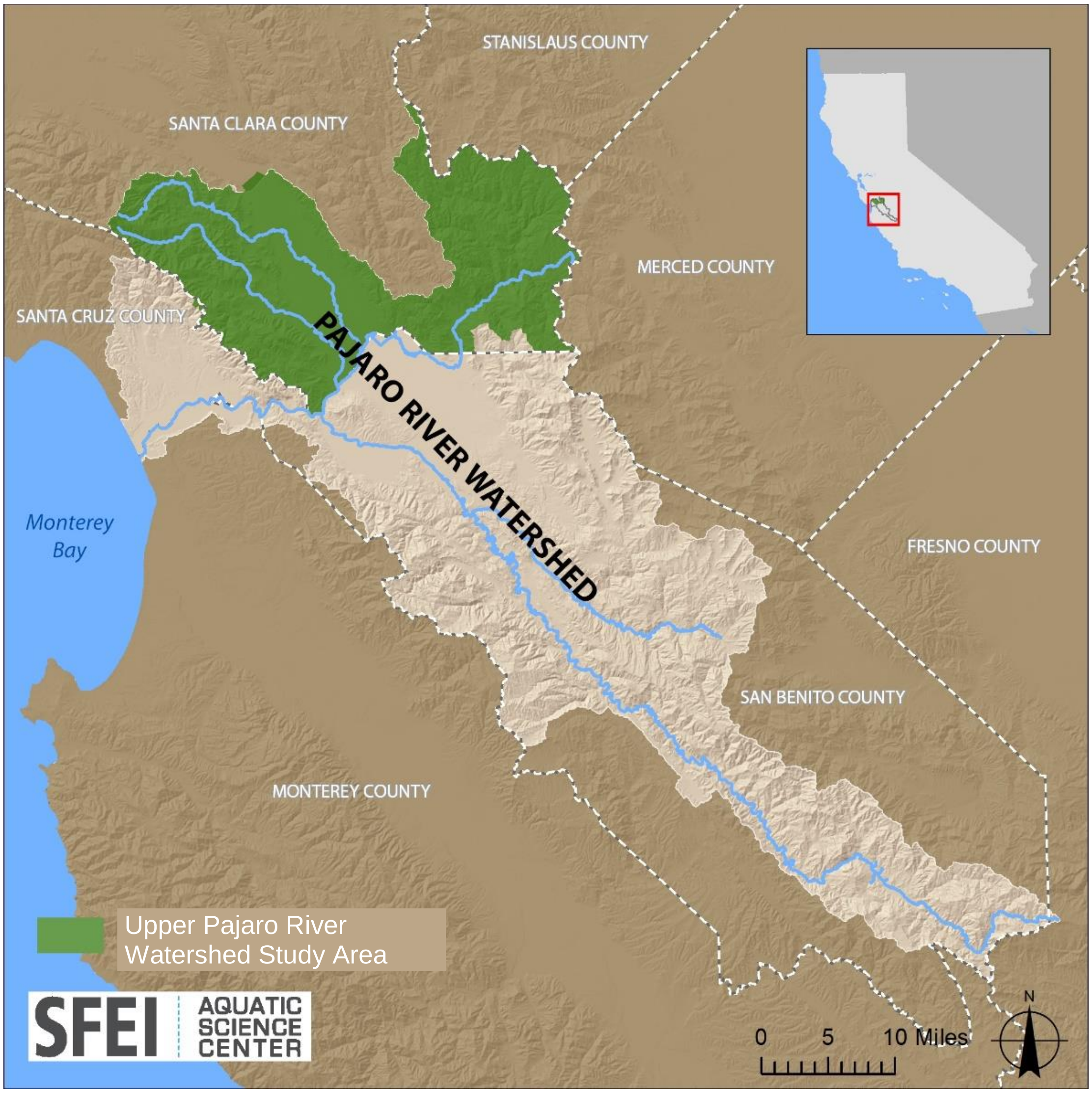

Figure 4. Map of the whole Pajaro River watershed extent, which covers four counties and drains to the Monterey Bay, CA. and the upper Pajaro River watershed study area within Santa Clara County (green).

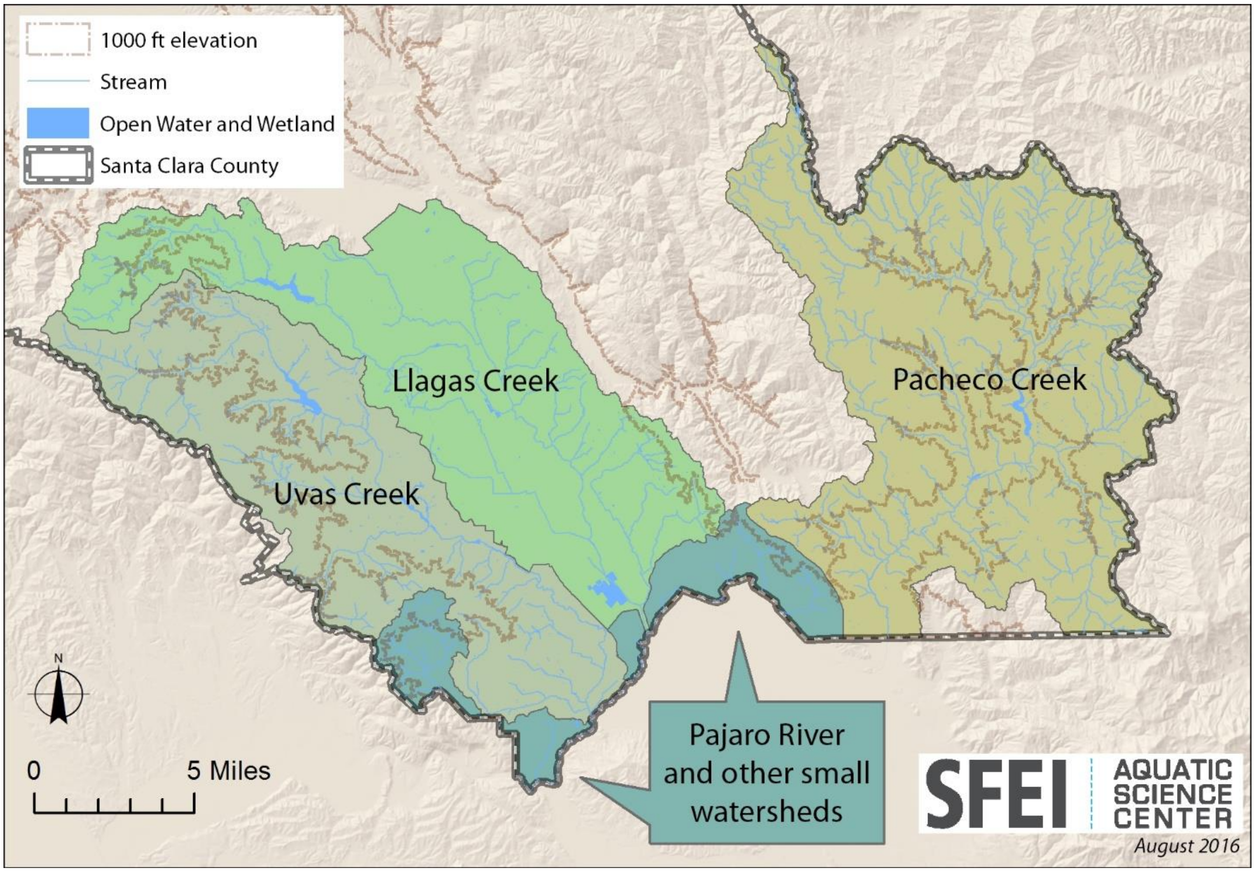

Figure 5. Map of the upper Pajaro River watershed in Santa Clara County and its three PAIs: Pacheco, Llagas, and Uvas Creek watersheds. Also shown are portions of the Pajaro River and other small sub-watersheds in the County, comprising the full study area extent. The SMP 1,000 foot elevation boundary is shown for reference.

The Pajaro River watershed is an important component of the Central California Coast region. Vast areas of highly productive agricultural land cover most of the valleys with rangelands in the hillsides. Henry Coe State Park, largest state park in northern California and second largest statewide, exists through much of the Pacheco Creek watershed. In the valley with the City of Morgan Hill and Gilroy, Soap Lake and farms provide a critical upper-watershed floodplain, attenuating flood flows through the Chittenden Gap, then west to the City of Watsonville, Pajaro, and agricultural valley bordering Monterey Bay. It provides valuable services (foraging, refuge, and spawning grounds) to a diverse regional flora and fauna. Streams provide spawning and rearing grounds for anadromous fish, especially Federally threatened steelhead / rainbow trout (Onchorynchys mykiss), and wetlands, which improve water quality by filtering runoff before it reaches the Monterey Bay National Marine Sanctuary.

Private and public managers of the Pajaro River watershed and other Central Coast watersheds face new opportunities (through new riparian protection policy development and new state resources for protection and restoration of these resources) and new threats (due to expanded urbanization, drought and climate change, local flood management efforts, flood safety concerns, fear of additional liability by land owners).

The upper Pajaro River watershed contains ranches and farms dating back to Spanish occupation, growing cities and towns, vast agriculture and important timber resources, critical transportation corridors, and rich natural habitats. Each of these land use sectors is currently addressing environmental protection and surface and ground water management objectives independently, often driven by different agencies and different management objectives. Additionally, conservation efforts in the Pajaro River watershed are challenged by a lack of coordination among the mosaic of jurisdictions, management agencies, planning initiatives and regulations; all struggling independently with insufficient local resources and capacity to manage their portion of the watershed.

Central Coast resource managers have documented serious riparian resource loss due to impacts from adjacent land uses. Concerns within the agriculture and food distribution industry regarding the safety of vegetable crops have led to new guidelines in an attempt to ensure the safety of food crops. Unfortunately, many of these guidelines have led to farm practices that undermine sustainable land stewardship practices without documented improvements in food safety. Since 2006, significant areas of riparian habitat have been lost in an attempt to take action to protect food sources, a reversal in previous agriculture practices that prized riparian and wetland habitat for its water quality and erosion control values. Recent surveys of Central Coast famers indicate that a large number of the respondents actively eliminated water quality and wildlife habitat conservation practices. Conservation practices that were removed include riparian buffers, detention basins and on-farm wetland restoration efforts (RCD of Monterey County 2007). The flood conveyance and environmental implications of these actions are unknown due to a lack of baseline data on riparian resources.

The effect on steelhead from loss of riparian habitat is well documented. Land use and streambed alterations, in combination with anthropogenic barriers to anadromy, have contributed significantly to the reduction in steelhead distribution, particularly in main stem habitats of the Pajaro River. The three watersheds in the South-Central Steelhead Recovery Plan Area most likely exhibiting the largest annual anadromous runs (Pajaro, Salinas, Carmel) have experienced significant declines in adult run size.

While the Pajaro Watershed contains some high-quality spawning and rearing habitat, it is compromised by several anthropogenic factors including groundwater extraction, Dams (Uvas, Chesbro, and Pacheco), flood control, and diversions in the lower reaches. Additionally, extensive agricultural development in the Pajaro River basin has significantly modified and degraded stream conditions in low lands and valleys.

Methods

Level-1: GIS-based Landscape Level Assessment Methods

1. Identify the best available digital stream network and wetlands dataset.

   The Coyote Creek and Guadalupe River watershed stream assessments, conducted by the District in 2010 and 2012 respectively (EOA and SFEI 2011, SFEI 2013) , relied on the Bay Area Aquatic Resources Inventory (BAARI), which is a GIS dataset of streams and other wetlands (developed by SFEI through separate funding). BAARI is a more accurate and complete intensification of the National Hydrography Database (NHD) and National Wetlands Inventory (NWI) data. The BAARI stream network is complete for most of the District's five major watersheds with the exception of the upper Pajaro River watershed, which does not drain into the San Francisco Bay and is therefore not included in BAARI. The BAARI GIS dataset was employed in the previous watershed condition assessments conducted by the District, and since then, BAARI has been incorporated in to the California Aquatic Resources Inventory (CARI), which is a compilation and standardization of the best available GIS datasets for California. Where more detailed, regional data are not available, the NHD stream data and the NWI wetlands data represent the aquatic resource base map for any given region.

   For the upper Pajaro River watershed, it was necessary to compare the District's "Creeks" GIS data to the NHD data from the California Aquatic Resources Inventory (CARI) to select the most complete and accurate available GIS dataset. The Creeks dataset was also compared to BAARI in order to understand the differences in the extents of the stream network for the purposes of comparing stream miles between the upper Pajaro River watershed and other District watersheds, and to identify a comparable level of stream network detail for the underlying GIS layer used as the sample frame for the watershed-wide stream condition survey employing CRAM.

   The District's "Creeks" GIS data layer was selected for the upper Pajaro River watershed assessment because it was more complete and accurate than the NHD data in CARI. The 'Creeks' stream network was found to be generally comparable to the BAARI's stream network for 2nd order and larger channels, but not for the 1st order channels. The 1st order channels of the "Creeks" data correspond to 1st and 2nd order channels in BAARI. Simply stated, the "Creeks" data for 1st and 2nd order streams in the upper Pajaro River watershed within Santa Clara County are not as detailed as BAARI. This means the Level 1 data for the upper Pajaro River watershed, which is based on the "Creeks" data, will generate lesser estimates of total stream miles than the level 1 data for the other District watersheds, which are based on BAARI. This discrepancy was taken into account when comparing stream miles for the upper Pajaro River watershed and other District watersheds (see Table 2 above).

   SFEI updated the District's 'Creeks' GIS data layer to include Strahler stream order and flow directions to support comparison between it and BAARI stream layer and to use it as the GIS-base sample frame for the development of the CRAM survey design and sample draw.

   The wetland polygons from CARI were used to estimate the abundance, distribution, and diversity of wetlands in the upper Pajaro River watershed. The CARI wetland GIS data for this region are sourced from the NWI wetland dataset (USFWS 2008-2011). SFEI omitted polygons corresponding with streams so as to not double count stream reaches as part of the wetland acres.

The two main non-riverine wetland types summarized in this report (based on the NWI data) include:

- Vegetated Wetland: Vegetated wetlands are a broad category which includes marshes, wet meadows, willow-dominated wetlands, and any other wetland that is persistently vegetated on an inter-annual basis. They may be naturally occurring or present as a result of human modifications to the landscape.
- Reservoir/Pond/Unvegetated Wetland: This class predominantly consists of large reservoirs and small artificial ponds used for water storage. In addition to these open water features, this category includes wetlands that are unvegetated. These are often found adjacent to vegetated wetlands as components of a larger wetland complex.

2. Determine the study area extent and the PAIs.

The upper Pajaro River watershed encompasses about 231,000 acres and its boundary is comprised of a combination of three GIS data layers:

- USGS HUC10 watersheds, California (2012),
- The District's revised "unofficial" watershed boundary layer for Uvas and Llagas watersheds, and
- The District's GIS layer of the Santa Clara County line.

The District identified three PAIs plus the Pajaro River mainstem and other small tributaries within the County that complete the full study area extent (see Figure 4 above). For additional information about the study area boundaries and extent, please refer to the *Task 2: Basis of Assessment Memorandum (10/2/2015)*.

3. Estimate Riparian Extent using the Riparian Zone Estimation Tool v2.0 (RipZET 2.0).

The Riparian Zone Estimation Tool (RipZET) is used with a GIS to estimate the existing or potential extent of riparian areas based on the concept of "functional riparian width." According to this concept, the kinds of functions that a riparian area can provide depend on its structure, which includes topographic slope, types of soils, density and height of vegetation, and plant species composition. For any given structure, the levels of specific functions within a riparian area depend on its width and length. Wider and longer riparian areas tend to support higher levels of more kinds of functions than shorter and narrower areas (Wenger 1999). The concept of functional riparian width is central to the riparian definition recommended by the National Research Council (NRC 2002) and is integral to many riparian design and management guidelines (e.g., Johnson and Buffler 2008).

RipZET has three main components: core code, modules, and output. The core code prepares the input data used by the modules. Each module generates separate output GIS layers that estimate riparian widths within a user define area for vegetative and hillslope riparian functions respectively. The output of each module is a unique visual display (GIS coverage) of the estimated functional riparian area based on the input vegetation layer and elevation data. The displays are not regarded as riparian maps *per se* because they do not depict areas with definite boundaries based on field indicators. Instead, they depict areas where the riparian functions represented by the individual modules are likely to be supported.

The vegetation and hillslope modules are run separately, and the GIS outputs from the different modules can be overlaid to represent the maximum riparian extent for all the functions represented by both modules.

The upper Pajaro River watershed assessment ran RipZET's hillslope and vegetation modules on existing vegetation (circa 2006, because of the date of the input vegetation layer) and elevation GIS data described below. The vegetation output was used to estimate the miles and area of stream associated riparian areas by functional width class based on height of vegetation and plant species composition. These classes are based on general relationships between riparian width and vegetation-based riparian function as summarized by Collins *et al.* (2006). The estimated riparian length and areas are based only on the output of the RipZET vegetation module (and not the hillslope processes module). The riparian extent for each width class is calculated for the left and right stream banks separately and therefore the estimated riparian stream length, by functional width class, is calculated as the sum of stream lengths that have associated riparian areas from both banks divided by 2. The resulting riparian stream length will not necessarily add up to the total length of the stream network, which is calculated from the flow-line down the thalweg of the channels[1].

The GIS input data to RipZET included:

- the Santa Clara County Habitat Conservation Plan's (HCP) landcover layer (Jones & Stokes 2006),
- USGS National Elevation Dataset, 10-meter node DEM for topography, and
- the "Creeks" data layer provided by the District attributed for stream order and flow direction.

4. GIS data sets used in the upper Pajaro River watershed assessment and report.

In order to describe the extent, distribution, and condition of the aquatic resources in the upper Pajaro River watershed, SFEI employed the District's updated 'Creeks' layer, CARI wetland polygons (based on NWI), and other geospatial data provided by the District or available online. The datasets used in this study included the following:

- District's "Creeks" GIS layer (2004), based on 2001 countywide orthophotos.

  SFEI added Strahler stream order, flow direction and an estimate of natural and unnatural channel planforms (based on Santa Clara County Historical Ecology GIS data - SFEI 2008-2015).
- District's revised "unofficial" watershed boundary layer for Uvas and Llagas watersheds (2011). Provided to SFEI by the District in 2015.

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[1] This is partly because the shape of the stream network is slightly altered by buffering the thalweg line to the estimated left and right stream banks in order to associate the left and right banks with the vegetation layer, and partly because some streams do not have associated riparian vegetation and are not included as stream associated riparian area.

- Santa Clara County line GIS layer provided by the District (2007). Provided to SFEI by the District in 2015.
- District's Stream Maintenance Program's (SMP) 1000-ft elevation boundary (2006). Provided to SFEI by the District in August, 2016. The SMP boundary is based on 2006 LiDAR contour datasets.
- District-owned lands from the District's fee title GIS layer (2009 [Unpublished]). Provided to SFEI by the District in August, 2016.
- CARI v0.2 wetland GIS polygon layer. San Francisco Estuary Institute (SFEI 2016). "California Aquatic Resource Inventory (CARI) version 0.2." Accessed [30 August 2016]. http://www.sfei.org/data/california-aquatic-resource-inventory-cari-version-02-gis-data.
- Watershed Boundary Dataset, Hydrologic Unit Code 10 (HUC 10, USGS 2012).
- California Protected Areas Database 2014 (CPAD, GreenInfo Network 2014).
- Santa Clara County Historical GIS Data. San Francisco Estuary Institute (SFEI). 2015. "Santa Clara Valley Historical Ecology GIS Data version 2" Accessed [30 August 2016]. http://www.sfei.org/content/santa-clara-valley-historical-ecology-gis-data.
    - The Southern Santa Clara County portion of this data was originally published in 2008 (SFEI 2008).
- Landcover GIS layer for the Santa Clara County HCP (Jones and Stokes 2006). These data were used by RipZET to assign tree heights to estimate forested stream riparian extents.
- U. S. and Canada Major Roads dataset, Tele Atlas North America (ESRI 2010)

Level-2: Rapid Assessment of Stream Condition Methods

1. Develop the survey design and sample draw.

   The D5 Project's watershed-wide, probability based, stream condition survey designs and sample draws employ the Generalized Random Tessellation Stratified (GRTS) design and analysis tools for aquatic resources that were developed by the USEPA for the National Environmental Monitoring and Assessment Program (EMAP; Messer *et al.* 1991; Stevens and Olsen 2003; Stevens and Olsen 2004). The D5 Project employs the tools to develop spatially-balanced stream survey designs and sample draws for assessing the overall condition of streams within their watersheds using CRAM. CRAM assessment areas (AAs) are randomly sampled from a GIS-based stream data layer (in this case, the updated District 'Creeks' layer described above). Each AA represents proportion of the stream resource allowing the results to estimate the overall ecological condition of stream in the watershed with a known level of confidence[2]. These statistically based CRAM stream surveys establish the baseline condition estimates for future 'reassessments' to characterize trends over time.

   The density of AAs in the upper Pajaro River watershed stream assessment sample draw was stratified across the study area (but, still maintained its unbiased probability based nature) by adjusting the relative number of of samples in the Uvas and Llagas Creek PAIs than would normally be allocated to those PAIs based on an un-stratified sample that would allocate AAs based on the relative proportion of streams across the whole watershed. The sample draw was further stratified to increase the number of AAs in higher stream orders (the lower elevation, valley floor areas of the watershed). These adjustments were made to increase the number of samples, and therefore the confidence levels around the means, in the areas of special interest to the District while preserving the ability to evaluate the conditions in the watershed as a whole. Confidence intervals can vary widely depending on how homogenous the sample population is within each PAI. As an initial design consideration, under normal circumstances, environmental statisticians generally recommend starting with about 20 sites per targeted area of interest.

   The final survey design and sample draw for the upper Pajaro River watershed stream condition survey targeted 88 AAs across the whole network and included all stream orders as defined by the District's "Creeks' stream layer (Strahler stream orders 1-7, Figure 6). Stratification of the sample draw forced more AAs into the Uvas and Llagas watersheds (targeting 23 AAs in each PAI), and more AAs into the lower elevation, higher-order channels (orders 3-7) than would have been assigned without any stratification.
   An oversample draw, equal to three times the targeted number of AAs, was included to replace sites that are dropped due to lack of legal access, dangerous terrain (extreme steepness, impenetrable and poisonous vegetation, etc.), inaccurate mapping, or for future intensification of the surveyed area or sub-area (if warranted). For more information about the GRTS survey design, sample draw methodology, and the R program code, please refer to the D5 Project's *Task 3: GRTS Survey Designs and Sample Draws Memorandum* (10/1/2015).

[2] The following link (a presentation by Tony Olsen of USEPA) provides a good visual overview of GRTS. http://acwi.gov/monitoring/conference/2006/2006_conference_materials_notes/WorkshopsandShortCourses/Spatial_Sampling_Workshops_Olsen/Surve_%20Design_Short_Courses/GRTS_Site_Selection.pdf

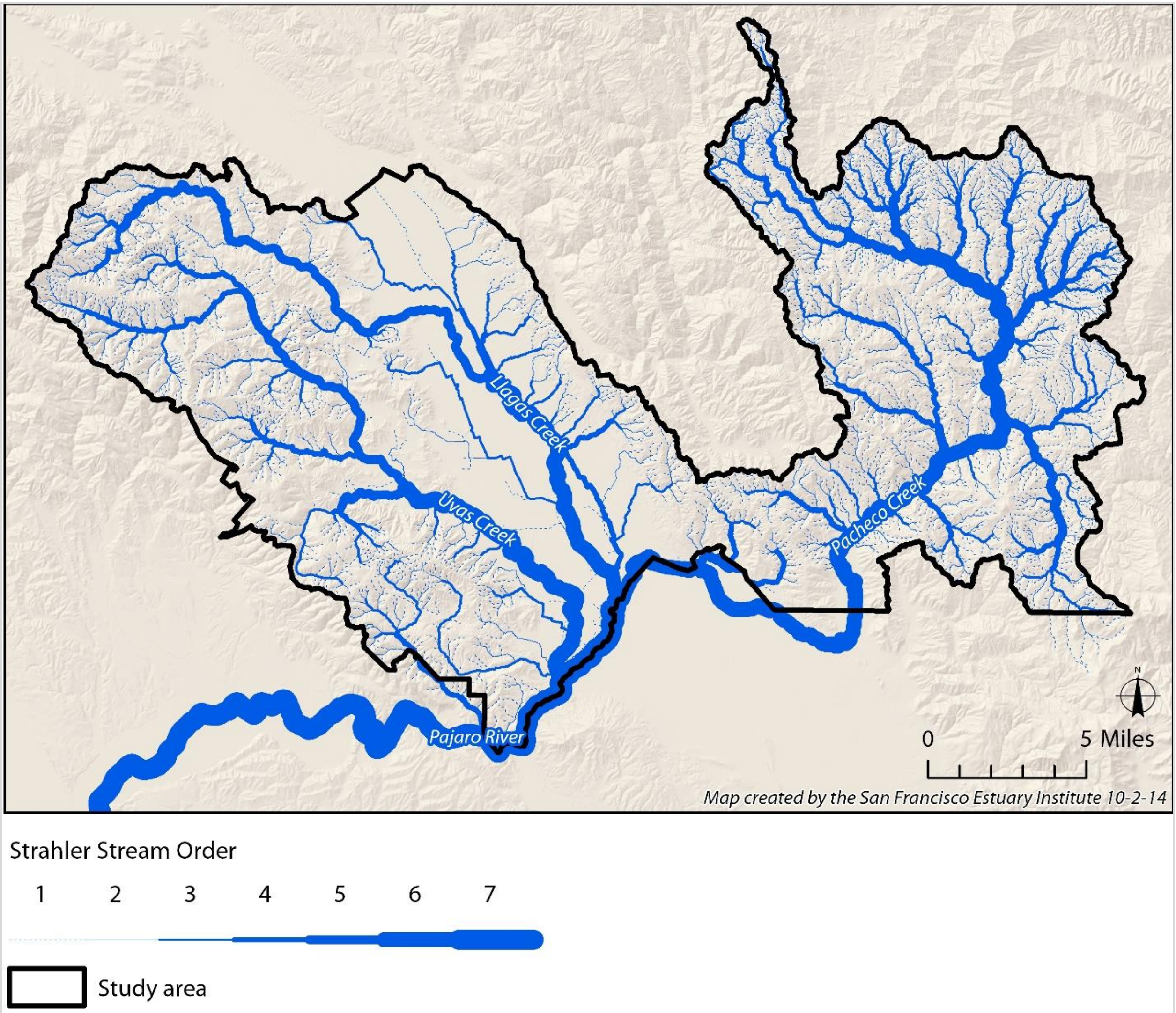


Figure 6. Sample frame for the Level 2 assessment of the upper Pajaro River watershed showing the stream network by Strahler stream order based on the District's Level 1 'Creeks' data.

2. Conduct CRAM Field Assessments of the Streams.

   The District and its consultants conducted the Level 2 ambient survey of stream conditions within the upper Pajaro River watershed using the CRAM Riverine Fieldbook (V6.1)[3]. Assessments were conducted between April and October 2015 by trained CRAM Practitioners from the District, SFEI, and Michael Baker LLC. Assessment results were entered into the online CRAM data management system[4], and are accessible (if permission is granted to make them public) through EcoAtlas[5] (an interactive, map-based website to visualize and access wetland and other environmental data). The upper Pajaro River watershed CRAM results are summarized in Appendix A.

[3] 2013.03.19_CRAM Field Book Riverine 6.1.pdf
[4] www.cramwetlands.org
[5] www.ecoatlas.org

Intercalibration exercises were conducted twice during the field season to document and compare consistency among the D5 Project's field teams, and to provide a forum for additional training on the CRAM methodology. These exercises and additional training help minimize Practitioner-introduced variation in CRAM Scores.

It is expected that AAs will be dropped at random due to a lack of legal access, dangerous terrain, or inaccurate mapping, such that the replacement AAs (drawn from the oversample draw) maintain a spatial balance across the stream network (or sample frame). However, in practice, the final distribution of assessed AAs can result in some regions being underrepresented. For example, high-elevation stream reaches in remote areas of a watershed can be extremely difficult to access. If the assessment teams decide that the final distribution of assessed areas adequately represent the unassessed areas, the overall survey area (the area that is characterized by the results) is not adjusted. If the teams expect that the inaccessible areas comprise a distinct set of conditions that are not represented by the assessed areas, the inaccessible areas are excluded from the final survey area.

In the previous watershed assessments by the D5 Project (Coyote Creek and Guadalupe River watersheds) it was decided that the inaccessible areas were similar enough to the assessed areas, such that the assessment could be applied to the whole watersheds. The assessment teams made the same finding for the upper Pajaro River watershed.

3. *Data Analyses of CRAM Results*

Statistical analyses were conducted on the Level 2 (CRAM) stream survey results with the *spsurvey* statistical library (Kincaid and Olsen 2016) and the R programing language (version 3.2.3), which is a software environment for statistical computing and graphics. The functions included in the *spsurvey* library were originally written for the USEPA's EMAP (Messer *et al.* 1991) to design and analyze probabilistic surveys of environmental resources (Diaz-Ramos *et al.* 1995). The analyses for the upper Pajaro River watershed stream survey evaluated the CRAM Index and Attribute Scores based on the original survey design with adjusted sample weights in order to estimate the overall condition of streams within the watershed and each of its PAIs. The output consists of cumulative distribution function (CDF) estimates that include CDF plots of CRAM Scores and percentile tables.

The CDF plots enable a user to visually evaluate and compare the percentage of the resource within the upper Pajaro River watershed equal to or less than any given CRAM Score with a known level of confidence (e.g., 95% confidence intervals). The median CRAM Scores, where half of the stream resources in the study area are below that score, are easily identified and can be used to compare subsets of data, such as for the PAIs.

The confidence intervals of a CDF are generally wider when there is a lot of variation in condition scores within a surveyed area or when the sample size is small. A curve that is shifted to the right indicates better overall stream conditions (higher CRAM Scores) than a curve that is shifted left.

The CRAM Index Score CDF for the upper Pajaro River watershed is shown in Figure 7 as an example plot to show how to interpret the curve. Reading the blue arrows (across and down), it indicates that 50% of all the streams in the watershed have a CRAM Index Score of 74 or less with a 95% confidence level that the 50th percentile score (or median score) is between 70 and 80 (or less) as indicated by the red confidence interval lines. The plot is also divided into three equal-interval subsets of the full range of possible CRAM Scores (25-100): poor ecological condition has a CRAM Score of 25 to 50, fair 50 to 75, and good 75 to 100. This is the most neutral approach and affords direct comparisons between different watersheds based on the distribution of scores, and stream miles among uniform health classes.

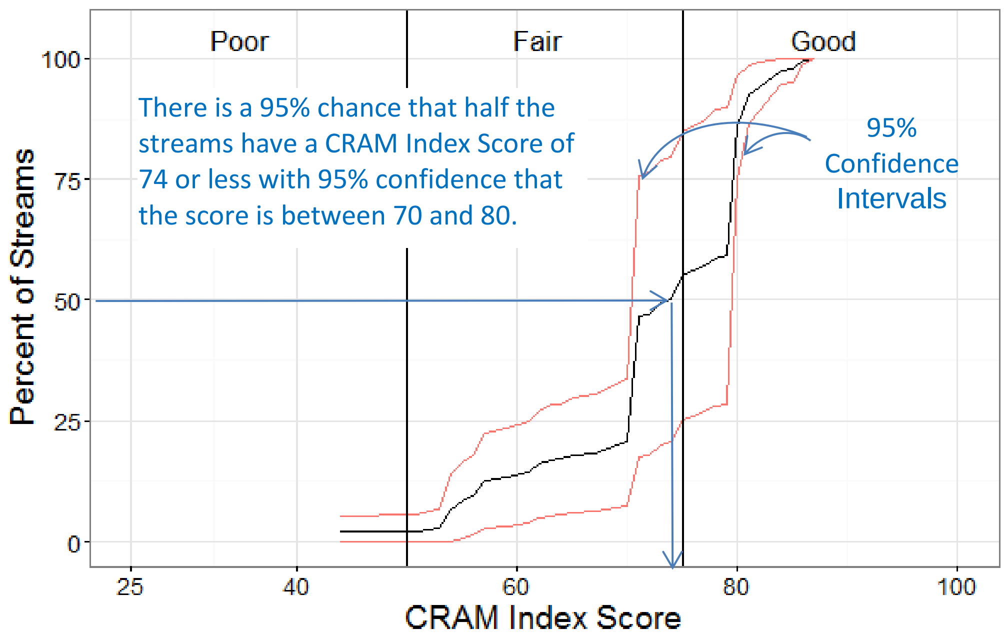


Figure 7. Example CDF plot of CRAM Index Scores for the upper Pajaro River watershed showing how to interpret the curve.

The three health classes could be refined based on specific ecological rationale. For example, the California Wetland Monitoring Workgroup with statewide CRAM oversight has agreed that reference sites for all CRAM wetland types must have an overall Index Score ≥ 80. The health classes in Figure 6 could be revised to reflect this recommendation. That is, the threshold Score between fair and good health could be set at 80 rather than 75. The U.S. Army Corps of Engineers guidance document (USACE 2015) for assessing mitigation sites (section 3.4.2) states: “As a basis of comparison, an aquatic resource in good ecological health is functioning at rates typical of its type in a least-disturbed setting (reference standard).” This suggests that regions or even watersheds might have their own reference sites used to define good health.

These decisions about Scores that delimit health classes do not alter the underlying CDF, but they do affect its interpretation. For this report, the classes are defined as three equal-interval subsets of the full range of possible CRAM Scores because it is the most neutral approach and it affords direct comparisons between different watersheds based on the of the distribution of scores and stream miles among uniform health classes.

Other stream condition analyses, based on the CRAM stream survey results, include calculating ESIs for the entire watershed and individual PAIs based on the CDF. The ESI is a simple statistic representing the sample-weighted average of all CRAM Scores in the ambient watershed survey. It was originally developed by the District's D5 Project (EOA and SFEI 2011) and applied to the Coyote Creek and Guadalupe River Watershed assessments in 2010 and 2012, respectively.

An ESI is calculated as the sum of individual CRAM Scores from the CDF estimate times the proportion of stream length represented by each Score:

ESI = ∑ (CRAM Score X Estimated proportion of stream length represented by each Score)

The ESIs are single numbers that can be used to compare the overall condition between watersheds (e.g., comparing the major watersheds within the District) or between PAIs within a watershed. The District could base management priorities (or set management goals) by identifying 'target ESI thresholds'[6] for each PAI (or the watershed as a whole). Progress towards meeting those thresholds could be monitored, tracked over time, and adopted into the District's watershed management plans as ecological condition metrics.

Although the District has not yet set any 'target ESI thresholds' for the upper Pajaro River watershed, the ESIs developed for the 2015 stream survey can be compared to future, repeated, watershed-wide condition surveys in order to track change over time. It is also possible to calculate ESIs for the CRAM Attributes, if warranted.

Results

Level-1 Distribution and Abundance of Aquatic Resources

Figure 8 below shows the distribution of the aquatic resources currently mapped in GIS, including streams, reservoirs, ponds, vegetated and unvegetated wetlands in the upper Pajaro River watershed.

[6] Note: 'Target ESI thresholds' were defined as Ecological Levels of Service (LOS) in the original Coyote Creek Plan and Technical Report #2 (EOA and SFEI 2011), then adopted as Key Performance Indicators (KPIs) for the District's D5 Project.

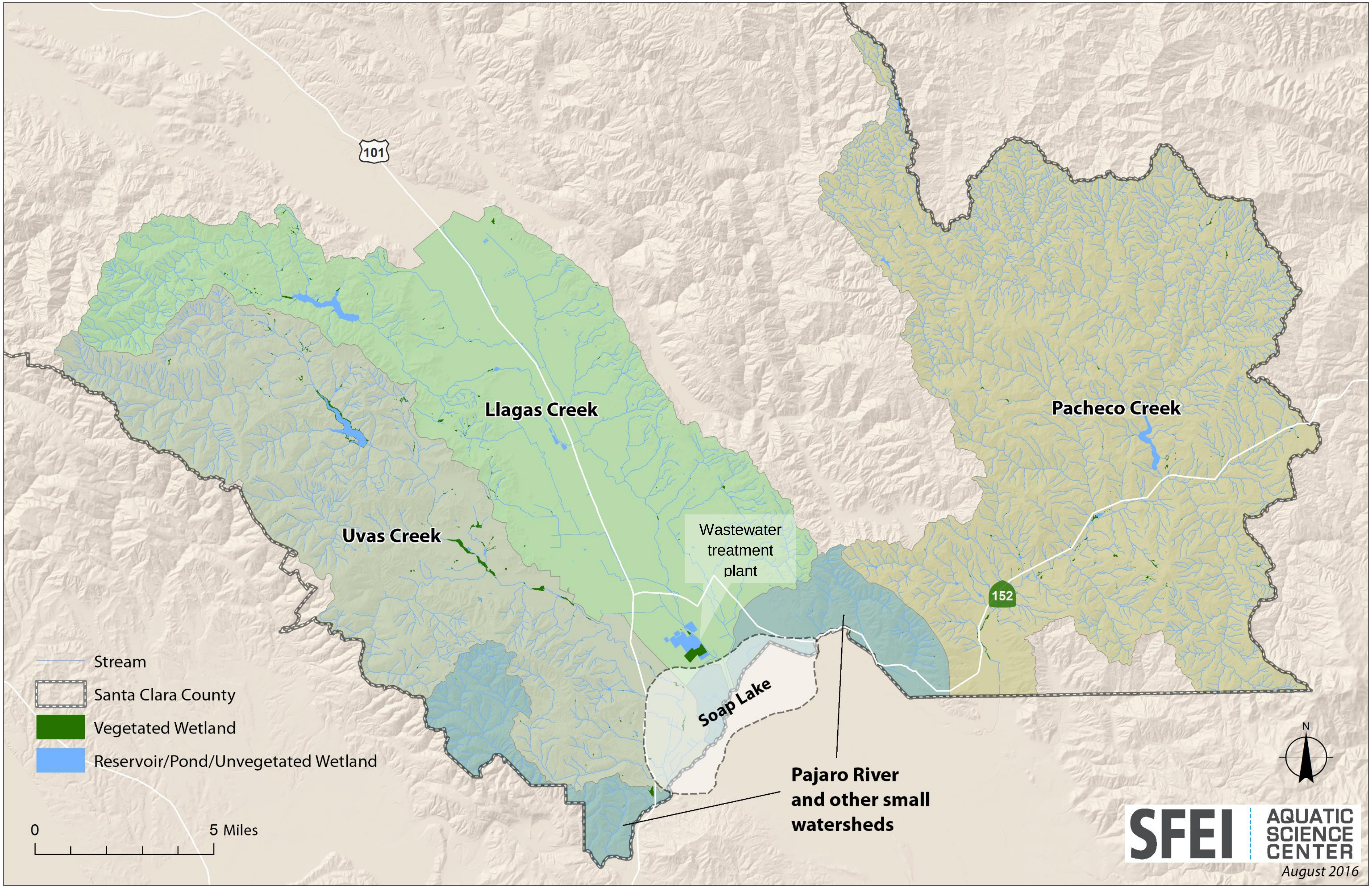


Figure 8. Map of the aquatic resources in the upper Pajaro River watershed study area based on the District's 'Creeks' GIS and NWI data reported in CARI v0.2.

- *How many miles of streams are there in the upper Pajaro River watershed within Santa Clara County?*

Table 3 summarizes the number of creek and river miles (riverine wetlands), in the upper Pajaro River watershed and its PAIs, based on the District's 'Creeks' GIS dataset. For this D5 Project, SFEI updated the 'Creeks' GIS dataset, within the watershed study area extent, to include Strahler stream orders and flow direction. First order streams[7] comprise just over half of the total stream miles in the watershed study area (56%), second and third order streams comprise another 30%, fourth and fifth order streams comprise 10%, and sixth and seventh order streams make up the remaining 3%.

Table 3 Total miles of streams in the upper Pajaro watershed study area based on the District's 'Creeks' GIS dataset

Sub-watershed	Length (Miles)	% of Watershed
Pacheco Creek	813	55%
Llagas Creek	251	17%
Uvas Creek	313	21%
Pajaro River and Other Small Watersheds	95	7%
Total	**1,472**	

- *What is the extent and distribution of non-riverine wetlands within the watershed?*

Table 4 summarizes the number of acres of other types of wetlands (non-riverine wetlands) in the upper Pajaro River watershed and its PAIs. The CARI wetlands GIS dataset for this region is NWI and therefore the wetland types and mapping methods are not directly comparable to those reported for other District watersheds, which employed the more detailed BAARI wetlands GIS dataset. The Llagas Creek watershed has the most reservoirs, ponds, and unvegetated wetlands, while the Uvas Creek watershed has the most vegetated wetlands.

Table 4. Total acres of the non-riverine wetlands in the upper Pajaro River watershed and its PAIs based on NWI in CARI and shown in Figure 7

Sub-watershed or PAI	Total Acres of Non-Riverine Wetlands	Acres of Vegetated Wetlands	Acres of Reservoirs, Ponds & Unvegetated Wetlands
Pacheco Creek	526	151	374
Llagas Creek	867	231	636
Uvas Creek	653	323	331

[7] Remember that the 1st order stream in the District's Creeks layer are similar to mostly 2nd order streams in BAARI.

Sub-watershed or PAI	**Total Acres of Non-Riverine Wetlands**	Acres of Vegetated Wetlands	Acres of Reservoirs, Ponds & Unvegetated Wetlands
Pajaro River and Other Small Watersheds	61	39	21
Total	**2,106**	744	1,362

- *What is the extent and distribution of stream associated riparian areas?*

Riparian areas adjoin all waterways and water bodies including wetlands (Brinson 2002). The width of a riparian area depends on many factors, such as topographic slope, adjacent land use, and plant community structure. For any give set of factors, the width of a riparian area varies by its function, such as wildlife support, runoff filtration, input of leaf litter and large woody debris, shading, flood hazard reduction, groundwater recharge, and bank stabilization. Width classes can be defined based on general relationships between width and function (Collins et al. 2006). Table 5 presents the estimated miles and acres of stream associated riparian areas in the upper Pajaro River watershed for five width classes.

Table 5. Miles of riverine riparian areas for each of five, vegetation-based, riparian functional width classes in the upper Pajaro River watershed. Riparian width classes reflect natural demarcations in the lateral extent of major riparian functions, as summarized in Collins *et al.* (2006). A function is assigned to a width class if the class is likely to support a very high level of the function.

Riparian Width Class in Feet (m)	Miles (Km)	Acres (Ha)	% Total Length	Shading	Bank Stabilization	Groundwater Recharge	Allochthonous Input	Runoff Filtration	Flood-water Dissipation	Wildlife Support
0 - 33 (0 - 10)	397 (638)	636 (257)	26%	■	■	■				
33 - 98 (10 - 30)	550 (885)	10947 (4430)	36%	■	■	■	■	■		
98 - 164 (30 - 50)	284 (457)	9032 (3655)	19%	■	■	■	■	■	■	
164 - 328 (50 - 100)	202 (325)	9895 (4004)	13%	■	■	■	■	■	■	
>328 (>100)	78 (125)	7764 (3142)	5%	■	■	■	■	■	■	■

RipZET outputs the estimated riparian habitat extents for vegetative and hillslope processes as separate GIS shapefiles. Figure 9 is a map of the RipZET output for both processes. Figures 10 and 11 are bar charts that summarize riparian habitat length and area by functional width class for both vegetative and hillslope processes.

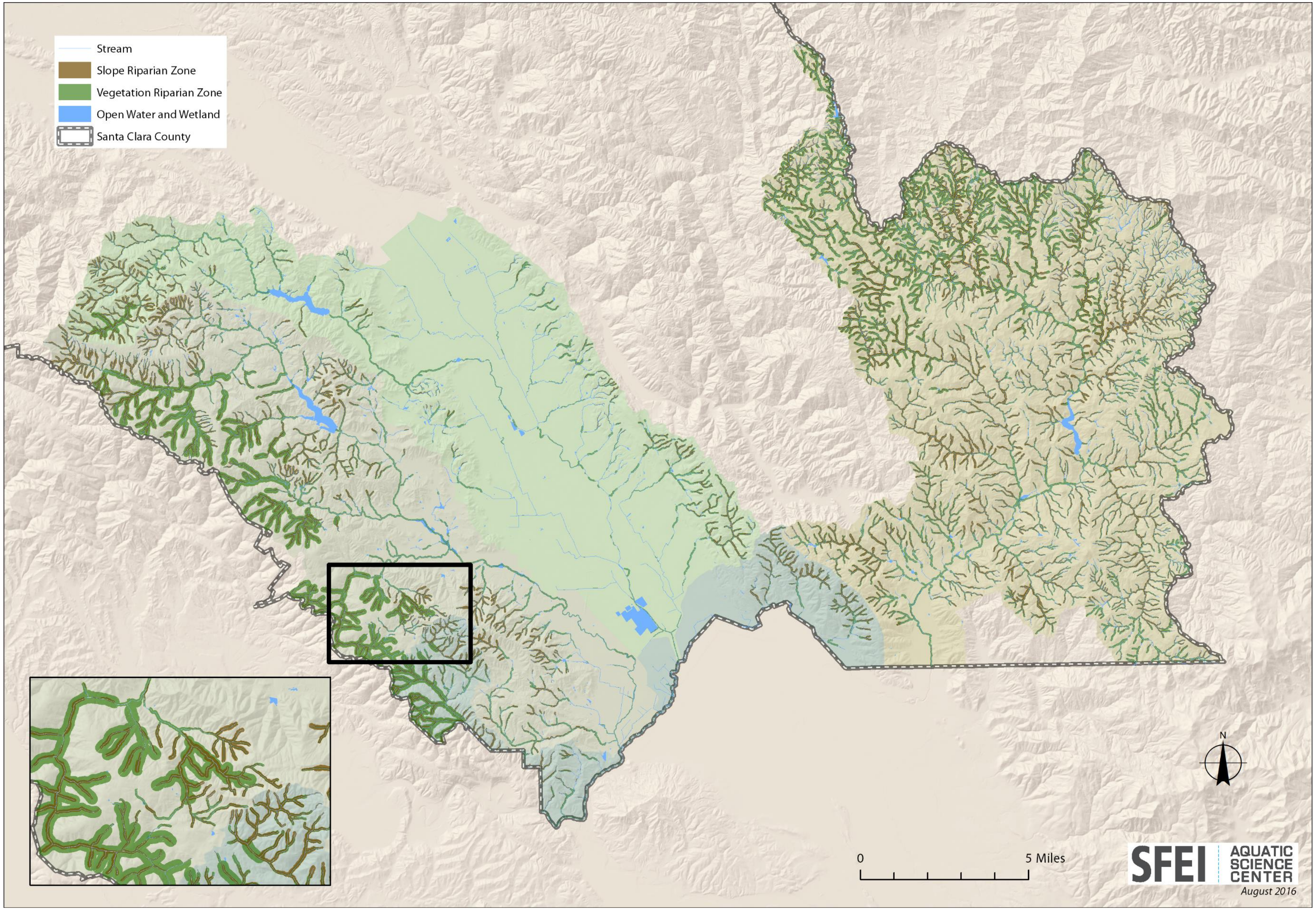


Figure 9. Map of the RipZET output based on vegetation and hillslope processes

Figure 10. Estimated miles of riparian stream lengths by riparian functional width class for the upper Pajaro River watershed based on vegetation and hillslope processes

Figure 11. Estimated acres of riparian area by riparian functional width class for the upper Pajaro River watershed based on vegetation and hillslope processes

- *How do the modern-day aquatic resources compare to historical extents within the low-lying, valley floor areas for which there is historical ecology information?*

Figure 12 shows the historical (circa 1850) and current aquatic resources in the upper Pajaro River watershed. Figures 13 and 14 show the historical and current distribution and abundance of natural and unnatural riverine wetlands. Natural and unnatural stream lengths for the modern stream network are rough estimates and were identified by overlaying the historical ecology GIS base-layer that exists for the valley floor. Streams that follow the historical planform were considered natural even though they may or may not be modified (e.g., dredged, cleared, or channelized).

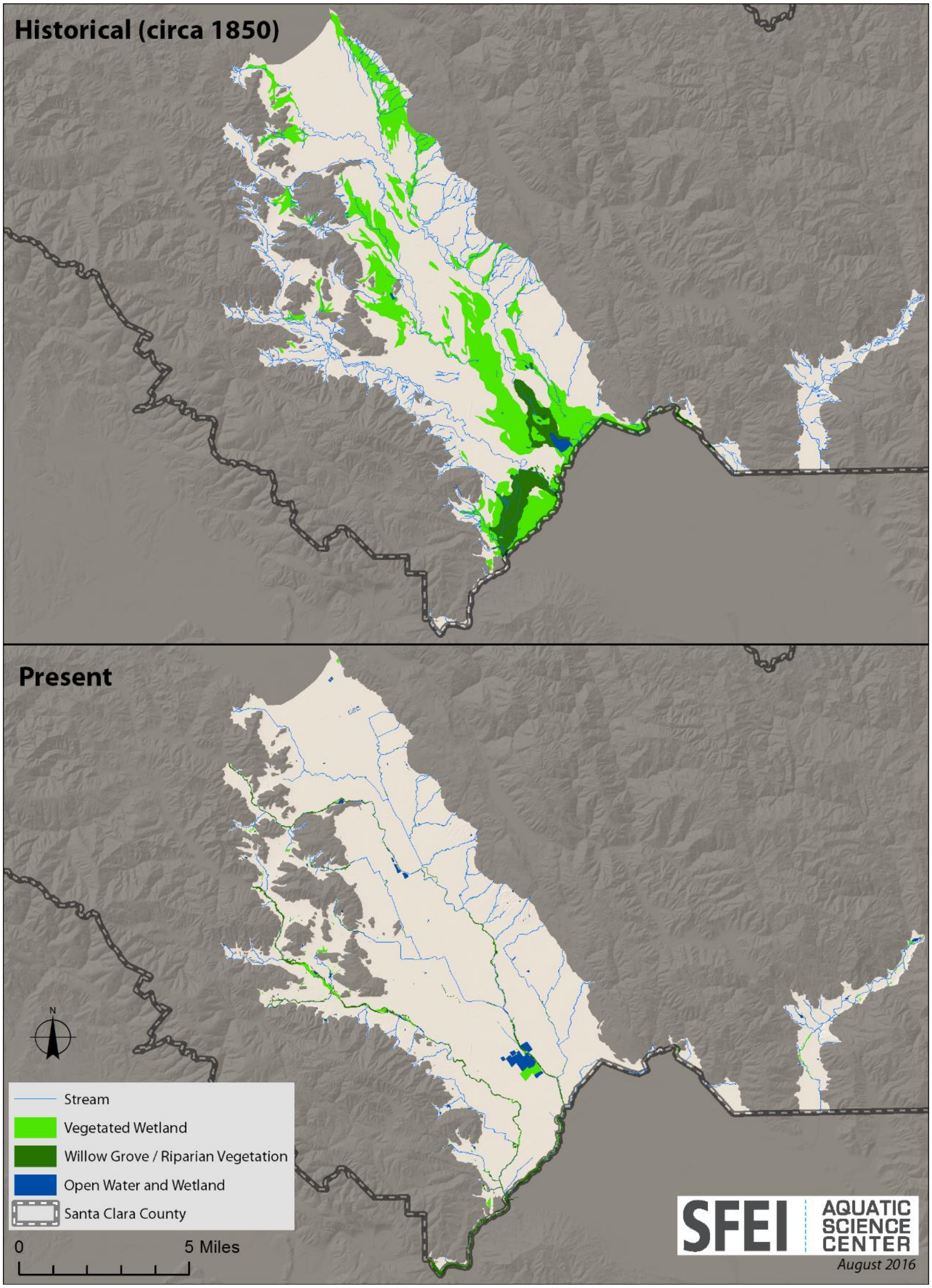


Figure 12. Maps of historical (circa 1850) and current aquatic resources in the upper Pajaro River watershed valley floors based on the *South Santa Clara Valley Historical Ecology Study* (SFEI 2008), the District's "Creeks" GIS data (2004), and CARI wetlands (NWI data 2008-2015).

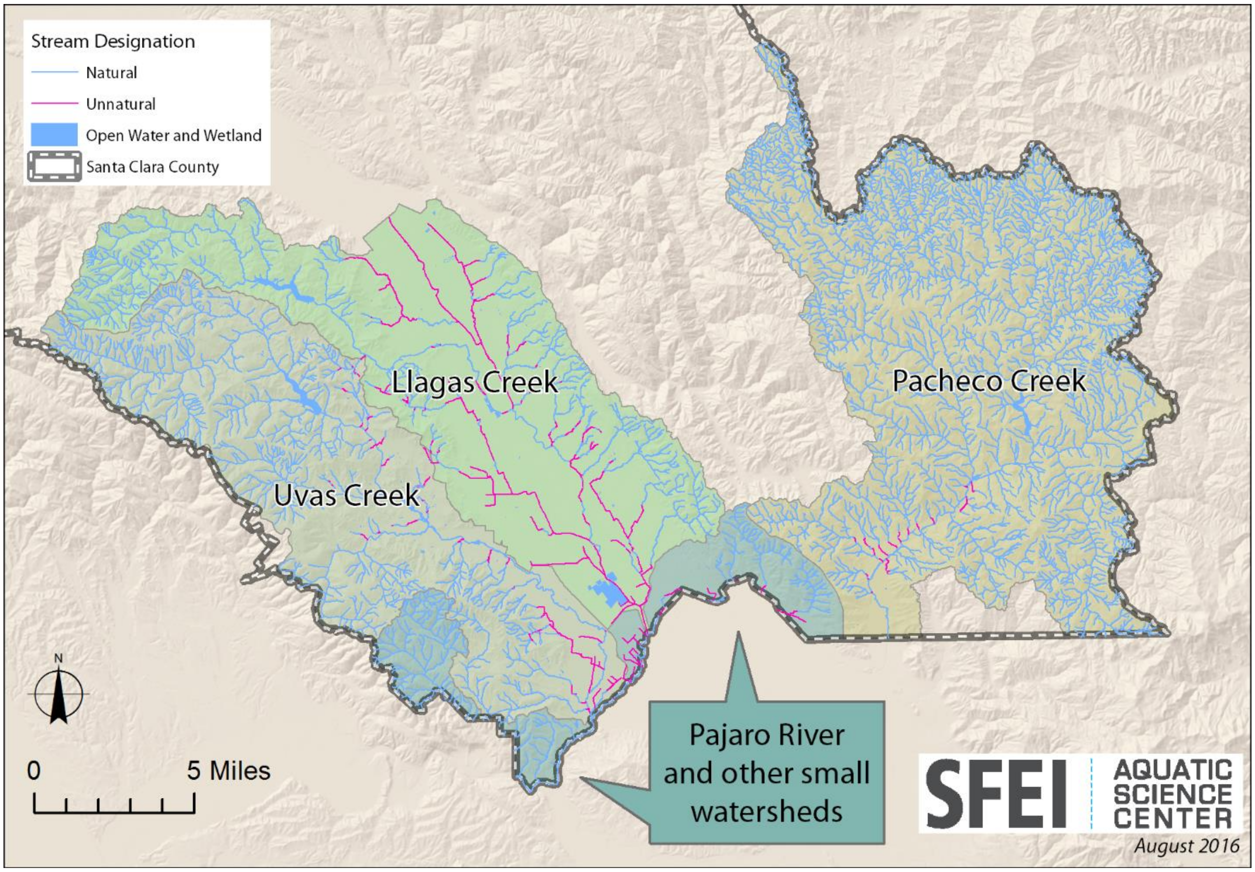


Figure 13. Natural and unnatural streams within the valley floor of the upper Pajaro River watershed based on a comparison with the historical streams base map (SFEI 2008).

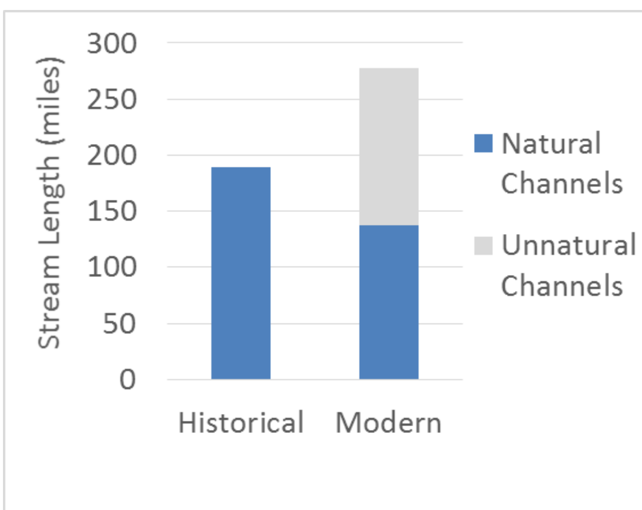


Figure 14. Historical (circa 1850) and modern stream lengths for the upper Pajaro River Watershed valley floors based on Figure 13.

- *What amount and proportion of streams are within the Stream Maintenance Program's (SMP) 1000 foot elevation boundary?*
- *What amount and proportion of the streams are District-owned?*
- *What amount and proportion of the streams are in protected areas?*

Figure 15 is a map of District-owned lands (District's fee title GIS dataset, August 2016) and protected lands (CPAD 2014) within the upper Pajaro River watershed. The accompanying bar chart (Figure 16) and Table 7 show the relative proportion and number of stream miles that are within the SMP boundary, District-owned, or protected lands based on CPAD (2014). The District owns a larger portion of unnatural stream reaches within the Llagas Creek valley floor (see Figure 13 for extent of unnatural streams). Note that these landscape extents overlap, so the miles of stream they represent are not mutually exclusive. For example, around Uvas Dam and Reservoir and Chesbro Reservoir (Llagas watershed), District-owned and CPAD protected lands overlap by about 12 miles (measurement includes the stream flow network passing through those reservoirs).

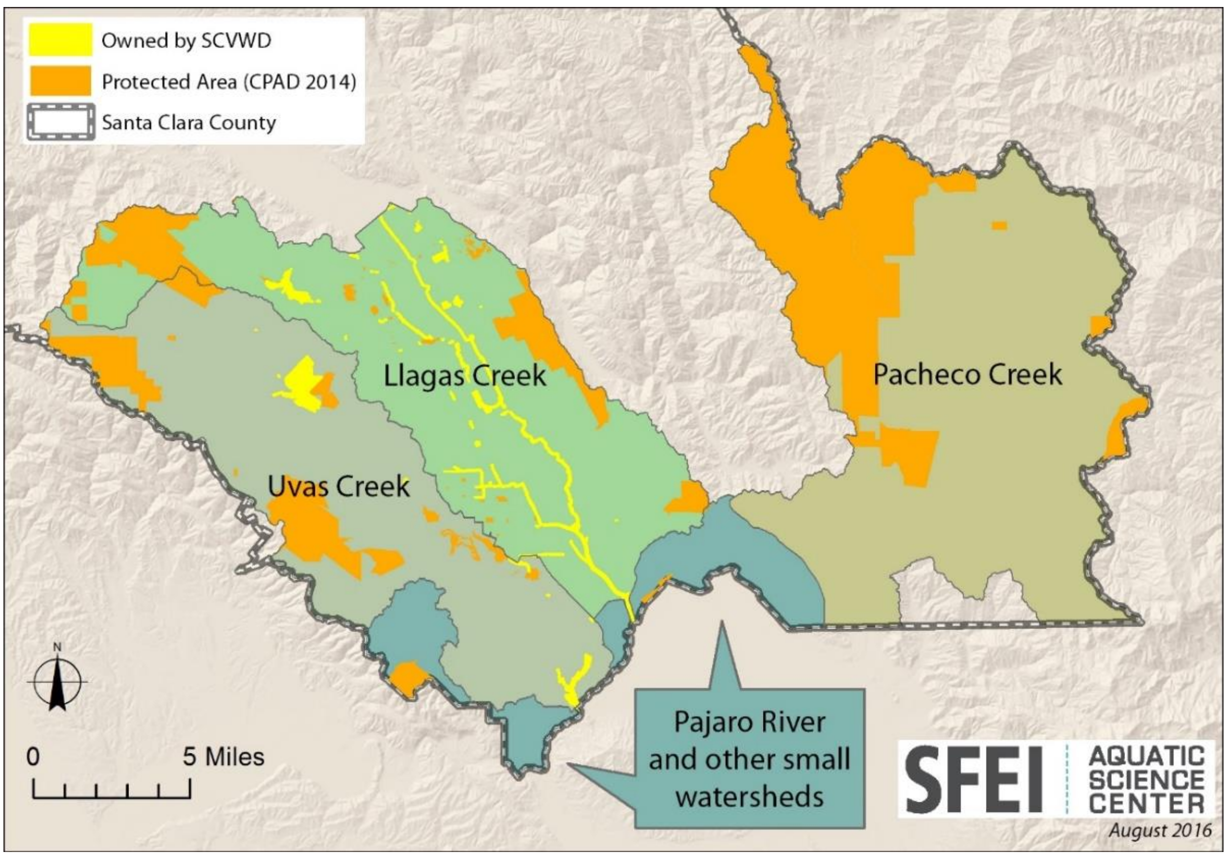


Figure 15. Map of District-owned and other protected areas based on the District's fee title (August, 2016) and the California Protected Areas Database (CPAD 2014) GIS datasets.

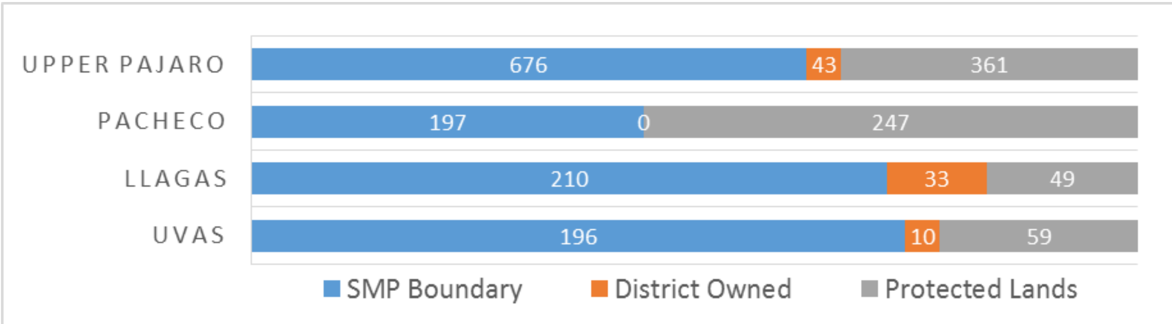


Figure 16. Relative proportion and number of stream miles that are within the District's SMP 1,000 foot boundary, District-owned (2016), or in protected lands (based on CPAD 2014) for the upper Pajaro River watershed study area and its three PAIs.

Table 7. Stream miles within the upper Pajaro River watershed study area, SMP, District-owned, and CPAD protected lands

Primary Area of Interest (PAI)	Total Stream Miles	Within the SMP 1000' Elevation	District Owned	CPAD Protected Lands
Pacheco Creek	813	197	0	247
Llagas Creek	252	210	33	49
Uvas Creek	312	196	10	59
Pajaro River and other small watersheds	95	74	0	6
Total	1,472	676 (46%)	43 (3%)	361 (25%)

The District does not own large lengths of the stream network (only 3%). Approximately 1/3 of the streams are either District-owned or within protected lands. This shows the importance of creating partnerships within the watershed in order to effectively manage and protect resources, and achieve desired goals. However, the District can significantly influence the delivery of water and sediment in the Uvas and Llagas systems since it owns reservoirs, and mainstem channels in lower portions of the watersheds.

Level-2 Stream Ecosystem Condition based on CRAM

The District and its consultants assessed 81 CRAM assessment areas (AAs) within the upper Pajaro River watershed. The GRTS sample design specified 88 target AAs. A total of 151 candidate AAs were considered, 70 of which were rejected due lack of legal access or dangerous terrain. Figure 17 shows a map of the distribution of the candidate AAs that were either assessed or rejected.

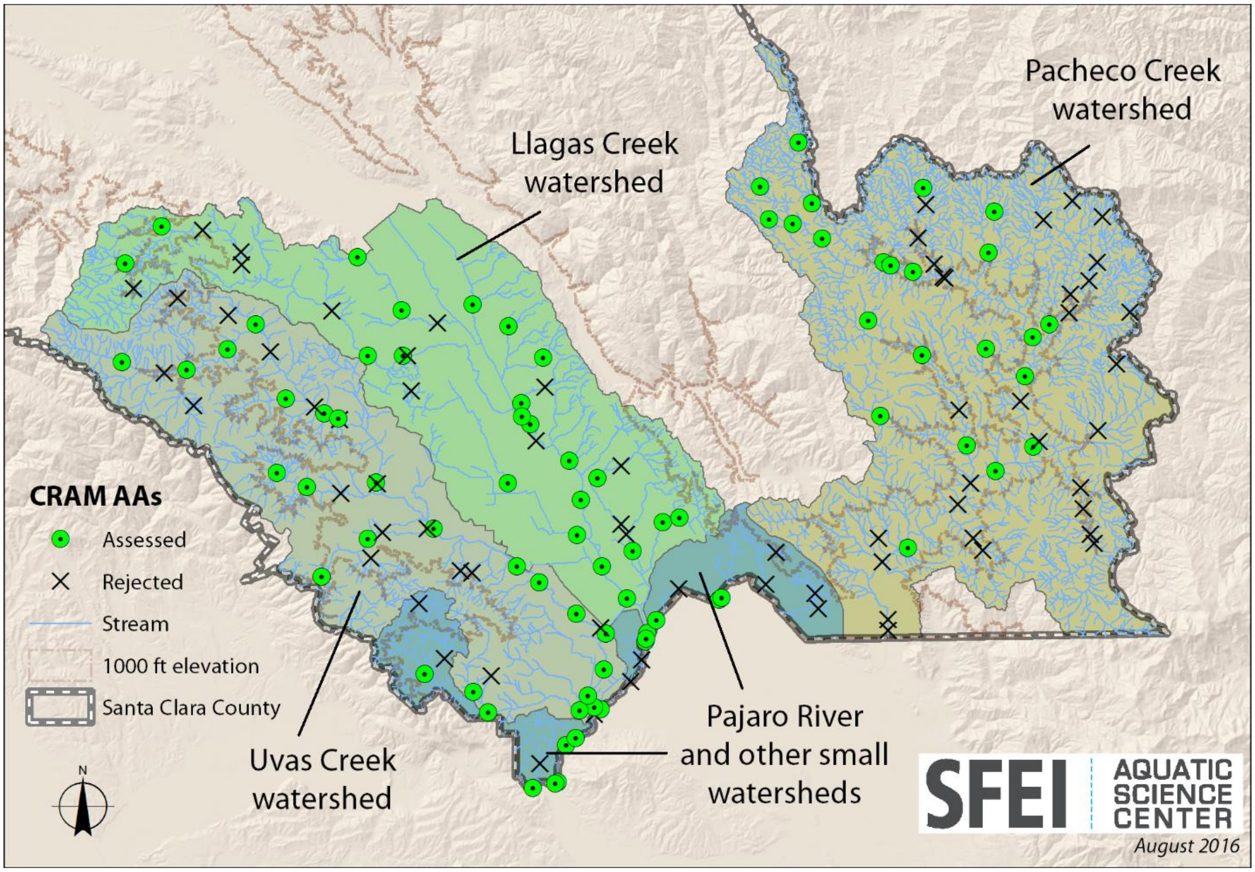


Figure 17. Distribution of CRAM stream survey locations assessed (green dots, n = 81) and rejected (black x) within the upper Pajaro River watershed study area.

The distribution of AAs that were rejected indicate five watershed areas where assessment was desired, but not possible due to access, and other restrictions: Pacheco Creek, northeast and southeast edges; confluence of Pacheco Creek and Pajaro River; north part of Llagas Creek; and a southwest portion of Uvas Creek. District staff, familiar with watershed conditions, decided missing these areas did not effectively change overall watershed health conditions determined by the multiple locations assessed using CRAM.

The number of target and oversample CRAM AAs measured throughout the three PAIs, Pajaro River and other small watersheds (primarily portions of the Pescadero Creek watershed) are listed in Table 8. Twenty-three assessments were successfully completed in each PAI; 12 assessments were completed in the Pajaro River mainstem and other small tributaries (9 on the Pajaro River and 3 on Pescadero Creek).

Table 8. Upper Pajaro River watershed CRAM AAs measured in 2016

Watershed	Target	Target Completed	Oversample Completed	Total Completed	% Completed
Pacheco	30	15	8	23	77
Llagas	24	19	4	23	96
Uvas	24	16	7	23	96
Pajaro mainstem & other small watersheds	10	6	6	12	120
Total	**88**	**56**	**25**	**81**	**92**

Applying the Riverine assessment method, CRAM provides numerical scores reflecting the overall potential of streams with their wetland and riparian habitats to provide high levels of the ecological services expected for the area given its type, condition, and environmental setting. CRAM Scores are based on visible indicators of physical and biological form and structure relative to best achievable conditions statewide.

To investigate stream ecosystem condition in the upper Pajaro River watershed, results from the 81 AAs within the 2015 CRAM ambient survey were analyzed to:

1. Evaluate the overall ecological condition of streams in the whole watershed;
2. compare the three PAIs;
3. compare conditions of the upper Pajaro River watershed to other watersheds;
4. review CRAM Attribute Scores and Stressor Checklist to identify potential stressors that might be impacting stream health within the three PAIs; and
5. calculate the watershed baseline ESIs of the streams in the watershed as a whole and its three PAIs, using the District's EMAF ecological service index methodology described in the methods section.

- *What is the overall ecological conditon of streams in the upper Pajaro River watershed?*

Figure 18 is a map of the assessed AAs showing their health class based on CRAM Score. Good conditions were most frequently observed in the upper reaches of the channel network. This reflects the nearly ubiquitous tendency for the overall condition of streams to decrease downstream, as the intensity and diversity of land uses increase. The Pacheco Creek watershed appears to have a relatively even spatial distribution of sites in the fair and good condition. The separation of good and fair conditions between upper and lower reaches is more obvious within the Llagas and Uvas watersheds.

The streams estimated to be in poor condition are represented by a single AA located on a second-order stream in the southern part of the Uvas Creek sub-watershed (Figure 17). There is no indication that these lower order streams were under-sampled. It can therefore be assumed that poor conditions are uncommon. It is estimated that 8% and 37% of the streams in the entire upper Pajaro River watershed and the Uvas watershed (respectively) are in poor condition, but the uncertainty is relatively high. The one AA, in poor condition, is located in the lower elevations of the watershed, where agriculture and ranching are more intensive.

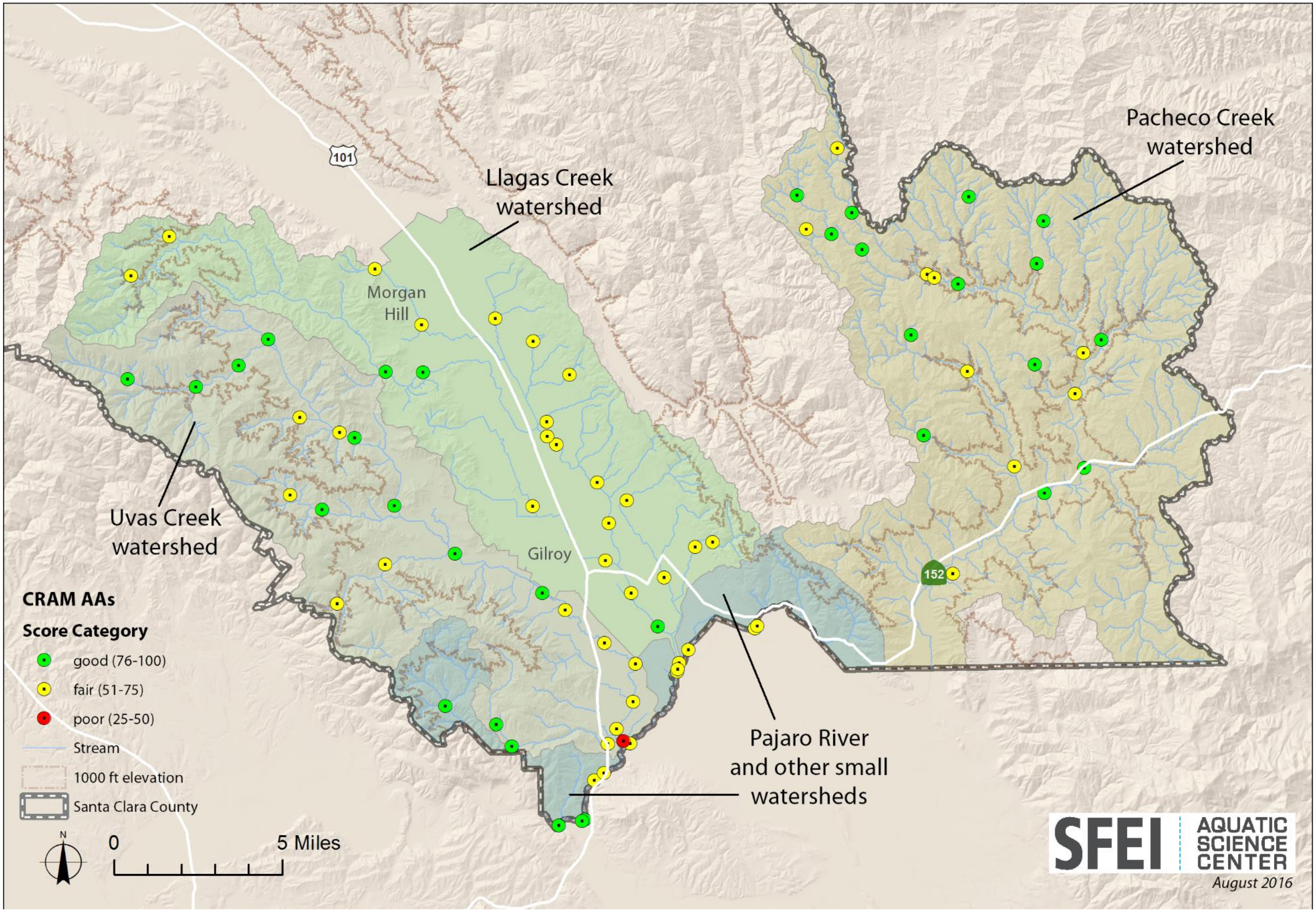


Figure 18. 2015 CRAM Assessment Areas (AAs) for the upper Pajaro River watershed and its PAIs

The overall ecological condition of streams in the upper Pajaro River watershed can be characterized as fair to good. This determination is based on a number of different analyses of the CRAM data.

Table 9 presents basic summary statistics of the *actual* CRAM Index Scores for the upper Pajaro River watershed including the minimum, maximum, median, mean, and standard deviation (Std. Dev). Please note that these statistics do not take into account the survey design's sample weights.

Table 9. Summary of CRAM Index Scores for the upper Pajaro River watershed and its PAIs based on the CRAM survey 2015.

	N	Min	Max	Median	Mean	Std. Dev.
Upper Pajaro	81	44	87	73	71	10
Pacheco	23	54	86	80	77	8
Llagas	23	51	85	62	64	10
Uvas	23	44	87	74	74	10

The CDFs for the upper Pajaro watershed and its PAIs were produced based on the sample-weighted CRAM Index Scores (Figure 19) that estimate proportions of the stream length that have a specific CRAM Score (or lower). The CDF plots were partitioned into poor, fair, and good health classes based on three equal-intervals of the full range of possible CRAM Index Scores. Since the Index Scores can range from 25 to 100, the health classes are delimited as ≤50 (poor health), 51-75 (fair health), and >75 (good health).

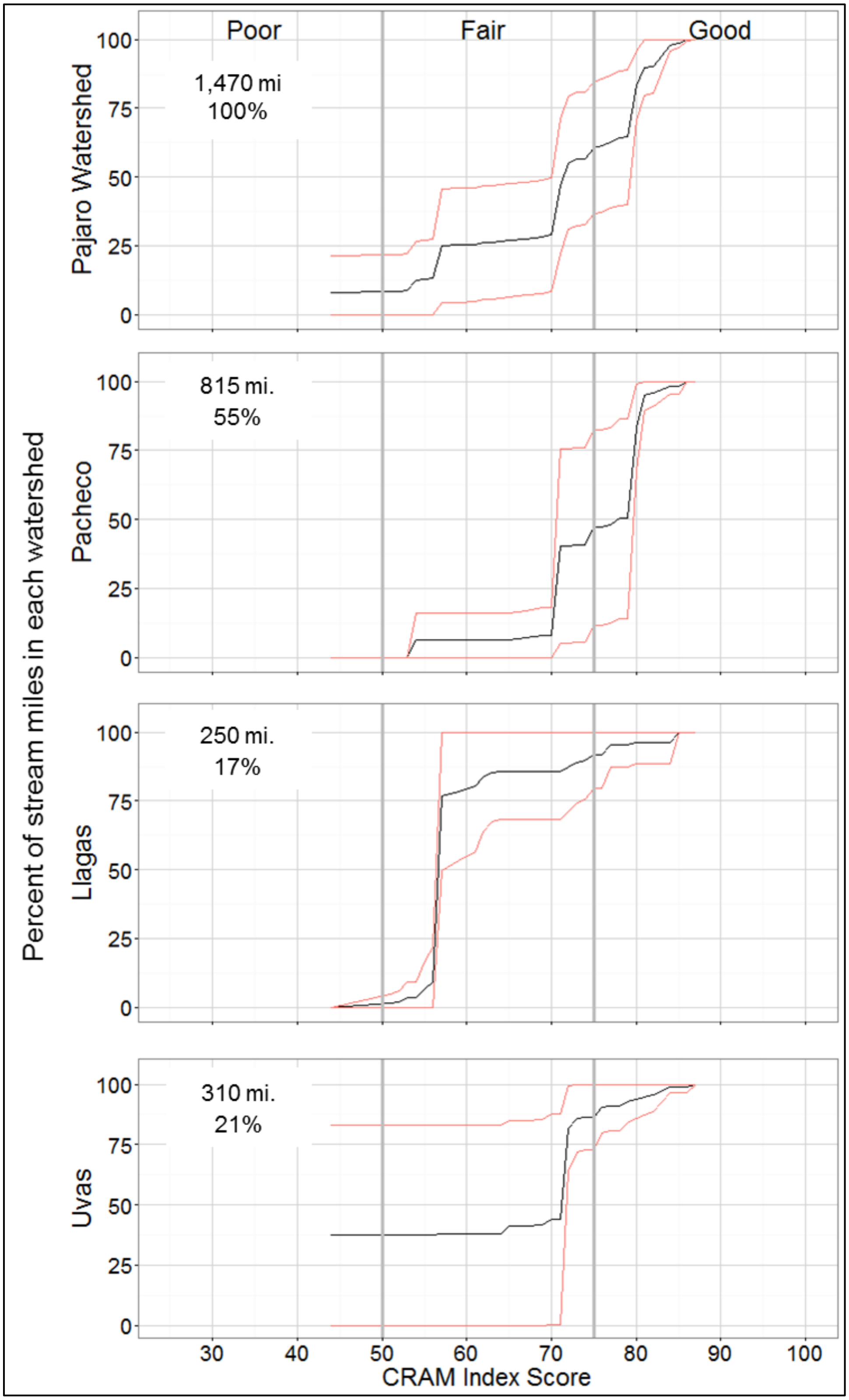


Figure 19. CDF plots of CRAM Index Scores for the upper Pajaro River watershed and its PAIs showing the distribution of scores among the three classes of health condition defined as three equal-intervals of the full range of possible scores (i.e., ≤50, 51-75, >75).

Shapes of the CDFs provide information about overall stream condition. The CDF plots based on CRAM Index Scores are commonly s-shaped or sigmoid. The s-shape is characterized by a gradual increase in slope across the low range of scores, a steep increase in slope in the mid-range of scores, and a gradual increase in slope or flattening of the curve in the high scores. This is because there are generally few very low Index Scores and few very high Index Scores. This is certainly evident for the Llagas CDF, which has a single upturn, but not the case for Pacheco or upper Pajaro River watershed as a whole, for which the CDFs have multiple upturns.

There may be several reasons for multiple upturns in the CDF for Pacheco, which are not obvious, but might relate to spatial land use patterns, such as Henry Coe State Park and relatively low urban development. For the upper Pajaro River watershed as a whole, the multiple upturns can be explained by the component CDFs for the PAIs. When the data for the PAIs are combined, each of their upturns, which occur at different positions along the condition gradient, are evident in the overall CDF. This signifies the importance of stratifying the overall watershed into its PAIs, especially if they differ in natural or anthropogenic character.

The position of the upturn in the s-shaped curve also has meaning. The further the upturn is shifted to the right along the condition gradient (x-axis), the greater the relative proportion of streams in fair to good condition. For Pacheco, there is a steep upturn within the range representing good condition, whereas for Llagas and Uvas watersheds, the upturns occur further left, in the range of fair condition. This signifies that conditions are generally better in the Pacheco watershed. Furthermore, the upturn in scores occurs further to the left of for Llagas than for Uvas, suggesting that a higher proportion of stream conditions are generally in better for Uvas than for Llagas.

Figure 20 summarizes information from the CDFs, providing the following basic facts:

- 39% of streams in the upper Pajaro River watershed are in good condition;
- 53% of streams in the upper Pajaro River watershed are in fair condition; and
- 8% of streams are in poor condition.

Streams in the three creek subwatersheds or PAIs differ markedly in condition.

  - Pacheco has the best overall condition (53% good, 47% fair);
  - Llagas creeks are predominantly in fair condition (92%); and
  - Uvas creeks are mostly in fair to poor condition although the relative proportions of stream in each category is difficult to assess due to the unusually large 95% confidence intervals that confound the results.

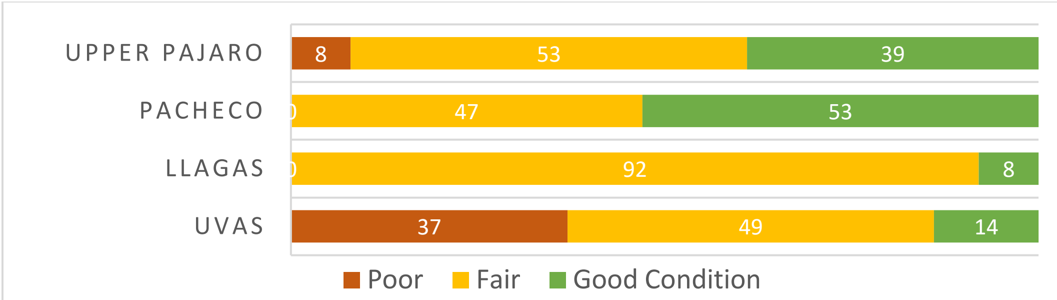


Figure 20. Percent of stream miles in the upper Pajaro River watershed and its three PAIs in poor, fair, or good condition based on their CDFs for the CRAM Index Scores.

The underlying CRAM Attribute Scores, which comprise the Index Scores, are presented in Figure 21 as side-by-side CDF plots for each of the three PAIs and the entire upper Pajaro River watershed. The shapes of the curves provide a visual comparison of similarities and differences between core wetland functions within a watershed and between them.

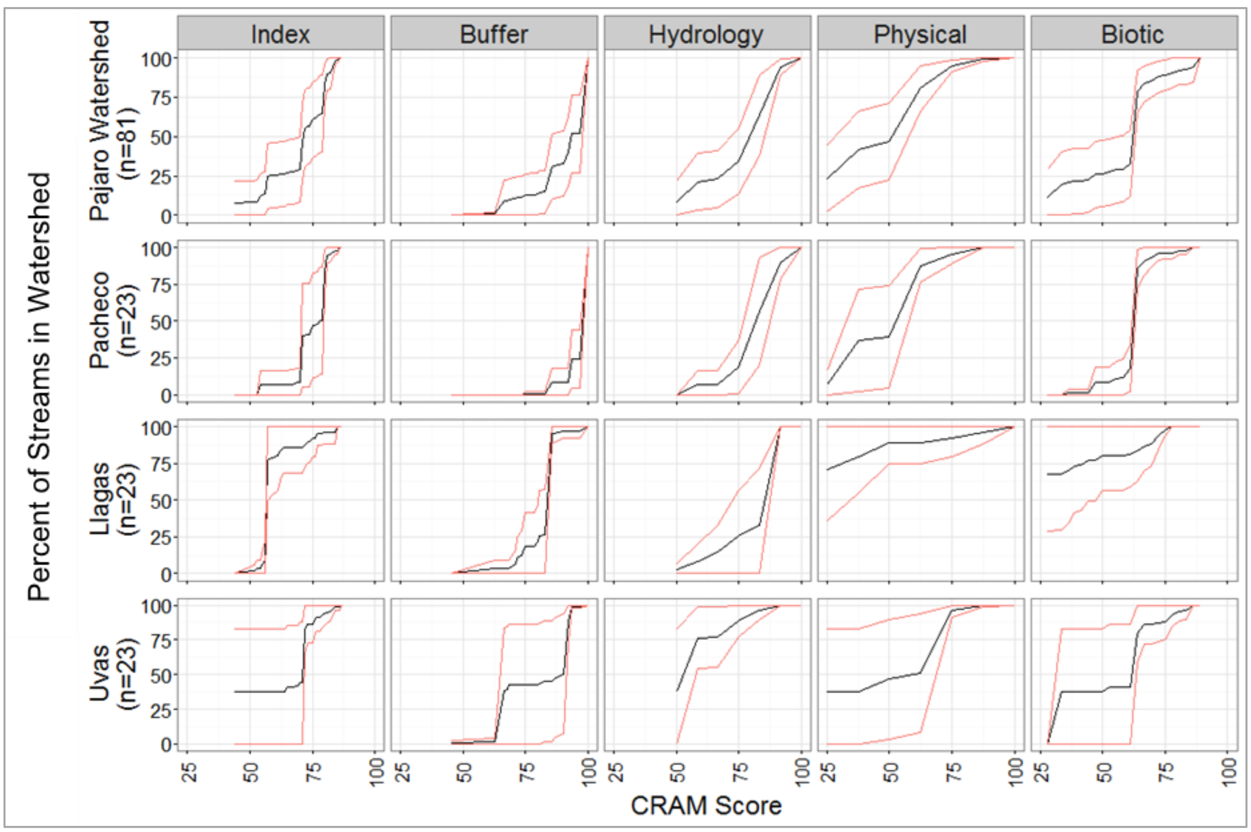


Figure 21. CDF plots of the CRAM Index and Attribute Scores for the upper Pajaro River watershed and its three PAIs.

In general, the CDF of Buffer and Landscape Context Attribute is shifted to the right for each watershed. This suggests that most streams in the watershed have good buffers and their surrounding landscapes support aquatic resources. The Pacheco watershed has the best buffer condition, which reflects its rural land uses, and public lands such as Henry Coe State Park. For the Uvas watershed, the CDF has very wide confidence limits making it difficult to interpret. The two upturns indicate about half of the streams represented by scores in the 60s, and the other half represented by scores in the 80s and 90s. This likely reflects one very low, heavily weighted, condition score in a 2nd order stream reach that represents an inordinately large portion of the stream network in that watershed.

With regard to the Hydrology Attribute, CDFs for Pacheco and Llagas watersheds are very similar. They are concave in overall shape, have similar “50th percentile scores”, and occupy similar positions along the condition gradient. However, the Uvas watershed Hydrology CDF is convex and has a much lower “50th percentile score”, indicating a greater abundance of streams with lower Hydrology Scores. All three creek watersheds have water supply reservoirs.

The Physical Structure Attribute Scores tend to indicate poor to fair condition. Poor physical structure is particularly prevalent for Llagas, where much of the mainstem channels are altered and simplified for efficiently conveying floodwaters (refer back to Figure 13). Much of the complexity typical of natural streams is lacking.

The Biotic Structure Attribute Scores for the three watersheds have markedly different CDFs. For the Pacheco watershed, the CDF is strongly s-shaped, with an upturn in the mid-range of scores, and the large majority of streams having fair condition. The Biotic Structure CDF for the Llagas watershed closely resembles its CDF for Physical Structure, with an overall concavity and clear dominance by poor to fair condition streams. The Biotic Structure CDF for the Uvas watershed resembles its CDF for Buffer and Landscape Context, since both have two upturns. However, the Uvas Scores for Biotic Structure tend to be lower than its Scores for Buffer and Landscape Context.

- *What are the baseline ESIs based on the 2015 CRAM stream survey?*

An ESI is a numerical statistic developed by the D5 Project, representing the sample-weighted average CRAM Index Score for a watershed or PAI based on its CDF. The ESI can be used to track stream ecosystem condition over time and a basis for establishing quantitative ecological levels of service (LOS), or benchmarks of performance. It is expected from the D5 Project that the District will set LOS for each of the 5 watersheds, and potentially subwatersheds (PAIs), taking into account specific, planned management actions, and/or needs. Progress towards meeting those performance targets can be tracked over time using the watershed approach. The District could further refine targets using intensive special studies to monitor site specific measures (e.g. Level-3 assessments of fish habitats, flow, wildlife, vegetation, etc.).

The baseline ESIs for the upper Pajaro River watershed as a whole and its three PAI's are presented graphically in Figure 22, and they are listed below in Table 10. Table 11 compares ESIs for the upper Pajaro River watershed and other watersheds assessed by the D5 Project.

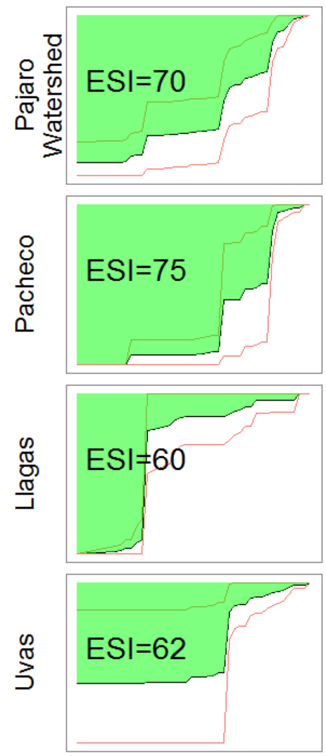


Figure 22. Calculated ESIs for the upper Pajaro River watershed and its three PAIs based on the 2015 stream condition survey and resulting CRAM Index Score CDF.

Table 10. Comparison of the ESIs for the upper Pajaro River watershed and its three PAIs.

	ESI (95% CI)
Pajaro Watershed	70 (63-77)
Pacheco Creek	75 (70-80)
Llagas Creek	60 (56-65)
Uvas Creek	62 (49-75)

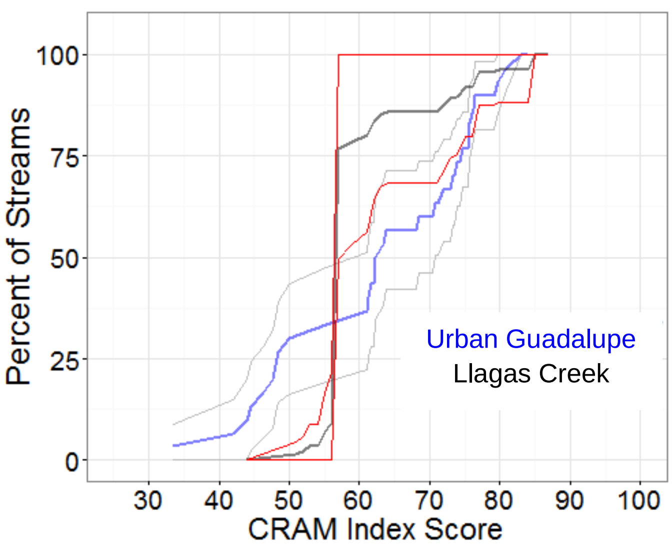
Table 11. Comparison of the ESIs for three major watersheds in Santa Clara County assessed by the District to date, and based on their CRAM Index Score CDFs.

Watershed	ESI (95% CI)	ESI (95% CI) for PAIs		
Pajaro Watershed (2015)	70 (63-77)	Pacheco = 75 (70-80)	Llagas = 60 (56-65)	Uvas = 62 (49-75)
Coyote Creek (2010)	75 (72-78)	Upper Penitencia = 73 (70-75)		
Guadalupe River (2012)	68 (65-71)	Non-urban = 72 (70-75)	Urban = 63 (57-68)	

For resource management decisions, the shape of the CDF should be considered in establishing a target LOS and prioritizing actions to achieve the target, rather than an ESI. The ESIs, by themselves, can oversimplify differences in stream condition between watersheds or PAIs. For example, the urban area within the Guadalupe River watershed has a similar ESI to the Llagas watershed (which is largely agricultural and suburban), but shapes of the CDFs for the two areas are markedly different.

To illustrate this point, Figure 23 overlays the CDFs for the urban areas of the Guadalupe River watershed and the entire Llagas Creek watershed and includes a table that lists specific percentages of stream lengths and Index Scores (with 95% confidence levels in parentheses) that are also shown in the figure.

Although ESIs for the two PAIs are similar (63 and 60, respectively), 75% of the stream miles in the Llagas watershed have relatively low CRAM Index Scores of 57 or less, while 75% of the urban streams in the Guadalupe watershed have Index Scores of 75 or less. 25% of urban streams in the Guadalupe River watershed are in poor condition (Scores ≤ 50), while <5% of the streams in the Llagas Creek watershed were found to be in poor condition. These differences are not revealed when looking at the ESI alone.



% of Streams	Urban Guadalupe Index Score (n=30)	Llagas Creek Index Score (n=23)
5	38 (34 - 44)	54 (44 - 56)
10	44 (34 - 48)	56 (44 - 56)
25	48 (44 - 61)	56 (44 - 57)
50	62 (58 - 72)	57 (44 - 85)
75	75 (71 - 76)	57 (44 - 85)
90	77 (76 - 82)	74 (57 - 85)
95	80 (76 - 83)	77 (63 - 85)
Mean	**63 (59 - 66)**	**60 (56 - 64)**
Std. Dev.	13 (11 - 15)	8 (3 - 12)

Figure 23. CDF plots that overlay the urban area of the Guadalupe River watershed (blue with grey 95% confidence lines) and Llagas Creek watershed (black with red 95% confidence lines) and a separate table that lists specific percentages of stream lengths and Index Scores (with 95% confidence levels in parentheses) that are also shown in the figure (y- and x-axes respectively).

- *How does the overall ecological condition of streams in the upper Pajaro River watershed compare to other watersheds in the District, and other regions?*

Figure 24 compares the upper Pajaro River watershed to the other Santa Clara County watersheds surveyed by the District's D5 Project, two San Francisco Bay area ecoregions, and statewide results based on steam conditions assessed using CRAM[8]. In each case, the figure shows the relative proportions of stream miles in poor, fair, and good ecological health.

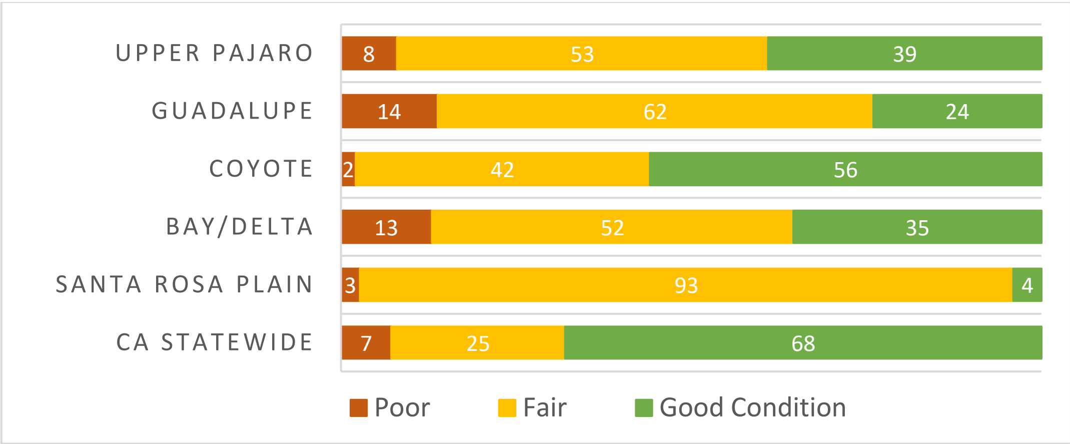


Figure 24. Comparison of watersheds based on probabilistic surveys of stream condition using CRAM.

- *What is the condition of higher order streams that are generally at lower elevation?*

A GRTS field survey can be subset (or enhanced) to further evaluate specific portions of a surveyed resource. For example, the Coyote Creek watershed assessment (conducted in 2010) included an intensification of CRAM assessments in the upper Penitencia sub-watershed to specifically characterize stream conditions in that region using a higher density of assessments. In the upper Pajaro River watershed survey, the District is particularly interested in the higher stream order (generally lower elevation) streams where it has more opportunities to manage stream resources. The condition of higher order streams was examined separately by sub-setting the CRAM data for stream orders 3 through 7. This involved excluding eight CRAM AAs in 1st and 2nd order streams and developing new CDF plots for that sub-region of the watershed, which includes about 1/3 of the whole stream network.

The CRAM CDFs for the lower elevation streams (3rd to 7th order) are presented in Figure 25. Sub-setting the data resulted in smaller 95% confidence intervals, and shifted the curves to the right along the condition gradient (compare Figures 18 above and 24 below).

[8] Data are from the following CRAM surveys: upper Pajaro River (District 2015), Guadalupe River (District 2012), Coyote Creek (District 2010), Bay/Delta Eco-Region based on a subset of PSA 2008-2014 data from the Surface Water Ambient Monitoring Program (SWAMP 2016), Santa Rosa Plain (Collins *et al.* 2014), and Statewide (PSA & SoCal SMC 2008-2014 data).

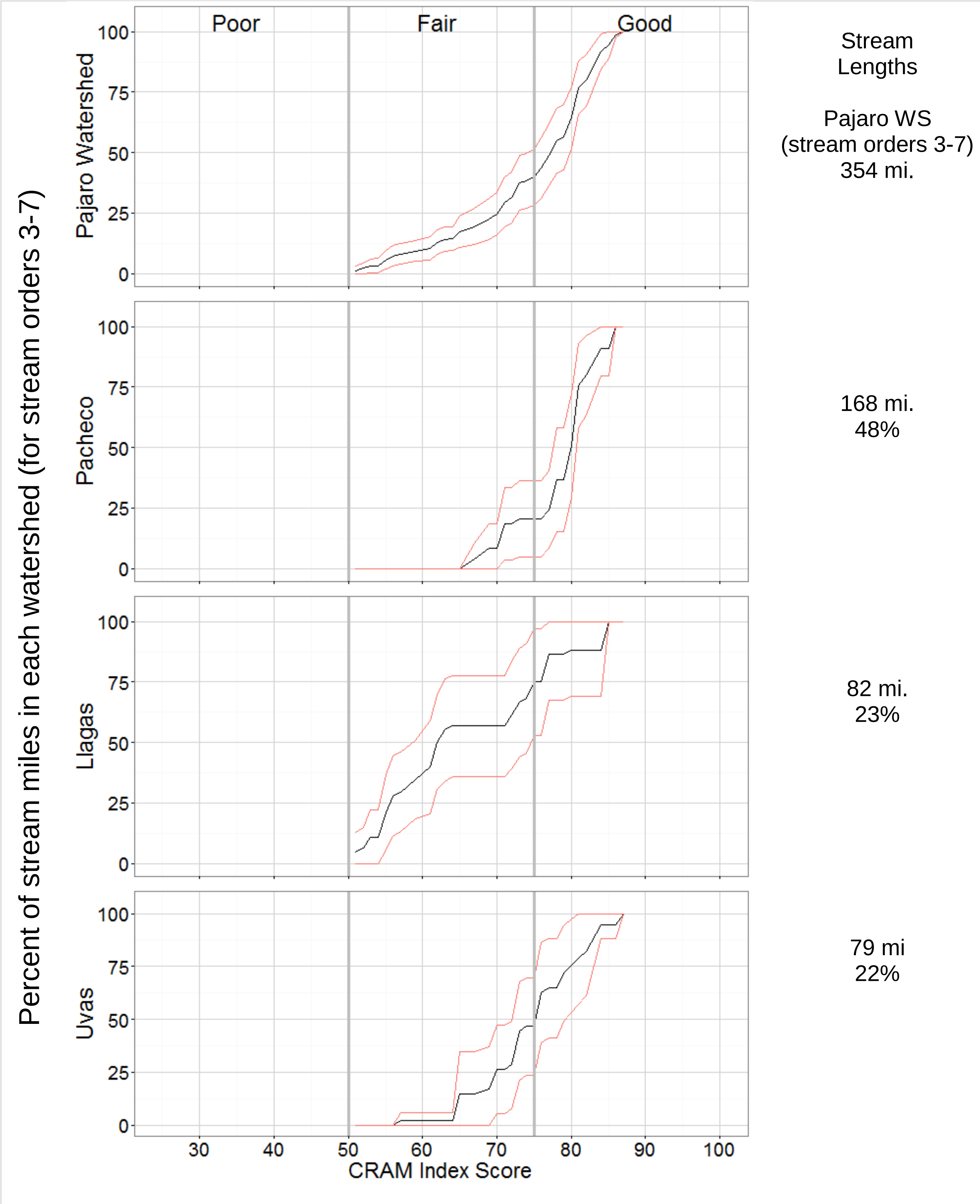


Figure 25. CDFs for the CRAM Index Scores of stream orders 3 -7 within the upper Pajaro River watershed and its three watersheds.

The shapes of the CDFs for Uvas and Pacheco watersheds are concave compared to the CDF for the Llagas watershed. This was observed for the full dataset as well (see Figure 18), indicating a greater portion of streams in the Llagas watershed are in lower condition than in Pacheco and Uvas watersheds. For example, looking vertically, across all the plots in Figure 25, at a CRAM Index Score of 75 (bold grey line indicating the cut-point between fair and good condition), 75% of the 3rd to 7th order streams in the Llagas watershed have CRAM Index Scores of 75 or less, whereas the Pacheco and Uvas watersheds have 21% and 47% of their streams scoring 75 or less (respectively).

The CDFs for stream orders 3-7 have tighter confidence intervals and are shifted slightly to the right, with no indication that any of the stream reaches are in poor condition. Basic facts about stream conditions in this sub-region of the watershed are more reliable (because of the tighter confidence limits – especially in the Uvas watershed) and indicate:

- 60% of 3rd – 7th order streams in the Upper Pajaro River watershed are in good condition; and
- 40% of 3rd – 7th order streams in the Upper Pajaro River watershed are in fair condition; and
- 3rd – 7th order streams in the three PAIs differ markedly in condition:
    - Pacheco has the best overall condition (79% good, 21% fair);
    - Llagas creeks are predominantly in fair condition (75%); and
    - Uvas creeks are a mix of fair and good condition (53% good, 47% fair).

Why did excluding results for 1st and 2nd order streams narrow the confidence intervals?

There are two reasons why the confidence intervals for the CDFs were increased by the sample data for 1st and 2nd order streams: the greater than expected variation in CRAM Scores within these stream orders, and the larger proportion of the stream system represented by their small sample size.

The sample draw stratified the AAs based on the PAIs and stream order. More AAs were allocated to the Uvas and Llagas watersheds, and to the lower elevation, higher-order channels (orders 3-7) than would have been allocated without any stratification. The stratification was done to assure adequate assessment of areas where the District's management opportunities are concentrated. Previous CRAM surveys of stream condition for the Coyote Creek and Guadalupe River watersheds indicated that 1st and 2nd order streams were homogenous in condition and therefore could be adequately assessed with small numbers of AAs. Similar conditions were expected for 1st and 2nd order streams in the upper Pajaro River watershed. However, the condition of these streams was more variable than expected.

Perhaps variability in upper Pajaro watershed creeks should have been predicted, since it is the only County watershed spanning very different moisture conditions and habitats, from the wet coast redwood (*Sequoia sempervirens*) and Douglas fir (*Pseudotsuga menziesii*) forest covering the Santa Cruz Mountains, across the entire valley and oak (*Quercus spp.*) savannah hills, to the drier eastern blue (*Q. douglasii*) and black oak (*Q. kelloggii*) with gray pine (*Pinus sabiniana*) dominated forests of the Hamilton (a.k.a., Diablo) Range. The Pajaro watershed in Santa Clara

County includes all habitats and climate conditions found in the Guadalupe and Coyote Creek watersheds combined.

The inclusion of their scores in the dataset increased the sample variance for each PAI. First and 2nd order streams comprise about 75% of the total stream miles in the upper Pajaro River watershed. Therefore, each of the eight CRAM assessments for 1st and 2nd order streams represented a very large proportion of the entire stream network and, since their CRAM Scores varied widely (range 44 - 81), they contributed a high degree of variability to scores for the watershed as a whole. Excluding the scores for 1st and 2nd order streams caused the remaining 25% of the stream network to be more spatially balanced among the remaining 73 AAs, which tightened the confidence intervals.

- *What are the likely stressors impacting stream condition based on the CRAM Stressor Checklist?*

The CRAM field assessment includes a Stressor Checklist that records the presence and absence of 48 different stressors, and indicates if the assessment team expects a stressor significantly and adversely impacts the AA, based on standard indicators and sets of considerations. For example, to be present, stressors for Hydrology, Physical Structure, and Biotic Structure must be evident within a distance of 50 m from the edge of the AA; for Buffer and Landscape Context, stressors must be evident within a distance of 50 m from the edge of the AA.

Table 12 indicates the percentage of AAs within the upper Pajaro River watershed three PAIs where each stressor was observed by field Practioners, and the percentage of AAs where the observed stressors are likely to have significant and adverse impact on the AA. It should be noted that the relative importance of different stressors is not considered by CRAM. The Checklist simply records the presence or absence of stressors, plus a fairly subjective determination if observed stressors are causing significant negative impacts on the AA. The CRAM Practitioner is not asked to rank stressors, nor provide any additional information about their frequency, duration, intensity, or extent. However, Practitioners are taught that stressors should be considered significant if they are directly affecting the score of any given CRAM Metric, or if they clearly affect the morphology or natural processes within the AA or its buffer. It should also be noted that many of the urban stressors are ubiquitous, and intrinsic to urban environments, and are very difficult to eliminate. Thus, for the urbanized portions of the watershed, we expect stressors such as transportation corridor, urban residential, and non-point source discharges to be common. The negative effect of some stressors can be mitigated through riparian buffers and /or changes in stream management practices. The last two columns in Table 11 indicate if the stress is responsive to those mitigation efforts.

Table 12. The CRAM Stressor Checklist with an indication of the percent of AAs where stressor was observed, the percent of AAs where the stressor was considered to cause significant negative impacts, and an indication if the stressor is responsive to having additional riparian buffer or changes in stream management practices.

Attribute	Stressor	Percent AAs where stressor was observed				Percent AAs where stressor was significant				Responsive to Buffer	Responsive to Management Practices
		Upper Pajaro	Pacheco	Llagas	Uvas	Upper Pajaro	Pacheco	Llagas	Uvas		
Buffer & Landscape Context	Active recreation (off-road vehicles, mountain biking, hunting, fishing)	16	44	9	9	0	0	0	0	X	
	Commercial feedlots	1	0	0	4	1	0	0	4	X	
	Dams (or other major flow regulation or disruption)	7	11	9	4	3	6	0	4		X
	Dryland farming	8	0	9	13	3	0	0	4	X	
	Industrial/commercial	12	0	22	17	3	0	0	9	X	
	Intensive row-crop agriculture	39	0	52	39	21	0	22	30	X	
	Military training/Air traffic	0	0	0	0	0	0	0	0		
	Orchards/nurseries	9	0	26	4	1	0	4	0	X	
	Passive recreation (bird-watching, hiking, etc.)	26	50	30	17	0	0	0	0	X	X
	Physical resource extraction (rock, sediment, oil/gas)	1	6	0	0	0	0	0	0	X	X
	Ranching (enclosed livestock grazing or horse paddock or feedlot)	16	17	13	9	3	6	0	4	X	
	Rangeland (livestock rangeland also managed for native vegetation)	24	22	9	26	0	0	0	0	X	
	Sports fields and urban parklands (golf courses, soccer fie	5	6	4	9	0	0	0	0	X	
	Transportation corridor	53	17	57	61	11	6	4	17	X	
	Urban residential	26	6	48	35	4	6	0	9	X	

Table 12 continued. The CRAM Stressor Checklist with an indication of the percent of AAs where stressor was observed, the percent of AAs where the stressor was considered to cause significant negative impacts, and an indication if the stressor is responsive to having additional riparian buffer or changes in stream management practices.

Attribute	Stressor	Percent AAs where stressor was observed				Percent AAs where stressor was significant				Responsive to Buffer	Responsive to Management Practices
		Upper Pajaro	Pacheco	Llagas	Uvas	Upper Pajaro	Pacheco	Llagas	Uvas		
Hydrology	Actively managed hydrology	3	0	4	4	1	0	0	4		X
	Dams (reservoirs, detention basins, recharge basins)	3	6	0	4	3	6	0	4	X	X
	Dike/levees	5	0	17	0	1	0	4	0	X	
	Ditches (agricultural drainage, mosquito control, etc.)	4	0	4	9	1	0	0	4	X	X
	Dredged inlet/channel	1	0	4	0	0	0	0	0		
	Engineered channel (riprap, armored channel bank, bed)	7	0	4	17	1	0	4	0		X
	Flow diversions or unnatural inflows	1	0	0	4	0	0	0	0		X
	Flow obstructions (culverts, paved stream crossings)	5	0	9	9	0	0	0	0		X
	Groundwater extraction	4	0	9	4	0	0	0	0		
	Non-point Source (Non-PS) discharges (urban runoff, farm drainage)	55	11	70	65	4	0	0	9	X	
	Point Source (PS) discharges (POTW, other non-stormwater discharge)	5	0	9	9	0	0	0	0		X
	Weir/drop structure, tide gates	4	0	9	4	1	0	4	0		X

Table 12 continued. The CRAM Stressor Checklist with an indication of the percent of AAs where stressor was observed, the percent of AAs where the stressor was considered to cause significant negative impacts, and an indication if the stressor is responsive to having additional riparian buffer or changes in stream management practices.

Attribute	Stressor	Percent AAs where stressor was observed				Percent AAs where stressor was significant				Responsive to Buffer	Responsive to Management Practices
		Upper Pajaro	Pacheco	Llagas	Uvas	Upper Pajaro	Pacheco	Llagas	Uvas		
Physical Structure	Bacteria and pathogens impaired (PS or Non-PS pollution)	7	0	4	9	5	0	4	9	X	
	Excessive runoff from watershed	1	0	0	4	0	0	0	0	X	X
	Excessive sediment or organic debris from watershed	5	0	9	4	3	0	0	4	X	X
	Filling or dumping of sediment or soils (N/A for restoration areas)	3	0	4	0	0	0	0	0	X	X
	Grading/compaction (N/A for restoration areas)	17	11	35	4	1	0	0	0	X	
	Nutrient impaired (PS or Non-PS pollution)	8	0	4	13	5	0	4	9	X	
	Pesticides or trace organics impaired (PS or Non-PS pollution)	14	0	9	22	3	0	0	4	X	
	Plowing/Discing (N/A for restoration)	36	0	43	30	13	0	9	13	X	
	Resource extraction (gravel, oil, gas)	0	0	0	0	0	0	0	0	X	
	Trash or refuse	38	11	61	26	0	0	0	0	X	X
	Vegetation management	17	0	35	17	5	0	9	4	X	X

Table 12 continued. The CRAM Stressor Checklist with an indication of the percent of AAs where stressor was observed, the percent of AAs where the stressor was considered to cause significant negative impacts, and an indication if the stressor is responsive to having additional riparian buffer or changes in stream management practices.

Attribute	Stressor	Percent AAs where stressor was observed				Percent AAs where stressor was significant				Responsive to Buffer	Responsive to Management Practices
		Upper Pajaro	Pacheco	Llagas	Uvas	Upper Pajaro	Pacheco	Llagas	Uvas		
Biotic Structure	Biological resource extraction or stocking (fisheries, aquaculture)	1	0	0	4	0	0	0	0		X
	Excessive human visitation	16	0	26	22	3	0	0	4	X	
	Lack of treatment of invasive plants adjacent to AA or buffer	45	33	52	43	30	28	26	30	X	
	Lack of vegetation management to conserve natural resources	11	0	17	17	4	0	9	4	X	
	Mowing, grazing, excessive herbivory	14	17	25	9	9	6	13	9	X	
	Pesticide application or vector control	18	0	22	17	3	0	0	4	X	
	Predation and habitat destruction by non-native vertebrates (e.g., Virginia opossum, feral pets)	14	6	35	9	0	0	0	0	X	
	Removal of woody debris	4	0	13	0	1	0	4	0	X	X
	Treatment of non-native and nuisance plant species	8	0	13	13	3	0	4	4	X	
	Tree cutting/sapling removal	7	0	13	9	1	0	4	0	X	X

Table 13 summarizes the stressor information. For the purposes of this report, the very important stressors are defined as those that were observed within at least 25% of the AAs within the upper Pajaro River watershed or within at least one of its PAIs, **and** were also expected to significantly impact at least 5% of those AAs. Moderately important stressors are defined as those that were observed within at least 25% of the AAs within the upper Pajaro River watershed or any one of its PAIs, **or** were expected to significantly impact at least 5% of those AAs.

Table 13. Very important and moderately important stressors listed in approximate descending order of importance. See text immediately above for ranking criteria.

Stressor	Upper Pajaro		Pacheco		Llagas		Uvas	
	% AAs Observed	% AAs Impaired	% AAs Observed	% AAs Impaired	% AAs Observed	% AAs Impaired	% AAs Observed	% AAs Impaired
Very Important Stressors								
Non-point Source (Non-PS) discharges (urban runoff, farm drainage)	55	4	11	0	70	0	65	9
Transportation corridor	53	11	17	6	57	4	61	17
Lack of treatment of invasive plants adjacent to AA or buffer	45	30	33	28	52	26	43	30
Intensive row-crop agriculture	39	21	0	0	52	22	39	30
Plowing/Discing (N/A for restoration)	36	13	0	0	43	9	30	13
Urban residential	26	4	6	6	48	0	35	9
Vegetation management	17	5	0	0	35	9	17	4
Mowing, grazing, excessive herbivory	14	9	17	6	25	13	9	9
Moderately Important Stressors								
Trash or refuse	38	0	11	0	61	0	26	0
Passive recreation (bird-watching, hiking, etc.)	26	0	50	0	30	0	17	0
Rangeland (livestock rangeland also managed for native vegetation)	24	0	22	0	9	0	26	0
Grading/compaction (N/A for restoration areas)	17	1	11	0	35	0	4	0
Active recreation (off-road vehicles, mountain biking, hunting, fishing)	16	0	44	0	9	0	9	0
Ranching (enclosed livestock grazing or horse paddock or feedlot)	16	3	17	6	13	0	9	4
Excessive human visitation	16	3	0	0	26	0	22	4

Table 13 continued. Very important and moderately important stressors listed in approximate descending order of importance. See text immediately above for ranking criteria.

Stressor	Upper Pajaro		Pacheco		Llagas		Uvas	
	% AAs Observed	% AAs Impaired	% AAs Observed	% AAs Impaired	% AAs Observed	% AAs Impaired	% AAs Observed	% AAs Impaired
Predation and habitat destruction by non-native vertebrates (e.g., Virginia opossum, feral pets)	14	0	6	0	35	0	9	0
Industrial/commercial	12	3	0	0	22	0	17	9
Lack of vegetation management to conserve natural resources	11	4	0	0	17	9	17	4
Orchards/nurseries	9	1	0	0	26	4	4	0
Nutrient impaired (PS or Non-PS pollution)	8	5	0	0	4	4	13	9
Dams (or other major flow regulation or disruption)	7	3	11	6	9	0	4	4
Bacteria and pathogens impaired (PS or Non-PS pollution)	7	5	0	0	4	4	9	9

The results of the stressor analysis reflect the rural and remote nature of middle and upper reaches in the upper Pajaro River watershed, and the developed or intensively farmed lower reaches. Much of the riparian areas have been invaded by non-native vegetation, and the lack of its effective treatment is the leading stream stressor that is having the most impact in all three PAIs based on the CRAM Stressor Checklist. Much of the middle and lower reaches of the stream systems are bounded by roadways, as reflected by the predominance of transportation stress. Most of each watershed is relatively remote and difficult to access, although many publicly accessible areas are intensively utilized. As a consequence, stressors associated with human visitation, such as trash and passive recreation, are moderately important.

Stream Condition Risks

This report provides a baseline against which future changes in the distribution, abundance and diversity of surface aquatic resources, and the conditions of streams can be assessed for the upper Pajaro River watershed and its three PAIs. When viewed as a whole, the most likely sources of overall change in aquatic resources for the next decade are conversion of open land to urban or suburban uses and climate change. Both are likely to strongly influence all other sources of risk in stream ecosystem health.

The District owns a very small percentage of the stream networks in any of the three PAIs, and the areas it owns are in the lower reaches. This means that streams managed directly by the District are subject to the upstream land management policies and practices of other entities. This puts a premium on partnerships between these entities and the District to manage stressors affecting streams owned by the District. The partnerships might consider setting shared targets LOS using the ESIs developed by the D5 Project based on CRAM, and coordinate their various efforts to reach the targets.

Results of the CRAM survey of overall stream conditions and stress for the upper Pajaro River watershed and its PAIs can be the basis for identifying potential risks that could adversely impact stream conditions within the District's watersheds. This chapter describes some of those risks and suggests what the District might do to ameliorate them.

- *What are the likely sources of risk to stream ecosystem resources?*

A watershed approach to the coordinated management of runoff, water quality, and sediment supplies will be especially important, given that they strongly affect all aspects of stream health. Their effective management will likely involve increasing riparian forest width and the extent of floodplains accessible by moderate to high flows along mid- to high-order channels. These are fundamental considerations about which a great wealth of scientific information is available.

Invasion by alien vegetation is a ubiquitous stressor within the riparian corridors of the watershed. The combined effects of invasion and the narrowing of the riparian zone due to its conversion to agriculture or other development have not been quantified, except in terms of plant community structure. The concomitant effects on wildlife can only be surmised. Significant negative effects on the riparian avian community can be expected. Indirect impacts can also be expected for in-stream aquatic life due to reductions in shade and changes in the quantity and quality of allochthonous inputs of organic matter. Again, these are fundamental considerations about which a great wealth of scientific information is available.

Agriculture is an important industry within the lower teaches of the watershed. However, future conversion of some existing agricultural lands to urban development can be expected. Consequences of agriculture and urban development that can be especially detrimental to stream ecosystems include increased runoff (due to both increased impervious cover as well as the addition of storm drains and ditches to improve drainage), channelization that simplifies channel structure, and conversion of riparian habitat to other land uses. Current environmental review and regulations can curtail these consequences going forward, but the legacy of historical land uses are abundantly evident in the lower reaches of the channel systems. Restoration of healthy streams in these reaches will require significant capital investments, which in turn will require political will, both of which can be difficult to generate. This puts a premium on developing partnerships for setting shared targets for LOS of the stream ecosystem. The target LOS will need to be consistent with existing watershed management objectives relating to water quality control, flood management, and wildlife conservation. Efforts to restore stream health that are not consistent with these objectives risk resistance by the local and regional communities of environmental agencies and advocates.

Climate change, especially changes in the amount or intensity of rainfall, will likely warrant changes in how streams and other aquatic resources are managed. Climate change is addressed separately below.

- *What are the fundamental risks to stream ecosystems presented by climate change?*

Much work is getting started in the Bay Area and elsewhere around the world to forecast changes in climate and to begin preparing for climate change. Work in the Bay Area has recently been catalogued (Association of Bay Area Governments (ABAG 2012). A critical aspect of forecasting and preparing for climate change in a region or watershed is the downscaling of climate change models (Snyder and Sloan 2005, Cayan et al. 2011). Downscaling is a set of techniques that relate local-scale and regional-scale climate variables to the larger scale forcing functions. In essence, it is the effort to predict local and regional climate changes from Global Climate Models. The spatial and temporal precision of downscaling is limited by inexact understanding of the cause-and-effect relationships controlling climate at any scale. The certainty in forecasting is improved when they reflect consistent results from multiple independent climate simulation models. In general, the certainty of forecasts decreases as their spatial scale decreases and their timeframe increases. Long-term forecasts for local settings can be very imprecise or even equivocal (Ackerly et al. 2012).

With regard to the distribution, abundance, diversity, and conditions of aquatic resources in the Bay Area, the most important climatic parameters are precipitation and evaporation. For the upper Pajaro River watershed, the most important physical processes affected by changes in these parameters are evapotranspiration and runoff or stream flow. Changes in these processes can have major effects on the hydrological cycle and therefore, they can influence all ecosystem goods and services, including water supplies. The District should consider the likely consequences of climate change on its mission to meet the demands of its service area for water supplies, flood management, and healthy watersheds.

Forecasts of future climatic conditions based on the best available science suggest precipitation amounts and patterns will change (e.g., storm intensity, frequency), temperatures will rise resulting in increased evaporation, and previously normal seasonal variations will change. These affect flows and hydrology that drive stream ecosystem health. Demand for water resources and flood protection will most likely increase or remain constant with continued conservation efforts, and managed urban growth.

Efforts to forecast local changes in temperature and precipitation are ongoing (ABAG 2012), based on the various scenarios for greenhouse gas emissions, and resultant temperature changes provided by the International Panel on Climate Change (IPCC AR4 SYR 2007). It is important to note that during the last decade, greenhouse gas emissions have exceeded the highest levels considered by the IPCC, such that the forecasts of “worst case” scenarios are increasingly likely (Ackerly et al. 2012).

At this time, many independent models suggest that mean annual temperature in the Bay Area will increase between 2 ºC and 6 ºC (3.6 ºF and 10.8 ºF) by the final decades of this century (Cayan et al. 2011), based on climate change scenario B1 (IPCC AR4 SYR 2007), which assumes major reductions in greenhouse gasses during this century (IPCC AR4 WG1 2007). As indicated above, this scenario seems optimistic, given that gas emissions have not been curtailed to date. Forecasts of precipitation are far less certain. Some models forecast drier conditions and other models forecast wetter conditions.

For the Santa Cruz Mountains in the south Bay Area, a recent modeling effort has predicted reduced early and late wet season runoff, and possibly a longer dry season, with greater inter-annual variability, and potentially increased rainfall intensity (Flint and Flint 2012). Forecasts of increased precipitation show it concentrated in midwinter months, such that peak flows in streams are increased.

Table 14 lists possible major effects of climate change on the distribution and abundance of aquatic resources in the upper Pajaro River watershed. These effects might also generally apply to other watersheds within the District’s service area. The District should consider the effects of these changes on its ability to continue providing reliable water supplies, flood protection, and stewardship goals and objectives, and how the effects might be ameliorated by management actions. It must be recognized that much more science is needed to understand the likelihood of these effects.

Table 14. List of possible landscape responses to climate change.

Climate Change	Potential Major Landscape Effects
Increased temperature translates into increased evaporation, which has similar landscape-scale effects as decreased precipitation.	Decreased dry season surface water storage
	Depressed aquifers
	Decreased acreage of perennial wetlands
	Increased acreage of seasonal wetlands
	Reduced perennial stream base flow
	Reduced total length of perennial streams
	Increased total length of episodic streams
Increased precipitation, or decreased duration of the wet season with no increase in precipitation, translates into increased peak flows.	Increased channel incision and bank erosion in upper watershed
	Increased channel head-cutting
	Increased hillslope gullying
	Increased landslides
	Increased sediment yields
	Decreased reservoir capacity
	Reduced flexibility to manage reservoir levels and stream flows
	Increased threat of flooding and storm damage

- *What is the likelihood that sources of risk may impact stream ecosystem conditions, and what are the likely consequences of these risks to stream ecosystem condition?*

The invasion of stream riparian zones by non-native, invasive vegetation is already a ubiquitous problem and its impacts are likely to continue unless a concerted effort among partners to effectively treat the invasion is conducted throughout the most heavily invaded areas. The first technical step in treatment would be the production of a comprehensive map of the invasion. Results of the CRAM survey can be used to identify the major, dominant invasive species.

The negative impacts of roads and agriculture are also likely to continue unless economically and politically difficult mitigating measures are taken. The main measure might be to increase the width and spatial complexity of the riparian zones of streams that are closely bordered by busy roads or intensive agriculture, especially truck crops. Best Management Practices (BMPs) including installation of Low Impact Develop measures (LID) should be used to retain and treat runoff from roads and croplands.

Most of the mid- to high-order streams are moderately to deeply entrenched. This limits the ability of flows to access floodplains that could help to moderate flood risks, store fine sediment, and filter other contaminants. Entrenchment also increases the sensitivity of the channels to further increases in flow. A general increase in either peak storm flows or mean annual flows, as might be expected from climate change, that are confined to the channel will tend to cause further incision, which in turn would increase the size of flows that would be confined by the channel. This positive feedback could trigger a period of chronic incision. If the channels encounter resistant substrate, then incision could be replaced by lateral channel migration, with coincident erosion of the channel banks. The likelihood of bank erosion or collapse increases, however, whether or not the channels migrate, given that the increased height of the banks increases their instability. Unless mitigating measures are taken, a reduction on the "50^{th} percentile score" for CRAM would be expected, given that further incision and the loss of riparian structure through bank erosion (or revetment to prevent such erosion) would reduce the biological and physical complexity of the channel and its immediate riparian area. Flood risks might be reduced, however, as the incision of channels increases the size of flows that the channels can convey. These consequences would vary along the length of the drainage system, in relation to local variations in existing channel and riparian conditions, and in relation to the proximity of the channels to sources of risk.

With regard to climate change, it is likely that the forecasted increases in storm intensity will cause an increase in peak flows, while increased temperature will generally cause an increase in total annual evaporative losses. Unless these losses are offset by increased groundwater storage, the total annual amount of water in the watershed will probably decrease. The watershed will probably become drier, with less acreage of wetlands, lower aquifers, and greater total lengths of ephemeral or episodic streams. The increased erosive power of the higher peak flows would probably initiate a new period of channel incision and head-cutting, especially where the flows are contained by entrenched channels. The resulting increase in sediment yield would increase the rate at which flood control channels aggrade, thus losing conveyance capacity. Dredging flood control channels to regain or maintain their capacity would likely impact in-stream resources, especially through downstream decreases in coarse sediment and increases in siltation. There would also be significant costs and risks associated with disposing dredged materials. Even with dredging, the aggradation of channels in valleys would very likely increase the risk of their flooding. More intense or frequent storms may also directly result in increased flooding, regardless of channel aggradation. Any efforts to restore the health of streams in the upper Pajaro River watershed through purposeful changes in the form or structure of channels or their riparian areas should reflect the best available information on likely future changes in rainfall and temperature regimes. Scientific frameworks and guiding principles are available to help assure the success of large-scale ecological restoration (e.g., Beller et al. 2015).

References

Beller E, A. Robinson, R. Grossinger, L. Grenier. 2015. Landscape Resilience Framework: Operationalizing ecological resilience at the landscape scale. Prepared for Google Ecology Program. A Report of SFEI-ASC's Resilient Landscapes Program, Publication #752, San Francisco Estuary Institute, Richmond, CA.

Ackerly, David D. 2012. Future Climate Scenarios for California: Freezing Isoclines, Novel Climates, and Climatic Resilience of California's Protected Areas. California Energy Commission. Publication number: CEC-500-2012-022.

ABAG. 2012. Preparing the Bay Area for a Changing Climate. Version 1.1 July - September 2012. Current Initiatives and Stakeholders. http://www.abag.ca.gov/jointpolicy/pdfs/Key%20Bay%20Area%20Projects%201.1%20July%202012.pdf

Brinson, M.M., L.J. MacDonnell, D.J. Austen, R.L. Beschta, T.A. Dillaha, D.A. Donahue, S.V. Gregory, J.W. Harvey, M.C. Molles Jr, E.I. Rogers, J.A. Stanford, and L.J. Ehlers. 2002. *Riparian areas: functions and strategies for management*. National Academy Press, Washington, DC.

California Protected Areas Database. 2014. GreenInfo Network (www.calands.org)

California Rapid Assessment Method (CRAM) for Wetlands and Riparian Areas: User's Manual, Version 6.1. April 2013. pp. 77. Available at: www.cramwetlands.org

California Rapid Assessment Method for Wetlands: Riverine Wetland Field Book, Version 6.1, January 2013. pp. 46. Available at: www.cramwetlands.org

CRAM Data Quality Assurance Plan: California Rapid Assessment Method for Wetlands – Draft version 7, July 2016. pp. 58. Available at: http://www.cramwetlands.org/documents#field+books+and+sops

California Wetland Monitoring Workgroup's (CWMW) coordinated strategy to assess the extent and health of California's wetland resources. 2010. *Tenets of the State Wetland and Riparain Monitoring Program (WRAMP).* Available at: http://www.mywaterquality.ca.gov/monitoring_council/docs/wramp_letter_release.pdf

Cayan, D. R., K. Nicholas, M. Tyree, and M. Dettinger. 2011. Climate and Phenology in Napa Valley: A Compilation and Analysis of Historical Data. Napa Valley Vintners, Napa CA.

Collins, J. N., M. Sutula, E. D. Stein, M. Odaya, E. Zhang, and K. Larned. 2006. Comparison of Methods to Map California Riparian Areas. Final Report Prepared for the California Riparian Habitat Joint Venture. pp. 85. San Francisco Estuary Institute, Contribution # 522. Richmond, CA. Available at: http://www.sfei.org/node/1572

Collins, J.N., S. Lowe, S. Pearce, and C. Roberts (2014). Santa Rosa Plain Wetlands Profile: A Demonstration of the California Wetland and Riparian Area Monitoring Plan. Final Report prepared for the California Natural Resources Agency - STD Agreement # 0CA10043-2.

San Francisco Estuary Institute & Aquatic Science Center, Richmond. CA. SFEI Contribution # 724.

Diaz-Ramos, S., D. L. Stevens, Jr., and A. R. Olsen. 1995. EMAP Statistics Methods Manual. EPA/620/R-96/002, U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory, Corvallis, OR.

EOA and SFEI. 2011. Ecological Monitoring & Assessment Framework Stream Ecosystem Condition Profile: Coyote Creek Watershed including the Upper Penitencia Creek subwatershed. Final Technical Report #2 prepared for the Santa Clara Valley Water District, San Jose, CA.

ESRI. 2010. Tele Atlas North America, U. S. and Canada Major Roads [GIS data files].

Flint, L. E., and A. L. Flint. 2012. Simulation of climate change in San Francisco Bay Basins, California: Case studies in the Russian River Valley and Santa Cruz Mountains. USGS Scientific Investigations Report: 2012-5132. http://pubs.er.usgs.gov/publication/sir20125132.

GreenInfo Network. 2014. California Protected Lands Database (CPAD). A GIS dataset. www.calands.org

IPCC AR4 SYR. 2007. Core Writing Team; Pachauri, R.K; and Reisinger, A. (editor). Climate Change 2007: Synthesis Report, Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. ISBN 92-9169-122-4.

IPCC AR4 WG1. 2007. Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M., and Miller, H.L. (editor). Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press. ISBN 978-0-521-88009-1 (pb: 978-0-521-70596-7).

Johnson, C.W. and S. Buffler. 2008. Riparian buffer design guidelines for water quality and wildlife habitat functions on agricultural landscapes in the Intermountain West. Gen. Tech. Rep. RMRS-GTR-203. U.S. Forest Service, Fort Collins CO.

Kincaid, T. M. and Olsen, A. R. (2016). spsurvey: Spatial Survey Design and Analysis. R package version 3.3. https://cran.r-project.org/web/packages/spsurvey/spsurvey.pdf

Messer, J.J ., R. A. Linthurst, and W. S. Overton. 1991. An EPA program for monitoring ecological status and trends. Environmental Monitoring and Assessment 17:67-78.

NRC. 2002. Riparian areas: functions and strategies for management. National Academy of Science. Washington, DC.

San Francisco Estuary Institute (SFEI). 2008. South Santa Clara Valley Historical Ecology Study. Prepared by SFEI: Robin Grossinger, E. Beller, M. Salomon, A. Whipple, R. Askevold, C. Striplen, E. Brewster, and R Leidy. SFEI Publication #558, San Francisco Estuary Institute, Oakland, CA. Available at: http://www.sfei.org/SouthStaClaraValleyHEStudy#sthash.Zp1sabIB.dpbs

San Francisco Estuary Institute (SFEI). 2011a. Bay Area Aquatic Resources Inventory (BAARI) Standards and Methodology for Stream Network, Wetland and Riparian Mapping. San Francisco Estuary Institute. Richmond, CA. Prepared for Wetland Regional Monitoring Program (WRMP). Revised January 06, 2011. http://www.sfei.org/BAARI

San Francisco Estuary Institute (SFEI) - Aquatic Science Center (ASC). 2011b. Riparian Areas Mapping Tool (RAMT). Richmond, CA. http://sfei.org/baari/ramt

San Francisco Estuary Institute (SFEI). 2013. Statistical Design, Analysis and Graphics for the Guadalupe River Assessment. Technical Memoranda Two, Four & Five. Report prepared for the Santa Clara Valley Water District Agreement Number A3562F. SFEI Publication #687. Richmond, California.

Snyder, M.A. and L.C. Sloan. 2005. Transient Future Climate over the Western U.S. using a Regional Climate Model, Earth Interactions, Vol. 9, Paper 11.

Stevens, D. L. and A. R. Olsen. 2003. Variance estimation for spatially balanced samples of environmental resources. EnvironMetrics, 14: 593-610.

Stevens, D. L. and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association, 99: 262-278.

Strahler, A. N. 1952. Hypsometric (area-altitude) analysis of erosional topology. Geological Society of America Bulletin, 63 (11): 1117–1142.

Strahler, A. N. 1957. Quantitative analysis of watershed geomorphology. Transactions of the American Geophysical Union, 8 (6): 913–920.

Surface Water Ambient Monitoring Program (SWAMP). 2016. CA Surface Water Ambient Monitoring Program's – Perennial Streams Assessment (PSA) CRAM data were provided by Andrew Rehn (CADFW) and R.D. Mazor (Southern California Coastal Water Research Project [SCCWRP]). http://www.waterboards.ca.gov/water_issues/programs/swamp/bioassessment/

U.S. Army Corps of Engineers. 2015. Regional Compensatory Mitigation and Monitoring Guidance for South Pacific Dividion. Final January 12, 2015. http://www.spd.usace.army.mil/Portals/13/docs/regulatory/mitigation/MitMon.pdf

Wenger, S. 1999. A review of the scientific literature on riparian buffer width, extent, and vegetation. Office of Publication Service and Outreach, Institute of Ecology, University of Georgia, Athens GA.

Appendix A

Upper Pajaro River Watershed CRAM Stream Survey Results

- *Map of final CRAM assessment areas (AAs) with SiteID labels (Figure A.1)*
- *CRAM assessment results with site information (Table A.1)*

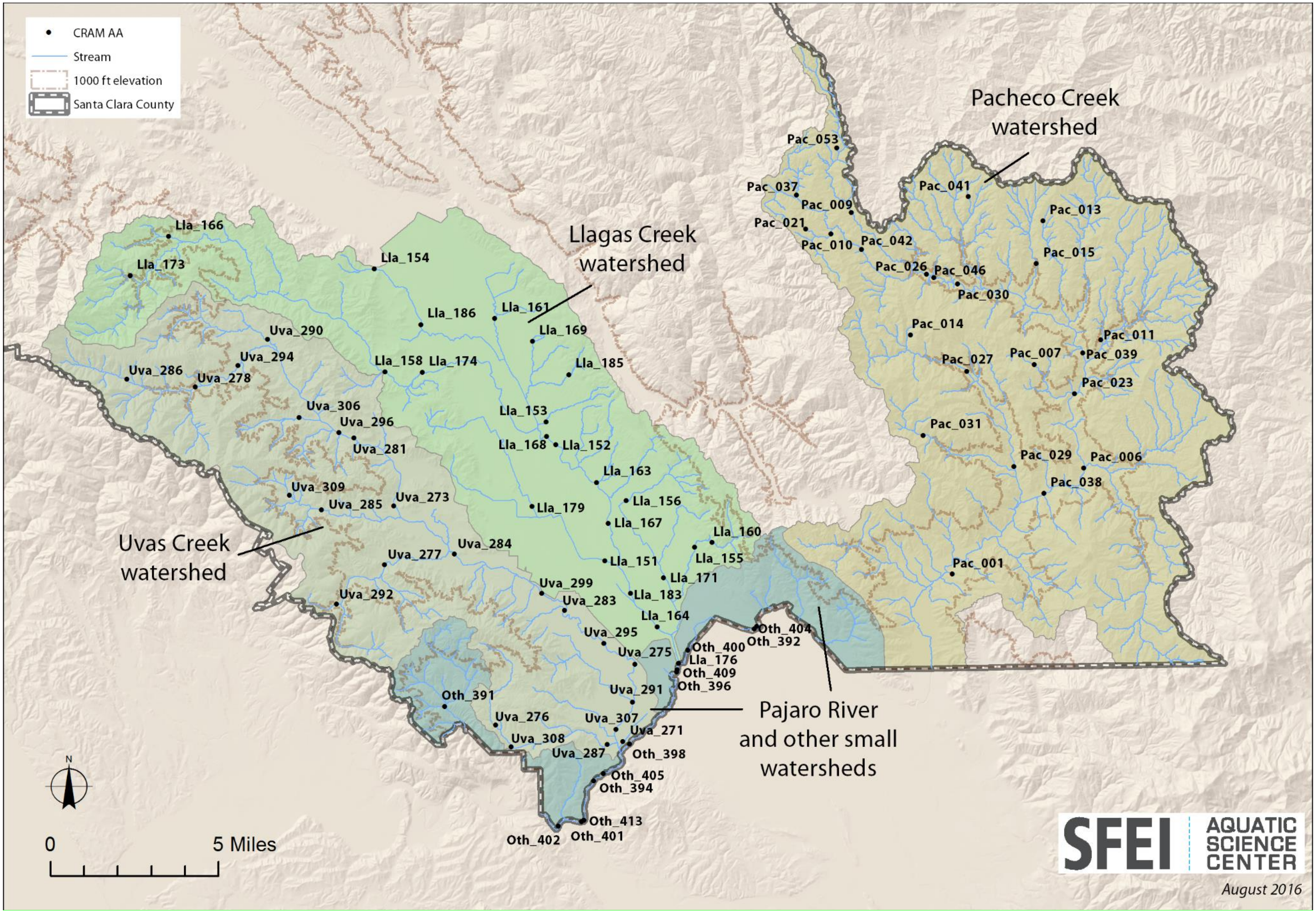


Figure A.1. District's Priority D5 Project's 2015 upper Pajaro River watershed CRAM stream survey assessment areas (AAs). Refer to Appendix Table 1 for additional site information and CRAM results.

Table A.1. 2015 upper Pajaro River watershed CRAM stream survey results including AA siteIDs, eCRAM AARowIDs, geospatial location, wetland type, basic field information, and CRAM Index and Attribute Scores.

SiteID	AARowID	Latitude	Longitude	Visit Date	Wetland Class	Wetland Subclass	Hydroregime (Riverine)	AA Size (ha)	Bankfull Width (m)	Strahler Stream Order	Flowing Water	Index Score	Buffer and Landscape Context	Hydrology	Physical Structure	Biotic Structure
Primary Area of Interest: Pacheco Creek Subwatershed																
Pac_001	4618	37.0004	-121.3605	10/28/2015	riverine	non-confined	ephemeral	0.14	1.27	2	0	54	85	58	25	47
Pac_006	4510	37.0450	-121.2889	10/21/2015	riverine	non-confined	intermittent	0.32	8.68	5	0	80	90	75	88	67
Pac_007	4229	37.0898	-121.3145	8/19/2015	riverine	confined	intermittent	0.22	6	3	0	81	93	75	88	67
Pac_009	4154	37.1568	-121.4114	7/6/2015	riverine	non-confined	intermittent	0.25	5	4	0	82	100	100	63	67
Pac_010	4169	37.1477	-121.4227	7/10/2015	riverine	non-confined	intermittent	0.17	4	3	0	81	93	83	75	72
Pac_011	4529	37.1001	-121.2784	10/22/2015	riverine	non-confined	intermittent	0.24	3.73	3	0	80	93	83	75	69
Pac_013	4606	37.1517	-121.3084	10/27/2015	riverine	non-confined	NA	0.04	0.77	2	0	81	100	100	63	61
Pac_014	4185	37.1035	-121.3809	7/6/2015	riverine	confined	ephemeral	0.25	1.5	1	0	80	100	92	63	64
Pac_015	4617	37.1332	-121.3123	10/27/2015	riverine	non-confined	ephemeral	0.29	2.7	4	0	84	93	83	75	86
Pac_021	4168	37.1498	-121.4361	7/10/2015	riverine	non-confined	ephemeral	0.37	1.13	2	0	75	100	75	63	64
Pac_023	4514	37.0770	-121.2930	10/22/2015	riverine	non-confined	intermittent	0.30	9.37	6	0	71	93	92	63	36
Pac_026	4155	37.1297	-121.3715	7/20/2015	riverine	non-confined	intermittent	0.22	15	5	0	73	93	75	50	75
Pac_027	4645	37.0874	-121.3509	10/31/2015	riverine	non-confined	ephemeral	0.30	6.67	4	0	71	93	75	50	67
Pac_029	4621	37.0462	-121.3265	10/31/2015	riverine	non-confined	intermittent	0.16	4.95	4	0	69	85	83	50	58
Pac_030	4180	37.1251	-121.3549	7/20/2015	riverine	non-confined	intermittent	0.26	13.5	5	0	84	93	100	75	69
Pac_031	4232	37.0602	-121.3748	8/19/2015	riverine	confined	intermittent	0.16	6	4	0	86	100	92	88	64
Pac_037	4162	37.1646	-121.4408	7/20/2015	riverine	non-confined	intermittent	0.85	3.48	4	0	84	100	75	75	86
Pac_038	4335	37.0343	-121.3105	9/9/2015	riverine	non-confined	perennial	0.23	8.71	6	1	77	75	92	63	81
Pac_039	4533	37.0945	-121.2882	10/22/2015	riverine	non-confined	intermittent	0.15	10.6	6	0	67	93	75	63	36

SiteID	AARowID	Latitude	Longitude	Visit Date	Wetland Class	Wetland Subclass	Hydroregime (Riverine)	AA Size (ha)	Bankfull Width (m)	Strahler Stream Order	Flowing Water	Index Score	Buffer and Landscape Context	Hydrology	Physical Structure	Biotic Structure
Pac_041	4470	37.1628	-121.3485	9/28/2015	riverine	non-confined	ephemeral	0.11	1.1	3	0	78	93	100	63	56
Pac_042	4471	37.1407	-121.4063	9/29/2015	riverine	confined	intermittent	0.29	6.04	4	0	86	93	83	88	81
Pac_046	4472	37.1281	-121.3677	9/28/2015	riverine	non-confined	intermittent	0.21	3.77	5	0	71	93	92	50	47
Pac_053	4456	37.1845	-121.4187	9/29/2015	riverine	non-confined	ephemeral	0.10	1.07	1	0	71	100	83	38	64
Primary Area of Interest: Llagas Creek Watershed																
Lla_151	4170	37.0085	-121.5472	5/13/2015	riverine	confined	intermittent	0.23	12.1	3	0	59	75	83	38	39
Lla_152	4171	37.0588	-121.5726	5/12/2015	riverine	non-confined	intermittent	0.18	9.8	6	0	64	80	58	50	67
Lla_153	4541	37.0686	-121.5776	10/20/2015	riverine	non-confined	ephemeral	0.14	2.95	3	0	56	63	50	38	72
Lla_154	4177	37.1355	-121.6688	7/21/2015	riverine	non-confined	ephemeral	0.05	2	3	0	61	73	67	38	67
Lla_155	4493	37.0137	-121.4987	10/15/2015	riverine	non-confined	ephemeral	0.19	3.85	3	0	62	71	75	50	50
Lla_156	4163	37.0342	-121.5350	7/27/2015	riverine	non-confined	NA	0.12	1.6	4	0	53	75	67	25	44
Lla_158	4179	37.0911	-121.6637	7/21/2015	riverine	non-confined	perennial	0.44	7	5	1	77	72	75	88	72
Lla_160	4673	37.0157	-121.4892	10/13/2015	riverine	confined	intermittent	0.28	4.27	3	0	75	90	58	75	78
Lla_161	4455	37.1134	-121.6043	9/30/2015	riverine	non-confined	ephemeral	0.12	2.8	3	0	55	71	58	25	64
Lla_163	4153	37.0422	-121.5509	5/13/2015	riverine	non-confined	intermittent	0.89	5.23	6	0	57	75	83	38	33
Lla_164	4173	36.9796	-121.5195	5/13/2015	riverine	non-confined	perennial	0.35	10	6	1	80	83	83	75	78
Lla_166	4479	37.1507	-121.7793	10/13/2015	riverine	non-confined	intermittent	0.23	3.18	3	0	73	100	75	50	67
Lla_167	4172	37.0245	-121.5449	5/13/2015	riverine	non-confined	intermittent	0.22	3.5	6	0	56	81	58	50	36
Lla_168	4174	37.0624	-121.5773	5/12/2015	riverine	non-confined	ephemeral	0.10	8.6	6	0	52	80	50	38	42
Lla_169	4480	37.1034	-121.5841	10/13/2015	riverine	non-confined	ephemeral	0.09	3.62	2	0	57	85	92	25	28
Lla_171	4294	37.0008	-121.5158	8/7/2015	riverine	non-confined	ephemeral	0.07	2.93	4	0	51	63	67	38	36
Lla_173	4631	37.1340	-121.8002	10/28/2015	riverine	non-confined	perennial	0.22	3.19	4	1	72	100	67	50	69
Lla_174	4620	37.0907	-121.6438	10/28/2015	riverine	non-confined	perennial	0.32	5.8	5	1	85	81	83	100	75

SiteID	AARowID	Latitude	Longitude	Visit Date	Wetland Class	Wetland Subclass	Hydroregime (Riverine)	AA Size (ha)	Bankfull Width (m)	Strahler Stream Order	Flowing Water	Index Score	Buffer and Landscape Context	Hydrology	Physical Structure	Biotic Structure
Lla_176	4443	36.9638	-121.5083	10/1/2015	riverine	non-confined	perennial	0.51	5.85	6	1	74	75	83	75	61
Lla_179	4452	37.0324	-121.5857	9/30/2015	riverine	non-confined	ephemeral	0.08	4.2	3	0	55	80	58	38	44
Lla_183	4449	36.9942	-121.5335	9/30/2015	riverine	non-confined	perennial	0.43	8.16	6	0	75	75	75	88	61
Lla_185	4682	37.0889	-121.5648	10/30/2015	riverine	non-confined	ephemeral	0.13	1.8	3	0	62	85	75	50	39
Lla_186	4625	37.1113	-121.6442	10/30/2015	riverine	non-confined	intermittent	0.09	1.94	3	0	63	75	75	50	50
Primary Area of Interest: Uvas Creek Watershed																
Uva_271	4538	36.9304	-121.5390	10/21/2015	riverine	non-confined	perennial	0.06	4.74	2	1	44	66	50	25	33
Uva_273	4509	37.0335	-121.6600	10/20/2015	riverine	non-confined	perennial	0.19	7.94	5	1	80	93	58	88	81
Uva_275	4640	36.9637	-121.5317	10/27/2015	riverine	non-confined	intermittent	0.46	10.97	6	0	57	63	50	50	67
Uva_276	4188	36.9384	-121.6072	8/4/2015	riverine	non-confined	perennial	0.36	2.5	3	0	84	93	92	75	78
Uva_277	4187	37.0082	-121.6654	8/7/2015	riverine	non-confined	perennial	0.10	5.12	5	0	70	90	75	50	67
Uva_278	4212	37.0858	-121.7661	8/13/2015	riverine	confined	perennial	0.23	6.8	4	1	87	90	83	88	86
Uva_281	4211	37.0653	-121.6891	8/13/2015	riverine	non-confined	perennial	1.04	7.5	5	1	70	45	83	75	75
Uva_283	4542	36.9873	-121.5691	10/20/2015	riverine	non-confined	intermittent	0.54	5.28	6	0	69	68	67	63	81
Uva_284	4638	37.0123	-121.6279	10/27/2015	riverine	non-confined	perennial	0.22	4.79	6	1	87	86	83	100	78
Uva_285	4178	37.0321	-121.6991	7/21/2015	riverine	non-confined	intermittent	0.17	5.45	4	0	82	93	75	88	72
Uva_286	4674	37.0895	-121.8028	10/14/2015	riverine	non-confined	perennial	3.59	4.48	4	1	79	100	75	75	67
Uva_287	4175	36.9293	-121.5473	5/12/2015	riverine	non-confined	perennial	0.95	5	3	1	65	68	75	50	67
Uva_290	4487	37.1059	-121.7268	10/15/2015	riverine	non-confined	intermittent	0.16	3.89	4	0	76	83	92	75	53
Uva_291	4184	36.9475	-121.5333	5/12/2015	riverine	non-confined	perennial	0.18	14	6	1	70	90	58	50	83
Uva_292	5107	36.9914	-121.6917	9/16/2015	riverine	non-confined	perennial	0.49	3	2	1	72	92	58	75	64
Uva_294	4176	37.0948	-121.7428	7/21/2015	riverine	non-confined	perennial	0.15	6.8	4	1	81	83	75	88	78
Uva_295	4189	36.9729	-121.5483	8/4/2015	riverine	non-confined	intermittent	0.54	5	6	0	74	81	75	63	78

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Uva_296	4637	37.0629	-121.6809	10/27/2015	riverine	non-confined	perennial	0.48	10.55	5	1	79	90	83	75	67
Uva_299	4450	36.9948	-121.5813	9/30/2015	riverine	non-confined	intermittent	0.33	9.31	6	0	77	86	83	75	64
Uva_306	4439	37.0721	-121.7104	10/1/2015	riverine	non-confined	intermittent	0.23	4.08	3	0	73	93	83	63	53
Uva_307	4684	36.9358	-121.5425	10/13/2015	riverine	non-confined	perennial	0.31	5.56	6	NA	72	73	75	75	67
Uva_308	4619	36.9289	-121.5988	10/28/2015	riverine	non-confined	intermittent	0.27	2.73	3	0	76	93	75	50	86
Uva_309	4616	37.0385	-121.7161	10/30/2015	riverine	non-confined	perennial	0.21	4.64	4	0	73	86	75	50	81
Pajaro River Mainstem and Other Small Watersheds																
Oth_391	4496	36.9467	-121.6342	10/14/2015	riverine	non-confined	perennial	0.47	4.8	4	1	84	100	83	63	89
Oth_392	4495	36.9782	-121.4675	10/14/2015	riverine	non-confined	intermittent	0.16	5.22	5	0	56	85	75	25	39
Oth_394	4190	36.9137	-121.5550	8/11/2015	riverine	non-confined	perennial	0.60	16	7	1	69	85	67	63	61
Oth_396	4442	36.9600	-121.5094	10/1/2015	riverine	non-confined	perennial	0.22	7	7	1	67	79	58	63	69
Oth_398	4537	36.9295	-121.5353	10/21/2015	riverine	non-confined	perennial	0.71	36.33	7	1	72	68	67	75	78
Oth_400	4683	36.9693	-121.5032	10/14/2015	riverine	non-confined	intermittent	0.11	3.56	6	0	52	66	67	38	39
Oth_401	4475	36.8969	-121.5603	10/6/2015	riverine	non-confined	perennial	0.83	9.57	7	1	77	93	83	75	58
Oth_402	4474	36.8945	-121.5743	10/7/2015	riverine	non-confined	perennial	0.40	7.67	7	1	82	93	83	75	78
Oth_404	4494	36.9791	-121.4661	10/14/2015	riverine	non-confined	intermittent	0.15	6.51	5	0	54	85	67	25	39
Oth_405	4191	36.9168	-121.5497	8/3/2015	riverine	non-confined	perennial	0.30	9	7	1	73	86	75	75	56
Oth_409	4473	36.9611	-121.5091	10/8/2015	riverine	non-confined	perennial	0.23	7.33	7	1	69	79	67	63	67
Oth_413	4476	36.8962	-121.5616	10/6/2015	riverine	non-confined	perennial	0.61	14.33	7	1	77	97	83	63	64