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Lower Peninsula Watershed Condition Assessment 2016:

Southwest San Francisco Bay, Santa Clara County, San Francisquito to Stevens Creeks

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)

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Executive Summary

This report describes baseline information about the amount and distribution of aquatic resources, and evaluates that overall ecological conditions of streams using the California Rapid Assessment Method (CRAM), for the Lower Peninsula watershed in Santa Clara County; consisting of Stevens-Permanente Creek, Adobe Creek, southern extent of San Francisquito Creek, and their tributaries. The Lower Peninsula watershed covers approximately 98 square-miles with creeks flowing from the Santa Cruz Mountains into southwest San Francisco Bay and its tidal wetlands.

The Santa Clara Valley Water District's (District) Safe, Clean Water and Natural Flood Protection Program has many priorities, including Priority D for restoring and protecting vital wildlife habitat, and providing opportunities for increased access to trails and open space. The D5 Project focuses on ecological data collection and analysis at a watershed scale to support the District, other County agencies and organizations in making informed ecological asset management decisions. The key performance indicators (KPIs) for D5 are to:

1. Establish new or track existing ecological levels of service for streams in 5 watersheds.
2. Reassess streams in 5 watersheds to determine if ecological levels of service are maintained or improved.

The Lower Peninsula watershed is the fourth watershed-wide aquatic resource inventory and stream condition survey completed by the D5 Project. It is located in the northwest portion of Santa Clara County and includes Stevens Creek, Permanente Creek, Adobe Creek, Barron Creek, Matadero Creek, Deer Creek, and southern portions of San Francisquito Creek and Los Trancos Creek. The cities of Cupertino, Sunnyvale, Mountain View, Los Altos, Los Altos Hills and Palo Alto are in the watershed. The top of the watershed extends up the eastern side of the Santa Cruz Mountains with the highest peaks reaching 2,500 feet. The upper watershed is largely open space, natural lands, or lightly grazed with some rural residential properties. Development is largely restricted due to the steep terrain at the top of the watershed.

The District owns about two percent (2%) of the streams (about 13 miles) in the Lower Peninsula study area: four and nine miles of streams in Adobe and Stevens Creek PAIs, respectively. Such a low amount is consistent with other watersheds, where the District only owns approximately 3% of streams in the Coyote Creek watershed, 8% of Guadalupe, and 3% of upper Pajaro streams in the Santa Clara County part of its watershed.

Almost half of the streams in the Lower Peninsula watershed study area (about 250 of 530 miles) are on protected lands in the upper watershed, and about 300 miles of streams (60%) are below the District's SMP 1,000-foot boundary. Streams in the upper watershed are mostly in their natural state, as evidenced by high CRAM Index scores (>75). Channels in the foothills are typically in fair condition (Index scores 51-75), retaining their natural structure and vegetation, but they are affected by adjacent land uses and changes in hydrology. Stream reaches in poor condition (Index scores ≤50) are located in mainstem channels in the highly urbanized alluvial plain near the Baylands. Many of those channels have been engineered over the past 150 years and development extends right up to their banks. The District owns key mainstem channels, which provides an important opportunity for applying cross-habitat resiliency improvements.

A probability-based, survey design was employed to assess the overall ecological condition of streams at 54 locations in the Lower Peninsula watershed within Santa Clara County in 2016 using CRAM. Cumulative Distribution Function (CDF) curves were developed that characterize the percentage of stream miles having CRAM ecological condition scores with known levels of confidence. The probabilistic survey allows one to compare stream conditions within and between Santa Clara County watersheds.

Figure E1 compares the percentage of streams in poor, fair, and good ecological condition in four Santa Clara County watersheds, other northern California regions, and statewide. Streams in the Lower Peninsula watershed are largely in fair ecological condition (86%) based on CRAM Index scores, 10% of the streams are in good condition, and 4% in poor condition. Figure E2 shows the percentage of streams in poor, fair, and good ecological condition for sub-watersheds within the Lower Peninsula study area in Santa Clara County.

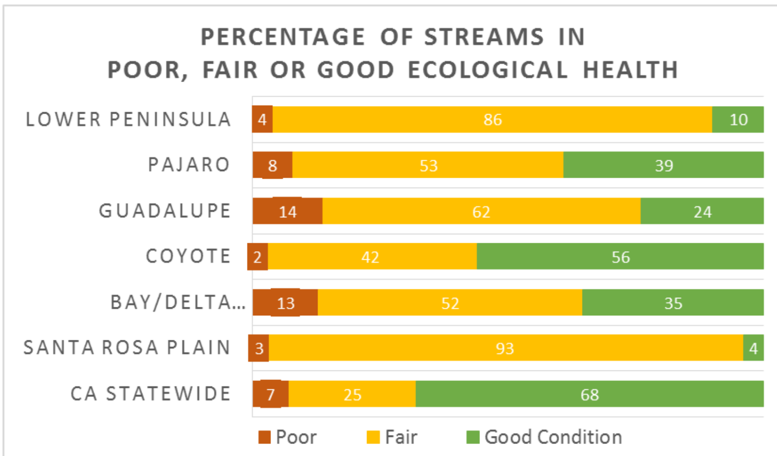

Figure E1. Percent of streams in poor, fair, or good ecological condition through four watersheds in Santa Clara County, other north coast regions, and statewide based on probabilistic surveys using CRAM. The three classes of condition correspond to three equal-intervals of the full range of possible CRAM Index scores: Poor ≤50, Fair 51-75, and Good >75.

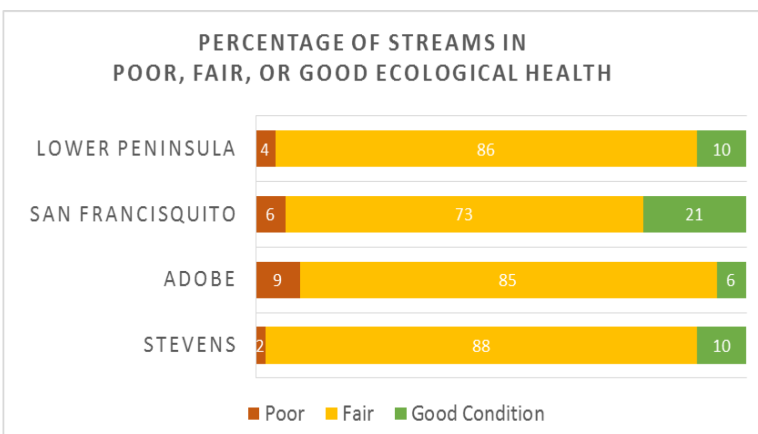

Figure E2. Percent of stream miles in the Lower Peninsula watershed study area and its three PAIs in poor, fair, and good ecological condition.

Another summary measure employed by the District is the Ecological Service Index (ESI), which could become an ecological level of service (LOS), and is a single number that represents the sample-weighted average CRAM score for the entire watershed or its sub-watersheds. The D5 Project defines the 5 major watersheds and several sub-watersheds as Primary Areas of Interest (PAIs). The ESI for the Lower Peninsula watershed was 66, while ESIs for each PAI were 64 (Adobe Creek) and 67 (Stevens-Permanente and south San Francisquito creeks). The Lower Peninsula ESI was the lowest of the four Priority D5 Project CRAM stream assessments to-date. Table E1 shows ESIs for all of the watersheds or PAIs assessed through 2017. The ESIs for Santa Clara County watersheds generally represent fair ecological conditions the year surveys were conducted. Higher ESI scores indicate that streams in the watershed are generally in better ecological condition. ESIs are another way to compare ecological conditions across watersheds or track change over time.

Table E1. Comparison of stream ESIs in Santa Clara County watersheds based on the District's D5 Project's CRAM surveys (2010 – 2016).

Watershed	**ESI (95% CI)**	**ESI (95% CI) for PAIs**		
Lower Peninsula (2016)	66 (63-77)	San Francisquito 67 (61-73)	Adobe 64 (57-71)	Stevens 67 (63-71)
Upper Pajaro (2015)	70 (63-77)	Pacheco 75 (70-80)	Llagas 60 (56-65)	Uvas 62 (49-75)
Guadalupe (2012)	68 (65-71)	Non-urban 72 (70-75)	Urban 63 (57-68)	
Coyote Creek (2010)	75 (72-78)	Upper Penitencia 73 (70-75)		

CRAM includes a checklist that records the presence of ecological stressors as observed in the field. Although variable throughout the watershed, the most common and significant stream and riparian area stressors observed in the Lower Peninsula watershed include transportation corridors, urban/residential stress, and lack of treatment of invasive plants.

List of Abbreviations

AA	Assessment Area
ABAG	Association of Bay Area Governments
BAARI	Bay Area Aquatic Resources Inventory
BMP	Best Management Practices
CARI	California Aquatic Resources Inventory
CDF	Cumulative Distribution Function
CPAD	California Protected Areas Database
CRAM	California Rapid Assessment Method
CWMW	California Wetland Monitoring Workgroup
CWQMC	California Water Quality Monitoring Council
DEM	Digital Elevation Model
District	Santa Clara Valley Water District
EMAF	Environmental Monitoring and Assessment Framework
EMAP	Environmental Monitoring and Assessment Program
ESI	Ecological Service Index
FSD	Fluvial Subsurface Drainage
GIS	Geographic Information System
GRTS	Generalized Random Tessellation Stratified
HCP	Habitat Conservation Plan
HUC 10	Hydrologic Unit Code 10
IPCC	International Panel on Climate Change
KPI	Key Performance Indicator
LID	Low Impact Development
LOS	Level of Service
NHD	National Hydrography Database
NWI	National Wetlands Inventory
PAI	Primary Area of Interest
PSA	Perennial Stream Assessment
RipZET	Riparian Zone Estimation Tool
SFEI	San Francisco Estuary Institute
SMP	Stream Maintenance Program
SWAMP	Surface Water Ambient Monitoring Program

USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WRAMP	Wetland and Riparian Area Monitoring Plan

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Introduction

This report describes baseline information and evaluates ecological conditions, primarily using the California Rapid Assessment Method (CRAM), for the Lower Peninsula watershed in Santa Clara County, consisting of Stevens-Permanente Creek, Adobe Creek, southern extent of San Francisquito Creek, and tributaries. The Lower Peninsula watershed is a 98 square mile area whose creeks extend from the Santa Cruz Mountains and feed tidal wetlands along the San Francisco Bay's southwest shoreline.

The Santa Clara Valley Water District's (District) Safe, Clean Water and Natural Flood Protection Program has many priorities, including eight projects under Priority D for "'restoring and protecting vital wildlife habitat and providing opportunities for increased access to trails and open space'." In 2010, during the development of the foundational roots of the Priority D5 Project: Ecological Data Collection and Analysis effort, the District implemented a watershed approach to environmental monitoring and assessment using the Wetland and Riparian Area Monitoring Plan's (WRAMP) 3-level framework recommended by the United States Environmental Protection Agency (USEPA). The 3-level framework has been endorsed by the California Wetland Monitoring Workgroup (CWMW 2010) of the California Water Quality Monitoring Council (CWQMC), and supports the Procedures for Discharges of Dredged or Fill Material to Waters of the State (formerly known as the Wetland and Riparian Area Protection Policy for California). The framework is a preferred strategy for monitoring and assessing the extent and health of California's wetland and stream resources, and was employed by the District in 2010 in the Stream Ecosystem Condition Profile for the Coyote Creek watershed (EOA and San Francisco Estuary Institute (SFEI) 2011).

The framework includes geographic information system (GIS) mapping of aquatic resources (Level 1), field-based rapid assessments of those mapped resources using a probability-based or targeted sampling design (Level 2), and discrete water quality or ecological field sampling (Level 3) to further investigate and address ecological condition, or other regulatory requirements. The District's D5 Project is systematically conducting an aquatic resource inventory and rapid assessment of streams, and their associated riparian areas in five major watersheds of Santa Clara County. These watersheds include: Coyote Creek, Guadalupe River, upper Pajaro River, Lower Peninsula, and West Valley. Since 2010, the District has been assessing the abundance, distribution, diversity, and condition of aquatic resources in the County by employing a standardized, monitoring and assessment framework, creating a baseline status and trends dataset to support informed, landscape-based, management decisions.

The D5 Project is applying the first two levels (GIS-based aquatic resource inventory and rapid condition assessments of streams) in five watersheds in Santa Clara County and is employing existing online data management and aquatic resource tools developed for statewide wetland monitoring and tracking at a landscape scale. The tools include the California Aquatic Resources Inventory's (CARI) GIS-based aquatic resource map (CRAM) for wetlands, EcoAtlas and eCRAM (for data management and access) coupled with statistically based, random sampling design methods developed by the USEPA to survey the ecological condition of streams within Santa Clara County.

A watershed approach for aquatic resource management, tracking, and protection is a stated priority for administering the Clean Water Act according to the USEPA and US Army Corps of Engineers (USACE). The D5 Project not only supports the District's watershed, countywide planning and stewardship actions, but monitoring data are available to regulatory managers, scientists, and the public through EcoAtlas, which allows one to compare the ecological condition of streams in Santa Clara County to conditions of streams in other ecoregions through the Landscape Profile Tool.

The District and its consultants conducted the Lower Peninsula watershed assessment within Santa Clara County in 2016. The best available (most complete and accurate) digital aquatic resource map for this watershed was the Bay Area Aquatic Resources Inventory (BAARI, SFEI 2011), which is a subset of CARI. This GIS dataset was queried to address the level-1 landscape based questions and served as the basemap for site selections for the CRAM stream survey (level-2 rapid assessment).

The District led the CRAM field assessment at 54 sites within the Lower Peninsula watershed during the summer of 2016. In addition to the entire watershed, the District analyzed 3 creek watersheds as Primary Areas of Interest (PAIs), Stevens-Permanente Creek, Adobe Creek, and the portion of San Francisquito Creek that is within Santa Clara County. This report summarizes the abundance, distribution, and diversity of the aquatic resources in the freshwater region of the watershed, and the overall ecological condition of streams using CRAM. The overall ecological condition of streams in the Lower Peninsula watershed were compared to the D5 Project's other completed stream assessments in Santa Clara County (upper Pajaro River, Guadalupe River, and Coyote Creek watersheds), as well as streams in the Bay-Delta ecoregion and statewide.

Management Questions

A fundamental purpose of the District's D5 Project monitoring and assessment framework 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 ecological concerns that the data should address. Management questions can be general and overarching, or specific, and can evolve over time based on monitoring findings and management needs. The purpose is to link monitoring and assessment efforts to trackable management questions that support an adaptive management strategy to protect aquatic resources and their beneficial uses. This report addresses the following management questions, which are organized around the first two levels of the District's monitoring and assessment framework:

Level 1: Resource management questions regarding extent, distribution, and ownership:

1. What is the distribution, quantity, and diversity of aquatic resources in the watershed and PAIs?
    a. How many miles of streams exist (including natural and unnatural stream lengths, if it is possible to identify that in the GIS dataset)?
    b. What is the extent and distribution of non-riverine wetlands?
    c. What is the extent and distribution of stream associated riparian areas?
2. How do the modern-day aquatic resources compare to historical extents within the low-lying, valley floor areas for which there is historical ecology GIS data?
3. Other landscape-level questions about streams and stream condition:

a. What amount/percent of streams and other wetland types are below the District's Stream Maintenance Program (SMP) 1,000-foot elevation boundary?

b. What amount and proportion of the streams are District-owned (designated as District fee title/ownership)?

c. What proportion of the streams are on publicly owned lands based on the California Protected Areas Database (CPAD)?

Level 2: Resource Management Questions regarding stream condition (evaluated for the watershed as a whole and individual PAIs using CRAM):

1. What are the overall ecological conditions of streams based on CRAM?
2. What are the likely ecological stressors influencing stream condition?
3. What are the Ecological Service Indexes (ESIs) for streams in the watershed?

D5 Project Overview

The D5 Project is monitoring five major watersheds within Santa Clara County, including Coyote, Guadalupe, Pajaro, Lower Peninsula, and West Valley (Figure 1). CRAM results are shared with land use agencies, environmental resource groups, and the public to support efficient restoration management decisions throughout the county. The District began the initial baseline assessments in the Coyote Creek watershed in 2010 and will complete the West Valley watershed assessment in 2018.

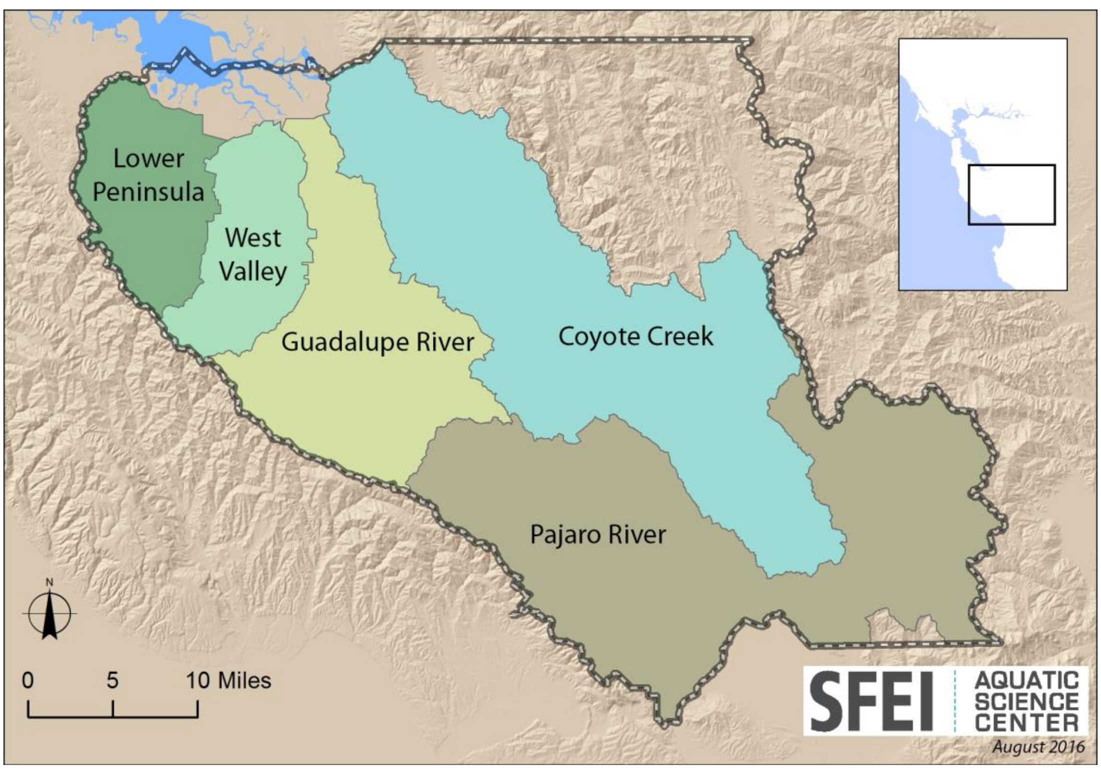

Figure 1. Map of the District's five watersheds in Santa Clara County located in the South San Francisco Bay Area.

The key performance indicators (KPIs) for D5 are to:

1) Establish new or track existing ecological levels of service for streams in 5 watersheds.
2) Reassess streams in 5 watersheds to determine if ecological levels of service are maintained or improved.

ESIs calculated for the watersheds and PAIs define an ecological level of service (LOS) based on existing environmental conditions at the time that the watersheds were assessed. Alternatively, natural resource decision-makers could choose to set a higher ecological LOS goal with the intention of improving ecological conditions.

Lower Peninsula Watershed Setting

The Lower Peninsula watershed covers approximately 98 square miles of northwest Santa Clara County. Its creeks mainly flow northeast down the east slopes of the Santa Cruz Mountains into southwest San Francisco Bay (Figure 1). The Lower Peninsula study area encompasses only about 85 square miles, since tidal baylands, estuarine wetlands, and tidal creek reaches adjacent to San Francisco Bay are not included. The top of the watershed on the eastern side of the Santa Cruz Mountains reaches 2,500 feet in elevation and creeks flow to sea level in San Francisco Bay. However, this watershed assessment of nontidal, freshwater riverine systems ends at roughly ten feet elevation. The active San Andreas Fault runs through the watershed, which is a mechanism for landslides and weakening of bedrock leading to high sediment yields in some creeks.

Notable creeks include Stevens, Permanente, Hale (combined as the Stevens-Permanente or Stevens PAI), Adobe, Barron, Matadero, Deer (combined as the Adobe PAI), and southern parts of San Francisquito and Los Trancos Creeks (combined into the San Francisquito PAI) within Santa Clara County. The District’s study area only includes portions of the San Francisquito and Los Trancos Creeks’ watershed in Santa Clara County, not San Mateo County (Figure 2), since the two creeks mark the county boundary. Several Santa Clara County cities are in the watershed from the Bay to the foothills, including Palo Alto, Los Altos, Los Altos Hills, Mountain View, Sunnyvale, and Cupertino.

Among the five District watershed designations, the Lower Peninsula watershed is smaller than the three previously assessed watersheds, though larger than the West Valley watershed that will be assessed in 2018. It covers only 8 percent (%) of the total 5-watershed extent, including 7% of the stream resources (not counting 1^{st} order streams). Table 1 summarizes watershed extents and stream lengths for the five watersheds within Santa Clara County. Once the initial baseline stream condition assessments are completed in all 5 watersheds, the D5 Project will repeat the stream condition assessments in each watershed to track change in conditions over time.

Table 1. Total watershed area and stream miles assessed by the District's D5 Project in Santa Clara County.

Watershed Name	Total Watershed Area			Total Miles of Streams by Watershed		
	Square Miles	Acres	% of Total Area	Length (Miles)*	% of Total Miles*	Additional Miles of 1st Order Stream Reaches
Coyote Creek	350	224,228	34%	1,245	35%	1,615
Guadalupe River	170	108,694	16%	464	13%	589
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
Total	**1,042**	**666,745**	**100%**	**3,563**	**100%**	**2,595***

* The BAARI 1st order steam reaches were not included in these columns to allow comparison of the relative amounts of stream miles between watersheds in Santa Clara County. The Pajaro watershed stream assessment employed the District's 'Creeks' GIS layer, which was does not include 1st order stream reaches as mapped in BAARI.

The headwaters of the watershed support mixed evergreen (Douglas fir/redwood) and oak/broadleaf woodland forest, interspersed with oak savannah, annual grassland, and chaparral habitats. The hillslopes are steep, and therefore headwater channels tend to be narrow with steep gradients. In the mid-region of the watershed, mountains transition to lower elevation foothills and slopes become gentler, and wider, with higher stream order channels and lower gradients. The foothills support mixed oak/broadleaf woodland forest, oak savannah, annual grasslands, and chaparral. There are many open-space areas and parks, as well as high-density, rural-residential properties on the west side of Highway 280. Permanente Creek has the Lehigh Permanente quarry in the foothills - a large limestone and aggregate open-pit quarry for cement manufacturing.

As the streams flow out of the foothills and onto the alluvial plains, they become wider and less steep, and typically have been modified and/or channelized to accommodate residential and commercial land uses, which extend right up to the top of the channel banks. The lowest stream reaches in the watershed were extended and straightened into flood control channels that direct flow out through the Baylands and into south San Francisco Bay. Historically, these channels were distributaries on the alluvial plain (SFEI 2010). Today, some reaches in the lower watershed have a buffer of riparian vegetation, while other reaches are concrete trapezoidal channels without any riparian zone.

Figure 2. Map of the Lower Peninsula watershed study area showing the major streams that drain towards South San Francisco Bay.

Methods

Level-1: GIS-based Landscape Level Assessment Methods

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

   BAARI v.2 is a GIS dataset of streams and other wetland types developed by SFEI through separate funding served as the best available digital GIS data for this watershed assessment. BAARI is an intensification of the National Hydrography Database (NHD) and National Wetlands Inventory (NWI) data for San Francisco Bay, and was incorporated into CARI.

2. Determine the study area extent and PAIs

   The Lower Peninsula watershed, within Santa Clara County, encompasses about 54,000 acres and its boundary is comprised of the 2012 US Geological Survey (USGS) Hydrologic Unit Code 10 (HUC 10) watershed, and northern extent of the San Francisquito Creek watershed that is within the County. There are about 500 miles of freshwater streams in the Lower Peninsula study area, based on BAARI v.2, which includes Strahler stream orders 1 through 6 (Strahler 1952, 1957).

   The District identified three PAIs in the Lower Peninsula watershed study area (Figure 3). They include only freshwater streams and extend to the tidal channels at the edge of the San Francisco Baylands.

   The three PAIs include:
   1) San Francisquito Creek within Santa Clara County (San Francisquito Creek_SC),
   2) Adobe, Barron and Matadero Creeks (Adobe Creek), and
   3) Stevens and Permanente Creeks (Stevens-Permanente Creek).

3. Estimate riverine riparian extents using the Riparian Zone Estimation Tool v2.0 (RipZET)

   RipZET (SFEI 2015) employs digital vegetation, aquatic resource, and elevation data within a GIS and Excel platform to estimate riparian habitat extents based on topographic slope, density and height of mapped vegetation. It has three main components: core code, modules, and output. The core code prepares the input GIS layers used by the modules. The Hillslope and Vegetation Processes modules are run separately for a geographic area defined by the user. Each module generates a GIS dataset that represents riparian habitat extent based on their respective riparian functions. The outputs are not regarded as riparian maps per se because they do not depict areas with definite boundaries based on field indicators. Instead, they represent areas where riparian functions are likely to be supported. The two module outputs can be overlaid to estimate the maximum riparian extent for all riparian functions represented by both modules.

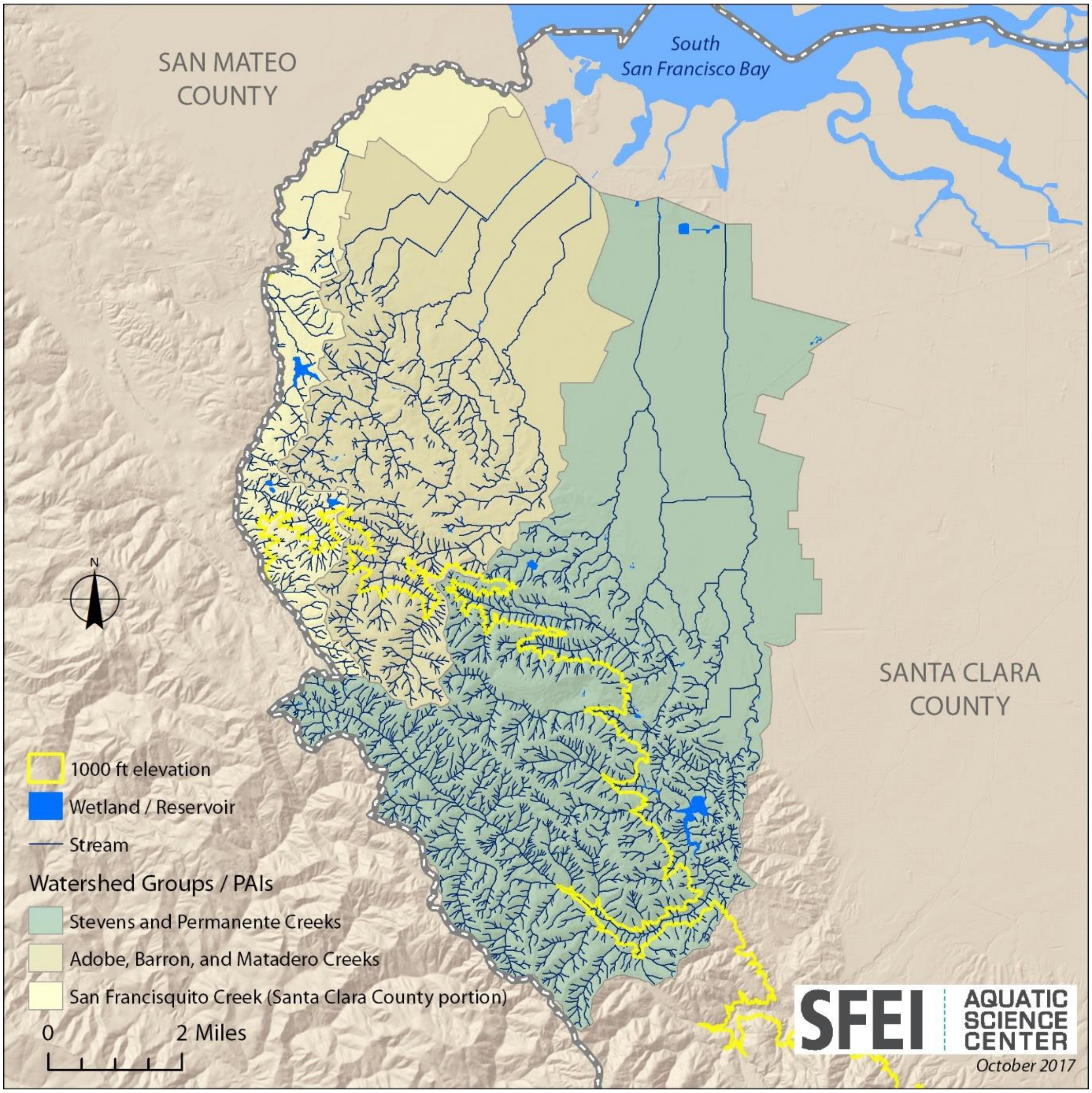

Figure 3. Map of the Lower Peninsula watershed study area within Santa Clara County including its major tributaries and three PAIs: San Francisquito Creek watershed within Santa Clara County; Matadero, Barron, and Adobe Creeks; Permanente and Stevens Creeks. The District's SMP area extends up to the 1,000-foot elevation contour.

The maximum riparian habitat extent from both modules is summarized according to the concept of "functional riparian width." According to this concept, the kinds of ecological functions that a riparian area can provide depends on its structure, which includes topographic slope, density and height of vegetation, plant species composition, and soil type. Some key riparian functions include wildlife support, runoff filtration, input of leaf litter and large woody debris (allochthonous inputs), shading, flood hazard reduction, groundwater recharge, and bank stabilization (Collins et al. 2006). 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, and a greater number 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 integral to many riparian design and management guidelines (e.g., Johnson and Buffler 2008).

The Lower Peninsula watershed assessment (2016) ran RipZET's Hillslope and Vegetation modules on the following vegetation and elevation GIS datasets:

- USDA Forest Service CALVEG data Zone 6 - Central Coast, published in 2014 and using imagery from 1997-2013;
- BAARI v.2; and
- USGS National Elevation Dataset, 10-meter node Digital Elevation Model (DEM) for topography.

RipZET results for the Lower Peninsula watershed were presented in this memo as a map of the overlaid Vegetation and Hillslope Processes GIS layers, and summarized by functional width class per Collins et al. (2006).

4. List the GIS datasets used in the landscape based analysis

To characterize the amount, distribution, and diversity of aquatic resources in the Lower Peninsula watershed, SFEI employed BAARI v.2 GIS layer and other geospatial data provided by the District or available online as referenced below:

- BAARI v.2, Mapping Methods
- Santa Clara County line GIS layer (District 2007)
- District's SMP 1,000-foot elevation boundary. The SMP boundary is based on 2006 LiDAR contour datasets (District 2006)
- District-owned lands from the District's fee title GIS layer (2009 [Unpublished]). Data layer was provided in August 2016
- Watershed Boundary dataset, HUC 10 (USGS 2012)
- California Protected Areas Database (CPAD, GreenInfo Network 2014)
- Santa Clara County Historical GIS Data
    - SFEI. 2015. "Santa Clara Valley Historical Ecology GIS Data version 2" Accessed [30 August 2016]. Data are available to download at: http://www.sfei.org/content/santa-clara-valley-historical-ecology-gis-data.
    - The final report based on this Historical Ecology study was completed by SFEI in 2010 and is available online: *Historical Vegetation and Drainage Patterns of Western Santa Clara Valley: A technical memorandum describing landscape ecology in Lower Peninsula, West Valley, and Guadalupe Watershed Management Areas*.
- The USDA Forest Service CALVEG (Zone 6 - Central Coast) data were used by RipZET to assign tree heights to estimate stream riparian extents using the Vegetation Processes module.

Level-2: Rapid Assessment of Stream Condition Methods

1. Develop a statistical survey design and sample draw

   The D5 Project's watershed-based stream condition surveys call for random designs and sample draws to characterize the overall condition of streams in the five watersheds. The Project employs the USEPA recommended Generalized Random Tessellation Stratified (GRTS) survey design and analysis tools for aquatic resources. The National Environmental Monitoring and Assessment Program (EMAP; Messer et al. 1991; Diaz-Ramos et al. 1995; Stevens and Olsen 2003; Stevens and Olsen 2004) developed the GRTS survey design and analysis methodology and the programing package is now available online (spsurvey). Spsurvey is an R programing package that includes sample design, sample draw, and analysis tools for both linear and area resources.

   The GRTS survey design and sample draw for the Lower Peninsula streams (a linear resource) employed a GIS-based stream layer (i.e., BAAARI) as the sample frame or stream network to be sampled. The GRTS sample draw allocates sampling sites (CRAM assessment areas or AA's) in a spatially balanced random manner across the sample frame, while accounting for the proportion of the stream resource that each site represents[1]. The CRAM survey results are later analyzed to estimate the proportions of stream resource that are likely to have any particular ecological condition score.

   The BAARI v.2 streams GIS-dataset was modified for the GRTS sample frame as follows:

   - First order, headwater streams were dropped because the Riverine CRAM module does not adequately assess them[2].
   - Underground stream drainage, identified in BAARI as fluvial subsurface drainage (FSD), were not included.
   - Tidal reaches were excluded since they exhibit estuarine or transitional ecological conditions.

   These modifications allow the Lower Peninsula results to be directly compared with the four other Santa Clara County watersheds and riverine watershed assessments conducted throughout California.

   The final sample frame (GIS shapefile) was imported into R statistical software for the CRAM sample draw. There are about 250 miles of streams in the Lower Peninsula same frame, which is about half of the total length of the actual BAARI v.2 stream network. Second order streams comprise about 40% of the final sample frame, third and fourth order streams make up just under 40%, and fifth and sixth order streams make up a little over 20% of the total stream length.

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[1] The following link (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

[2] BAARI first order stream reaches are much more detailed than NHD, District GIS creeks layer, and most other stream datasets in California. It is often not necessary to drop first order streams from NHD datasets because they usually represent higher order reaches.

The Lower Peninsula sample draw was stratified to increase the number of samples in the lower elevation streams and re-distribute the number of targeted sites among the PAIs. It was necessary to ensure that San Francisquito Creek within Santa Clara County had at least ten target sites for an adequate ecological condition assessment. An unstratified GRTS survey design and sample draw allocates samples proportionally across the resource being sampled. In an unstratified sample draw, more sites are allocated to the upper watershed (2^{nd} and 3^{rd} order streams) because there are more stream miles in the upper watershed than in the lower elevation, urban valley floor region, where the District programs, projects, and activities are located.

Stratification of a GRTS sample draw can increase the efficiency of a survey design yet still maintain its unbiased nature. By increasing the proportion of samples in areas of particular interest (i.e., specific PAIs or higher stream orders within the lower elevation, valley floor regions), one can increase the sample size and thus, confidence levels around the means in areas of interest, while preserving the ability to evaluate conditions in the watershed as a whole.

Prior to implementing the CRAM field survey in 2016, the District asked SFEI to rerun the CRAM sample draw, initially developed and submitted to the District in the fall of 2015, to include the whole San Francisquito Creek watershed, including portions within San Mateo County. At the time, it was anticipated that a partner agency might concurrently assess the north portion of the watershed in San Mateo County using CRAM, so it made sense to include those reaches as a new stratum (or PAI, as represented in Figure 4). However, concurrent CRAM field surveys in both counties in the summer of 2016 did not happen

The final stratified sample draw for the Lower Peninsula watershed included 68 target CRAM AAs distributed across four PAIs (Figure 4). The streams surveyed included freshwater reaches for Strahler stream orders 2 through 6. A total of 50 target AAs were located in Santa Clara County (Stevens-Permanente = 22, Adobe = 18, SanFranq_SC = 10) and 18 in San Mateo County (SanFranq_SM). An oversample draw was included with three times the number of target sites for each PAI. Oversample AAs replace target AAs that are inaccessible or not able to be measured for any reason. Oversample AAs can also be used in intensification surveys for other probability-based stream assessments the District may be interested in. As mentioned above, the sample draw was stratified to ensure that San Francisquito Creek within Santa Clara County had ten target AAs, and to force more AAs into lower elevation stream reaches than would have been assigned without stratification.

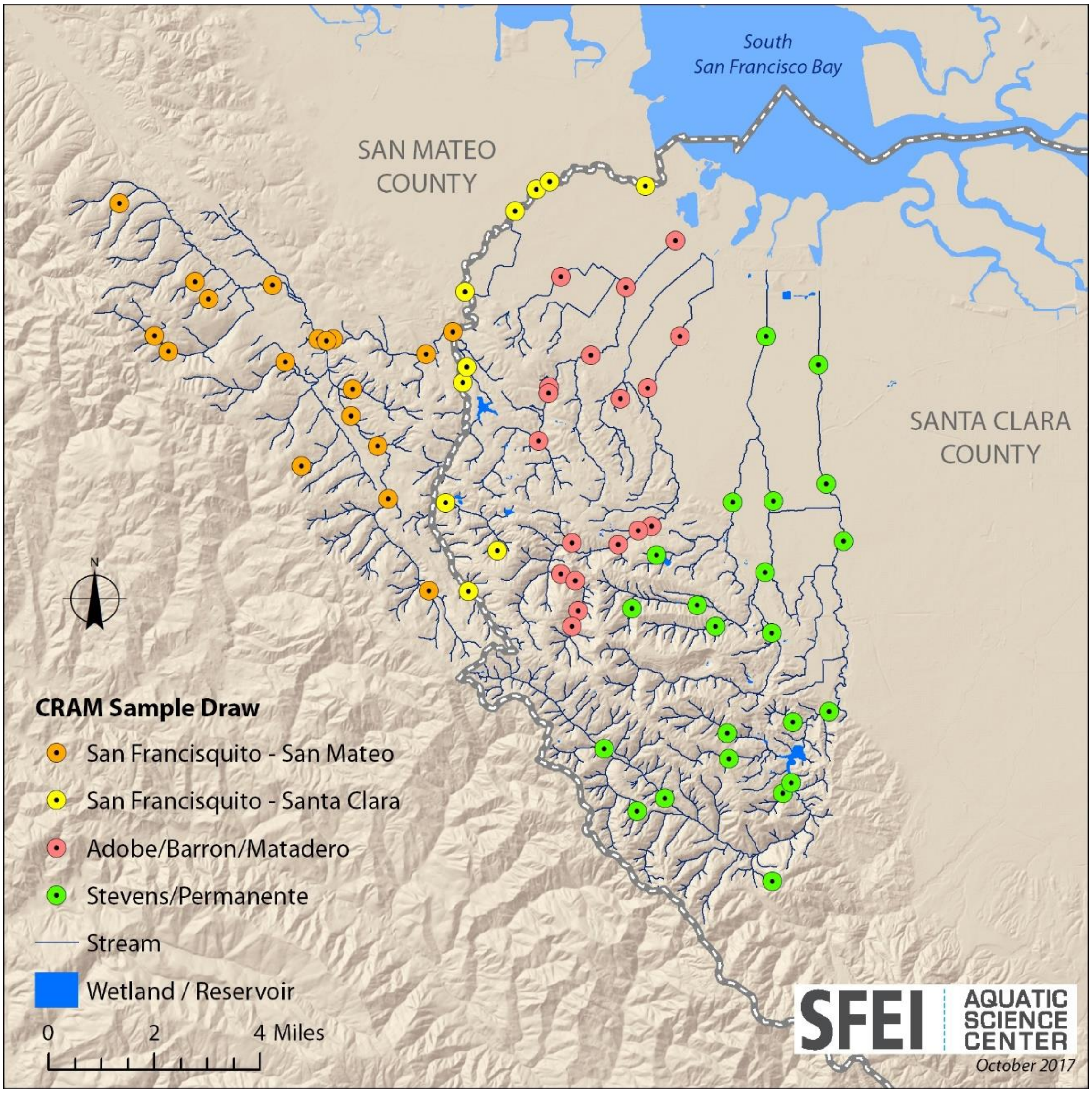

Figure 4. Map of the targeted CRAM stream condition sites in the Lower Peninsula watershed by PAI. The San Francisquito Creek stream reaches within San Mateo County (sites shown here in orange) were not assessed in 2016.

2. Conduct a field survey to assess the ecological condition of streams using CRAM

   The District and its consultants conducted an ambient field survey of stream conditions at 54 sites in the Lower Peninsula watershed study area within Santa Clara County using the CRAM Riverine Fieldbook (V6.1)[3]. The field team consisted of trained CRAM Practitioners from the District, SFEI, and Michael Baker International who conducted the field survey between April and August 2016. Assessment scores were recorded on field sheets and entered into the online CRAM data management system[4]. Through this system, CRAM

[3] 2013.03.19_CRAM Field Book Riverine 6.1.pdf
[4] http://www.cramwetlands.org/

assessment results are publicly available online through EcoAtlas[5], which allows the user to access and summarize the amount, diversity, and condition of aquatic resources in a user-defined landscape profile. CRAM results are also included in Appendix A.

Intercalibration exercises were conducted twice during the CRAM field season to document and compare consistency among the Project's field teams and to provide a forum for additional training on the CRAM methodology. These exercises and additional training opportunities help reduce Practitioner-introduced variation, which is unavoidable in large surveys where many field teams are involved in data collection. Results of the intercalibration exercises were summarized and submitted to the District in a separate memorandum.

It is generally assumed that: 1) AAs are dropped due to random or unforeseen circumstances, because they are inaccessible, permission to enter is denied by the property owner, site may not actually be located on a stream, or for any other reason; and 2) replacement AAs drawn from the oversample list maintain the spatial balance of assessments across the sample frame (or stream network in this case). To assure the second assumption holds, oversample AAs are chosen in order from a prioritized or ranked list. However, in practice, the final distribution of measured AAs in the study area may result in some regions being underrepresented.

In previous watershed assessments conducted by the D5 Project, any inaccessible areas were considered similar enough to sampled areas, therefore the final stream condition estimates applied to the whole study area. Similarly, the Project team evaluated the final distribution of completed AAs compared to dropped AAs in the Lower Peninsula watershed, and decided that the inaccessible areas were sufficiently similar to the assessed areas. Therefore, the stream condition estimates in this report apply to the whole Lower Peninsula watershed within Santa Clara County.

3. Complete Data Analyses of the CRAM Stream Survey

Statistical analyses were conducted on the CRAM survey results with the spsurvey statistical library (Kincaid and Olsen 2016) and R programing language (version 3.2.3), which is a software environment for statistical computing and graphics. The analyses for the Lower Peninsula watershed evaluated CRAM Index and Attribute scores based on the original survey design with adjusted sample weights in order to estimate the overall ecological condition of streams within the watershed, and its PAIs. The outputs consisted of CDF estimates, plots, and percentile tables of CRAM Index and Attribute scores.

The CDF plot enables a user to visually evaluate and compare the percent of the resource (in this case – stream length within the study area) with CRAM scores. Essentially, a specific percent of stream miles has an estimated CRAM score that is equal to or less than the statistically measured score with a known level of confidence (95% confidence intervals). The median CRAM scores (where 50% of the stream resources in the surveyed stream network are at or below that score) are easily identified.

[5] Project Name = 'SCVWD Lower Peninsula Watershed Stream Condition Assessment 2016'. (Note: CRAM assessments where the landowner requested results be kept private are not visible on EcoAtlas, however, results are calculated into EcoAtlas summary measures.)

Reading the CRAM Index score CDF curve in the example plot below (Figure 5), the horizontal and vertical arrows show 50% of the streams in the Lower Peninsula watershed have an Index score of 65 or lower, representing a fair ecological condition. The black line indicates the estimated CRAM score (x-axis) for any percentage of stream length in the watershed (y-axis) and red lines indicate the 95% confidence intervals around that estimate. Interpreting the red confidence intervals in the example CDF, 50% of the streams in the watershed have a CRAM Index score estimated to be between 63 and 71 with a 95% confidence level.

The confidence intervals are generally wider when there is a lot of variation in condition within a surveyed area or when only a few samples represent a large proportion of the surveyed area. A curve that is shifted to the right indicates better overall ecological condition (higher CRAM scores) than a curve that is shifted left.

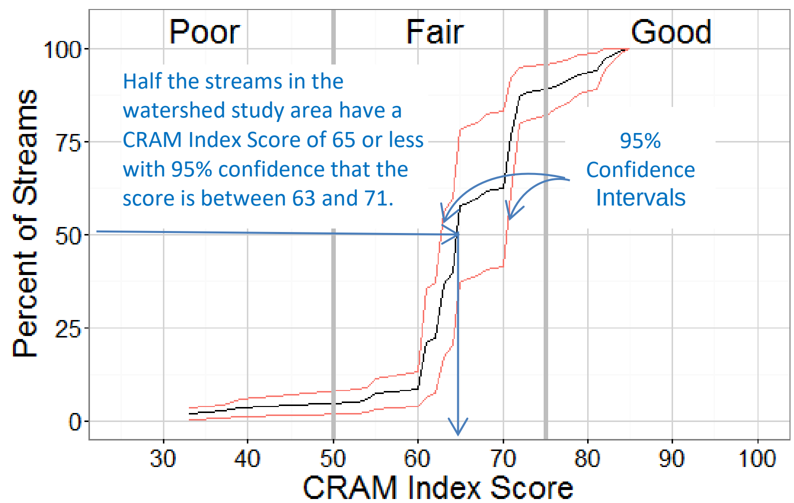

Figure 5. CDF of CRAM Index Score for the Lower Peninsula watershed.

Three ecological health classes (poor, fair, and good) are represented on the CDF plots and used to qualitatively summarize ecological conditions at a watershed scale. The three health classes are equal intervals of the full range of possible CRAM scores (between 25 and 100) and assigned as follows: 25 to ≤50 = Poor, >50 to ≤75 = Fair, >75 = Good.

Health classes were derived mathematically and do not specifically reflect ecologically relevant cut-points or the best professional judgement of the CRAM Level-2 Committee. The range of scores in each category could be adjusted based on recommendations from the Committee or by District scientists who provide a rationale for the update. Further correlation analyses between CRAM scores and regional level-3 wildlife and habitat data could provide additional insight into ecologically meaningful health classes in the region. The Coyote and Guadalupe watershed assessments applied quartile health classes (25-43 = poor or very low, 44-62 = moderately poor or low, 63-81 = moderately good or medium, and 81-100 = good or high). These were updated to compare watershed conditions using the three health classes presented here.

Another summary index employed by the District is the Ecological Service Index (ESI), which is a single number that represents the sample-weighted average CRAM score for the watershed as a whole and its PAIs. The District developed the ESI based on the CDF estimates. It was originally developed in 2011 for the District's Ecological Monitoring and Assessment Framework (EMAF), which evolved into the D5 Project (EOA and SFEI 2011), and ESIs have been calculated for each of the District's completed stream condition surveys.

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

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

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 Lower Peninsula watershed, the ESIs developed for the 2016 stream survey can be compared to future, repeated, watershed-wide condition surveys in order to evaluate 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 6 below shows the distribution of the aquatic resources currently mapped in GIS, including streams, vegetated wetlands, reservoirs, ponds, and unvegetated wetlands in the Lower Peninsula watershed in Santa Clara County. The following management questions were addressed based on spatial data.

- How many miles of streams are there in the Lower Peninsula watershed within Santa Clara County?

There are about 760 miles of streams in the entire Lower Peninsula watershed, which falls within both San Mateo and Santa Clara Counties. Approximately, 70% or about 530 miles of the streams located in Santa Clara County (Table 2). The San Francisquito Creek watershed straddles both counties with 66 miles of streams, or 22% of the stream network, located in Santa Clara County. First order streams comprise about half of the total stream miles within the study area, 2^{nd} and 3^{rd} order streams comprise another 30%, and the remaining 4^{th}, 5^{th} and 6^{th} order streams make up the remaining 20%.

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

Table 2. Total watershed area and miles of streams in the Lower Peninsula watershed study area and its PAIs* based on BAARI v.2.

Watershed or PAI	Watershed Area (Square Miles)	Stream Length (Miles)	% of Watershed
San Francisquito Creek*	11	66	12
Adobe Creek	28	138	26
Stevens Creek	46	327	62
Lower Peninsula Total*	**85**	**531**	

* Includes only the area within Santa Clara County.

- How many acres of non-riverine wetlands are there within the watershed?

Table 3 summarizes the acres of non-riverine wetlands in the Lower Peninsula watershed study area and its PAIs. Vegetated wetlands include depressional and sloped wetlands (such as seeps and springs), and unvegetated wetlands include playas and flats as classified in BAARI v.2.

Table 3. Total acres of non-riverine wetlands broken out by two wetland types in the Lower Peninsula watershed study area and its PAIs, based on BAARI v.2.

Watershed or PAI	Total Acres of Non-Riverine Wetlands	Acres of Vegetated Wetlands	Acres of Reservoirs, Ponds & Unvegetated Wetlands
San Francisquito Creek	72	8	64
Adobe Creek	11	0	11
Stevens Creek	145	11	134
Lower Peninsula Total	**228**	**19**	**209**

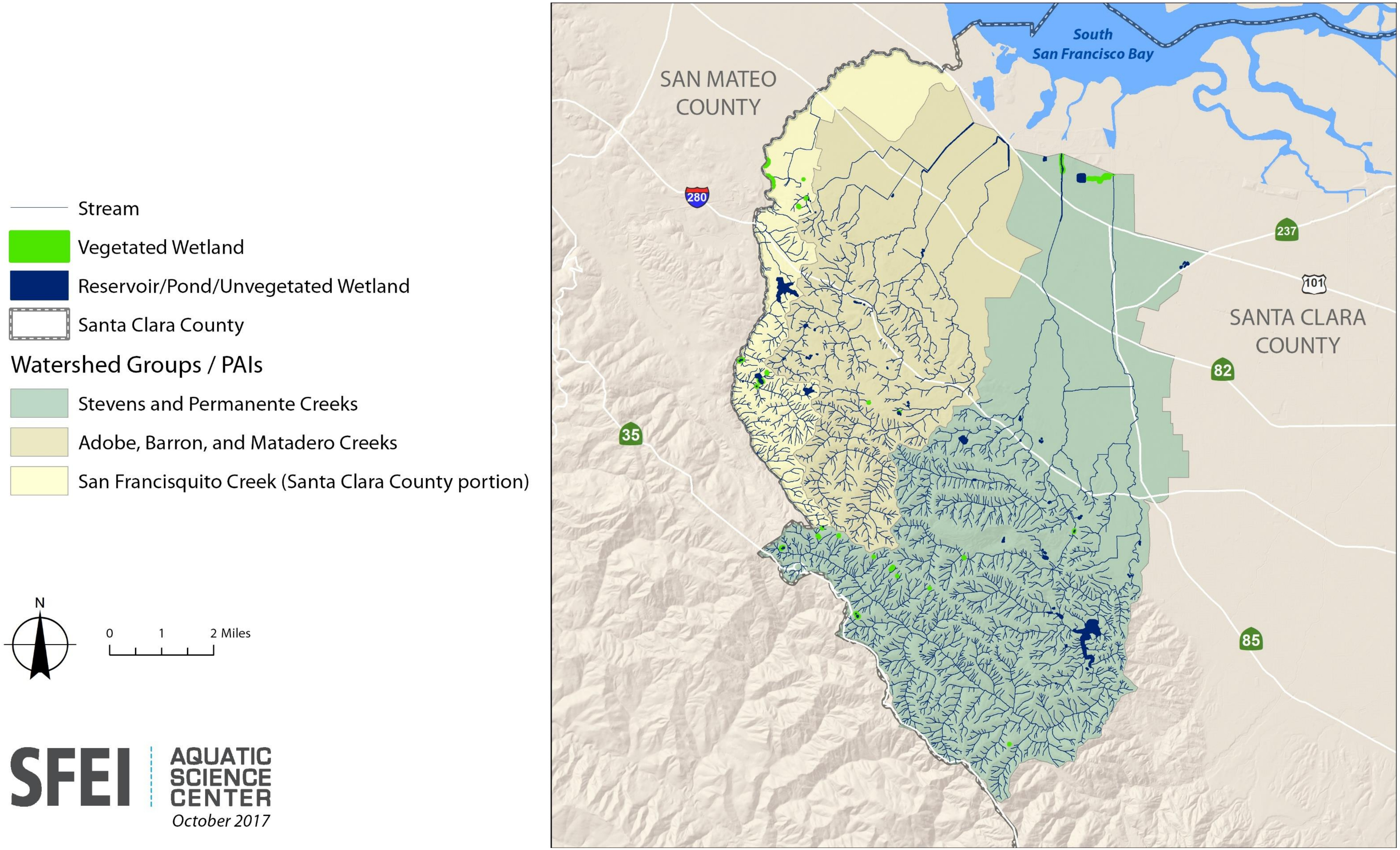

Figure 6. Map of the aquatic resources in the Lower Peninsula watershed study area based on BAARI v.2

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

Riparian areas adjoin waterways and water bodies, including wetlands (Brinson *et al.* 2002). Riparian areas vary in function or value (i.e., the services or benefits riparian habitat provides) primarily depending on their width, such as wildlife support, runoff filtration, input of leaf litter and large woody debris, shading, flood hazard reduction, groundwater recharge, and bank stabilization (Collins et al. 2006). Wider areas tend to provide higher levels of more functions.

RipZET outputs the estimated riparian habitat extents as GIS shapefiles. Figures 7 is a map of RipZET output, which overlays the extents of vegetation (green) and hillslope (brown) processes on a single map. Figures 8 and 9 chart the miles and acres of riparian habitat by functional width class for vegetation and hillslope processes, respectively.

Table 4 lists the estimated miles of stream riparian areas in the Lower Peninsula watershed study area by functional riparian width class. Classes are based on general relationships between riparian width and vegetation-based riparian function as summarized by Collins et al. (2006). A riparian function is assigned to a width class, if the class is likely to support a high level of the function. The estimated stream miles and acres of riparian area are based on the output of the RipZET vegetation module[7]. Riparian width classes reflect natural demarcations in the lateral extent of major riparian functions (Collins et al. 2006).

Table 4. Miles of stream-associated riparian areas for each of five vegetation-based riparian functional width classes in the Lower Peninsula watershed

Riparian Width Class (m)	Miles (Km)	Acres (Ha)	% Total Length	Shading	Bank Stabilization	Allochthonous Input	Runoff Filtration	Flood Dissipation	Groundwater Recharge	Wildlife Support
0 - 10	193 (311)	307 (124)	26%							
10-30	105 (168)	2091 (846)	36%							
30- 50	136 (220)	4220 (1708)	19%							
50 - 100	7 (11)	403 (163)	13%							
>100	86 (139)	6188 (2504)	5%							

[7] Note that riparian length and area for each width class is calculated for the left and right stream banks separately. Therefore, the estimated riparian stream miles are the sum of both banks divided by two. Total miles in Table 4 will not add up to the total stream network length (flow-line down the thalweg of the channels). This is partly because the shape of the stream network is slightly altered by buffering from the thalweg line to the estimated left and right stream banks. And, partly because stream reaches that are not associated with vegetation, or that do not have significant slopes, are not counted.

Figure 7. Map of RipZET output for the Lower Peninsula watershed based on vegetation and hillslope processes (September 2016).

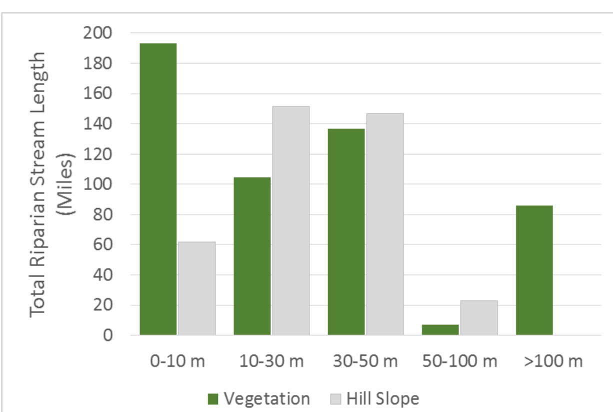

Figure 8. Estimated miles of riparian stream lengths by riparian functional width class (m = meters).

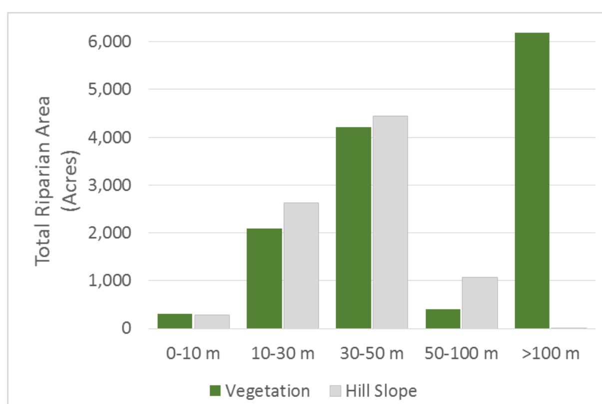

Figure 9. Estimated acres of riparian area by riparian functional width class (m = meters).

- 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 10 shows the historical (circa 1850) and current aquatic resources in the Lower Peninsula valley floor for which there are overlapping historical ecology data from the Western Santa Clara Valley Historical Ecology Study (SFEI 2010) and BAARI v.2. Historically, almost all of the Lower Peninsula streams spread out into undefined channels on the valley floor. Matadero, Adobe, Permanente, and Stevens creeks, in addition to many smaller watercourses, all terminated before reaching the Bay, either sinking into the coarse sediments of their alluvial fans, or spreading into wet meadows, marshes, and willow groves, frequently connecting surface waters during high flows (SFEI 2010).

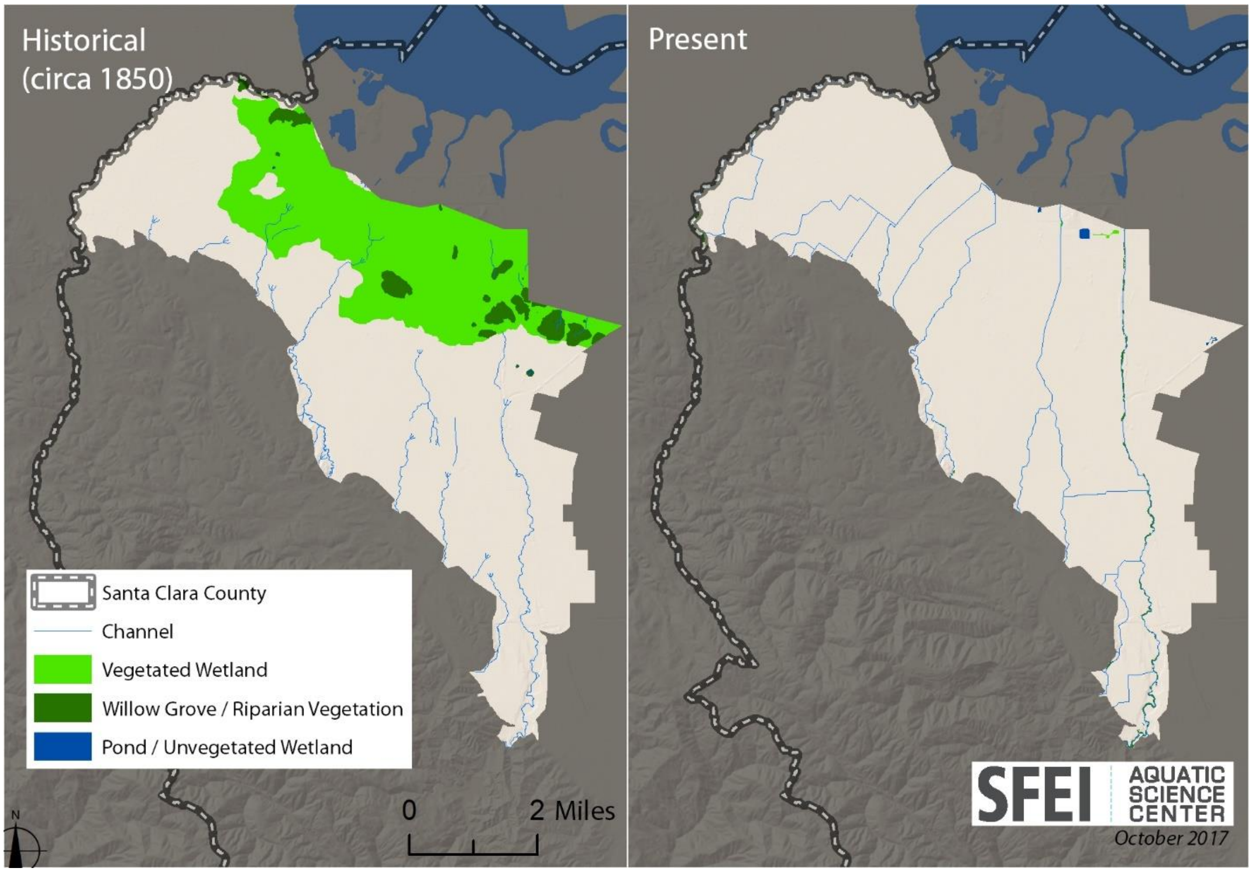

Figure 10. Maps of the historical (circa 1850) and current aquatic resources in the Lower Peninsula valley floor areas for which there are overlapping historical ecology spatial data from the *Western Santa Clara Valley Historical Ecology Study* (SFEI 2010) and BAARI v.2.

As shown on the right side of Figure 10, the creeks were permanently connected through constructed channels to south San Francisco Bay in the late 1800s by enlarging existing drainages, perhaps following articulations of existing channels, or dredging completely new channels. Permanente Creek is a combination of both processes. A ditch was dug in the mid-1870s to divert Permanente Creek into another small creek in the Hale Creek drainage (SFEI 2010), then the Permanent Diversion Channel was constructed in 1960 to divert upper watershed flows into Stevens Creek as a response to the 1955 flood.

San Francisquito Creek is an exception, however. Over geologic time, San Francisquito Creek followed several courses forming an alluvial fan, but historically, remained fairly stable in its current alignment between the Santa Cruz Mountains and Highway 101. The creek once flowed into an extensive tidal marsh that contained many salt pannes and tidal channel networks connected to large sloughs. In the 1930s, the lower portion of the creek from Highway 101 to San Francisco Bay was channelized into its current alignment to accommodate adjacent land uses (SFEI 2016).

Figure 11 shows the current natural and unnatural stream reaches within the watershed as classified in BAARI v.2. Unnatural streams include ditches, engineered channels, and subsurface drainage, such as pipes or culverts of extended length.

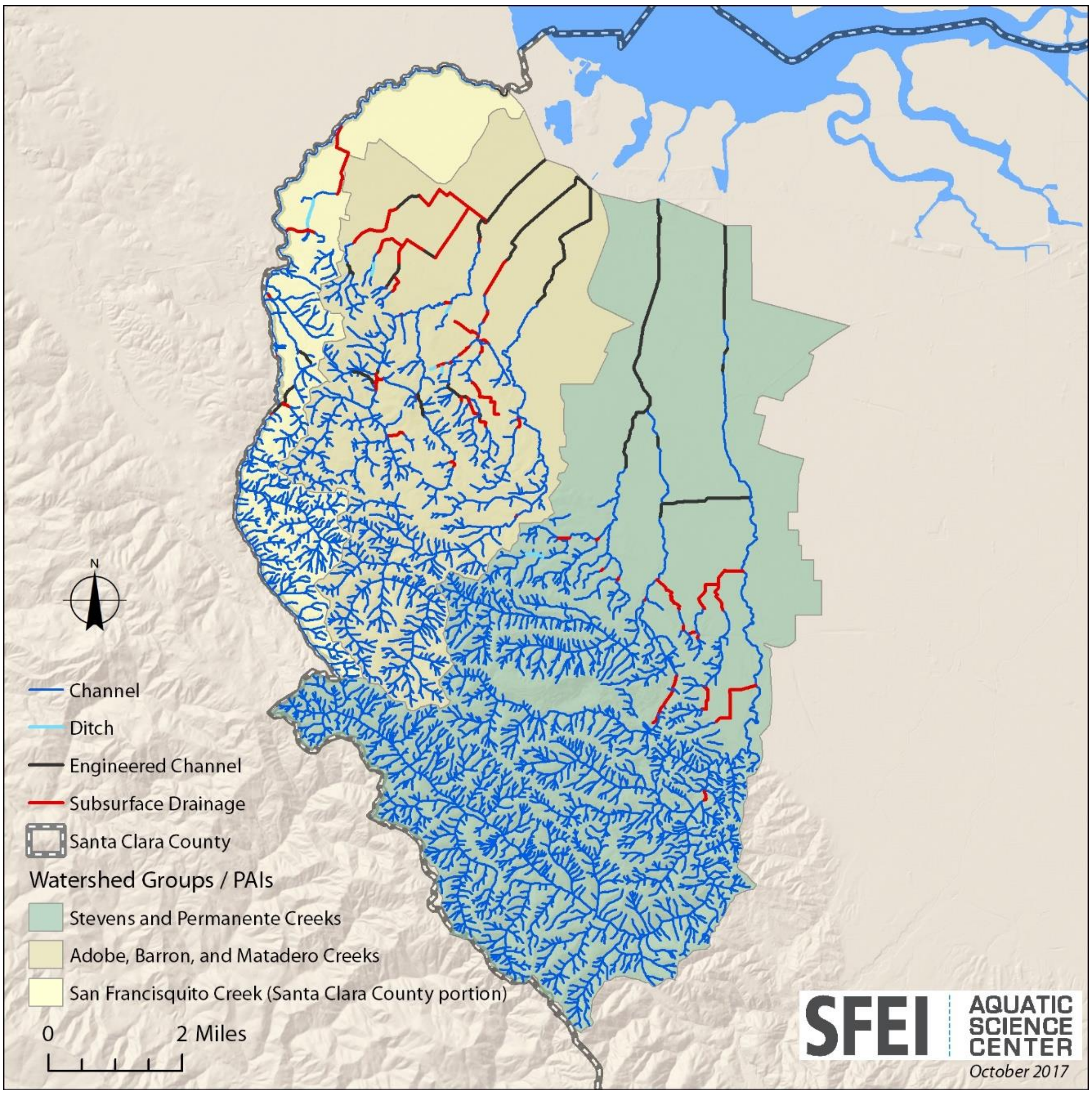

Figure 11. Map of the stream network within the Lower Peninsula watershed study area showing natural and unnatural (ditches, engineered channels, subsurface drainage) stream reaches as classified in BAARI v2

The bar chart in Figure 12 compares the amount of streams that existed historically to current stream miles in the valley floor area as depicted in Figure 10 (above).

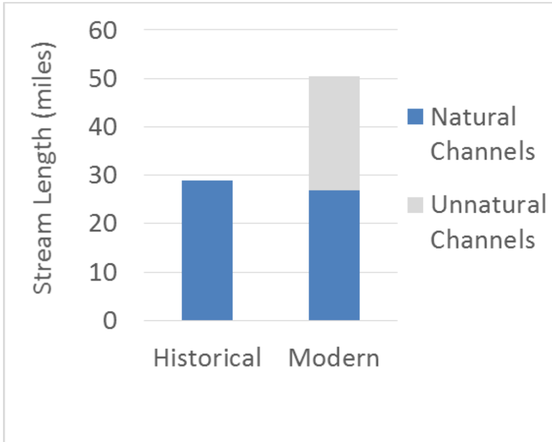

Figure 12. Historical and modern stream lengths for the Lower Peninsula watershed valley floor based on Figures 10 and 11.

- Other landscape based Level-1 questions:
    - What amount and proportion of streams are within the SMP 1,000-foot elevation boundary?
    - What amount and proportion of the streams are District-owned (based on District's fee title GIS layer (August 2016)?
    - What amount and proportion of the streams are in protected areas based on CPAD (2014)?

Figure 13 shows a map of District-owned lands (District's fee title GIS dataset, August 2016) and protected lands based on the CPAD (2014). The District owns only about 2% of the streams (about 13 miles) in the Lower Peninsula watershed study area: 4 and 9 miles of streams in Adobe and Stevens Creek PAIs, respectively (Figure 13 and Table 5). Almost half of the streams in the watershed study area (about 250 of 530 miles) are on protected lands, the majority of which are high elevation streams in the upper watershed. About 60% of the streams (300 miles) are below the District's SMP 1,000-foot boundary.

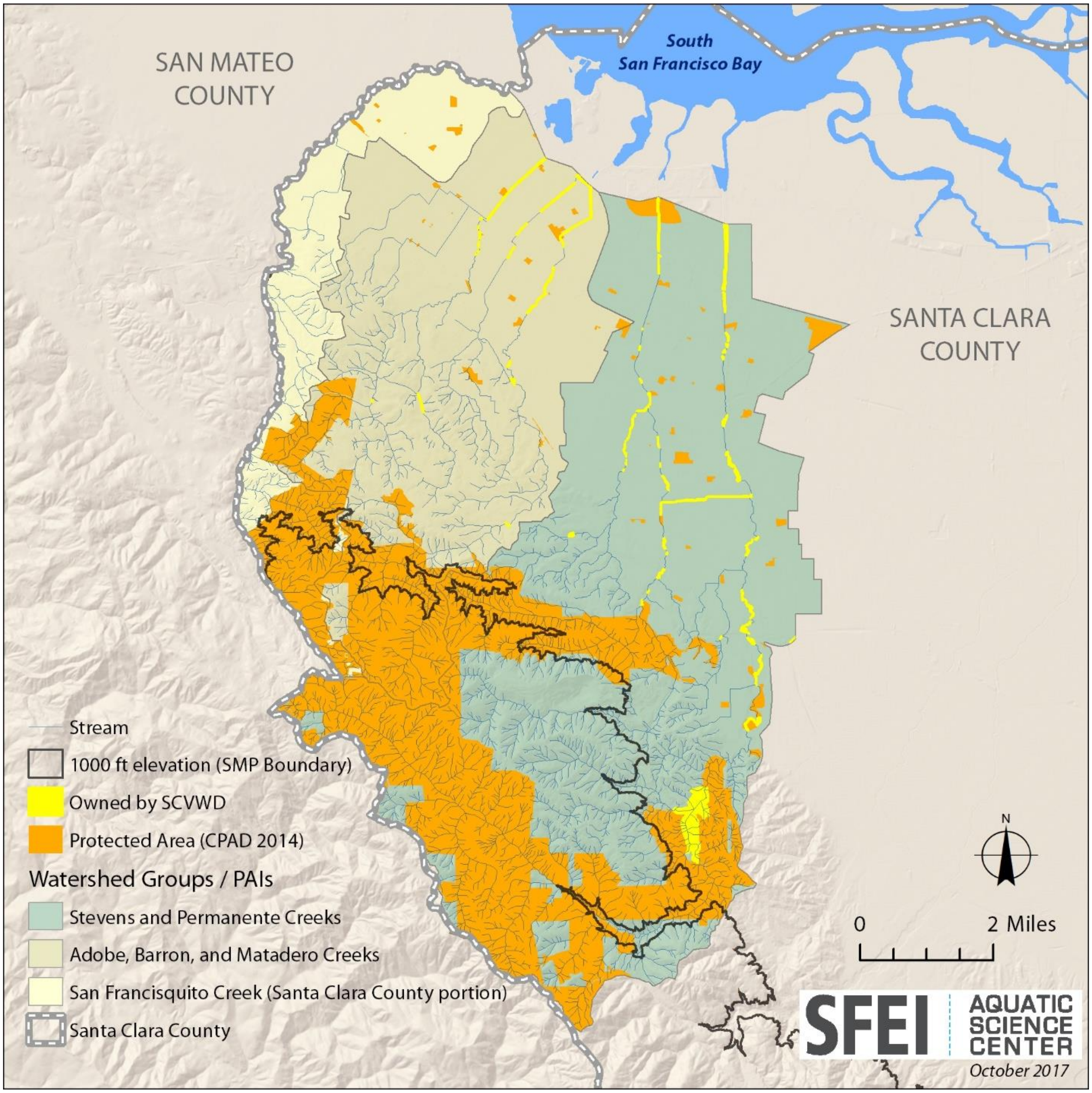

Figure 13. Map of District-owned and other protected areas based on the District's fee title (August 2016) and the CPAD (2014) GIS datasets

As Figure 13 illustrates, the District does not own large portions of the stream network in the Lower Peninsula watershed, and although almost half of the streams are on protected lands, those reaches are largely located in the upper watershed. To achieve intended management goals in the lower watershed, it will be important to coordinate and create partnerships with other agencies and organizations. The District is a member of the San Francisquito Creek Joint Powers Authority with the cities of East Palo Alto, Palo Alto, Menlo Park, and San Mateo County. The District does own key mainstem channels adjacent to the Baylands, which provide an important opportunity for applying cross-habitat resiliency improvements. For example, the District could have a significant impact on the delivery of water and sediment to estuarine Baylands, and the development of transitional habitats between the watershed and the Bay.

Table 5. Summary of total stream miles within the Lower Peninsula watershed study area and three PAIs, and stream miles within SMP, District-owned, or protected lands based (CPAD 2014)

Primary Area of Interest (PAI)	Total Stream Miles	Within SMP	District Owned	Within Protected Lands
San Francisquito Creek*	66	53	0	31
Adobe Creek	138	112	4	46
Stevens Creek	327	136	9	174
Lower Peninsula Total*	**531**	**300 (57%)**	**13 (2%)**	**251 (47%)**

* Includes only the streams within Santa Clara County.

Level-2 Stream Ecosystem Condition based on CRAM

The District and its consultants assessed 54 CRAM AAs within the Lower Peninsula watershed study area. Eighty-eight candidate AAs were considered, 34 of which were rejected, or dropped (Table 6). Dropped AAs were not assessed for two primary reasons: permission to enter was denied, or the site was inaccessible (e.g., steep terrain, excessive distance from road, or inundated with impenetrable noxious vegetation [blackberries, poison oak]). The sample draw was created so that oversample AAs replace rejected AAs. The goal is to assess target and oversample AAs in sequential order as much as possible to maximize random spatial distribution of the GRTS sample draw. Figure 14 shows distribution of the candidate AAs that were either assessed or rejected.

Table 6. Summary of targeted, assessed, and rejected AAs in each PAI within the Lower Peninsula watershed study area for the CRAM-based ambient stream condition survey (2016)

Primary Area of Interest (PAI)	Targeted AAs	Assessed AAs	Rejected AAs
San Francisquito Creek watershed	10	10	14
Adobe Creek watershed	18	19	10
Stevens Creek watershed	22	25	10
Total	**50**	**54**	**34**

CRAM provides numerical scores to estimate the overall potential of a wetland or riparian area to provide high levels of the ecological services expected of 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 statewide reference conditions.

To investigate stream ecosystem condition in the Lower Peninsula watershed study area, results from the 54 AAs within the 2016 CRAM ambient survey were analyzed to:

1. evaluate the overall ecological condition of the streams in the whole watershed, compare the three PAIs, and compare the conditions to other CRAM assessment studies;
2. review the CRAM Attributes and stressor check-lists to identify and compare ecological stressors that might be impacting stream health within the three PAIs; and
3. calculate the watershed baseline ESIs of the streams in the watershed as a whole and its three PAIs, using the District's methodology (described in the methods section).

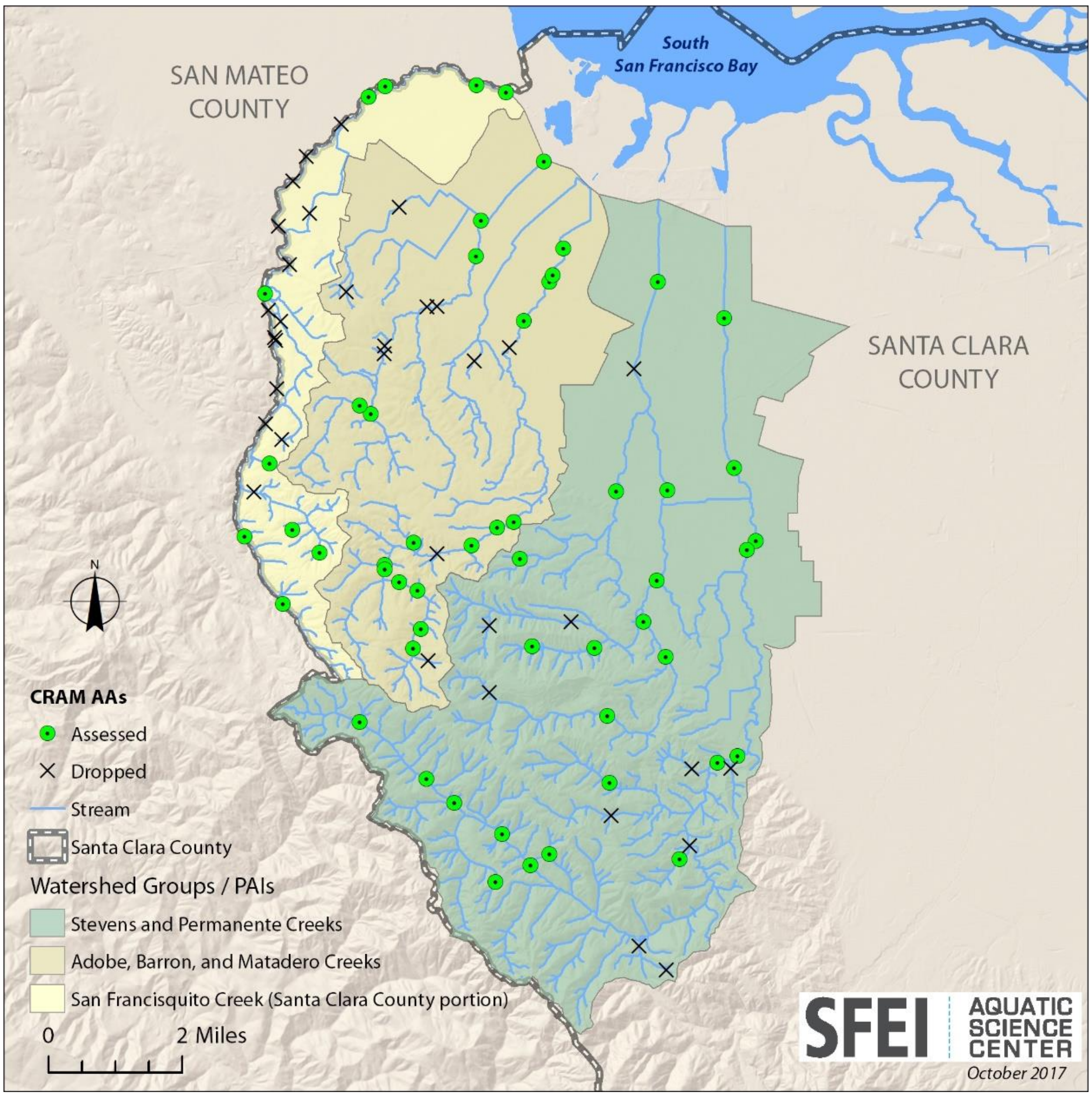

Figure 14. Map of the distribution of assessed (green dots) and rejected (black x) 2016 CRAM stream survey AAs within the Lower Peninsula watershed study area. The three target PAI boundaries are shown for reference.

- What is the overall ecological condition of streams in the Lower Peninsula watershed within Santa Clara County?

The streams in the Lower Peninsula watershed can be characterized as largely in fair condition. This determination is based on a number of different analyses of the CRAM stream survey, each evaluating a specific aspect of the field results. The following analyses describe the overall ecological health of the watershed based on CRAM, spatial distribution of conditions within the watershed, and present CDF plots that characterize the ecological condition of streams versus stream length.

First, overall ecological health of the watershed was summarized based on sample weighted CDF estimates grouped into three equal interval health classes:

- 10% of the streams in the entire watershed are in good condition (CRAM Index scores >75),
- 86% of the streams in the watershed are in fair condition (Index scores of 51 to 75), and
- 4% of the streams are in poor condition (Index scores ≤50).

At the sub-watershed level (Figure 15), the Adobe Creek watershed has the poorest ecological health with almost 10% of its streams in poor condition and 6% in good condition. Stevens Creek watershed has only 2% of its streams in poor condition, while San Francisquito Creek watershed (within Santa Clara County) has the largest proportion of its streams in good condition (21%).

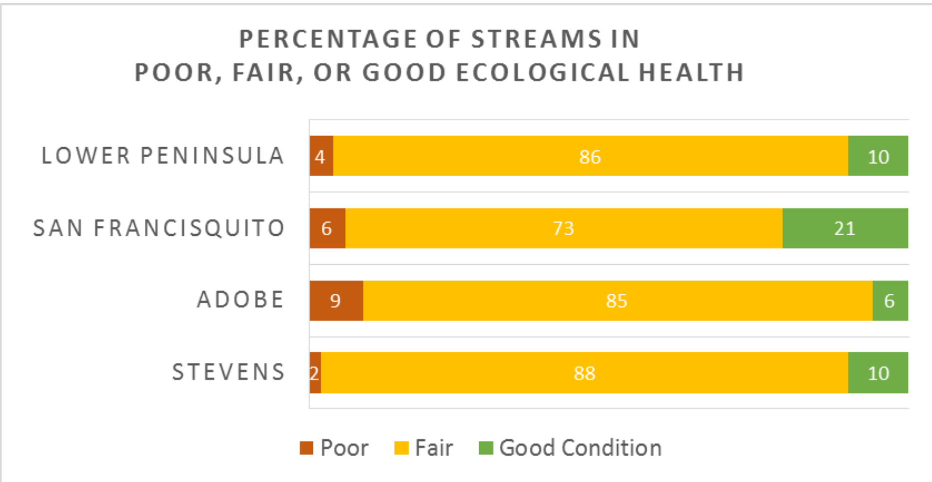

Figure 15. Percent of stream miles in the Lower Peninsula watershed study area and its three PAIs in poor, fair, and good ecological condition based on three equal interval health classes based on the CRAM Index CDF estimates (≤50, 51-75,>75, respectively).

The CRAM Index scores can be mapped to show spatial distribution of condition based on ecological health classes (Figure 16). Due to steep hillslopes at the top of the watershed, most of this land is used for open space, natural watershed lands, or light grazing with minor rural residential properties. This has kept the channels mostly in their natural state, as evidenced by the good condition CRAM Index scores. Channels in the foothills are typically in fair condition, due to overall retention of their structure and vegetation, but are affected by adjacent land uses and change in hydrology. The only sites within the watershed that have poor condition are found in the engineered channels (Figure 11) in the lowest reaches near South San Francisco Bay and are the result of extensive urbanization and channel modification over the past 150 years. The lack of channel complexity in those channels result in relatively low CRAM scores. Figure 17 shows photographic examples of different stream reaches in the Lower Peninsula study area.

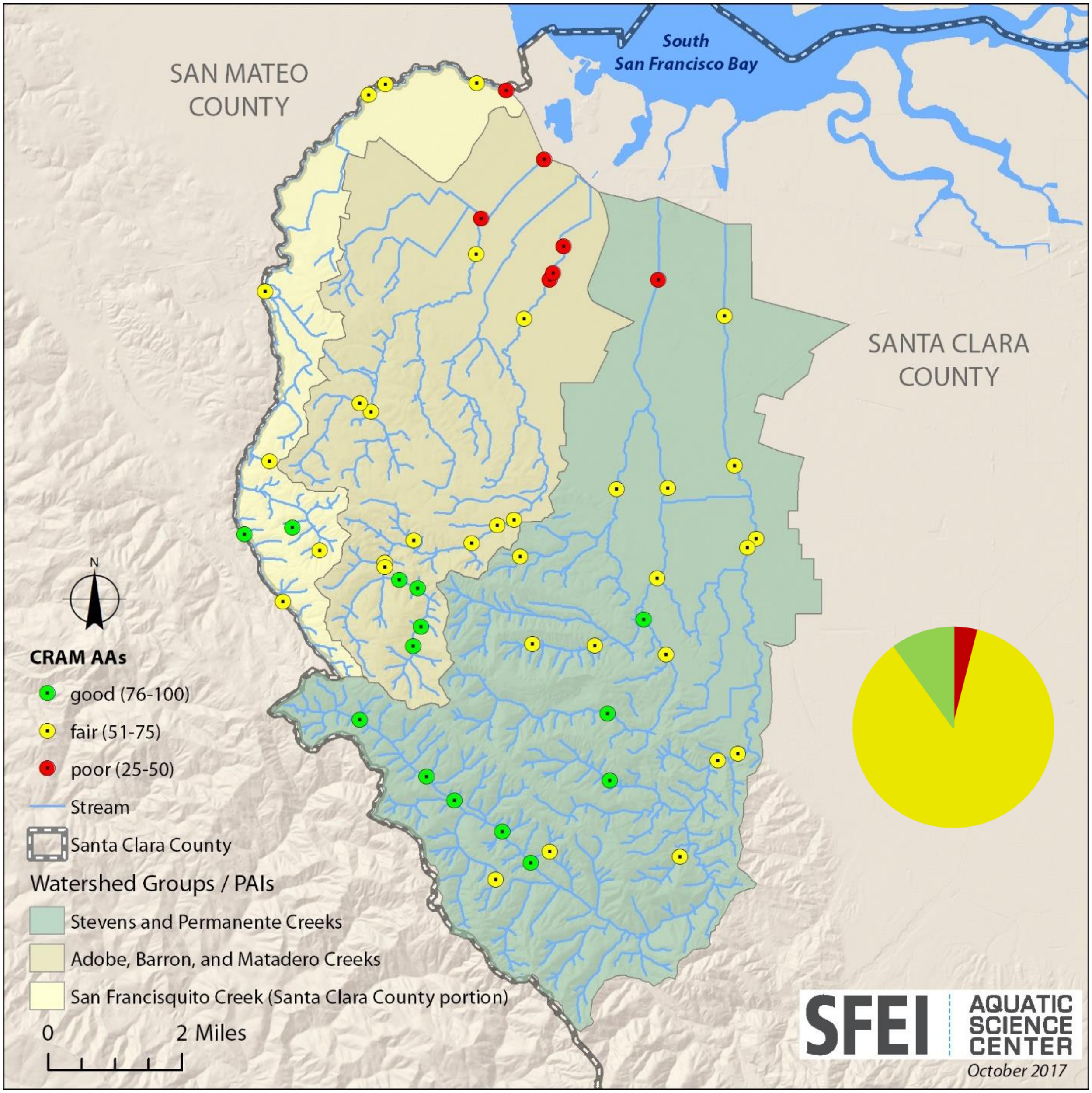

Figure 16. Map of the 2016 stream condition survey AAs for the Lower Peninsula watershed and its PAIs indicating overall ecological condition: poor, fair, and good ecological condition (≤50, 51-75,>75, respectively). The pie chart indicates the estimated proportion of stream miles in each health class.

Figure 17. Photographic examples of different stream reaches within the Lower Peninsula watershed study area. Upper left: headwater stream in good condition. Upper right: foothills stream in good condition. Lower left: upper alluvial plain in fair condition. Lower right: lower alluvial plain in poor condition.

The CDFs of CRAM Index and Attribute scores indicate the proportion of streams and range of ecological conditions in the watershed and PAIs. Differences in shape and position of the CDFs indicate differences in the proportions of streams or percent of stream miles in poor, fair, and good condition with a known level of confidence (Figure 18). A CDF curve (black line) that is shifted to the right reflects better overall stream conditions and conversely a curve shifted to the left reflects relatively poorer ecological conditions. Figure 18 CDFs for the watershed as a whole, and its PAIs are not shifted left or right relative to each other, indicating that the streams are mostly in fair condition.

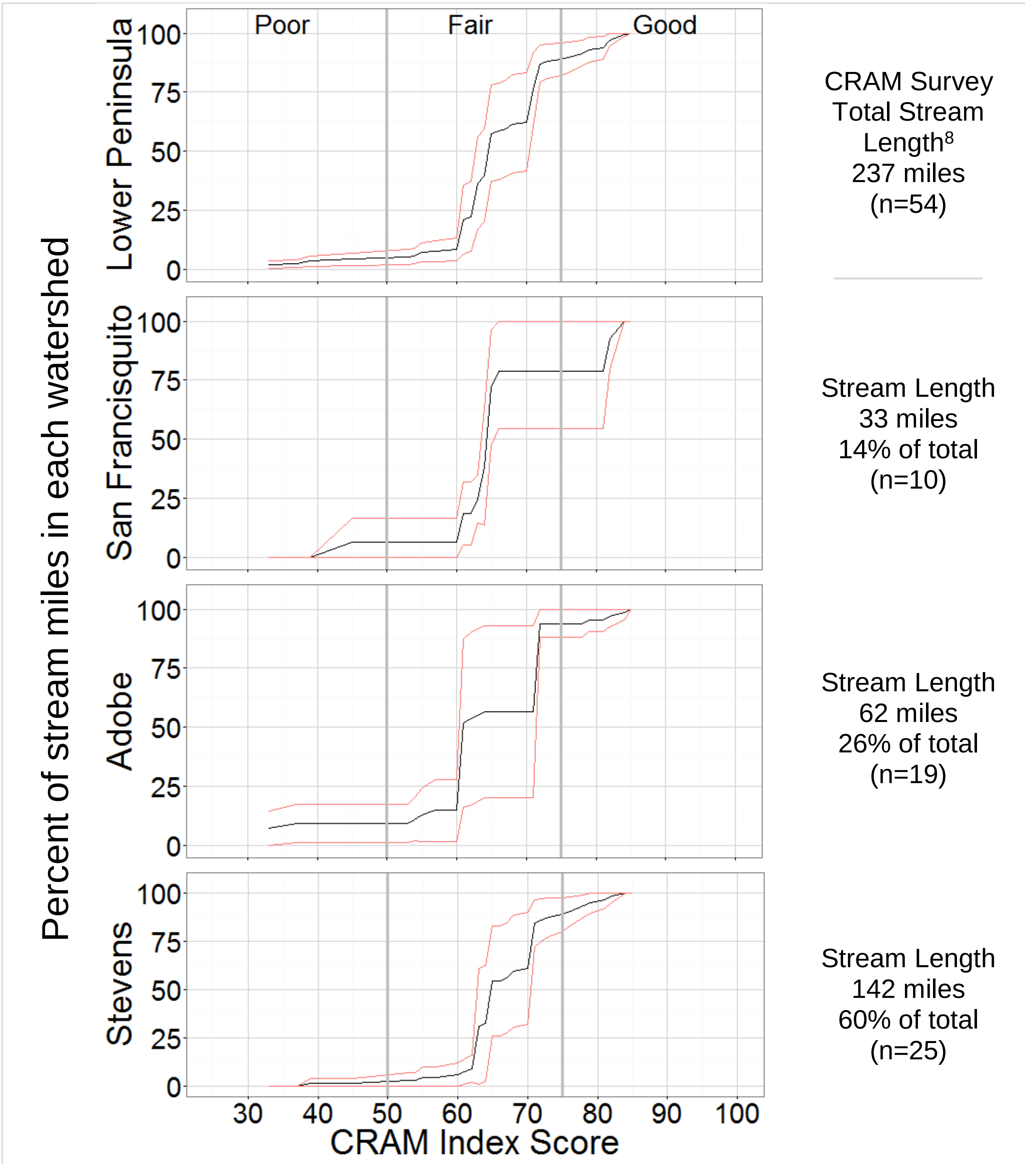

Figure 18. CDF plots of CRAM Index Scores for the Lower Peninsula watershed study area and its three PAIs The red lines represent upper and lower 95% confidence limits around the estimated Index Score CDF (black line). The three equal interval health classes indicate the range of CRAM scores that represent poor (≤50), fair (51-75), and good ecological condition (>75).

In general, the CRAM Index Score CDFs for all three sub-watersheds have similar shapes with clear differences in the amount of uncertainty in the curves (95% confidence limits red lines) and some differences in the proportions of streams in the lowest and highest health classes. With more stream miles in the valley floor region, 10% of streams in the Adobe Creek PAI are in poor condition (Index Scores <50), while the other two PAIs have fewer tributaries in the

[8] This does not include 1st order streams as mapped in BAARI v.2; it is the total length of the streams in the CRAM survey sample frame (see the methods section for more information).

urban valley floor, and less than 6% of streams are in poor condition. San Francisquito Creek within Santa Clara County has 21% of its streams in good condition, while Stevens and Adobe Creek PAIs have 10% and 6% of their streams in good condition, respectively.

To compare the CDF curves and their respective confidence levels across sub-watersheds Figure 19 shows CRAM Index and Attribute Scores in a matrix of small multiple plots. The similar shapes and positions of the curves reflect similar ranges of conditions across PAIs with some differences in the proportions of streams in each health class (as summarized in Figure 15 above). As indicated in Figure 15 (above), 21% of streams in the San Francisquito Creek watershed are in good ecological condition (CRAM Index scores >75), however the wide 95% confidence interval indicates a large amount of uncertainty (between 0 and 46% of the streams are likely to be in good ecological condition). Adobe and Stevens Creek sub-watersheds have 6% and 10% of their streams in good condition, respectively, and their confidence intervals are relatively small. The Biotic Structure Attribute CDF curves indicate that Adobe and Stevens Creek watersheds may have more streams with better Biotic Structure than San Francisquito Creek watershed, although the large uncertainties around the estimates may confound results. The concave shape of the Physical Structure Attribute CDF curves indicate that most of the streams in the watershed have poor physical structure.

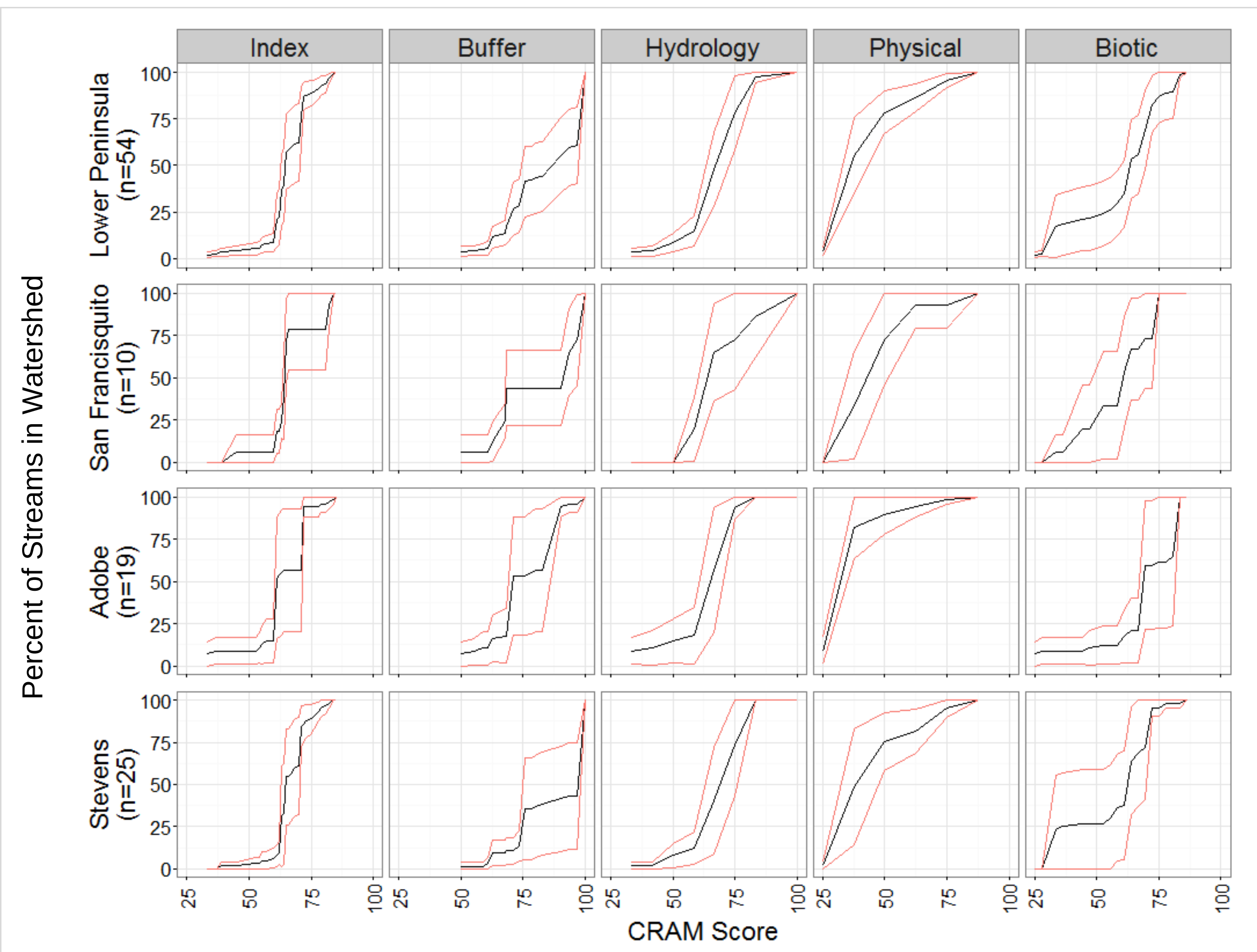

Figure 19. CDF plots of CRAM Index and Attribute scores for the Lower Peninsula study area and its three PAIs

Attribute scores were similar across the four watersheds and indicated that stream buffer conditions are good, hydrology and biotic conditions are fair, but physical conditions are poor. The Lower Peninsula watershed CDFs were further compared using the Wald and Rao-Scott statistical test (Kincaid 2016, Gitzen et al. 2012). Results indicated that only the Adobe Creek Index score CDF was significantly different from the San Francisquito and Stevens Creek CDFs (Wald F distribution = 7 and 29; p-values = 0.004 and 0.000; with 2/25 and 2/40 degrees of freedom, respectively). None of the underlying Attribute Score CDFs were significantly different from each other except for the Buffer Attribute CDF of the Adobe Creek PAI, which was statistically different from the Stevens Creek CDF (Wald F distribution = 6; p-value = 0.01; with 2/40 degrees of freedom), and not significantly different from the San Francisquito Creek CDF.

- What are the ESIs based on the 2016 CRAM stream survey?

An ESI is a numerical statistic, developed for the D5 Project that represents the sample weighted average CRAM score of a watershed or PAI, based on the CDF estimates. The ESI can be used to track stream ecosystem condition over time and can be the basis for establishing a quantitative ecological LOS, or benchmarks of performance for each PAI or watershed as a whole.

Baseline ESIs for the Lower Peninsula watershed study area as a whole and its three PAI's are presented graphically in Figure 20, and listed below in bold along with the number of AAs assessed in each region (n), and their respective 95% confidence interval ranges (in parentheses):

- Lower Peninsula watershed: **66** (63-70) n=54
- San Francisquito: **67** (61-73) n=10
- Adobe: **64** (57-71) n=19
- Stevens: **67** (63-71) n=25

The ESIs from 64 to 67 indicate that the Lower Peninsula and its sub-watersheds are in fair ecological health as a 2016 baseline or existing condition.

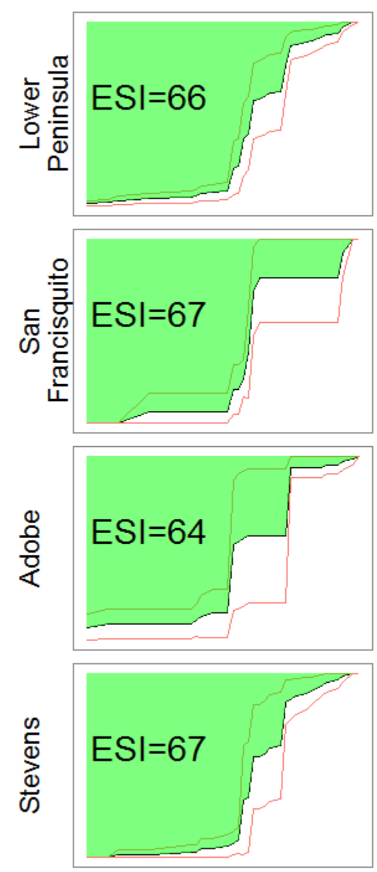

Figure 20. ESIs for the Lower Peninsula watershed and its PAIs based on the 2016 stream condition survey CRAM Scores

- How does the overall ecological condition of streams in the Lower Peninsula watershed compare to other watersheds in the District, and other regions?

The D5 Project's watershed-wide ambient stream condition survey results (based on CRAM) can be compared to other District watersheds previously assessed and other stream condition surveys that employed GRTS survey designs and CRAM.

Figure 21 compares the overall ecological health of streams in Santa Clara County's four major watersheds and other regions based on their ecological health classes. The chart shows relative proportions of streams in poor, fair, and good ecological health for each watershed, or region using probability-based CRAM stream condition surveys conducted by the District, SFEI, and California Surface Water Ambient Monitoring Program's (SWAMP 2016) Perennial Stream Assessment Program (PSA[9]):

- Lower Peninsula watershed: n= 54 (District 2016[10])
- Upper Pajaro River watershed: n=81 (District 2015)
- Guadalupe watershed n=53 (District 2012)
- Coyote Creek watershed: n=47 (District 2010)
- Bay/Delta Ecoregion CDF: n=40 (subset of PSA 2008-2014)
- Santa Rosa Plain - WRAMP demonstration project: n=30 (SFEI 2013[11])
- Statewide Perennial Stream Assessment: n=765 (PSA and Southern California Stormwater Monitoring Coalition 2008-2014[12])

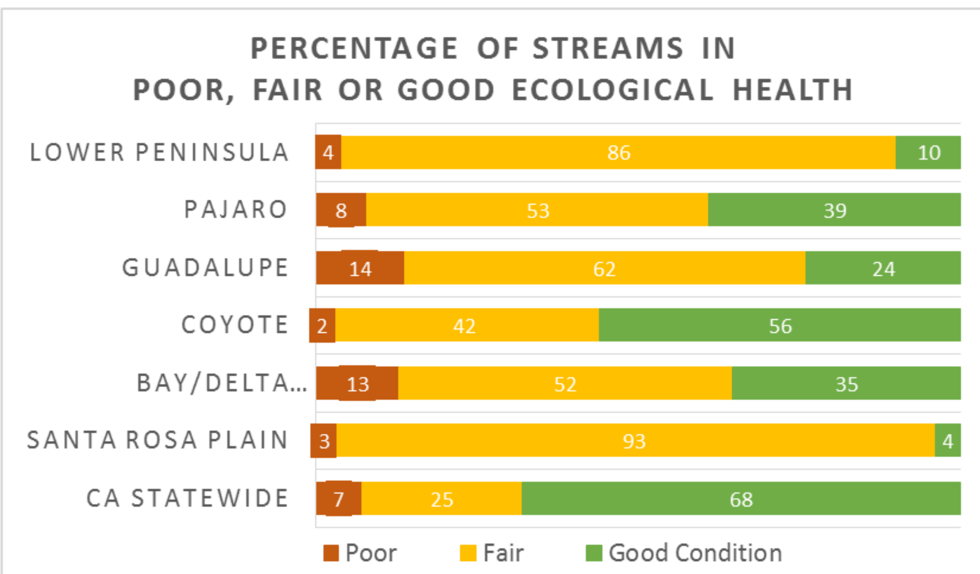

Figure 21. Percent of streams in poor, fair, or good ecological condition in four District watersheds, other nearby regions, and statewide based on probabilistic surveys using CRAM. The three classes of condition (poor, fair, and good) correspond to three equal intervals of the full range of possible CRAM Index scores: ≤50, 51-75, and >75 respectively.

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[9] http://www.waterboards.ca.gov/water_issues/programs/swamp/bioassessment/
[10] District watershed assessments available at http://www.valleywater.org/SCW-D5.aspx
[11] Collins *et al.* 2014.
[12] Perennial Stream Assessment Program of the Stated Water Resources Control Board; http://www.waterboards.ca.gov/water_issues/programs/swamp/bioassessment/

Table 7 further compares Santa Clara County's watersheds based on stream ESIs of the four major watersheds as described above.

Table 7. Comparison of stream ESIs in Santa Clara County watersheds based on the District's D5 Project's CRAM surveys (2010 – 2016).

Watershed	ESI (95% CI)	ESI (95% CI) for PAIs		
Lower Peninsula (2016)	66 (63-77)	San Francisquito 67 (61-73)	Adobe 64 (57-71)	Stevens 67 (63-71)
Upper Pajaro (2015)	70 (63-77)	Pacheco 75 (70-80)	Llagas 60 (56-65)	Uvas 62 (49-75)
Guadalupe (2012)	68 (65-71)	Non-urban 72 (70-75)	Urban 63 (57-68)	
Coyote Creek (2010)	75 (72-78)	Upper Penitencia 73 (70-75)		

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

The CRAM field assessments include a stressor checklist that records the presence of up to 52 different stressors and indicates if the assessment team expects a stressor to significantly, and adversely influence an AA based on standard indicators and sets of considerations. A stressor is an anthropogenic perturbation within a wetland or its environmental setting that is likely to negatively influence the condition and function of the AA. For example, stressors for hydrology, physical structure, and biotic structure must be evident within 50 meters of the AA; buffer and landscape context stressors must be present within 500 meters of the AA in order for the Practitioner to record them.

Table 8 is the CRAM Stressor Checklist showing stressors observed in the Lower Peninsula watershed study area. It indicates: 1) percentage of AAs where the stressor was observed (or present) within the whole study area and each PAI, and 2) percentage of AAs where the observed stressor was thought to have a significant and adverse impact on the AA. Table 8 also indicates which stressors respond to management efforts, because negative effects of some stressors can be mitigated through the presence of riparian buffers and/or changes in stream and riparian management practices.

It should be noted that the relative importance of different stressors and their significant impact on the stream is disregarded by CRAM. The Checklist simply records the presence or absence of the stressor, and then adds a subjective determination about whether the stressor is causing a significant negative effect upon the AA or not. The Practitioner is not asked to rank stressors, nor provide any additional information on the frequency, duration, or extent of the stress. However, Practitioners are taught that stressors generally should be considered significant if they are directly affecting the score of any given metric within the AA, or if the activity is clearly affecting morphology, function, or other natural processes within the stream. Many of the urban stressors are ubiquitous and intrinsic to built environments, and are very difficult to eliminate. Thus, for urban areas, one would expect stressors such as transportation corridors, urban residential, and non-point source discharges to be common.

Table 8. CRAM Stressor Check List indicating: 1) proportion of AAs where the stressor was observed within the whole Lower Peninsula watershed and each PAI, and 2) proportion of AAs where the stressor was thought to have a significant and adverse impact on the AA. 'X' indicates the stressor is responsive to changes in buffer condition and/or in-stream management practices.

Attribute	Stressor	Percent of AAs where stressor was observed				Percent of AAs where stressor was considered to be a significant impact				Responsive to Buffer	Responsive to In-stream Management Practices
		Whole Watershed	Adobe	San Francisquito	Stevens	Whole Watershed	Adobe	San Francisquito	Stevens		
Buffer & Landscape Context	Active recreation (off-road vehicles, mountain biking, hunting, fishing)	27	18	11	41	4	6	0	5	X	
	Commercial feedlots	0	0	0	0	0	0	0	0	X	
	Dams (or other major flow regulation or disruption)	0	0	0	0	0	0	0	0		X
	Dryland farming	2	6	0	0	0	0	0	0	X	
	Industrial/commercial	33	35	44	27	4	6	0	5	X	
	Intensive row-crop agriculture	4	12	0	0	0	0	0	0	X	
	Military training/Air traffic	0	0	0	0	0	0	0	0		
	Orchards/nurseries	4	0	11	5	0	0	0	0	X	
	Passive recreation (bird watching, hiking, etc.)	58	59	56	59	6	6	0	9	X	X
	Physical resource extraction (rock, sediment, oil/gas)	2	0	0	5	2	0	0	5	X	X
	Ranching (enclosed livestock grazing or horse paddock or feedlot)	8	18	0	5	0	0	0	0	X	
	Rangeland (livestock rangeland also managed for native vegetation)	2	6	0	0	2	6	0	0	X	
	Sports fields and urban parklands (golf courses, soccer fie	19	18	0	27	4	6	0	5	X	
	Transportation corridor	65	71	78	55	27	35	33	18	X	
	Urban residential	69	76	78	59	38	41	33	36	X	

Table 8 (continued). CRAM Stressor Check List indicating: 1) proportion of AAs where the stressor was observed within the whole Lower Peninsula watershed and each PAI, and 2) proportion of AAs where the stressor was thought to have a significant and adverse impact on the AA. 'X' indicates the stressor is responsive to changes in buffer condition and/or in-stream management practices.

Attribute	Stressor	Percent of AAs where stressor was observed				Percent of AAs where stressor was considered to be a significant impact				Responsive to Buffer	Responsive to In-stream Management Practices
		Whole Watershed	Adobe	San Francisquito	Stevens	Whole Watershed	Adobe	San Francisquito	Stevens		
Hydrology	Actively managed hydrology	4	0	0	9	0	0	0	0		X
	Dams (reservoirs, detention basins, recharge basins)	6	6	0	9	2	0	0	5	X	X
	Dike/levees	6	18	0	0	4	12	0	0		X
	Ditches (agricultural drainage, mosquito control, etc.)	0	0	0	0	0	0	0	0	X	X
	Dredged inlet/channel	0	0	0	0	0	0	0	0		
	Engineered channel (riprap, armored channel bank, bed)	44	65	44	27	23	35	22	14		X
	Flow diversions or unnatural inflows	2	0	0	5	0	0	0	0		X
	Flow obstructions (culverts, paved stream crossings)	8	12	0	9	0	0	0	0		X
	Groundwater extraction	0	0	0	0	0	0	0	0		
	Non-point Source (Non-PS) discharges (urban runoff, farm drainage)	48	71	33	36	8	6	0	14	X	X
	Point Source (PS) discharges (POTW, other non-stormwater discharge)	2	6	0	0	0	0	0	0		X
	Weir/drop structure, tide gates	10	6	22	9	0	0	0	0		X

Table 8 (continued). CRAM Stressor Check List indicating: 1) proportion of AAs where the stressor was observed within the whole Lower Peninsula watershed and each PAI, and 2) proportion of AAs where the stressor was thought to have a significant and adverse impact on the AA. 'X' indicates the stressor is responsive to changes in buffer condition and/or in-stream management practices.

Attribute	Stressor	Percent of AAs where stressor was observed				Percent of AAs where stressor was considered to be a significant impact				Responsive to Buffer	Responsive to In-stream Management Practices
		Whole Watershed	Adobe	San Francisquito	Stevens	Whole Watershed	Adobe	San Francisquito	Stevens		
Physical Structure	Bacteria and pathogens impaired (PS or Non-PS pollution)	0	0	0	0	0	0	0	0	X	
	Excessive runoff from watershed	2	0	0	5	0	0	0	0	X	X
	Excessive sediment or organic debris from watershed	0	0	0	0	0	0	0	0	X	X
	Filling or dumping of sediment or soils (N/A for restoration areas)	0	0	0	0	0	0	0	0	X	X
	Grading/compaction (N/A for restoration areas)	31	29	22	36	17	18	11	18	X	
	Heavy metal impaired (PS or Non-PS pollution)	2	0	11	0	0	0	0	0	X	
	Nutrient impaired (PS or Non-PS pollution)	2	6	0	0	0	0	0	0	X	
	Pesticides or trace organics impaired (PS or Non-PS pollution)	2	0	0	5	0	0	0	0	X	
	Plowing/Discing (N/A for restoration areas)	0	0	0	0	0	0	0	0	X	
	Resource extraction (sediment, gravel, oil and/or gas)	2	0	0	5	0	0	0	0	X	
	Trash or refuse	40	41	44	36	6	0	22	5	X	X
	Vegetation management	42	53	33	36	2	6	0	0	X	X

Table 8 (continued). CRAM Stressor Check List indicating: 1) proportion of AAs where the stressor was observed within the whole Lower Peninsula watershed and each PAI, and 2) proportion of AAs where the stressor was thought to have a significant and adverse impact on the AA. ‘X’ indicates the stressor is responsive to changes in buffer condition and/or in-stream management practices.

Attribute	Stressor	Percent of AAs where stressor was observed				Percent of AAs where stressor was considered to be a significant impact				Responsive to Buffer	Responsive to In-stream Management Practices
		Whole Watershed	Adobe	San Francisquito	Stevens	Whole Watershed	Adobe	San Francisquito	Stevens		
Biotic Structure	Biological resource extraction or stocking (fisheries, aquaculture)	2	0	0	5	0	0	0	0		X
	Excessive human visitation	29	24	22	36	15	0	22	23	X	
	Lack of treatment of invasive plants adjacent to AA or buffer	44	47	33	45	35	47	33	27	X	
	Lack of vegetation management to conserve natural resources	13	29	0	5	8	24	0	0	X	
	Mowing, grazing, excessive herbivory (within AA)	21	24	22	18	0	0	0	0	X	
	Pesticide application or vector control	0	0	0	0	0	0	0	0	X	
	Predation and habitat destruction by non-native vertebrates (e.g., Virginia opossum and domestic predators, such as feral pets)	15	24	0	14	0	0	0	0	X	
	Removal of woody debris	0	0	0	0	0	0	0	0	X	X
	Treatment of non-native and nuisance plant species	2	6	0	0	2	6	0	0	X	
	Tree cutting/sapling removal	17	12	11	23	0	0	0	0	X	X

Table 9 summarizes the stressor information. For the purposes of this report, very important stressors are defined as those that were observed within at least 25% of the AAs in the Lower Peninsula 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 in the Lower Peninsula watershed or any one of its PAIs, or were expected to significantly impact at least 5% of those AAs. The four most common and significant impact stressors in the Lower Peninsula watershed and its PAIs include:

- Urban residential
- Transportation corridor
- Engineered channel (riprap, armored channel bank or bed)
- Lack of treatment of invasive plants adjacent to AA or buffer

Table 9. Very important and moderately important stressors listed in approximate descending order of importance (see text immediately above for ranking criteria)

Stressor	Lower Peninsula Watershed		San Francisquito		Adobe		Stevens	
	% AAs Observed	% AAs Impaired	% AAs Observed	% AAs Impaired	% AAs Observed	% AAs Impaired	% AAs Observed	% AAs Impaired
Very Important Stressors								
Active recreation (off-road vehicles, mountain biking, hunting, fishing)	27	4	11	0	18	6	41	5
Industrial/commercial	33	4	44	0	35	6	27	5
Passive recreation (bird watching, hiking, etc.)	58	6	56	0	59	6	59	9
Sports fields and urban parklands (golf courses, soccer fields)	19	4	0	0	18	6	27	5
Transportation corridor	65	27	78	33	71	35	55	18
Urban residential	69	38	78	33	76	41	59	36
Engineered channel (riprap, armored channel bank, bed)	44	23	44	22	65	35	27	14
Non-point Source (Non-PS) discharges (urban runoff, farm drainage)	48	8	33	0	71	6	36	14
Grading/compaction (N/A for restoration areas)	31	17	22	11	29	18	36	18
Trash or refuse	40	6	44	22	41	0	36	5
Vegetation management	42	2	33	0	53	6	36	0

Stressor	Lower Peninsula Watershed		San Francisquito		Adobe		Stevens	
	% AAs Observed	% AAs Impaired	% AAs Observed	% AAs Impaired	% AAs Observed	% AAs Impaired	% AAs Observed	% AAs Impaired
Excessive human visitation	29	15	22	22	24	0	36	23
Lack of treatment of invasive plants adjacent to AA or buffer	44	35	33	33	47	47	45	27
Lack of vegetation management to conserve natural resources	13	8	0	0	29	24	5	0
Moderately Important Stressors								
Physical resource extraction (rock, sediment, oil/gas)	2	2	0	0	0	0	5	5
Dams (reservoirs, detention basins, recharge basins)	6	2	0	0	6	0	9	5
Dike/levees	6	4	0	0	18	12	0	0
Treatment of non-native and nuisance plant species	2	2	0	0	6	6	0	0

Stream Condition Risks

The D5 Project watershed assessments provide a baseline against which future changes in the distribution, abundance, and diversity of wetlands and conditions of streams can be assessed. When viewed as a whole, the most likely sources of change in aquatic resources for the next decade are development (or re-development), and climate change. Both are likely to strongly influence all other sources of risk in stream ecosystem health.

The District owns a small portion of the stream networks in the Lower Peninsula watershed (see Figure 13) and the properties are generally located in the urban, lower watershed reaches. This means that streams managed directly by the District are largely subject to upstream land management practices and policies of other entities. This puts a premium on partnerships between these entities and the District to manage stressors affecting streams. The partnerships might consider using performance targets (which could be based on the D5 Project CRAM stream surveys) to coordinate and monitor progress of their various management efforts.

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 habitat widths and the extension 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.

Results of the CRAM stream condition survey in the Lower Peninsula 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 conditions?

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. Project D2, other Safe, Clean Water and Natural Flood Protection Program projects, and SMP are attempting to reverse the trend. The first technical step in treatment would be the production of a comprehensive map of the invasions. There are statewide attempts to do this (e.g., see the California Invasive Plant Council (Cal-IPC) and Calflora). In addition, results of the D5 Project CRAM stream condition surveys can be used to identify the dominant invasive species within Santa Clara County watersheds.

The negative impacts of roads and development are also likely to continue unless economically and politically difficult mitigating measures are taken. The main measure might be to increase the width, continuity, and spatial complexity of the riparian zones of streams that border by busy roads, or are in residential and urban areas. Best Management Practices (BMPs) including installation of Low Impact Development (LID) measures should be used to retain and treat runoff from roads and parking lots before it reaches the streams and their associated riparian areas.

Most of the mid- to high-order streams are moderately to deeply entrenched, if they have not already been converted to engineered channels. Entrenched channels limit 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 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 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. Bank erosion or collapse increases regardless of whether or not the channels migrate, because increased height of the banks increases their instability. Unless mitigating measures are taken, a reduction in the ESI for the watershed 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 types and their riparian conditions.

Climate change, especially 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 being done 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 south Bay Area watersheds, 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, influence all ecosystem goods and services, including water supplies. The District should and is considering 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[13].

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, capacity, and flood risk. 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

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[13] http://www.valleywater.org/Services/ClimateChange.aspx

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).

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 mid-winter months, such that peak flows in streams are increased.

Table 10 lists possible major effects of climate change on the distribution and abundance of aquatic resources in the Lower Peninsula 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 10. 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

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 higher peak flows would probably initiate a new period of channel incision and head-cutting, especially where 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 likely increase the risk of flooding. More intense or frequent storms may also directly result in increased flooding, regardless of channel aggradation. Any efforts to restore health of streams in the upper 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).

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Appendix A

Lower Peninsula Watershed CRAM Stream Survey Results

Figure A1. Map of final the CRAM assessment areas (AAs) with SiteID labels

Table A1. CRAM assessment scores with site information

Figure A1. Map of the District's D5 Project's 2016 Lower Peninsula watershed CRAM stream survey AAs and site IDs.

Appendix Table A1. 2016 Lower Peninsula watershed CRAM stream survey results including AA siteIDs, eCRAM AARowIDs, visit date, and CRAM Index and Attribute Scores.

Site ID	AARow ID	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: San Francisquito Creek Watershed (within Santa Clara County)														
SanFSC-073	4973	5/25/2016	riverine	confined	intermittent	0.4	9.47	6	0	61	68	67	50	61
SanFSC-074	5118	7/14/2016	riverine	non-confined	intermittent	0.24	9.95	6	0	61	68	58	50	69
SanFSC-078	4974	5/25/2016	riverine	confined	perennial	0.23	10.11	6	1	45	50	58	38	33
SanFSC-079	5050	6/7/2016	riverine	non-confined	perennial	0.7	1.25	2	1	64	100	67	38	53
SanFSC-082	5053	6/7/2016	riverine	non-confined	perennial	0.33	4.43	4	1	66	93	58	50	61
SanFSC-083	4972	5/23/2016	riverine	non-confined	ephemeral	0.54	1.98	2	0	65	93	83	38	44
SanFSC-086	5003	6/15/2016	riverine	non-confined	ephemeral	0.23	0.72	2	0	82	100	100	63	64
SanFSC-090	5116	7/14/2016	riverine	confined	intermittent	0.22	5.48	6	0	63	63	67	63	61
SanFSC-094	5125	7/11/2016	riverine	non-confined	perennial	0.23	3.72	4	1	84	97	75	88	75
SanFSC-096	5288	8/15/2016	riverine	non-confined	perennial	0.26	6	5	1	65	68	67	50	75
Primary Area of Interest: Adobe Creek Watershed														
Adb-001	4971	5/23/2016	riverine	non-confined	perennial	0.22	NA	5	1	55	59	50	38	75
Adb-002	5318	6/2/2016	riverine	non-confined	perennial	NA	4.58	4	1	82	100	83	75	69
Adb-004	5320	4/26/2016	riverine	confined	intermittent	0.13	6.8	5	1	33	50	33	25	25
Adb-005	5085	6/29/2016	riverine	non-confined	perennial	0.2	2.9	5	1	62	79	58	50	61
Adb-006	5004	6/14/2016	riverine	non-confined	perennial	0.21	2.38	4	1	84	100	83	88	64
Adb-008	4968	5/24/2016	riverine	confined	perennial	0.05	6.15	4	1	33	50	33	25	25
Adb-009	5082	6/27/2016	riverine	non-confined	ephemeral	0.13	1.39	3	0	72	90	75	38	83
Adb-010	5081	6/27/2016	riverine	non-confined	intermittent	0.21	3.01	4	0	64	68	58	63	69

Site ID	AARow ID	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
Adb-012	4966	5/24/2016	riverine	confined	ephemeral	0.14	4.57	5	0	33	50	33	25	25
Adb-013	4997	6/6/2016	riverine	confined	perennial	0.17	3.2	4	1	85	100	83	75	81
Adb-017	5086	6/29/2016	riverine	confined	perennial	0.27	2.1	5	1	57	63	42	63	61
Adb-018	5319	6/2/2016	riverine	non-confined	perennial	0	2.69	4	1	79	93	67	75	81
Adb-019	4970	5/24/2016	riverine	non-confined	intermittent	0.16	NA	4	0	61	55	67	63	61
Adb-020	4989	5/24/2016	riverine	confined	ephemeral	0.07	5.3	5	0	33	50	33	25	25
Adb-024	5322	7/7/2016	riverine	confined	intermittent	NA	6.84	5	1	37	63	33	25	28
Adb-025	5051	6/6/2016	riverine	non-confined	intermittent	0.08	1.67	4	0	63	80	75	50	47
Adb-026	5323	7/7/2016	riverine	non-confined	intermittent	0	2	3	0	61	71	67	38	69
Adb-028	5324	7/8/2016	riverine	non-confined	intermittent	0	3.66	5	0	54	63	50	50	53
Adb-029	5049	6/6/2016	riverine	confined	perennial	0.23	3.03	5	1	72	90	83	50	64
Primary Area of Interest: Stevens Creek Watershed														
Stev-113	4975	5/25/2016	riverine	non-confined	perennial	0.28	7.25	5	1	61	61	50	75	58
Stev-114	4991	6/9/2016	riverine	non-confined	perennial	0.29	1.57	4	1	72	93	75	63	58
Stev-115	4967	5/26/2016	riverine	non-confined	intermittent	0.47	3.09	4	1	82	100	83	88	56
Stev-116	5121	7/12/2016	riverine	non-confined	intermittent	0.28	2.4	4	1	67	100	83	50	36
Stev-117	5119	7/13/2016	riverine	confined	perennial	0.29	2.29	4	1	55	63	50	50	58
Stev-118	5120	7/13/2016	riverine	non-confined	perennial	0.23	3.18	6	1	64	73	50	63	69
Stev-119	5055	6/8/2016	riverine	non-confined	perennial	0.21	5.72	5	1	78	100	75	75	61
Stev-120	5006	6/13/2016	riverine	non-confined	perennial	0.5	1.92	3	1	71	100	83	38	64
Stev-121	5054	6/8/2016	riverine	non-confined	perennial	0.23	2.46	6	1	53	63	67	38	44
Stev-122	5009	6/16/2016	riverine	non-confined	perennial	0.17	3.1	5	1	68	80	67	63	64

Site ID	AARow ID	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
Stev-123	4969	5/26/2016	riverine	non-confined	perennial	0.22	4.81	5	1	73	63	75	75	78
Stev-124	5005	6/13/2016	riverine	non-confined	perennial	0.18	4.09	5	1	81	100	83	63	78
Stev-126	5321	4/26/2016	riverine	non-confined	perennial	0.2	6	5	1	71	68	75	75	67
Stev-129	5087	6/29/2016	riverine	confined	perennial	0.12	3.67	6	1	39	63	33	25	33
Stev-133	5123	7/12/2016	riverine	confined	intermittent	0.29	4.53	5	0	62	73	67	50	58
Stev-134	5325	7/27/2016	riverine	non-confined	ephemeral	NA	1.13	3	0	63	76	67	38	72
Stev-135	5090	6/30/2016	riverine	non-confined	intermittent	0.24	1.5	4	0	68	100	67	38	69
Stev-136	5088	6/30/2016	riverine	non-confined	perennial	0.27	5.24	5	1	78	100	75	75	64
Stev-137	5002	6/15/2016	riverine	non-confined	perennial	0.14	5.7	4	1	84	100	75	75	86
Stev-138	5010	6/16/2016	riverine	non-confined	perennial	0.15	3.37	5	1	76	90	58	88	67
Stev-139	5084	6/28/2016	riverine	non-confined	perennial	0.12	5.7	5	1	70	83	58	75	64
Stev-140	5083	6/28/2016	riverine	non-confined	perennial	0.34	5.69	4	1	79	100	75	75	67
Stev-142	5122	7/11/2016	riverine	non-confined	perennial	0.29	5.85	5	1	60	50	58	75	56
Stev-146	4992	6/9/2016	riverine	non-confined	intermittent	0.31	1	3	0	65	100	75	50	33
Stev-147	5314	8/15/2016	riverine	confined	perennial	0.29	12	5	1	75	90	50	88	72