Statistical Design, Analysis and Graphics for the Guadalupe River Assessment

Technical Memoranda Two, Four & Five
Report prepared for the Santa Clara Valley Water District
Agreement Number A3562F

by

San Francisco Estuary Institute

& Aquatic Science Center

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Introduction

The Santa Clara Valley Water District (District) is assessing the condition of streams in the Guadalupe River watershed based on the District s Ecological Monitoring and Assessment Framework (EMAF). EMAF is consistent with the Wetland and Riparian Area Monitoring Plan (WRAMP) developed by the California (CA) Wetland Monitoring Workgroup of the CA Water Quality Monitoring Council to increase the capacity of agencies to assess status and trends of California wetlands, streams, and riparian areas. The District conducted an EMAF pilot study in the Coyote Creek watershed in 2010 (EOA and SFEI 2011) and subsequently asked the San Francisco Estuary Institute and Aquatic Science Center (SFEI-ASC) to assist with the Guadalupe River Streams Assessment in 2012. SFEI-ASC is working with the District to:

- Review and advise on the preliminary resource management questions developed for this assessment (technical memorandum one);
- Design the monitoring following established methods, particularly sampling design and site selection, and assist with implementation (technical memorandum two);
- Provide California Rapid Assessment Methodology (CRAM) Riverine training to District field staff;
- Assist with conducting CRAM assessments in the Guadalupe watershed according to the study design;
- Discuss and advise on appropriate monitoring designs to address environmental resource indicators requiring intensive study (Level-3 management questions in technical memorandum three); and
- Conduct data analyses, summarize aquatic resource distribution and stream condition assessment results based on District needs (technical memoranda four and five).

This document describes the distribution of aquatic resources within the Guadalupe River watershed and summarizes the Guadalupe River Streams Assessment study design and results. Therefore, it fulfills SFEI-ASC contractual obligations to the District for Technical Memoranda two, four and five as outlined above.

Management Questions

A fundamental purpose of EMAF is alignment of ecological data collection and analysis with the needs of water resource decision-making. This is achieved by carefully developing management questions or concerns that the data should address. This Technical Memoranda Two, Four, and Five of the Guadalupe River Assessment addresses the following Management Questions, as provided by the District and based on the 1-2-3 Framework of EMAP (EOA and SFEI 2011).

Level 1: Resource Management Questions regarding extent, distribution and ownership

1) What is the extent and distribution of stream ecosystem resources (or aquatic resources) in the watershed?
    - How many miles are there of modified and unmodified channel (unnatural and natural stream lengths)?

2) What is the extent and distribution of stream associated riparian and riparian areas associated with other wetlands?
3) What is the extent and distribution of non-riverine wetlands?
4) Who owns the streams?
    - What is the proportion of streams for which District has land rights?
    - What proportion of the streams fall within city boundaries?
    - Where are the District owned/fee title stream reaches located?
5) How and where are the stream corridors interrupted?

Level 2: Resource Management Questions regarding condition

1) What are the conditions of streams in the watershed?
2) What are the likely stressors impacting stream condition?
3) What are the Levels of Service (LOS) for stream ecosystem resources?

Integrated Level 1-3 Management Questions: Stream Condition Risks

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

Geographic Setting

The Guadalupe River begins in tributaries near the summits of Loma Prieta and Mount Umunhum, draining the eastern Santa Cruz Mountains of Santa Clara County to the west, then north as the Guadalupe River flows into South San Francisco Bay through Alviso Slough (Figure 1). The sparsely developed upper portion of the 170 square mile (mi^2), 440 km^2) watershed includes the historic New Almaden mercury mines, now a County Park. Almost 49 percent (%) of the watershed lies within unincorporated parts of Santa Clara County (District 2007) and most of the upper watershed is forested land owned by the Midpeninsula Regional Open Space District and San Jose Water Company. The lower portion includes the densely developed Silicon Valley municipalities of San Jose, Los Gatos, Monte Sereno, Campbell, and Santa Clara. San Jose is the tenth most populous city in the United States (U. S. Census Bureau 2012) and covers just over 40% of the Guadalupe River watershed. In total, parts of these five cities cover just over 50% of the watershed (District 2007).

The District manages five reservoirs in the watershed: Calero Reservoir on Calero Creek, Guadalupe Reservoir on Guadalupe Creek, Almaden Reservoir on Alamitos Creek, Vasona Reservoir, and Lexington Reservoir both on Los Gatos Creek. Lake Elsman, above Lexington Reservoir on upper Los Gatos Creek, is owned by the San Jose Water Company. Winter runoff is stored in the reservoirs and released in the summer months to recharge groundwater basins and maintain flows for fish. Locally conserved water is augmented with imported water for recharge. Routing the river from Guadalupe Slough into Alviso Slough in the late nineteenth century disconnected the river from San Tomas Aquino Creek and Calabazas Creek, thus reducing the size of the Guadalupe River watershed.

The Guadalupe River Assessment Study is focused on streams within the Guadalupe River watershed above the region of tidal influence, as delimited by the Bay Area Aquatic Resource Inventory (upstream limit of tidal waters is assumed to correspond to Tasman Drive; BAARI; SFEI 2011a). BAARI has all surface waters including wetlands, creeks, streams, lakes, ponds, etc. The stream network of the Guadalupe River watershed includes Strahler stream orders 1 through 7 (Strahler 1952, 1957). There are approximately 15 named tributaries to the Guadalupe River.

City boundaries, major roadways, and the District s Urban Service Area within the Guadalupe River watershed have been added to BAARI for the purposes of this project at the District s request. The urban area is essentially the same as the District s official Urban Service Area with a recent modification at its southeastern extent to include the urban area near Los Paseos in San Jose.

Methods

Level-1 Mapping Methods

In order to describe the extent and distribution of the aquatic resources, and identify District ownership of streams in the Guadalupe River watershed, SFEI-ASC used BAARI plus additional geospatial data provided by the District or available online. The datasets used in the data analyses included the following.

> **Bay Area Aquatic Resource Inventory (BAARI)** BAARI is the Bay Area version of the California Aquatic Resource Inventory (CARI). BAARI is fully documented online (http://www.sfei.org/BAARI). It is an intensification of the National Wetland Inventory (NWI) of the U. S. Fish and Wildlife Service (USFWS) and National Hydrologic Dataset (NHD) of the U. S. Geologic Survey (USGS). It is consistent with federal and state mapping standards.

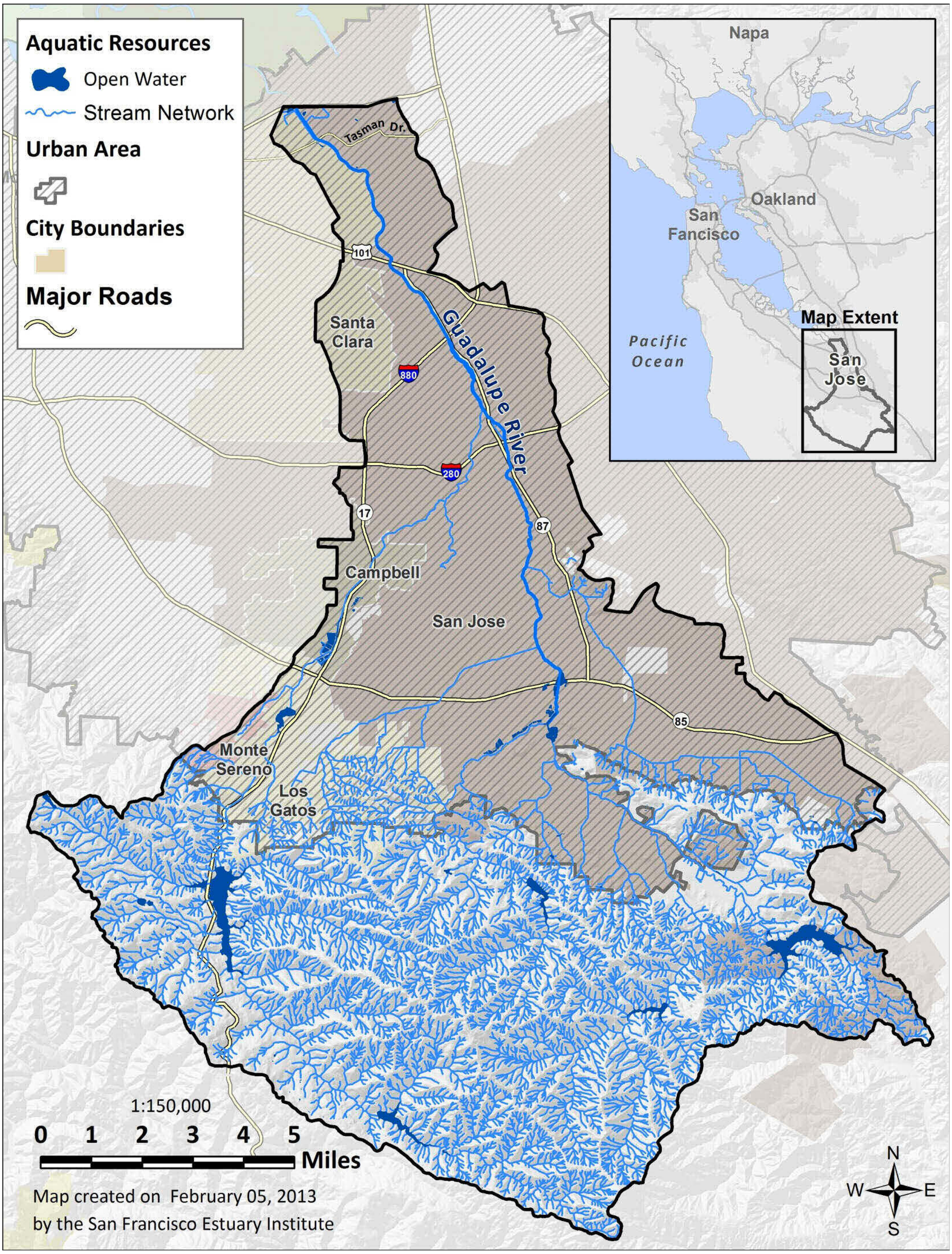


Figure 1. Map of the Guadalupe River watershed boundary and stream network for the freshwater reaches of the streams based on the Bay Area Aquatic Resource Inventory (BAARI, SFEI 2011a). The stream network includes Strahler stream orders 1-7, connecting storm drains (which link the drainage of the upper and lower watershed), and open water (e.g., reservoirs and groundwater recharge ponds). City boundaries, major roadways, and the District s Urban Service Area (urban area) are also shown in this map.

BAARI further classifies stream channels as natural or engineered (i.e., unnatural channels) based on local knowledge and the degree to which they resemble natural fluvial channels in plan-view. Small unnatural channels are classified as ditches. BAARI includes medium to large sized underground storm drains that connect streams to each other or to other water bodies. BAARI also supports the Riparian Width Decision Tool (RWDT, SFEI-ASC 2012b) that estimates the width of riparian zones based on vegetation structure, topography, and developed land cover. Table 1 describes the aquatic resources presented in the maps of this report including the underlying BAARI definitions.

Table 1. Description of aquatic resources presented in the maps in this report.

Aquatic Resource	Description
Slope Wetland	Wetland depending mainly on groundwater as its water source and lacking abundant standing water. This wetland type is most common along the lower slopes of hills and alluvial fans, and includes seeps and springs as well as seepage from manmade impoundments or water storage structures such as earthen dams.
Vegetated Wetland	Includes depressional vegetated and Lacustrine vegetated wetlands as defined by BAARI. These features include the aquatic or wetland vegetation adjoining an open water areas of feature such as a lake, pond, or depressional wetland.
Open Water	Includes depressional open water and lacustrine open water wetlands as defined by BAARI.
Riparian Area	The functional riparian area as defined by the slope and vegetation height adjacent to any above ground water body.
Natural Channel	As defined in BAARI, Natural Channels are landscape features having well-defined beds and banks that have direct connection to the atmosphere and that are formed and maintained by the gravity flow of water.
Unnatural Channel	As defined in BAARI, Engineered Channels are landscape features having well-defined beds and banks that have direct connection to the atmosphere and that have been constructed to convey water. They include ditches.
Channel Connector	These are subsurface (buried) storm drains included in BAARI that convey flow between natural or unnatural channels.
Urban Drainage	These include all storm drains at least 2.0 ft in diameter that are not included in BAARI but are instead provided by the William Lettis & Associates (WLA) storm drain dataset. These storm drains do not connect segments of natural or unnatural channels.

Riparian Width Decision Tool (RWDT) RWDT is a planning tool for estimating the widths of riparian areas needed to support selected riparian functions or services. It is a component of the CA Wetland and Riparian Area Monitoring Plan (WRAMP).The riparian definition is provided by the National Research Council (Brinson et al. 2002), which the State Water Board is considering for adoption (TAT 2010). Based on this definition, the RWDT assumes that all water bodies, including all lakes, ponds, rivers and streams, estuarine and marine waters, and all wetlands have adjoining riparian areas. It also assumes that different riparian functions tend to extend different distances away from the water bodies. Therefore, the tool further assumes that the diversity of functions that can be provided by a riparian area tends to increase with the area s width.

The likely width of a riparian area for some functions can be influenced by the vegetation structure of the area and topographic slope. For example, the amount of shade that a riparian area can provide to its adjoin water body is related to the length of the shadow of the riparian vegetation, which is related to its maximum height. The likelihood of allochthonous input from riparian vegetation or from hillslope processes is positively related to topographic slope of the riparian area, normal to shore of the water body. The RWDT therefore increases riparian width for these functions as slope increases.

The RWDT operates on a basemap of surface waters, using vegetation maps and topography as input data to help estimate riparian extent around the waters, depending on the riparian functions of interest. For example, a user might select the shade and allochthonous input functions, and the RWDT would generate a map of the estimated maximum the width of the riparian areas that provide those functions, based on vegetation height and topographic slope.

For this project, RWDT was used to estimate the maximum riparian extent based on bank stability, shading, allochthonous input, and hillslope processes, on BAARI as the base map, and using the USGS 10-m node DEM and the USFS CalVeg as input data for topography and vegetation, respectively. It should be noted that, except in topographically flat areas with very low-growing vegetation (where the riparian area as estimated by the RWDT for any function is very narrow), the riparian area included in a CRAM AA is only a portion of the total riparian area depicted by the RWDT.

Guadalupe Watershed The boundary of the upper portion of the watershed was provided by BAARI and the boundary of the lower portion was by provided by the District. Watershed boundaries in BAARI are generated based on a digital elevation model that does not perform well in very low-gradient (i.e., flat) terrain. For the valley floor of the watershed, the boundary map that was developed by the District and provided to SFEI. This extent was deemed more accurate than the map generated by BAARI, and therefore was used in this study.

Storm Drains The storm drain dataset incorporated into BAARI for this project was provided as part of the Creek and Watershed Map of the Santa Clara Basin created in 2005 by William Lettis and Associates, Inc., based on data compiled from cities and counties, plus aerial imagery dating between 1999 and 2004 with field inspection (Sowers et al. 2005).

Cities and Roads - These data were downloaded as Tiger Places shape files from the U. S. Census Bureau website in November of 2012 (U. S. Census Bureau 2012a). These data were then filtered by SFEI-ASC to display only the cities and roads within the Guadalupe watershed.

Urban Area The map of the urban area was provided by the District as a shape file titled URBSRV.shp. This is the area within the watershed that currently receives urban services, facilities, and utilities, or that is proposed to be provided with such services within five years. This dataset includes the southeastern portion of the watershed near the Los Paseos area of San Jose.

ESRI Road Network This dataset was created by Tele Atlas (ESRI 2010) and is more accurate than the 2012 Tiger data with regard to small roads. It was used to identify places where roads cross streams.

Level-2 Rapid Assessment Methods

Study Design

The study design for this project consisted of identifying management questions or concerns to be addressed, definition of the study area to which the results should pertain, definition of the sample frame (or study area), identification of data to be collected, sample draw for data collection, and the plan for data analyses and reporting.

The District defined the study area for stream condition assessments as the Guadalupe River watershed drainage network excluding storm drains, first-order streams, and aquatic resources other than streams (i.e. lakes, reservoirs, wetlands, percolation ponds, etc.), based on BAARI. The extent of the study area included Strahler stream orders 2-7 extending from above the region of tidal influence in the north to the upper, eastern slopes of the Santa Cruz Mountains in the south (Figure 2). Headwater stream reaches (Strahler stream order 1) were not included in the CRAM assessment because they are ecologically very simple and the CRAM Riverine Module is not currently calibrated to accurately assess the ecological condition of headwater streams. CRAM scores tend to be artificially low for 1st-order channels, and these low scores can create misleading profiles of overall stream condition. The study area was divided in urban and non-urban areas in order to compare the condition of streams in both areas.

The study design focused on rapid assessment using the CRAM Riverine Module v6.0 (CWMW 2012). Data collection was based on a probabilistic sample draw employing the Generalized Random-Tesselation Stratified (GRTS) approach developed by the U. S. Environmental Protection Agency (EPA) for the National Environmental Monitoring and Assessment Program (EMAP; Messer et al. 1991; Stevens and Olsen 2003; Stevens and Olsen 2004). This spatially balanced probability survey design using CRAM is a statistical way to estimate the overall condition of streams with known levels of confidence. In a probability survey, assessment areas are randomly selected from the sample frame, while accounting for the proportion of the resource that each area represents. Results can be analyzed to estimate the proportion of the total resource in the sample frame that is likely to have any particular condition as assessed using CRAM. The efficiency of the survey design can be increased (but, still maintain its unbiased nature) by ensuring the sample is distributed among classes of the resource (in this case the urban ad non-urban areas) for which condition is expected to differ. In this project, assessment areas were distributed across Strahler stream orders 2-7 in urban and non-urban settings.

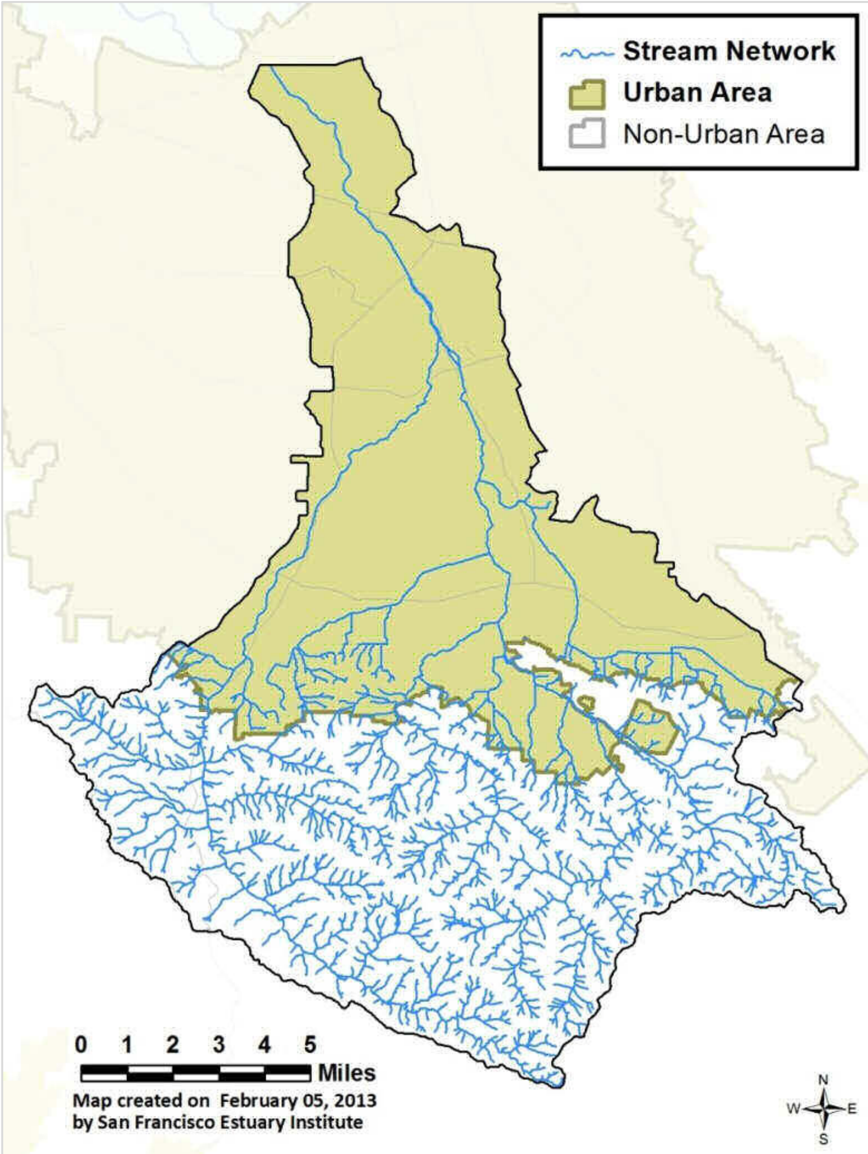


Figure 2. Map showing the Guadalupe River watershed CRAM assessment study area, which consists of non-tidal Strahler stream orders 2-7 stratified into urban or non-urban areas.

The sample draw for the Guadalupe River Assessment is further described below and in Table 2.

- **Sample Frame:** Strahler stream orders 2 through 7 within the Guadalupe watershed above the region of tidal influence based on BAARI.
- **Stratification:** urban and non-urban areas of the watershed to make statistically meaningful inferences and comparisons about stream condition in these two settings; based on sample

design, the number of sites per stream order is proportional to the total stream length within each stratum (urban, non-urban).

- **Sample Size:** 53 target CRAM riverine Assessment Areas (AAs); a large sample draw of 1,000 candidate AAs was produced to provide replacements for AAs that, for whatever reasons, could not be assessed, and for future studies. The final 53 target AAs include the first 30 AAs in sequential order (and were proportionally drawn on the whole watershed) and additional urban AAs added (in sequential order) to total 30 urban AAs and 23 non-urban AAs. The first 30 AAs drawn included the six pre-existing RMC program sites (described in the next bullet below).
- **Coordination with the Regional Monitoring Coalition of Stormwater Programs (RMC):** The study design was developed in coordination with the RMC, a multi-county program to comply with the National Pollution Discharge Elimination System (NPDES) Municipal Regional Permit. The RMC had already developed a Master Sample Draw[1] for a multi-year survey of streams in five Bay Area counties (including Santa Clara). The RMC assessed six AAs within the Guadalupe River watershed using CRAM in the summer of 2012. The District s Guadalupe River Assessment was able to integrate the six RMC AAs into the project s GRTS sample draw.

Table 2. Summary of Guadalupe River Assessment GRTS parameters for the sample draw.

Study Area	Guadalupe River watershed, Santa Clara County, CA
Sample Frame	Freshwater streams of Strahler stream orders 2 to 7 in the Guadalupe River watershed, as represented by BAARI, and above the tidal prism
Sample Strata	2: Urban (n = 30; defined by the District) and Non-urban (n = 23)
Survey Design	Generalized Random-Tesselation Stratified Design (GRTS)
Resource Type	Natural and unnatural streams as defined in BAARI
Target Sample Size	53 AAs
Over sample	at least 5x Target Sample Size (total sample draw = 1,000 points)
Panels	None (one year study with no revisits planned)

It is expected that a portion of the initially targeted CRAM Assessment Areas (AAs) in the sample draw will have to be dropped or omitted because of inaccessibility, or inconsistency with CRAM AA selection criteria (i.e., the AA in the field does not fit the required CRAM AA conditions). A dropped AA is replaced by the next AA of the same stratum listed in the oversample (in this case non-urban AAs are replaced with non-urban oversample AAs). It is also expected that AAs will be dropped at random, such that the AAs drawn from the oversample maintain the spatial balance of the sample across the sample frame.

[1] See RMC GRTS Stream Design Overview 10.31.11.doc from Chris Sommers (EOA) for a summary of the design

CRAM Field Assessments

Teams of District staff were trained in the Riverine CRAM Module (CWMW 2012a and 2012b) by SFEI s CRAM trainers (Sarah Pearce and April Robinson) in June 2012, and then conducted CRAM field assessments in the Guadalupe River watershed during July and August 2012. To evaluate and document that field teams were using the same approach and were obtaining information consistently when conducting CRAM assessments, two inter-team calibration exercises involving the District and the RMC were conducted, one at the beginning and one near the middle of the field season. Inter-calibration results were evaluated between field teams and against SFEI s CRAM trainers to track consistency (or differences) in CRAM assessment results. The resulting CRAM scores indicated that all field teams were calibrated among themselves and the SFEI CRAM trainer s scores with less than ten points difference between CRAM Index scores. Results of the inter-calibration exercises were submitted to the District previously.

Data Analyses of the CRAM Results

Statistical analyses were conducted on the CRAM field assessment results with the *spsurvey* statistical library and the R programing language (version 2.13.0), which is a software environment for statistical computing and graphics (http://www.epa.gov/nheerl/arm/analysispages/software.htm). The functions included in the *spsurvey* library were originally written for the EPA's EMAP (Messer et al*.* 1991) to design and analyze probabilistic surveys of environmental resources (Diaz-Ramos et al*.* 1995). The functions in *spsurvey* were written to accommodate data generated by GRTS sampling designs. *Spsurvey* analyses for the Guadalupe River Assessment depend on inputs of CRAM results from the field assessments and the output consists of cumulative distribution function (CDF) plots and percentile tables of CRAM scores. The CDF plot enables the user to visually evaluate or compare the percentage of the stream resources in the study area with CRAM scores less than or equal to any given score with a known level of confidence (i.e. 95% confidence intervals). Median CRAM score, where half of the stream resources in the study area are below that score, are easily identified and can compare sub-sets of data such as comparing urban vs. non-urban stream reaches.

Results

SFEI-ASC conducted the initial data analyses for the Guadalupe River watershed study by utilizing BAARI and District s GIS data to describe the extent, distribution, and ownership of streams in the study area, and by summarizing the associated CRAM survey results. These summaries will be used by the District to help assess stream condition, stress, and risk in the Guadalupe watershed. The results are organized by Management Question.

Extent, Distribution, and Ownership of the Streams

1) What is the extent and distribution of stream ecosystem resources?

Figure 3 is a map of the distribution of aquatic resources in the Guadalupe River watershed above the tides of San Francisco Bay. The Guadalupe River watershed has a total of 1,024 miles (mi; 1,648 kilometers (km))) of streams and 29 mi (48 km) of storm drains (channel connectors) connecting streams to each other, or to other water bodies. Only 2% of the stream miles (23 mi or 38 km) consists of unnatural channels, defined in BAARI as engineered channels or ditches (Table 3).

Table 3. Summary of the length of surface channels and storm drains in the Guadalupe River watershed in miles and kilometers (in parentheses). Percentages of total channel length are also listed.

Steam Setting	Natural Channel	Unnatural Channel	Sub-Total Channels	Channel Connectors	Urban Storm Drains	Totals
Non-Urban	895 87% (1,441)	2 0.2% (4)	897 88% (1,445)	2 (3)	0 (0)	899 (1,448)
Urban	106 10% (170)	21 2% (34)	127 12% (204)	28 (45)	251 (404)	406 (653)
Total	**1,001 (1,611)**	**23 (38)**	**1,024 (1,649)**	**29 (48)**	**251 (404)**	**1,305 (2,101)**

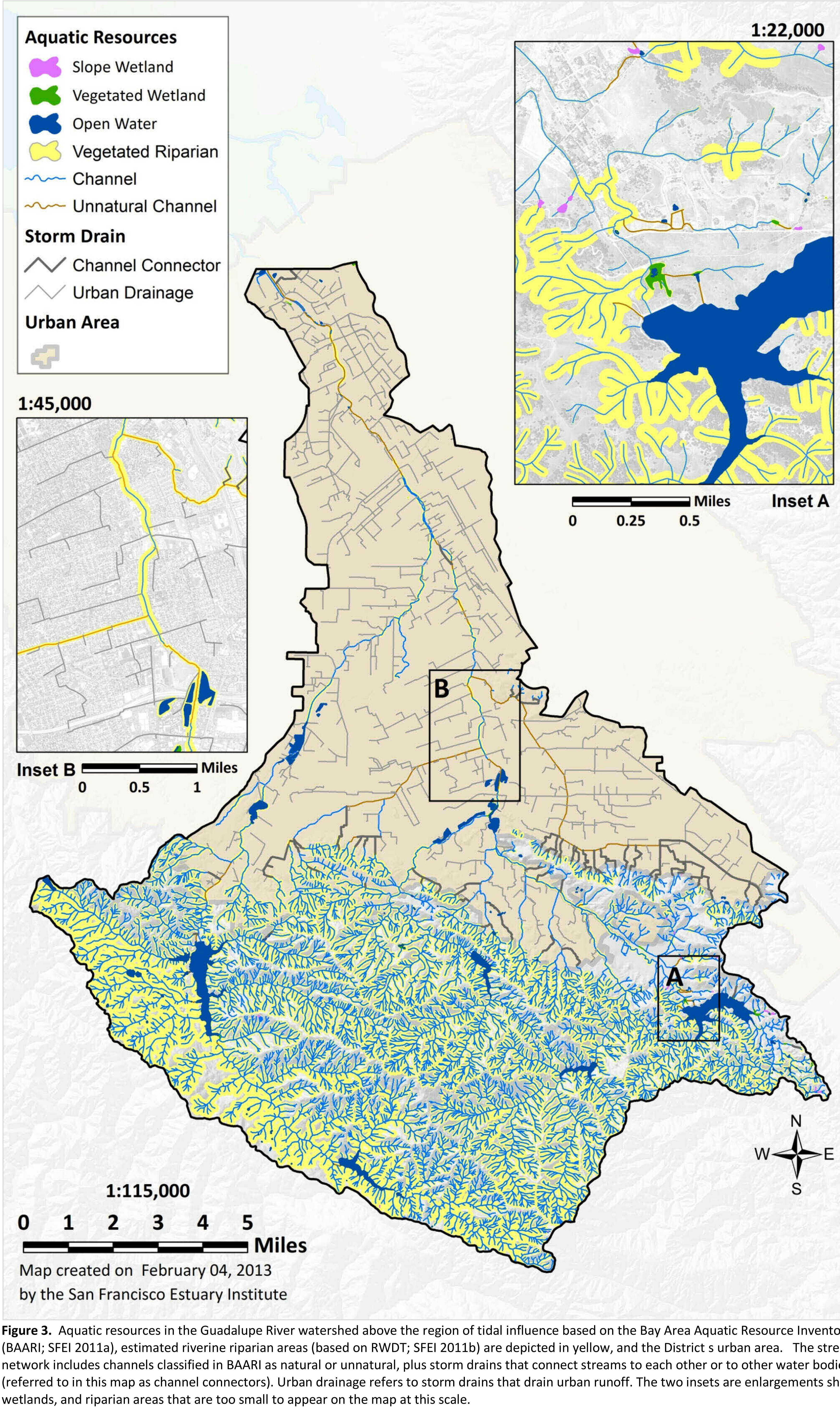


Figure 3. Aquatic resources in the Guadalupe River watershed above the region of tidal influence based on the Bay Area Aquatic Resource Inventory (BAARI; SFEI 2011a), estimated riverine riparian areas (based on RWDT; SFEI 2011b) are depicted in yellow, and the District s urban area. The stream network includes channels classified in BAARI as natural or unnatural, plus storm drains that connect streams to each other or to other water bodies (referred to in this map as channel connectors). Urban drainage refers to storm drains that drain urban runoff. The two insets are enlargements show wetlands, and riparian areas that are too small to appear on the map at this scale.

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

Riparian areas adjoin all waterways and water bodies including wetlands (Brinson 2002). The riparian areas vary in width depending on their functions, 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. Table 4 presents the miles of stream riparian areas of the Guadalupe River watershed by width class. These classes are based on general relationships between riparian width and riparian function as summarized by Collins et al. (2006).

Table 4. Miles of stream-associated riparian areas for each of five riparian width classes in the Guadalupe River watershed. Riparian width classes reflect natural demarcations in the lateral extent of major riparian functions, as summarized in Collins et al. (2006). A function is assigned to a width class if the class is likely to support a very high level of the function.

Width Class (m)	Miles (Km)	Acres (Ha)	% Total Length	Shading	Bank Stabilization	Allochthonous Input	Runoff Filtration	Flood-water Dissipation	Groundwater Recharge	Wildlife Support
0 - 10	214 (345)	518 (209)	21							
10 - 30	194 (312)	1,387 (561)	19							
30- 50	309 (497)	6,597 (2,670)	30							
50 - 100	200 (322)	9,008 (3,645)	20							
>100	107 (172)	9,224 (3,733)	10							

Figure 4 is a map of the stream riparian areas by width class (see Table 4 above) in the Guadalupe River watershed. Almost all of the areas in the widest class exist in the forested uppermost reaches of the watershed, where riparian areas extend laterally to incorporate tall trees that can fall into channels, and erosional processes of steep slopes that tend to deliver sediment and other materials directly to channels.

Based on a comparison between the current output of the RWDT for the valley floor of the watershed and the recent report on the historical ecology of much of the same area (SFEI 2010), It is inferred that the historical (i.e., pre-European settlement) middle reaches of the drainage network on the valley floor supported wider areas of riparian forest than exist today. It should be noted that the historical ecology report employs a different definition of riparian than used here, in that it focuses on riparian forests and assumes that all areas of forests that are contiguous with a channel are riparian in their full extent, even if the areas of forest are wider than typically required to support a full suite of local riparian functions. However, the historical ecology Report indicates that there were historically many more miles of riparian areas wider than 100m than there are today. The reduction in width of the riparian areas along the valley floor has many, mostly anthropogenic, causes. During the earliest stages of European settlement, riparian forests were harvested for fuel and construction materials. Some of the remaining riparian forests were further cleared for agriculture. Later withdrawals of groundwater to irrigate extensive farmlands and orchards depressed the groundwater levels, which could have contributed to the loss of riparian forests. The subsequent encroachment of urbanization into the remnants of riparian forests further reduced their extent. There was also a significant historical shift from ephemeral and episodic stream flow regimes to a more perennial regime, due to reservoir management practices. In the absence of the other causes for the reductions in the extent of riparian forest, this shift in flow regime would have likely caused a change in riparian forest species composition as well as a change in forest extent.

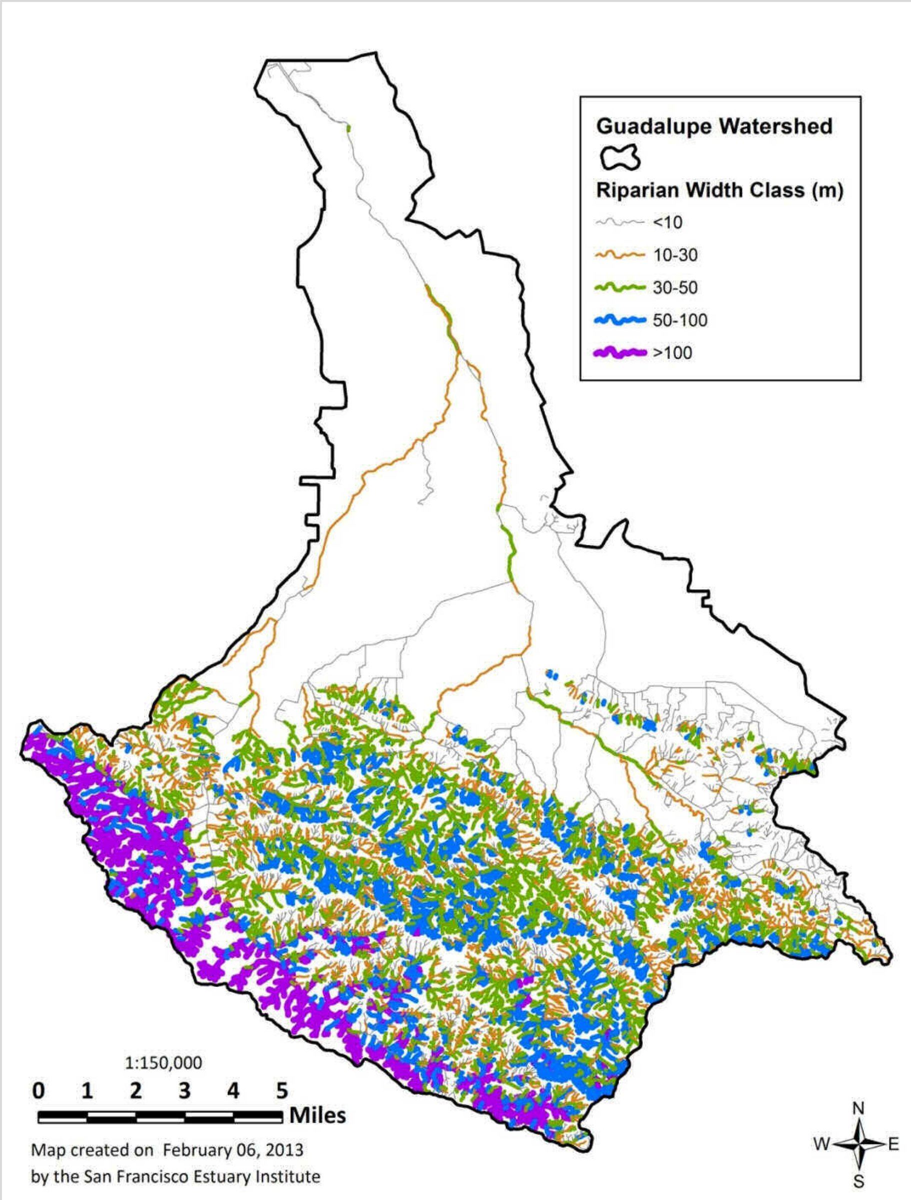


Figure 4. Distribution of the estimated riparian areas by functional width class (Collins, 2006) in the Guadalupe River watershed, based on RWDT (SFEI, 2011b).

The width classes shown in Figure 4 follow from Table 2 above. These are generic width classes that have been used in other watershed profiles of riparian extent (SFEI 2012, 2013), and can be used to compare such profiles for different watersheds. A different set of classes might be warranted based on watershed-specific relationships between riparian width, riparian function, topography, and vegetation structure. Such localized relationships can be built into the RWDT through its user-defined parameters, but the development of such relationships is beyond the scope of the current study.

Figure 5 shows the lengths of streams grouped by the five riparian width classes for urban and non-urban areas of the watershed. Almost 90% of all the total length of stream riparian areas is located in the less-developed, non-urban areas in the upper portion of the watershed, where streams are naturally much more abundant (see Figure 3). In the urban area, nearly 65% of the total length of riparian areas is less than 30 m wide. This suggests that most of this riparian area in the urban, lowland portion of the watershed is helping to provide bank stabilization shading, and allochthonous inputs, but they are less likely to provide flood-water dissipation, groundwater recharge, or foster diverse communities of wildlife, based on Table 4. In the non-urban area, about 35% of the total length of riparian areas is less than 30 m wide, about 30% is between 30 and 50 m wide, and about 35% is wider than 50 m. This suggests that most of the stream riparian areas in the non-urban portion of the watershed are providing some amount of most of the main riparian functions. Since the streams in both the urban and non-urban areas are mostly entrenched (see Table 3 and related discussion of stream condition), their riparian areas are probably not helping to dissipate floodwaters, although the gravelly nature of the substrate in these reaches may promote groundwater recharge through the channel beds. Flood water storage, peak stage reduction, and groundwater recharge are major riparian functions of broad active floodplains that have largely been lost from the Guadalupe River watershed (see Figures 6 and 7 plus accompanying text).

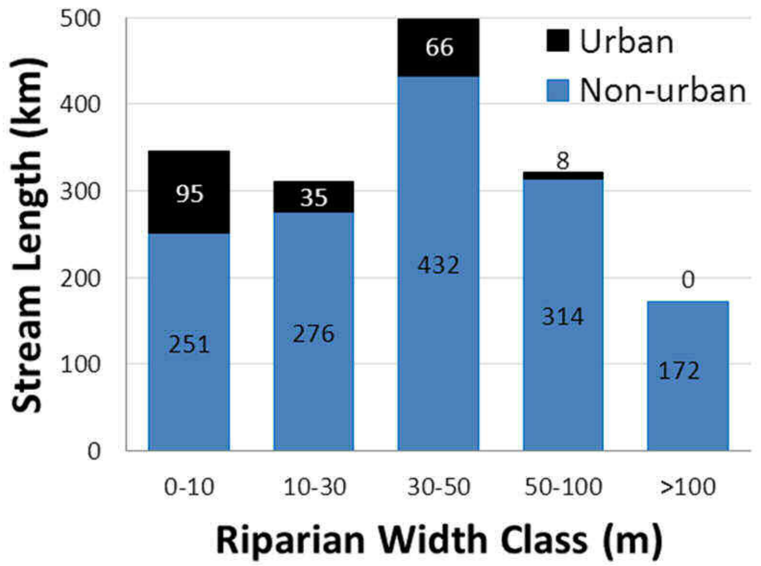


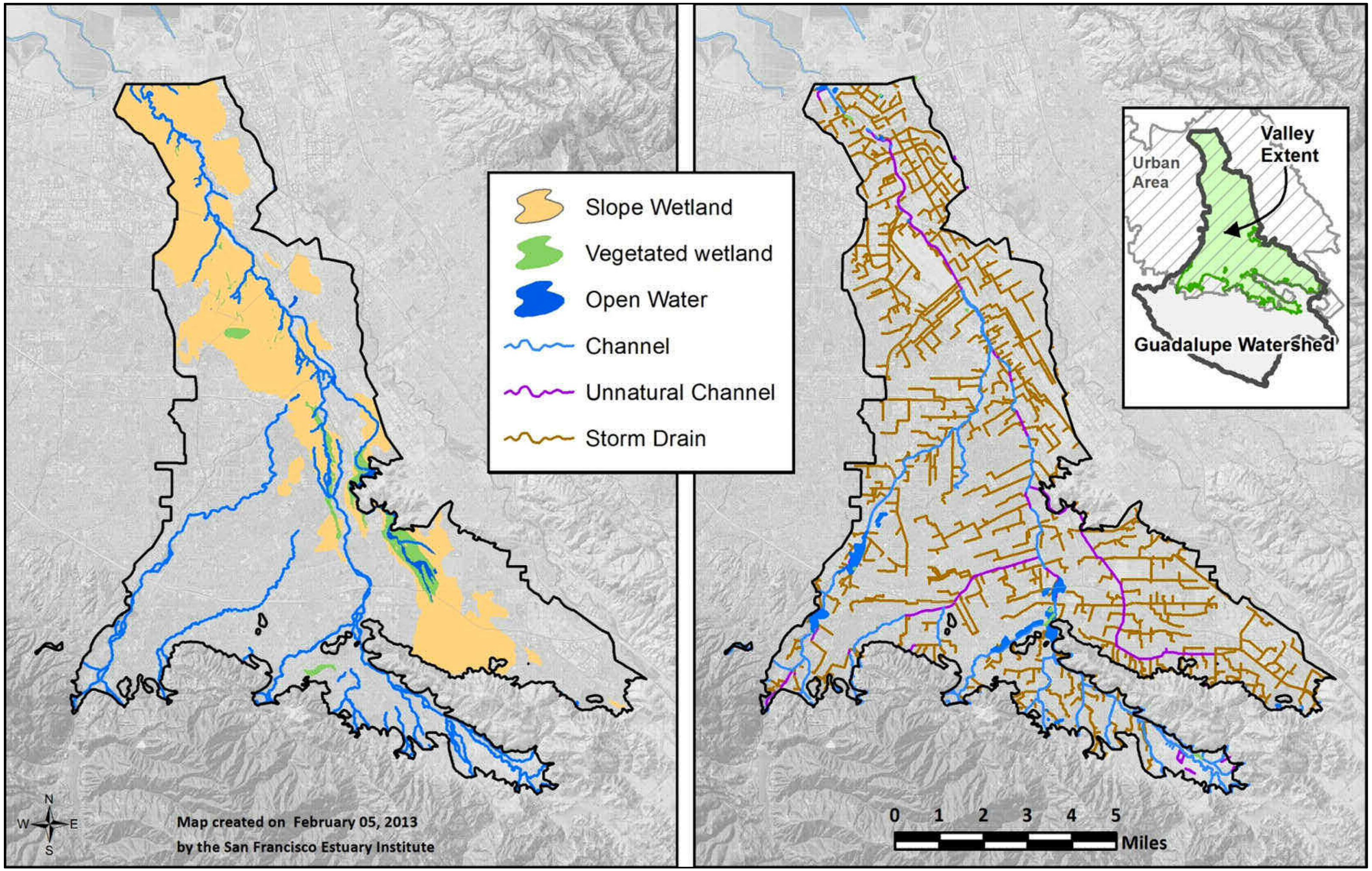
Figure 5. Lengths of streams with riparian areas by functional width class (Collins et al. 2006) for urban and non-urban areas of the Guadalupe River watershed.

The width classes shown in Figure 5 follow from Table 2 above. A different set of classes might be warranted based on watershed-specific relationships between riparian function and riparian width. The total length of stream riparian areas in the Guadalupe River watershed is about 1,025 mi (1,650 km).

3) What is the extent and distribution of non-riverine wetlands?

The Guadalupe River watershed contains approximately 1,249 ac (505 ha) of non-riverine wetlands, of which about 4 ac (2 ha) are natural. Approximately 83% of the wetlands (1,036 ac or 419 ha) are unnatural lacustrine wetlands (emergent wetlands along the shores of reservoirs and livestock ponds). Seventeen percent (207 ac or 84 ha) are depressional wetlands (characterized by topographic lows that lack surface drainage), almost all of which are due to human modifications to the landscape. These non-riverine wetlands have about 795 ac (322 ha) of riparian areas adjacent to them, based on the Riparian Width Decision Tool. Slope wetlands (i.e., wetlands depending on groundwater and lacking standing surface water) comprise only about 0.1% of the non-riverine wetlands in the watershed.

The modern distribution, abundance, and diversity of streams and wetlands are much different now than they were historically (circa 1850). **Figures 6 & 7** compare the historical and modern landscapes in the lower portion (valley extent) of the Guadalupe River watershed where historical ecology maps have been developed and are available in GIS. The historical data were created for the *Historical Vegetation and Drainage Patterns of the Western Santa Clara Valley* (SFEI 2010). The modern data are from BAARI plus storm drains (Sowers *et al.* 2005). The historical 95 mi (153 km) of natural streams have been reduced to 54 mi (87 km) of natural streams and 23 mi (37 km) of unnatural streams today, not including storm drains, of which there are more than 251 mi (404 km). This comparison highlights the degree to which the watershed has been artificially plumbed to increase drainage. The historical watershed had much more wetlands and most of these were depressional wetlands and slope wetlands (characterized in the *Historical Vegetation and Drainage Patterns of the Western Santa Clara Valley* report as Alkali Meadow, Wet Meadow, Wild Rose Thickets, Willow Groves, and Freshwater Marsh). The depressional wetlands represent off-channel water storage and recharge, and slope wetlands represent large areas of near-surface groundwater levels.



A. Historical **B. Modern**

Figure 6. Comparison of the distribution of historical (circa 1850) (map A) and modern (map B) aquatic resources in the Guadalupe River within the Santa Clara valley. The historical landscape probably included a few more miles of low-order channels and the modern landscape certainly includes many more miles of unnatural channels and storm drains; only the

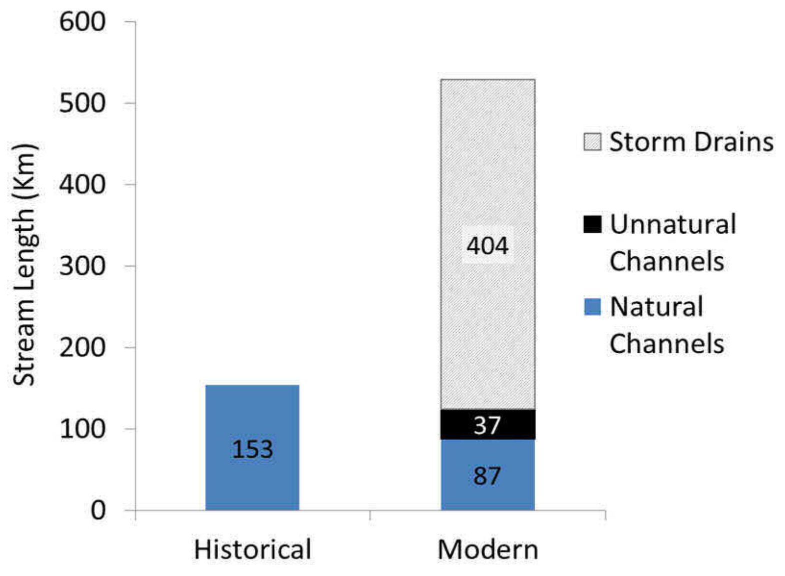


Figure 7. Comparison of historical (circa 1850) and modern stream lengths for the Guadalupe River valley floor based on data provided by the *Historical Vegetation and Drainage Patterns of the Western Santa Clara Valley* (SFEI. 2010) and BAARI.

The comparison of stream lengths summarized in Figure 7 includes only the areas in the valley floor where the historical and modern datasets overlap (as depicted in Figure 6) and, while the valley floor is very similar to the modern urban area, the two are not exactly the same. The inset in Figure 6 shows the extent of the valley floor compared to the urban area and whole Guadalupe River watershed.

4) Who owns the streams?

Figure 8 shows that the District owns lands adjoining surface waters in the Guadalupe River watershed. The District has fee title to only 8% (132 km or 83 mi) of the total stream length. District lands are mostly distributed throughout the portion of the stream network that is below the headwaters of the major reservoirs, with larger tracts adjacent to the reservoirs.

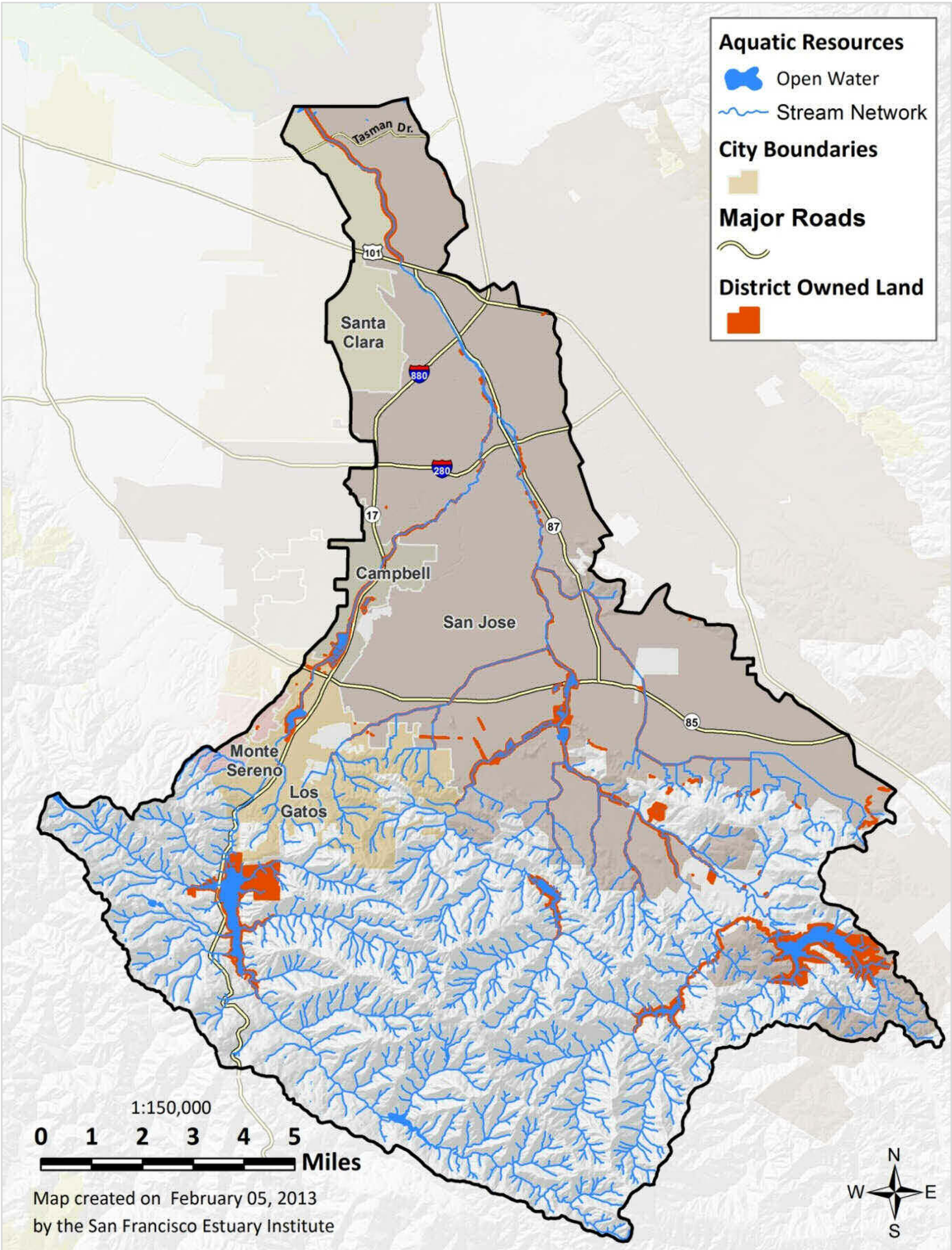


Figure 8. Map of lands owned by the District (fee title) that are adjacent to streams in the Guadalupe River watershed.

Figure 9 shows the proportions of stream lengths in each of the five municipalities located in the study area. There are 391 km (243 mi) of streams within those municipalities, of which 94% (368 km or 229 mi) are within the boundaries of San Jose and Los Gatos, and 6% (23 km or 14 mi) are within the boundaries of Campbell, Monte Sereno, and Santa Clara combined.

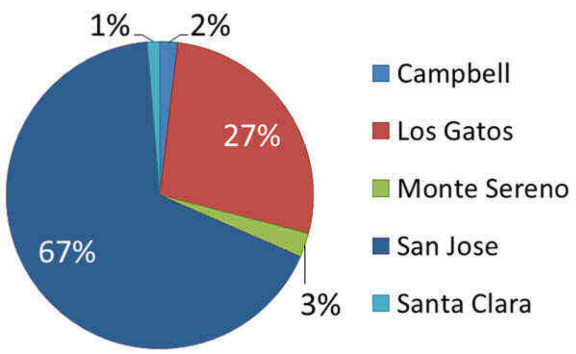


Figure 9. Proportions of streams in the Guadalupe watershed within municipal boundaries.

5) How and where are the streams interrupted?

The stream network and its riparian corridor in the Guadalupe River watershed is interrupted by dams creating water storage reservoirs, drop structures for flow management, storm drains connecting stream segments, and a multitude of highway and road crossings. Figure 10 shows the locations of some of these interruptions for Strahler stream orders 1-7. In the upper, less developed portion of the watershed, individual roads cross back and forth across streams, creating long lines of crossings on Figure 10 that trace the roadways. In the lower watershed, numerous crossings represent separate roads that are part of the urban grid, including 5 major highways (U. S. Route 101, Interstate 880 and CA Route 17, CA Route 87, Interstate 280, and CA Route 85), some of which cross the river multiple times. Many bridges are multiple lane roads. The Guadalupe River flows through the urban center of San Jose with areas of concrete lined channel, flood bypasses, and downtown parks.

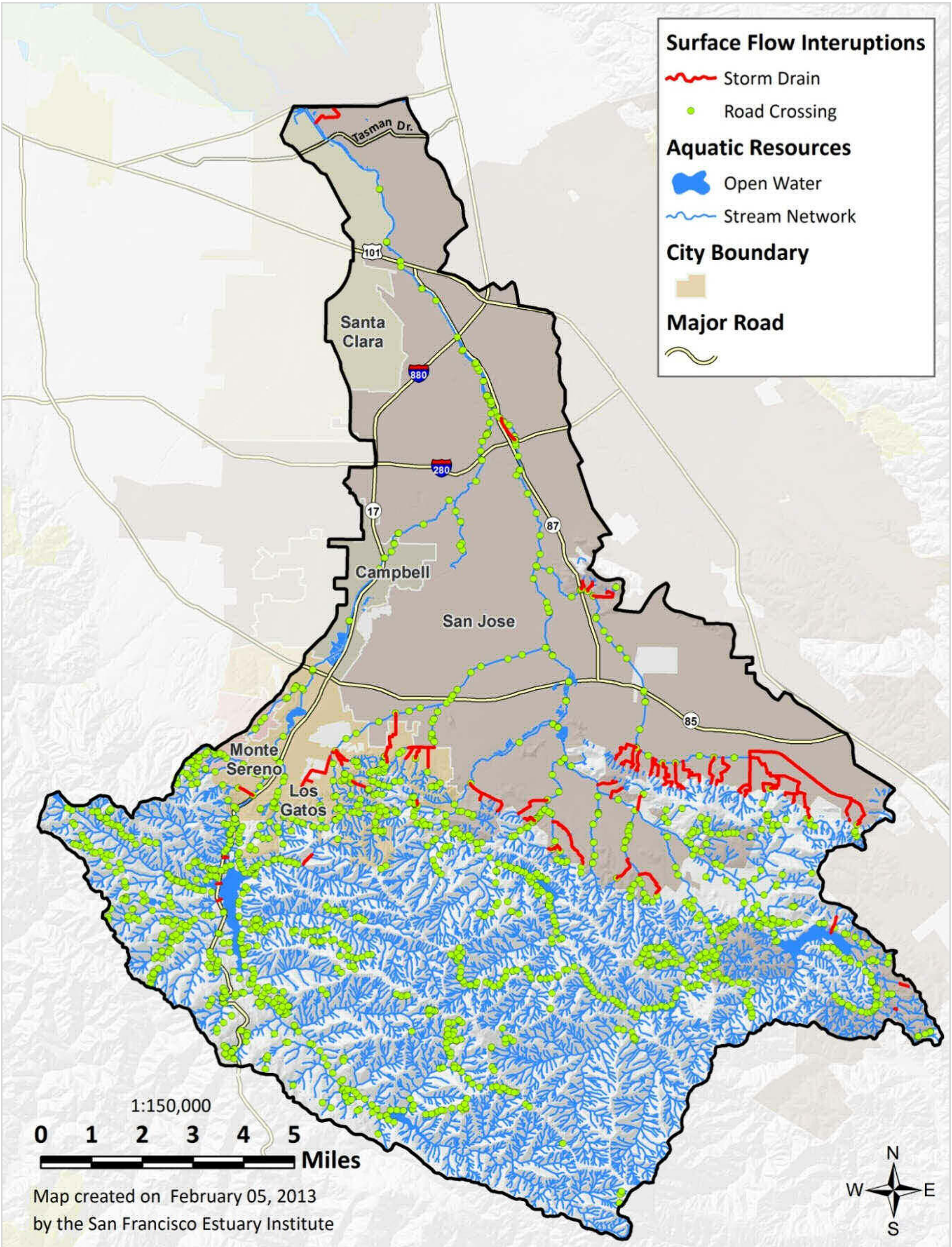


Figure 10. Map of storm drains (channel connectors), highways and roads that interrupt the stream network within the Guadalupe River watershed.

Stream Ecosystem Condition Based on Guadalupe River CRAM Assessments

A total of 53 AAs using CRAM were spread throughout the watershed from the edge of the brackish tidal zone at Tasman Drive to second order streams in the Santa Cruz Mountains. District staff assessed 47 AAs (24 urban, 23 non-urban), whereas RMC assessed 6 AAs (urban). To reach this target sample size, a total of 121 candidate AAs were considered: 61 were dropped because of access issues (mostly due to landowner concerns). Only 7 were dropped because of inconsistencies with AA selection criteria for the CRAM Riverine Module, indicating that the sample frame was reasonably accurate.

Figure 11 shows the distribution of the 53 AAs that were assessed using CRAM and locations of the AAs that were considered, but dropped for reasons mentioned above (dropped AAs are marked with an x). Most of the dropped AAs were located in the non-urban, upper reaches of watershed.

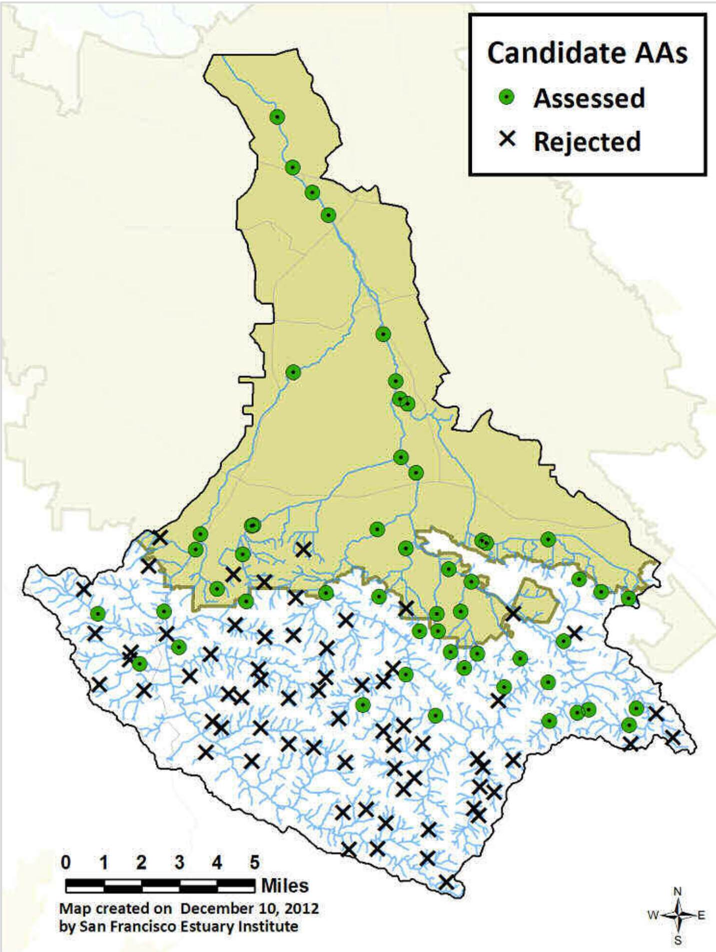


Figure 11. Map showing the distribution of assessed and rejected CRAM Riverine AAs within the urban area (north shaded portion of the watershed) and the non-urban area.

CRAM provides numerical scores for 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. Stream ecosystem conditions in the Guadalupe River watershed were evaluated using the District s and RMC s CRAM field assessments at 53 AAs during the summer of 2012.

To investigate ecosystem condition in the Guadalupe River watershed the 2012 CRAM assessments were analyzed to:

1) evaluate the overall ecological condition of the streams in the whole watershed , compare the urban and non-urban settings, and compare the conditions to other CRAM assessment studies,
2) review the CRAM Attributes and stressor check-lists to identify potential stressors that might be impacting stream health, and
3) calculate the Guadalupe River watershed baseline Levels of Service (LOS) of the streams using the District s EMAF ecological service index as described in the Coyote Creek watershed 2010 CRAM assessment report (EOA and SFEI 2011).

1) What are the conditions of stream ecosystem resources?

Stream conditions were assessed based on CRAM for the whole watershed, and for its urban and non-urban areas. Table 5 presents the minimum and maximum CRAM Index and Attribute Scores, plus the median, mean, and standard deviation (Std.Dev) values for the scores based on the weighted survey results. Based on this survey, it is expected that any randomly selected new AA has a 50% chance of getting a score either above or below the median score (see Figure 12 for a visual presentation of a median score). The Mean and Standard Deviations of the Index Scores can be used to test for differences between the populations of scores that they represent.

Table 5. Summary of CRAM Index Scores for the Guadalupe River watershed based on the CRAM survey 2012.
Whole Watershed (WS) n=53, Urban (n=30), Non-urban (n=23)

	Min	Max	Median	Mean	Std. Dev
Overall CRAM Score					
Whole WS	34	84	71	68	11
Urban	34	84	62	63	13
Non-urban	62	84	72	72	5
Biotic Structure					
Whole WS	31	86	67	64	15
Urban	31	86	67	63	17
Non-urban	36	86	67	64	13
Buffer and Landscape Context					
Whole WS	25	100	79	77	18
Urban	25	100	67	66	15

	Min	Max	Median	Mean	Std. Dev
Non-urban	46	100	87	87	14
Hydrology					
Whole WS	42	92	70	72	13
Urban	42	92	62	65	15
Non-urban	47	92	73	78	7
Physical Structure					
Whole WS	25	88	49	58	17
Urban	25	88	46	56	20
Non-urban	38	88	51	59	14

Figure 12 shows the CDF plot of CRAM Index Scores[2] for the Guadalupe River Assessment study area. The CDF estimates the proportion of total stream length with CRAM Scores less than or equal to a given score calculated using the weighted survey results. For example, as illustrated in Figure 12, the watershed survey indicates that 50% of the total stream length has a 95% chance of having a CRAM Index Score of 71 or lower. The range of CRAM Index Scores in the whole watershed was 34-84, the mean Index Score was 68, and the median Index Score was 71 (based on the weighted survey results).

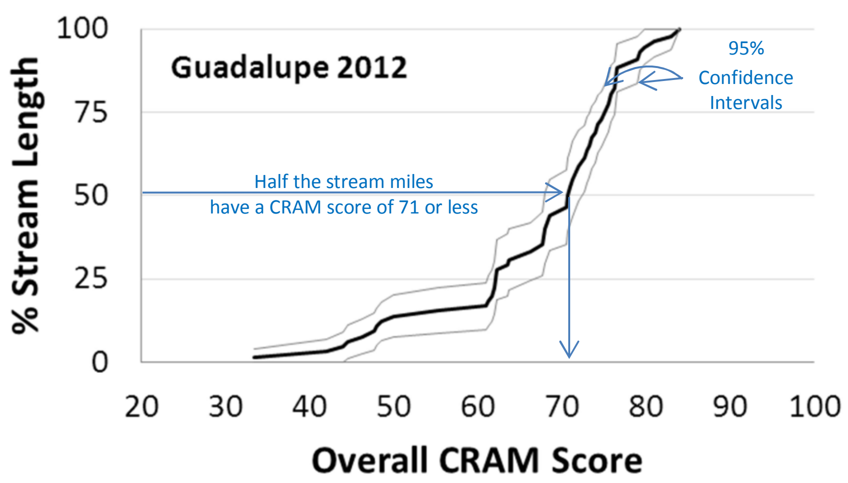


Figure 12. Plot of the cumulative distribution function (CDF) of CRAM Index Scores for the Guadalupe River watershed (n=53), showing the 95% confidence intervals.

[2] The CRAM Index Score is synonymous with the Overall CRAM Score. These are the terms used to describe the score across all attributes for an AA.

Comparisons of stream conditions (as estimated using the CRAM Riverine Module) were made between; (1) urban and non-urban areas of the Guadalupe River watershed study area, (2) Guadalupe River and Coyote Creek watersheds (based on results of the Coyote Creek watershed CRAM assessment conducted in 2010), and (3) Guadalupe watershed and a statewide dataset developed by the California Surface Water Ambient Monitoring Program (SWAMP) Perennial Streams Assessment Program in 2008. Additionally, CRAM attribute scores and metrics from the Guadalupe River watershed were analyzed to help explain differences in CRAM Index Scores, and to provide additional insights into spatial patterns in stream condition throughout the watershed. The ESIs as defined by EMAF are also presented.

CRAM Index Scores have a precision of 6 points (CWMW 2012c). This means, in the absence of any sample error, differences between any two CRAM Index Scores of 6 points or less are within the error of the method, and should not be considered to represent significant differences in condition (personal communication, statewide L-2 Committee of the Wetland Monitoring Workgroup, 2012). Therefore, in this study, individual scores differing by 6 points or less are regarded as similar. The 95% confidence limits were used to compare CDF s. Portions of CDFs having overlapping confidence limits are regarded as statistically similar.

Figure 13 presents CDF plots comparing CRAM Index Scores for streams in the urban and non-urban areas of the Guadalupe River watershed. CRAM Index Scores in these different areas ranged from 34-84, and from 62-84, respectively. Mean Index Scores were 63 and 72 for the urban and non-urban areas, respectively. Median Index Scores (i.e., corresponding to the 50th percentile) were 62 and 72, respectively. Scores for the two areas tend to be similar above their median scores, converging on a common maximum score, and dissimilar below their median scores, diverging to different minimum scores. The plots indicate that the median condition is lower for the urban streams than for the non-urban streams. Scores above the 50th percentile are comparable for both areas (i.e., the confidence limits for the two CDFs overlap substantially, and their maximum scores are essentially the same (80 points or 80% of the maximum possible score in both cases). However, urban streams below the median score tend have much lower Index Scores, and the minimum score for the urban area is also much lower than the minimum score for the non-urban area (34 vs. 62, respectively). If we consider CRAM Index Scores greater than 63 to represent moderately-good to good stream health), then stream health is moderately-good to good for all miles of non-urban streams, and for about half of the miles of urban streams in the watershed, and poor to moderately-poor for the remainder of urban stream miles.

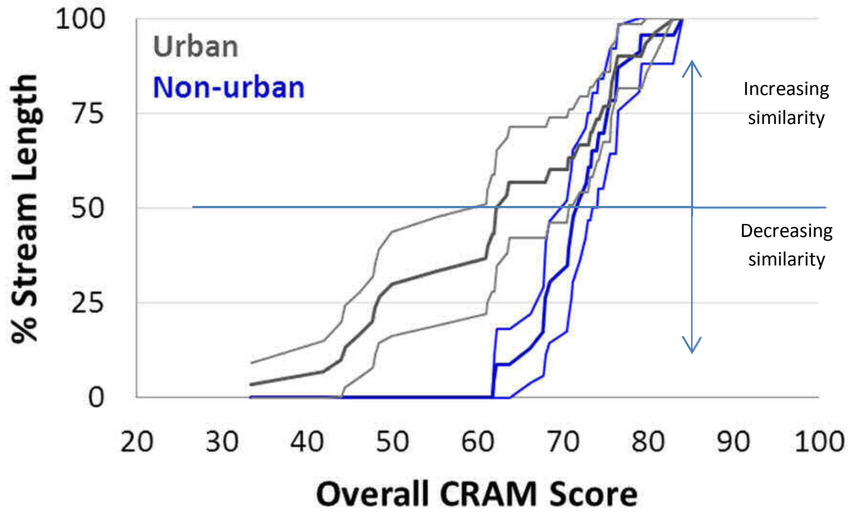


Figure 13. Plots of the cumulative distribution functions (CDFs) of CRAM Index Scores for the urban (n = 30 AAs) and non-urban streams (n = 23 AAs) of the Guadalupe River watershed.

Of the 30 CRAM assessments in the Urban area, 19 (63%) were located on District owned lands. CRAM Index Scores for the District owned (n=19) and non-District owned (n=11) assessment in the urban setting ranged from 34-81 and 50-83 respectively. Mean Index Scores were 59 and 70 for the District owned and non-District owned urban streams, respectively. Median Index Scores (i.e., corresponding to the 50^{th} percentile) were 61 and 73, respectively.

Figure 14 compares plots of CDFs for CRAM Index Scores from the Guadalupe River watershed to the Coyote Creek watershed (EOA and SFEI-ASC 2011). Both surveys employed the same GRTS sampling design. The comparison indicates that stream health is uniformly better in the Coyote Creek watershed than in the Guadalupe River watershed. That is, CDF plots are parallel and generally separated by a distance greater than their 95% confidence limits. The minimum, median, and maximum Index Scores tended to differ by about 9 points. This is likely due to the Guadalupe River watershed being over 50% urban and Coyote Creek watershed only about 28% urban (SCVWD 2007).

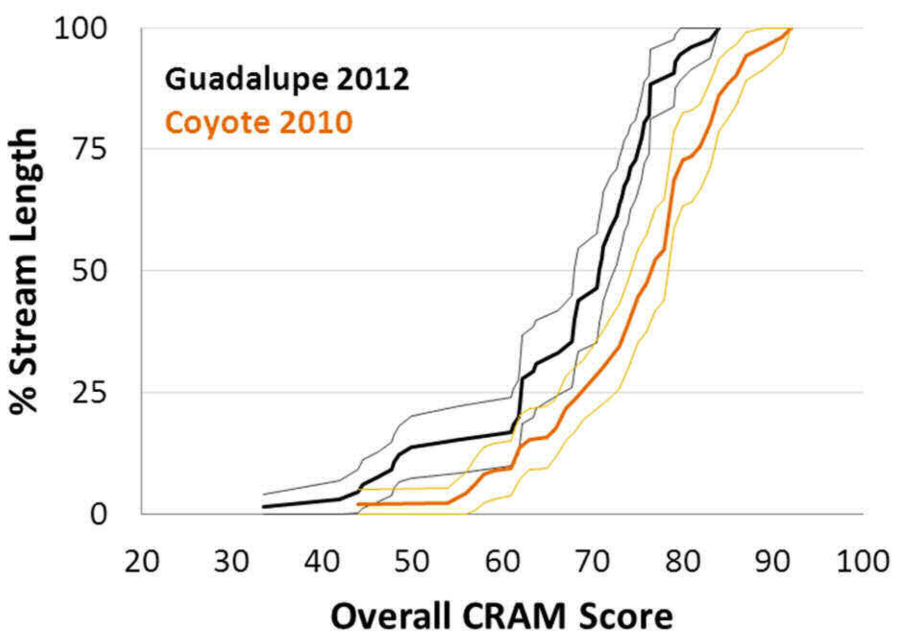


Figure 14. Plots of the cumulative distribution functions (CDFs) of CRAM Index Scores for the Guadalupe River watershed (n=53) and Coyote Creek watershed (n=77).

Figure 15 compares CRAM Index Scores from the Guadalupe River watershed to those provided by the 2008 statewide validation of the CRAM Riverine Module (SCCWRP, 2008). The comparison indicates that health is similarly moderate to low for half of the state s streams and about half of the Guadalupe River watershed, although poorer condition streams in the Guadalupe watershed are in slightly better condition than the rest of the state. The minimum score is slightly lower statewide than for the Guadalupe watershed. However, scores for the state and Guadalupe watershed diverge above a common median score (i.e., the score corresponding to the 50th percentile), such that the maximum score is much higher for the state than it is for the Guadalupe watershed. In other words, while median scores are essentially the same, the minimum score is lower and maximum score is higher statewide than for Guadalupe River watershed. It should be noted that the statewide dataset includes scores from some of the least disturbed and most disturbed streams in the state.

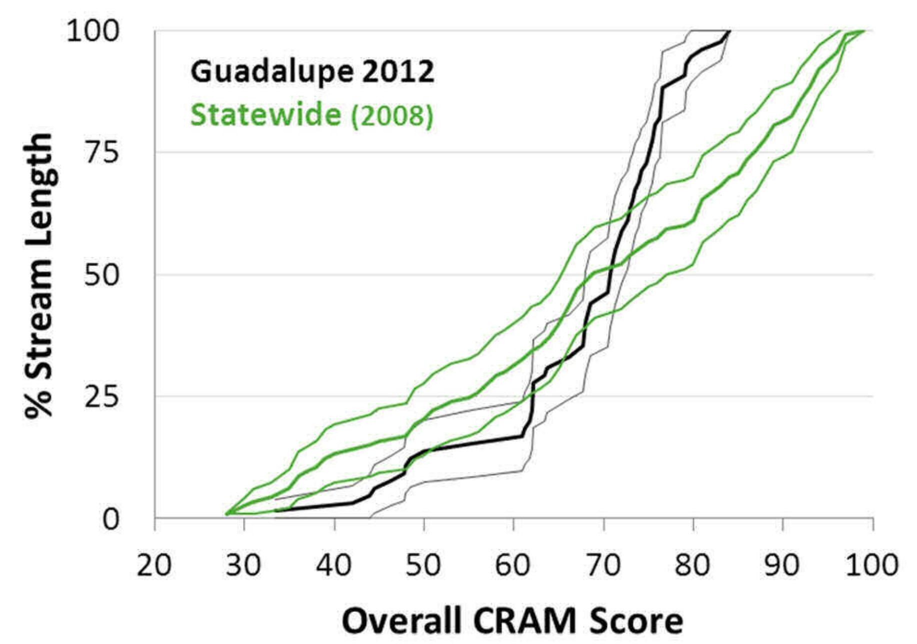


Figure 15. Plots of cumulative distribution functions (CDFs) for CRAM Index Scores for the Guadalupe River watershed (n=53) and Statewide Riverine Assessment (n=90; SCCWRP 2008).

The CDF plots of CRAM scores can be subdivided into categories or classes of health status. This is especially meaningful if the numerical thresholds between classes correspond to critically important differences in levels of ecological service. Such thresholds have not yet been determined for any CRAM module, although it is expected that thresholds will become evident as CRAM validation studies accumulate throughout the state.

In the meantime, two simple approaches to classifying stream health are readily available. One approach is to simply divide the range of possible scores into equal intervals. For example, the 75 CRAM points represented by the maximum possible range of index scores (i.e., 25-100) can be sub-divided into four equal intervals of 18.75 points each. This approach ignores the frequency distribution of the scores (i.e., the shape of the CDF) and therefore the range of scores comprising each equal interval class does not vary among surveys. This approach can be used to compare different watersheds (or the same watershed over time) based on the number of scores belonging to each health class.

Another approach is to use the quartiles of the actual CRAM Index Scores as health classes. Using this approach, the range of scores comprising each interval can vary among surveys. This approach can be used to compare watersheds (or the same watershed over time) based on their different quartile scores. For example, a first (25%) quartile value of 30 represents poorer condition than a fist quartile value of

40. However, this approach is not useful unless of the quartiles represent ranges in scores that are numerically greater than the precision of the method. If the range of scores comprising a quartile is less than 6 points (the precision of the method), then the AAs that are classified into that quartile might just as likely belong to one or the other adjoining quartile. This is the situation with the results of the Guadalupe River watershed survey. The second and third quartiles are very narrow, limiting the usefulness of these quartiles as classes of health status. For this reason, the quartile approach was not used in this assessment.

Figure 16 shows the spatial distribution of AAs representing four health classes defined by equal intervals (the maximum possible range of CRAM Index Scores). Using this approach, and for the purposes of this report, scores less than 44 CRAM points represent poor condition; scores between 44 and 62 represent moderately poor condition; scores between 63 and 81 represent moderately good condition; and scores greater than 81 represent good condition**.** Based on these health classes, about two-thirds of the miles of 2^{nd} 7^{th} order streams in the Guadalupe River watershed are in moderately good condition, and only about 4% are in good condition (see pie chart in Figure 17). The cases of poor or moderately poor condition (28%) are not restricted to the urban area of the watershed. However, almost all the AAs in the non-urban area represent moderately good condition.

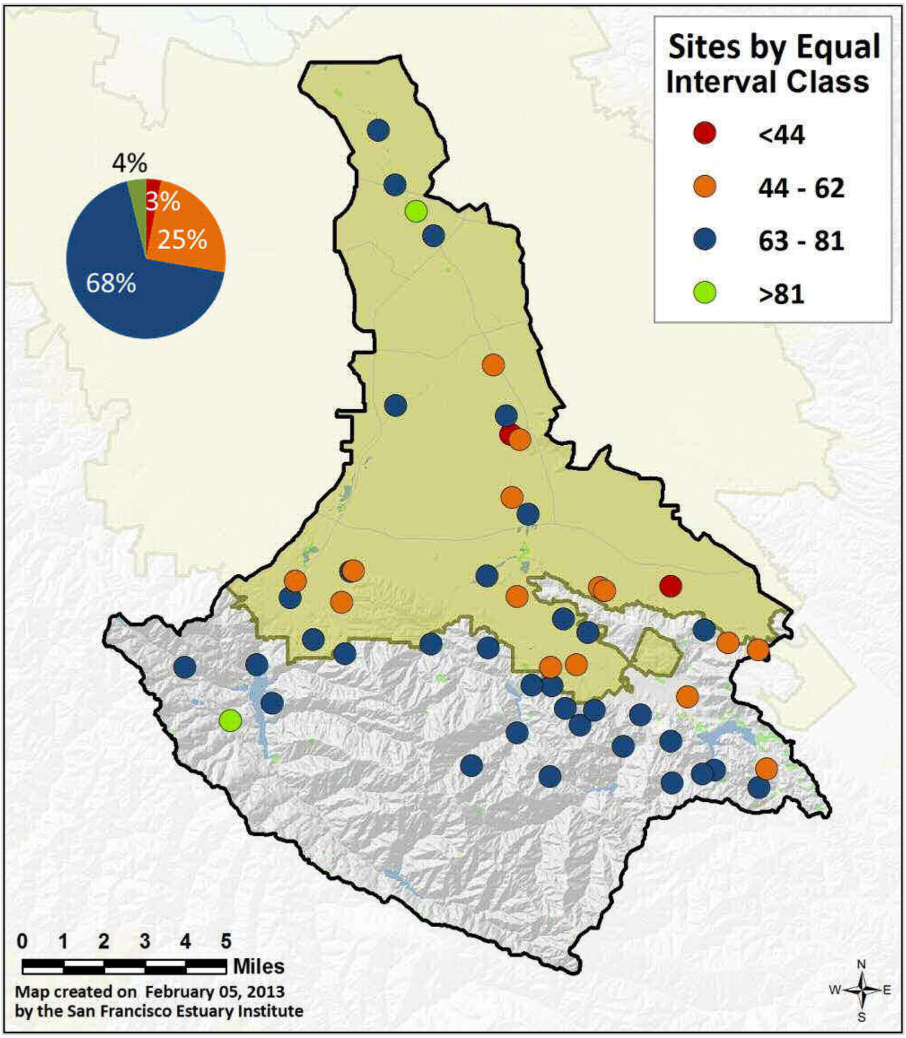


Figure 16. Distribution of CRAM AAs based on equal interval health classes. Based on the maximum possible range of Scores divided into equal intervals of 18.75 points each sites were categorized as poor (red), moderately poor (orange), moderately good (blue) or good health (green). The pie chart indicates the percentage of stream miles (Strahler stream orders 2-7) represented by each health class.

The distribution of CRAM Index Scores among the equal interval classes of health status differed between the Guadalupe River watershed and Coyote Creek watershed (see Table 6).

Table 6. Stream health condition based on the equal interval health classes for the Guadalupe River and Coyote Creek watersheds**.**

Watershed	Percent of stream miles by equal interval health class				CRAM Index Scores	
	Poor	Moderately Poor	Moderately Good	Good	Range	Median
Guadalupe River	3	25	68	4	34-84	71
Coyote Creek	0	14	60	26	44-92	77

2) What are the likely stressors impacting stream condition based on CRAM?

Some diagnostic details of stream health for the Guadalupe River watershed were revealed by examining the Attribute Scores that comprise the CRAM Index Scores. Figure 17 compares the Index and Attribute Scores between the urban and non-urban areas of the watershed. This comparison involves a visual inspection of the amount of overlap between error bars for pairs of scores representing the same Attribute, but in different areas (i.e., urban vs. non-urban). Based on this inspection, the higher Index Scores for non-urban areas is mainly due to differences in two Attributes; Buffer and Landscape Context, and Hydrology.

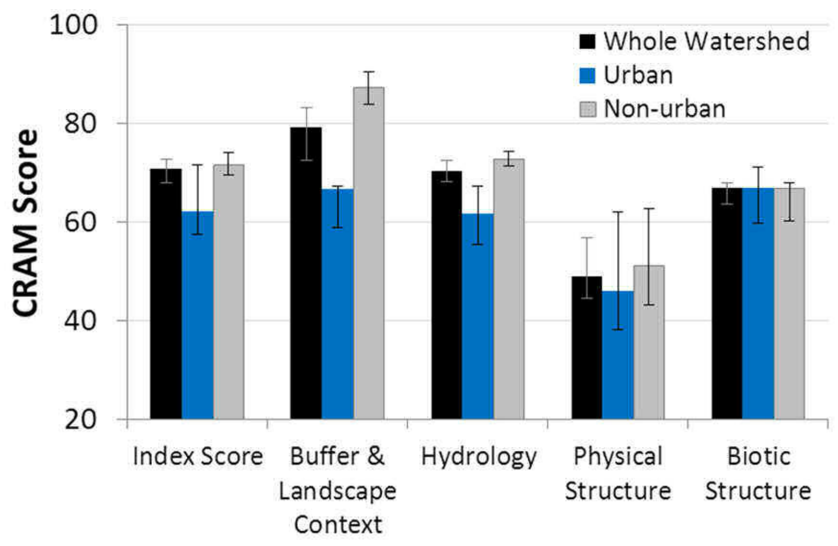


Figure 17. Median CRAM Index and Attribute scores for urban area (n=30), non-urban area (n=23) and entire Guadalupe River watershed (n=53)**.** Error bars represent the upper and lower 95% confidence intervals.

Figure 18 compares CRAM Index and Attribute Scores for the Guadalupe River and Coyote Creek watersheds. The differences between the two watersheds are most pronounced for the Buffer and

Landscape Context, and the Hydrology Attributes. Those Attributes from the Guadalupe River watershed assessment scored significantly lower than the same Attributes assessed in the Coyote Creek watershed. As mentioned above (Figure 14), this could be partially explained by the fact that the Guadalupe River watershed is 51% urban while the Coyote Creek watershed is only 28% urban.

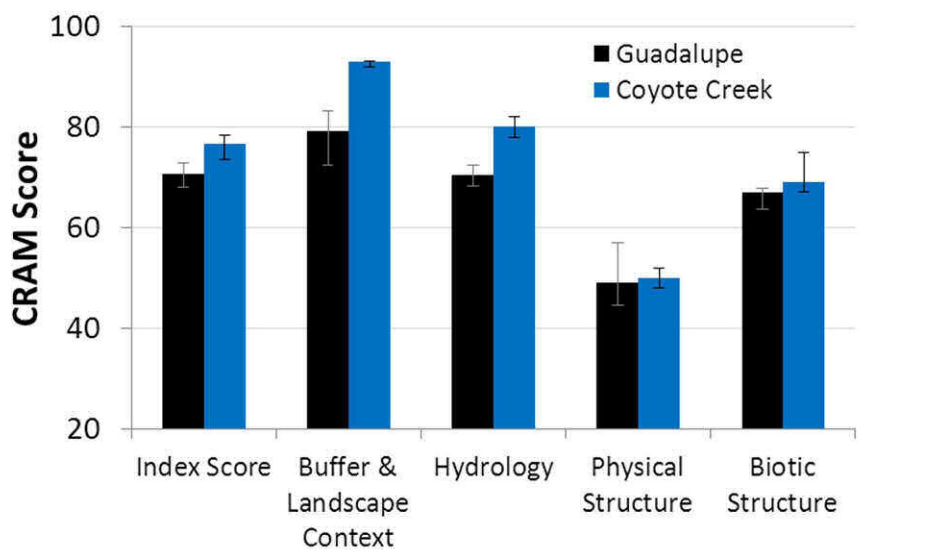


Figure 18. Median CRAM Index and Attribute scores for the Guadalupe River watershed (n=53) and the Coyote Creek watershed (n=77). Error bars represent the upper and lower 95% confidence intervals.

To better understand the differences in scores between urban and non-urban areas for the Buffer and Landscape Context, and Hydrology Attributes, their component Metric scores were examined for the Guadalupe River watershed (Table 7). As expected, the difference in the Buffer and Landscape Context scores is due to small and/or relatively low quality buffers.

The difference in Hydrology Attribute scores between urban and non-urban areas of the Guadalupe River watershed is due to unnatural water sources in the urban area (Table 7). Any riverine AA that is nearby and downstream from a dam loses at least 16 points on the Hydrology Attribute score. The Guadalupe River has six major reservoirs that are managed for water supply, fisheries, and other beneficial uses. The relatively low scores for the Hydrology Attribute reflect this abundance of dams.

It should also be noted that for both urban and non-urban areas of the Guadalupe River watershed, the streams are at least moderately entrenched (i.e., they lack effective floodplains), based on the Hydrological Connectivity metric of the Hydrology Attribute. This is most likely a legacy condition of past land uses (i.e., intensive agriculture and initial years of dam operation), plus more recent increases in flow due to urbanization, and increased confinement of the flow due to artificial levees. These factors together tend to cause chronic channel incision, resulting in channel entrenchment.

The moderately high scores for the Channel Stability metric suggest that channel incision has mostly stopped in urban and well as non-urban streams. Simply stated, the entrenched channels seem to be stabilizing, where stability is defined by no net aggradation or degradation (i.e., raising or lowering of the channel bed) over periods of years. This apparent trend toward stabilized conditions might result from many factors. The channels might be achieving equilibrium with the prevailing, albeit modified, flow regimes and sediment supplies. It might also result from repeated excavations to remove excess sediment as it accumulates. Areas upstream of grade control structures, such as culverts and cement aprons beneath road crossing, where sediment has accumulated to capacity and is not being removed, can also be assessed as stable according to CRAM. However, CRAM AAs are not supposed to include areas directly affected by grade-control structures, unless such areas are targeted for assessment, and they tend to get low scores for the Physical Structure and Biological Structure Attributes. The survey results for these Attributes and the locations of AAs relative to road crossings do not indicate that grade control structures have influenced the apparent trend toward channel stability.

Table 7. Mean metric scores for the Buffer and Landscape Context Attribute and for the Hydrology Attribute in urban and non-urban areas of the Guadalupe River watershed. Values are the means of the final metric scores, which are calculated as percentages of the maximum possible scores.

Metric	**Mean Score**	
Buffer and Landscape Context Attribute	Urban	Non-urban
Aquatic Area Abundance	83	92
Percent of AA with Buffer	66	100
Average Buffer Width	33	92
Buffer Condition	42	83
Hydrology Attribute	Urban	Non-urban
Water Source	58	100
Channel Stability	75	83
Hydrologic Connectivity	58	50

The frequency at which various stressors were identified as significant is presented in Table 8. This project was designed to compare the conditions of stream resources for urban and non-urban areas of the Guadalupe River watershed. As a result, the analyses tend to point to urban stressors as the likely cause of condition problems. It should be noted that the relative importance of different stressors deemed significant is disregarded by CRAM[3]. It should also be noted that many of the urban stressors are ubiquitous, intrinsic to urban environments, and very difficult to eliminate. The negative effects of

[3] The CRAM Stressor Checklist will be replaced in 2014 with a numerical index that reflects both the magnitude and abundance of stressors.

some stressors can be mitigated, however, through riparian buffers and/or changes in stream management practices (Table 8).

It seems evident from the survey results that substantial stream health benefits can be realized through the enhancement of riparian areas as buffers. The design of these buffers will vary depending on the stressors, but overall increases in riparian width and structural complexity are likely to be very beneficial to improve ecological conditions, especially if the buffer increases the area of active floodplains.

Table 8. Summary of the CRAM Stressor Checklist for 46 SCVWD AAs[4] (23 Urban AAs and 23 Non-urban AAs) for the Guadalupe River watershed.

Attribute	Stressor	% of AAs Non-urban	% of AAs Urban	Sensitivity to Buffer	Sensitivity to In-steam Management Practices
Buffer & Landscape Context	Urban residential	13	74	X	
	Transportation corridor	9	48	X	
	Industrial/commercial	0	30	X	
	Passive recreation (bird-watching, hiking, etc.)	0	13	X	X
	Active recreation (off-road vehicles, mountain biking, hunting, fishing)	0	9	X	
	Sports fields and urban parklands (golf courses, soccer fields, etc.)	4	9	X	
	Dams (or other major flow regulation or disruption)	4	4		X
	Military training/Air traffic	0	4		
	Dryland farming	0	0	X	
	Intensive row-crop agriculture	0	0	X	
	Orchards/nurseries	0	0	X	
	Physical resource extraction (rock, sediment, oil/gas)	4	0		X
	Ranching (enclosed livestock grazing or horse paddock or feedlot)	4	0	X	
	Rangeland (livestock rangeland also managed for native vegetation)	0	0	X	
Hydrology	Non-point Source (Non-PS) discharges (urban runoff, farm drainage)	0	61	X	
	Engineered channel (riprap, armored channel bank, bed)	4	43		X
	Dike/levees	0	30	X	
	Flow obstructions (culverts, paved stream crossings)	4	17		X
	Actively managed hydrology	4	13		X

[4] One of the forty seven AAs entered into eCRAM by the SCVWD did not have a Stressor Checklist entry, and the RMC AA Stressor Checklists were not available at the time of this report.

Attribute	Stressor	% of AAs Non-urban	% of AAs Urban	Sensitivity to Buffer	Sensitivity to In-steam Management Practices
Hydrology cont.	Point Source (PS) discharges (POTW, other non-stormwater discharge)	4	9		X
	Ditches (agricultural drainage, mosquito control, etc.)	0	4	X	X
	Flow diversions or unnatural inflows	0	4		X
	Weir/drop structure, tide gates	0	4		X
	Dams (reservoirs, detention basins, recharge basins)	0	0	X	X
	Dredged inlet/channel	0	0		
Physical Structure	Grading/compaction (N/A for restoration areas)	26	39	X	
	Vegetation management	9	39	X	X
	Trash or refuse	13	30	X	X
	Heavy metal impaired (PS or Non-PS pollution)	4	26	X	
	Excessive runoff from watershed	0	22	X	X
	Nutrient impaired (PS or Non-PS pollution)	0	13	X	
	Bacteria and pathogens impaired (PS or Non-PS pollution)	0	9	X	
	Pesticides or trace organics impaired (PS or Non-PS pollution)	0	4	X	
	Excessive sediment or organic debris from watershed	0	0	X	X
	Filling or dumping of sediment or soils (N/A for restoration areas)	4	0	X	X
	Plowing/Discing (N/A for restoration areas)	0	0	X	
Biotic Structure	Lack of treatment of invasive plants adjacent to AA or buffer	17	30	X	
	Mowing, grazing, excessive herbivory (within AA)	0	26	X	
	Lack of vegetation management to conserve natural resources	13	22	X	
	Excessive human visitation	13	17	X	
	Predation and habitat destruction by non-native vertebrates (e.g., Virginia opossum and domestic predators, such as feral pets)	9	13	X	
	Treatment of non-native and nuisance plant species	0	9	X	
	Pesticide application or vector control	0	4	X	
	Biological resource extraction or stocking (fisheries, aquaculture)	0	0		X
	Removal of woody debris	4	0	X	X
	Tree cutting/sapling removal	9	0	X	X

3) What are the Levels of Service (LOS) for stream ecosystem resources?

The District s EMAF includes recommendations for how to establish Levels of Service (LOS) for stream ecosystems to help the District periodically assess progress towards meeting stewardship objectives and the appropriateness of associated strategies and measurable objectives. These LOS can be established in each watershed by analyzing results of ambient surveys of stream ecosystem conditions. The District s EMAF Pilot Study and 2010 Coyote Creek watershed assessment (EOA and SFEI 2011) developed and described how the District could use a summary statistic called the Ecological Services Index (ESI) to track stream condition at the watershed and sub-watershed scales.

Using the CRAM Index Scores from the Guadalupe River watershed assessment, the ESI was calculated and presented in Figure 19 for the watershed as a whole (A), and the urban (B), and non-urban (C) areas separately. The ESI represents the area-weighted average of all CRAM Index Scores in the survey and can be visualized as the area to the left of the CDF curve (shown in light green in Figure 19). It is calculated as the summation of the products of individual Index Scores and the proportion of the stream length that they represent (see the 2010 Coyote Creek watershed assessment report (and appendix) for more information (EOA and SFEI 2011).

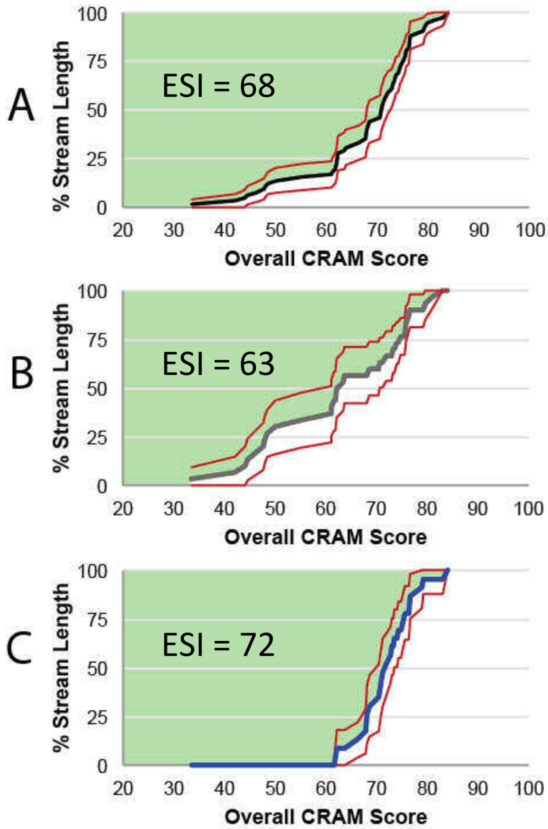


Figure 19. Ecological Service Index (ESI) for the Guadalupe River watershed as a whole (**A**, n=53), and for the urban (**B**, n=30) and non-urban (**C**, n=23) areas.

Watersheds can be compared based on their ESIs. For example, ESIs for the Guadalupe River and Coyote Creek watersheds (as a whole) were 68 and 75, respectively. As mentioned above, this could be explained (in part) by the differences in the urban extent in the two watersheds. ESIs can be compared over time, although no such data yet exist, or among sample strata. For example, ESIs for urban and non-urban areas of the Guadalupe watershed were 63 and 72, respectively (Figure 19).

The ESI can also be used to guide watershed stewardship. For example, the CRAM survey results could be adjusted to test sensitivity of the ESI to stewardship actions, such as stream restoration or riparian area enhancement, based on assumptions about the scores and percentage of the stream system that might be restored. Such analyses of alternative scenarios can help establish LOS targets.

Stream Condition Risks

1) What are the likely sources of risk to stream ecosystem resources?

As stated above, conditions are generally not as good for the District s streams as for other streams in the watershed. However, it would be misleading to conclude from these results that the District is necessarily at fault for the conditions of its streams. Most of the District s streams are located in urban areas that generally have poorer conditions due to land uses and stressors originating outside of the District s lands. The ability of the District to improve the conditions of its urban streams is therefore limited.

The results of this survey suggest, however, that the District could improve the conditions of its streams within the Guadalupe River watershed by enhancing the width and structural complexity of their riparian areas, especially if the enhancements include increasing the area of active floodplains. The District has already begun such activities. Floodplains with riparian habitats were established in downtown San Jose between Coleman Avenue to Interstate 880, and floodplains have been widened from Interstate 280 to Edwards Avenue, and similar efforts will extend up-river of Willow Street in the near future. Partnerships with other land management agencies, local interest groups, and private land owners could generate effective stream and riparian enhancements.

The relationship between riparian area design and stress reduction has been intensively studied (Collins *et al.* 2006 and citations therein). Substantial improvements in some parameters of water chemistry can be realized through moderate increases in riparian width and complexity, especially in low-gradient environments. Ecological services of stream corridors, such as the support of riparian wildlife, can be enhanced through careful landscaping of public and private lands that abut stream channels. Low Impact Development (LID) that reduces, retards, and filters urban and agricultural runoff can have significant positive effects on in-stream conditions, especially if the LID is carefully tuned to the environmental setting and stressors. One possible long-term management action to consider is the elimination of channel bank revetment wherever feasible, such that entrenched channels can naturally develop floodplains over time. There are many possible approaches to enhancing the capacity for existing riparian areas to buffer streams, and to increase the extent of riparian buffers. The District might consider a comprehensive strategy to assign riparian enhancement of different kinds for different reaches of the stream system, based on the particular stressors of concern.

It should also be noted that, since most District s streams are located in the downstream, urban area of the watershed, they are subject to the effects of the District s reservoirs. This study does not assess the effects of the reservoirs on stream conditions. However, it can be assumed that any change in flow regime resulting from a change in reservoir operation will trigger changes in stream structure, and that any decreases in the physical stream structure or stability would likely be deleterious to stream health.

2) What is the likelihood that sources of risk may impact stream ecosystem conditions?

The streams have apparently adjusted, or nearly adjusted, to past increases in runoff caused by the advent of European grazing practices and subsequently urbanization, and to regulated flows downstream of the reservoirs. Most of the streams are moderately to deeply entrenched, however. This limits the ability of flows to access floodplains that could help to moderate flood risks, store fine sediment, and filter other contaminants. Entrenchment also increases the sensitivity of the channels to further increases in flow. A general increase in either peak storm flows or mean annual flows that are confined to the channel will tend to cause further incision, which in turn would increase the size of flows that would be confined by the channel. This positive feedback could trigger a period of chronic incision. If the channels encounter resistant substrate, then incision could be replaced by lateral channel migration, with coincident erosion of the channel banks. The likelihood of bank erosion or collapse increases, however, whether or not the channels migrate, given that the increased height of the banks increases their instability.

There is a strong likelihood that urban runoff will continue to have negative effects on water quality, unless ways to retain and filter runoff before it enters the stream network are implemented. Furthermore, encroachment of urban development into historical riparian areas will continue to reduce the kinds and levels of service that these areas can provide, unless development is redesigned to be consistent with riparian processes, including flooding. The following section regarding climate change is relevant to this discussion.

3) What are the likely consequences of these risks to stream ecosystem condition?

Realization of the likely risks to stream health discussed immediately above would cause continuing declines in the functional width of riparian areas, and continuing declines in the kinds and levels of in-stream services. A general decline in the miles of wide riparian areas, and an increase in the miles of narrow areas would be expected. A reduction on the median CRAM Index score would also 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 conditions and riparian conditions, and in relation to the proximity of the channels to sources of risk. The following section regarding climate change is relevant to this discussion.

4) What are the fundamental risks to stream ecosystems represented by climate change?

The District recognizes that this report provides a baseline against which future changes in the distribution, abundance and diversity of surface aquatic resources, and conditions of streams can be assessed for the Guadalupe River watershed. When viewed as a whole, the most likely source of overall change in aquatic resources for the next decades is climate change. It is likely to strongly influence all other sources of risk in stream ecosystem health.

Much work is getting started in the Bay Area and elsewhere around the world to forecast changes in climate and to begin preparing for climate change. Work in the Bay Area has recently been catalogued (Association of Bay Area Governments (ABAG2012). 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.* 2012). 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 (GCMs). 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 time frame 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. The most important physical processes affected by changes in these parameters are evaporation, runoff or stream flow, and sea level rise. Changes in these processes can have major effects on the hydrological cycle and therefore, they can influence all ecosystem goods and services, including water supplies. The District should consider the likely consequences of climate change on its mission to meet the demands of its service area for water supplies, flood management, and healthy watersheds. Forecasts of future climatic conditions based on the best available science suggest precipitation amounts and patterns will change (e.g., storm intensity, frequency), temperatures will rise resulting in increased evaporation, and previously normal seasonal variations will change. These affect flows and hydrology that drive stream ecosystem health. Demand for water resources and flood protection will most likely increase or remain constant with continued conservation efforts, and managed urban growth.

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

A this time, many independent models suggest that mean annual temperature in the Bay Area will increase between 2 ^{o}C and 6 ^{o}C (3.6 ^{o}F and 10.8 ^{o}F) by the final decades of this century (Cayan *et al.* 2012), 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 condition. Sea level is expected to rise 22 to 51 in (55 to 130 cm) by the end of this century (Ackerly *et al.* 2012).

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). Forecast of increased precipitation show it concentrated in midwinter months, such that peak flows are increased.

Table 9 lists possible major effects of climate change on the distribution and abundance of aquatic resources in the Guadalupe River watershed. These effects might also generally apply to other watersheds within the District s service area. The District should consider the effects of these changes on its ability to continue providing reliable water supplies, flood protection, and stewardship goals and objectives, and how the effects might be ameliorated by management actions. It must be recognized that much more science is needed to understand the likelihood of these effects and their timing.

Table 9. 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 landsliding
	Increased sediment yields
	Decreased reservoir capacity
	Reduced flexibility to manage reservoir levels and stream flows
	Increased threat of flooding and storm damage
Increased global temperature translates into increased sea levels.	Increased salt water intrusion
	Increased channel base elevation causing channel aggradation
	Increased tidal flooding
	Increased river flooding

In summary, it is likely that increased temperature will generally increase the total annual evaporative losses throughout the watershed. Unless these losses are offset by increased precipitation and 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. Changes in flow regimes caused by either increased precipitation or a shorter wet season (i.e., increased rainfall intensity) would likely increase peak flows. The increased erosive power of these greater flows would probably initiate a new period of channel incision and head-cutting, especially where the flows are contained by the entrenched channels. The resulting increase in sediment yield above the reservoirs will increase the rate at which the reservoirs fill-in with sediment and lose water storage capacity. Dredging reservoirs in the Guadalupe watershed to regain or maintain their capacity would likely increase the risk of biological exposure to mercury. There would also be significant cost and risks associated with disposing contaminated dredged materials. Channel incision and other erosion in the catchments of streams that do not drain to any reservoirs would increase sediment yields to streams in the valley, causing them to aggrade. This aggradation would probably be enhanced by sea level rise that elevates the base elevation of streams. The aggradation would very likely increase the risk of flooding in some areas of the lower watershed. More intense or frequent storms may also directly result in increased flooding, regardless of channel aggradation. The effects of these physical changes in landscape form and structure on the ecological services of the watershed would be many and varied. Some of the most prominent effects are being forecasted for the Bay Area and beyond (Stralberg et al. 2011, Bay Area Open Space Council 2011, Ackerly et al. 2012).

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Appendix A Guadalupe River CRAM Assessment Results 2012

Map of CRAM AA Locations, Stratum Assignments, and CRAM Assessment Results
These data are also available online through EcoAtlas.

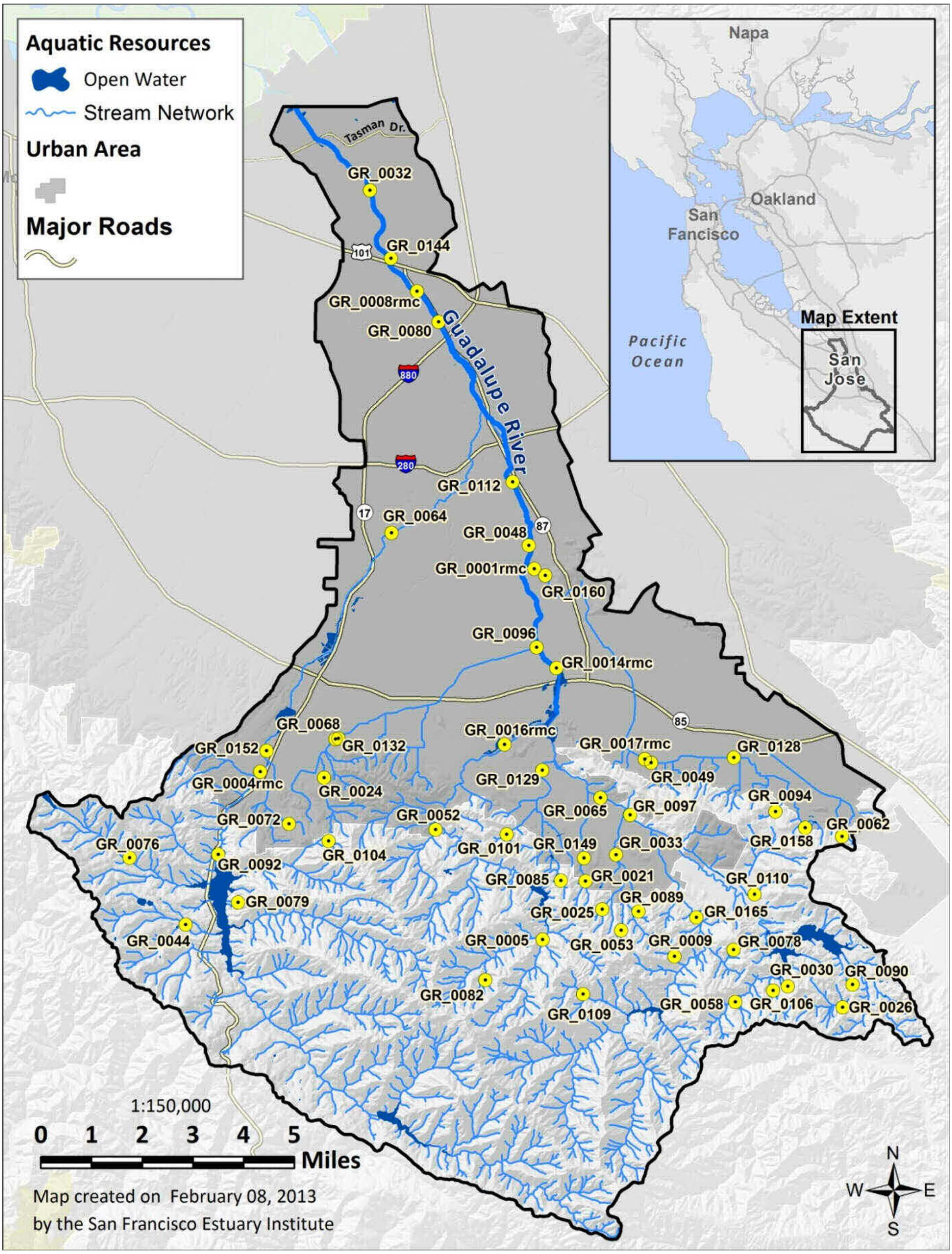

Figure A-1. Map of CRAM Assessment Areas (AAs) sampled in the Guadalupe River Assessment, 2012.

Table A-1. Assessment Area descriptions, field teams, and final CRAM scores for the Guadalupe River Assessment, 2012.

											Final Scores				
Site Code	Site Location	Polygon Area (ha)	Perimeter (m)	Investigators	Wetland Class	Visit date	Latitude	Longitude	Is Urban	District Owned	Overall Score	Buffer and Landscape Context	Hydrology	Physical Structure	Biotic Structure
GR_0001rmc	Canoas Cr, 250m DS of Nightengale Dr	0.19	273.81	Paul Randall, Carol Boland	Riverine Confined	7/18/2012	37.2879	-121.8786	1	1	42	54	42	38	33
GR_0004rmc	Los Gatos Cr, 500m DS of Saratoga-Los Gatos Rd	0.50	383.84	Paul Randall, Nick Zigler	Riverine Non-confined	7/25/2012	37.2302	-121.9736	1	0	74	79	75	75	67
GR_0005	Guadalupe Creek US of Guad Reservoir	0.37	292.62	Matt Parsons, Doug Titus	Riverine Non-confined	7/3/2012	37.1817	-121.8734	0	0	71	79	75	50	81
GR_0008rmc	Guadalupe River at airport, between Brokaw/Skyport	0.78	390.27	Paul Randall, Carol Boland, Nick Zigler	Riverine Non-confined	7/24/2012	37.3669	-121.9241	1	0	83	75	83	88	86
GR_0009	Unnamed Creek in Almaden Quicksilver County Park	0.34	317.34	Matt Parsons, Doug Titus	Riverine Confined	7/3/2012	37.1793	-121.8268	0	0	71	63	75	75	69
GR_0014rmc	Guadalupe River 300m US of Branham Ln	0.38	417.84	Paul Randall, Carol Boland	Riverine Non-confined	7/18/2012	37.2593	-121.8693	1	1	81	83	75	88	78

											------------------ Final Scores ------------------				
Site Code	Site Location	Polygon Area (ha)	Perimeter (m)	Investigators	Wetland Class	Visit date	Latitude	Longitude	Is Urban	District Owned	Overall Score	Buffer and Landscape Context	Hydrology	Physical Structure	Biotic Structure
GR_0016rmc	Guadalupe Creek, US Meridian near Perc pond	0.32	369.48	Lucy Buchan, Carol Boland, Nick Zigler	Riverine Non-confined	7/16/2012	37.2372	-121.8888	1	1	71	83	75	50	75
GR_0017rmc	Canoas Cr, 300 m DS of Tillamook Dr	0.14	273.89	Paul Randall, Carol Boland	Riverine Confined	7/19/2012	37.2338	-121.8370	1	1	49	67	42	38	47
GR_0021	Greystone Creek west of Glenview Dr	0.30	290.94	Brett Calhoun, Lisa Porcella, Doug Titus	Riverine Non-confined	7/2/2012	37.1986	-121.8582	0	0	74	92	75	63	67
GR_0024	East Ross Creek at Hillbrook School	0.37	329.87	Sarah Pearce, April Robinson	Riverine Non-confined	6/27/2012	37.2279	-121.9525	1	0	50	25	50	50	75
GR_0025	West branch of Randol Creek in Almaden Quicksilver Park	0.20	235.96	Brett Calhoun, Doug Titus, Lisa Porcella	Riverine Confined	7/2/2012	37.1914	-121.8518	0	0	79	100	75	75	67
GR_0026	Calero Creek in Calero County Park US of reservoir	0.37	350.62	Megan Malone, Lisa Porcella	Riverine Non-confined	7/3/2012	37.1647	-121.7658	0	0	73	92	67	63	69
GR_0030	Unnamed Creek in Calero County Park adj to Javalina Loop	0.19	252.74	Lisa Porcella, Megan Malone	Riverine Non-confined	7/3/2012	NA	NA	0	0	68	92	75	38	67

											------------------ Final Scores -----------------				
Site Code	Site Location	Polygon Area (ha)	Perimeter (m)	Investigators	Wetland Class	Visit date	Latitude	Longitude	Is Urban	District Owned	Overall Score	Buffer and Landscape Context	Hydrology	Physical Structure	Biotic Structure
GR_0032	Guadalupe River US of Montague Expy	0.58	325.39	Sarah Pearce, April Robinson	Riverine Non-confined	6/27/2012	37.3949	-121.9403	1	1	76	67	75	75	86
GR_0033	Randol Creek btw Serenity Way and Calcaterra Way	0.21	262.17	Navroop Jassal, Matt Parsons, Louisa Squires	Riverine Non-confined	6/26/2012	37.2073	-121.8479	1	1	49	50	50	38	56
GR_0044	Briggs Creek	0.31	240.84	Jae Abel, Lisa Porcella, Brett Calhoun	Riverine Non-confined	8/8/2012	37.1844	-122.0018	0	0	84	92	75	88	81
GR_0048	Guadalupe River DS of Curtner Ave	0.26	267.55	Megan Malone, Lisa Porcella, Matt Parsons	Riverine Confined	7/24/2012	37.2942	-121.8807	1	0	73	63	67	88	75
GR_0049	Canoas Creek DS of Tillamook Dr	0.13	230.94	Megan Malone, Matt Quinn, Louisa Squires, Doug Titus	Riverine Confined	6/25/2012	37.2333	-121.8360	1	1	48	67	50	38	36
GR_0052	Pheasant Creek	0.40	312.59	Megan Malone, Matt Parsons,	Riverine Non-confined	7/23/2012	37.2125	-121.9125	1	0	76	83	92	63	67

											------------------ Final Scores ------------------				
Site Code	Site Location	Polygon Area (ha)	Perimeter (m)	Investigators	Wetland Class	Visit date	Latitude	Longitude	Is Urban	District Owned	Overall Score	Buffer and Landscape Context	Hydrology	Physical Structure	Biotic Structure
				Brett Calhoun											
GR_0053	Tributary to Randol Creek in Almaden Quicksilver Park	0.11	223.92	Megan Malone, Matt Parsons, Lisa Porcella	Riverine Confined	7/24/2012	37.1837	-121.8454	0	0	77	100	92	75	39
GR_0058	Cherry Canyon	0.15	239.46	Jae Abel, Navroop Jassal, Megan Malone	Riverine Confined	8/21/2012	37.1666	-121.8024	0	0	72	92	75	63	58
GR_0062	Unnamed Creek above Coyote-Alamitos Canal	0.16	215.44	Megan Malone, Janell Hillman, Navroop Jassal	Riverine Confined	8/8/2012	37.2135	-121.7666	0	0	62	54	75	63	56
GR_0064	Los Gatos Creek DS of Bascom Ave	0.38	324.10	Navroop Jassal, Matt Parsons, Louisa Squires, April Robinson	Riverine Confined	6/26/2012	37.2974	-121.9306	1	1	75	63	75	75	86
GR_0065	Alamitos Creek DS of Greystone Rd	0.57	351.42	Megan Malone, Lisa	Riverine Non-confined	7/26/2012	37.2228	-121.8530	1	1	71	75	83	50	75

											------------------ Final Scores -----------------				
Site Code	Site Location	Polygon Area (ha)	Perimeter (m)	Investigators	Wetland Class	Visit date	Latitude	Longitude	Is Urban	District Owned	Overall Score	Buffer and Landscape Context	Hydrology	Physical Structure	Biotic Structure
				Porcella, Doug Titus											
GR_0068	Ross Creek US of Linda Ave	0.15	236.83	Janell Hillman, Navroop Jassal	Riverine Confined	7/23/2012	37.2380	-121.9495	1	0	69	63	67	75	69
GR_0072	Ross Creek off of Quarry Rd	0.10	223.35	Brett Calhoun, Megan Malone, Doug Titus	Riverine Confined	7/9/2012	37.2141	-121.9630	1	0	64	54	58	75	67
GR_0076	Lyndon Canyon Creek	0.75	339.53	Janell Hillman, Megan Malone, Navroop Jassal	Riverine Non-confined	8/14/2012	37.2022	-122.0215	0	0	79	100	75	63	78
GR_0078	Tributary to Chilean Gulch	0.19	238.84	Jae Abel, Megan Malone, Lisa Porcella	Riverine Non-confined	8/7/2012	37.1807	-121.8050	0	0	71	92	92	38	61
GR_0079	Unnamed Tributary of Los Gatos Creek (Lexington Reservoir)	0.05	204.66	Doug Titus, Janell Hillman, Navroop Jassal	Riverine Confined	8/20/2012	37.1911	-121.9823	0	0	76	100	83	50	69

											Final Scores				
Site Code	Site Location	Polygon Area (ha)	Perimeter (m)	Investigators	Wetland Class	Visit date	Latitude	Longitude	Is Urban	District Owned	Overall Score	Buffer and Landscape Context	Hydrology	Physical Structure	Biotic Structure
GR_0080	Guadalupe River adjacent to Airport Blvd	0.38	275.18	Navroop Jassal, Megan Malone, Matt Parsons	Riverine Non-confined	7/16/2012	37.3575	-121.9148	1	0	77	79	83	75	69
GR_0082	Unnamed Tributary to Rincon Creek	0.11	221.38	Navroop Jassal, Jae Abel, Megan Malone	Riverine Confined	8/15/2012	37.1698	-121.8933	0	0	68	100	83	50	39
GR_0085	Golf Creek in Almaden-Quicksilver Park	0.10	218.81	Lisa Porcella, Megan Malone	Riverine Confined	8/13/2012	37.1988	-121.8668	0	0	73	92	75	75	50
GR_0089	Tributary to Randol Creek in Almaden Quicksilver Park	0.15	235.77	Janell Hillman, Navroop Jassal, Megan Malone	Riverine Confined	8/8/2012	37.1909	-121.8395	0	0	76	100	83	50	69
GR_0090	Tributary to Calero Creek	0.15	277.71	Lisa Porcella, Jae Abel, Megan Malone	Riverine Non-confined	8/7/2012	37.1708	-121.7621	0	0	62	83	92	38	36
GR_0092	Los Gatos Creek at Lexington Reservoir	0.28	258.78	Lisa Porcella, Megan Malone	Riverine Non-confined	8/13/2012	37.2045	-121.9903	0	1	68	46	67	75	83

											Final Scores				
Site Code	Site Location	Polygon Area (ha)	Perimeter (m)	Investigators	Wetland Class	Visit date	Latitude	Longitude	Is Urban	District Owned	Overall Score	Buffer and Landscape Context	Hydrology	Physical Structure	Biotic Structure
GR_0094	Unnamed tributary to Coyote-Alamitos Canal	0.07	207.22	Louisa Squires, Shree Dharasker, Lisa Porcella	Riverine Confined	8/21/2012	37.2194	-121.7923	0	0	66	79	83	50	53
GR_0096	Ross Creek at Briarglen Ct	0.18	280.32	Megan Malone, Lisa Porcella, Matt Parsons	Riverine Confined	7/18/2012	37.2652	-121.8788	1	1	46	50	58	38	39
GR_0097	Alamitos Creek across from Leland HS	0.38	307.26	Megan Malone, Lisa Porcella, April Robinson, Doug Titus	Riverine Non-confined	6/26/2012	37.2179	-121.8425	1	1	64	75	58	50	72
GR_0101	McAbee Creek	0.09	219.37	Jae Abel, Navroop Jassal, Megan Malone	Riverine Non-confined	8/21/2012	37.2119	-121.8872	0	0	69	83	75	38	78
GR_0104	Tributary of Lime Kiln Gulch	0.17	235.61	Doug Titus, Janell Hillman, Navroop Jassal	Riverine Non-confined	8/20/2012	37.2087	-121.9504	0	0	74	92	83	50	69

											------------------ Final Scores ------------------				
Site Code	Site Location	Polygon Area (ha)	Perimeter (m)	Investigators	Wetland Class	Visit date	Latitude	Longitude	Is Urban	District Owned	Overall Score	Buffer and Landscape Context	Hydrology	Physical Structure	Biotic Structure
GR_0106	Tributary to Cherry Canyon Creek	0.08	217.65	Brett Calhoun, Jae Abel, Megan Malone	Riverine Confined	8/20/2012	37.1684	-121.7904	0	0	71	92	75	50	67
GR_0109	Jacques Gulch	0.11	218.50	Louisa Squires, Lisa Porcella	Riverine Confined	8/21/2012	37.1668	-121.8586	0	0	77	92	75	75	64
GR_0110	SE Santa Teresa Creek US of San Vicente Ave	0.12	232.01	Navroop Jassal, Megan Malone, Matt Parsons	Riverine Non-confined	7/2/2012	37.1964	-121.7973	1	1	62	75	83	38	53
GR_0112	Guadalupe River adj to Lelong St and US of Willow St	0.51	362.43	Megan Malone, April Robinson, Louisa Squires, Doug Titus	Riverine Confined	6/25/2012	0.0000	0.0000	1	1	61	63	67	50	64
GR_0128	Canoas Creek DS of Cottle Rd	0.14	230.81	Donna Ball, Janell Hillman, Navroop Jassal, Matt Parsons, April Robinson	Riverine Confined	7/25/2012	37.2352	-121.8055	1	1	34	25	42	25	42

Guadalupe River CRAM Assessment 2012 Results

											------------------ Final Scores ------------------				
Site Code	Site Location	Polygon Area (ha)	Perimeter (m)	Investigators	Wetland Class	Visit date	Latitude	Longitude	Is Urban	District Owned	Overall Score	Buffer and Landscape Context	Hydrology	Physical Structure	Biotic Structure
GR_0129	Golf Creek DS of Redmond Ave	0.09	219.75	Donna Ball, Janell Hillman, Navroop Jassal, Matt Parsons	Riverine Confined	6/25/2012	37.2300	-121.8747	1	1	55	63	67	38	53
GR_0132	Ross Creek DS of Linda Ave	0.21	207.75	Janell Hillman, Navroop Jassal, Matt Parsons	Riverine Confined	7/17/2012	37.2384	-121.9485	1	1	62	63	67	50	69
GR_0144	Guadalupe River at U.S. 101	0.95	384.32	Megan Malone, Matt Parsons, Lisa Porcella	Riverine Non-confined	7/18/2012	37.3765	-121.9333	1	1	80	67	83	88	81
GR_0149	Greystone Creek US of Hampton Dr	0.18	259.41	Navroop Jassal, Megan Malone, Matt Parsons	Riverine Non-confined	7/2/2012	37.2051	-121.8591	1	1	44	63	42	38	33
GR_0152	Los Gatos Creek US of Blossom Hill Rd	0.48	330.07	Janell Hillman, Navroop Jassal	Riverine Non-confined	7/23/2012	37.2337	-121.9736	1	0	62	54	58	63	72
GR_0158	Tributary to Canoas Creek US of Santa Teresa Golf Course	0.23	275.65	Megan Malone, Lisa Porcella,	Riverine Non-confined	7/17/2012	37.2154	-121.7800	1	0	61	92	67	25	61

											Final Scores				
Site Code	Site Location	Polygon Area (ha)	Perimeter (m)	Investigators	Wetland Class	Visit date	Latitude	Longitude	Is Urban	District Owned	Overall Score	Buffer and Landscape Context	Hydrology	Physical Structure	Biotic Structure
				Louisa Squires											
GR_0160	Canoas Creek US of Nightingale Dr	0.23	269.89	Janell Hillman, Navroop Jassal, Matt Parsons	Riverine Confined	7/17/2012	37.2859	-121.8745	1	1	45	67	42	38	31
GR_0165	Alamitos Creek adj to Almaden Rd	0.25	250.30	Megan Malone, Lisa Porcella, Louisa Squires	Riverine Non-confined	7/17/2012	37.1897	-121.8188	1	0	76	83	67	75	78

Table A-2. CRAM assessment scores (raw Metric and Attribute Scores) for the Guadalupe River Assessment, 2012.

					---------- Raw Scores ----------																	
Site Code	Visit date	Is Urban	District Owned	**Overall Score**	**Buffer and Landscape Context**	Aquatic Area Abundance Score	Percent of AA with Buffer	Average Buffer Width	Buffer Condition	**Hydrology**	Water Source	Hydroperiod or Channel Stability	Hydrologic Connectivity	**Physical Structure**	Structural Patch Richness	Topographic Complexity	**Biotic Structure**	Interspersion and Zonation	Vertical Biotic Structure	Number of Plant Layers Present	Number of Co-dominant Species	Percent Invasion
GR_0001rmc	7/18/2012	1	1	**42**	13	9	12	3	3	15	6	3	6	9	3	6	12	3	3	6	9	3
GR_0004rmc	7/25/2012	1	0	**74**	19	12	12	3	9	27	6	12	9	18	9	9	24	6	9	12	12	3
GR_0005	7/3/2012	0	0	**71**	19	12	9	3	9	27	12	12	3	12	6	6	29	9	9	12	9	12
GR_0008rmc	7/24/2012	1	0	**83**	18	12	9	3	6	30	6	12	12	21	9	12	31	9	12	12	12	6
GR_0009	7/3/2012	0	0	**71**	15	3	12	12	12	27	12	9	6	18	12	6	25	6	9	12	6	12
GR_0014rmc	7/18/2012	1	1	**81**	20	12	12	9	6	27	6	12	9	21	9	12	28	9	9	12	12	6
GR_0016rmc	7/16/2012	1	1	**71**	20	12	12	9	6	27	6	12	9	12	6	6	27	9	9	9	9	9
GR_0017rmc	7/19/2012	1	1	**49**	16	12	12	3	3	15	6	3	6	9	3	6	17	3	6	9	12	3
GR_0021	7/2/2012	0	0	**74**	22	12	12	9	9	27	12	12	3	15	9	6	24	6	9	9	6	12
GR_0024	6/27/20	1	0	**50**	6	3	3	3	3	18	6	6	6	12	6	6	27	9	9	12	9	6

					Raw Scores																		
Site Code	Visit date	Is Urban	District Owned	**Overall Score**	**Buffer and Landscape Context**	Aquatic Area Abundance Score	Percent of AA with Buffer	Average Buffer Width	Buffer Condition	**Hydrology**	Water Source	Hydroperiod or Channel Stability	Hydrologic Connectivity	**Physical Structure**	Structural Patch Richness	Topographic Complexity	**Biotic Structure**	Interspersion and Zonation	Vertical Biotic Structure	Number of Plant Layers Present	Number of Co-dominant Species	Percent Invasion
	12																						
GR_0025	7/2/2012	0	0	**79**	24	12	12	12	12	27	12	9	6	18	12	6	24	6	9	6	9	12
GR_0026	7/3/2012	0	0	**73**	22	12	12	12	9	24	12	9	3	15	9	6	25	6	9	12	6	12
GR_0030	7/3/2012	0	0	**68**	22	12	12	12	9	27	12	9	6	9	6	3	24	6	9	9	6	12
GR_0032	6/27/2012	1	1	**76**	16	12	12	3	3	27	6	9	12	18	6	12	31	12	9	12	9	9
GR_0033	6/26/2012	1	1	**49**	12	9	3	3	3	18	6	9	3	9	3	6	20	6	6	9	9	6
GR_0044	8/8/2012	0	0	**84**	22	12	12	9	9	27	12	9	6	21	9	12	29	9	9	12	9	12
GR_0048	7/24/2012	1	0	**73**	15	12	3	3	3	24	6	9	9	21	12	9	27	9	9	12	12	3
GR_0049	6/25/2012	1	1	**48**	16	12	12	3	3	18	6	3	9	9	6	3	13	3	3	9	9	3
GR_0052	7/23/2012	1	0	**76**	20	12	12	9	6	33	12	12	9	15	9	6	24	9	6	9	9	9
GR_0053	7/24/20	0	0	**77**	24	12	12	12	12	33	12	9	12	18	12	6	14	3	3	9	3	12

					Raw Scores																	
Site Code	Visit date	Is Urban	District Owned	**Overall Score**	**Buffer and Landscape Context**	Aquatic Area Abundance Score	Percent of AA with Buffer	Average Buffer Width	Buffer Condition	**Hydrology**	Water Source	Hydroperiod or Channel Stability	Hydrologic Connectivity	**Physical Structure**	Structural Patch Richness	Topographic Complexity	**Biotic Structure**	Interspersion and Zonation	Vertical Biotic Structure	Number of Plant Layers Present	Number of Co-dominant Species	Percent Invasion
	12																					
GR_0058	8/21/2012	0	0	**72**	22	12	12	12	9	27	12	9	6	15	12	3	21	6	6	12	3	12
GR_0062	8/8/2012	0	0	**62**	13	3	12	12	9	27	12	9	6	15	9	6	20	6	6	9	3	12
GR_0064	6/26/2012	1	1	**75**	15	9	12	3	6	27	6	12	9	18	12	6	31	12	9	12	12	6
GR_0065	7/26/2012	1	1	**71**	18	12	12	3	6	30	6	12	12	12	6	6	27	6	9	12	12	12
GR_0068	7/23/2012	1	0	**69**	15	12	3	3	3	24	6	12	6	18	12	6	25	6	9	12	12	6
GR_0072	7/9/2012	1	0	**64**	13	3	12	9	9	21	6	9	6	18	12	6	24	6	9	9	6	12
GR_0076	8/14/2012	0	0	**79**	24	12	12	12	12	27	9	12	6	15	9	6	28	9	9	12	6	12
GR_0078	8/7/2012	0	0	**71**	22	12	12	12	9	33	12	12	9	9	3	6	22	6	6	12	6	12
GR_0079	8/20/2012	0	0	**76**	24	12	12	12	12	30	12	12	6	12	9	3	25	6	9	12	6	12
GR_0080	7/16/20	1	0	**77**	19	12	9	3	9	30	6	12	12	18	6	12	25	6	9	12	12	6

					Raw Scores																	
Site Code	Visit date	Is Urban	District Owned	**Overall Score**	**Buffer and Landscape Context**	Aquatic Area Abundance Score	Percent of AA with Buffer	Average Buffer Width	Buffer Condition	**Hydrology**	Water Source	Hydroperiod or Channel Stability	Hydrologic Connectivity	**Physical Structure**	Structural Patch Richness	Topographic Complexity	**Biotic Structure**	Interspersion and Zonation	Vertical Biotic Structure	Number of Plant Layers Present	Number of Co-dominant Species	Percent Invasion
	12																					
GR_0082	8/15/2012	0	0	**68**	24	12	12	12	12	30	12	12	6	12	9	3	14	3	3	9	3	12
GR_0085	8/13/2012	0	0	**73**	22	12	12	12	9	27	12	9	6	18	12	6	18	3	6	9	6	12
GR_0089	8/8/2012	0	0	**76**	24	12	12	12	12	30	12	12	6	12	9	3	25	6	9	12	6	12
GR_0090	8/7/2012	0	0	**62**	20	12	12	12	6	33	12	9	12	9	3	6	13	3	3	6	3	12
GR_0092	8/13/2012	0	1	**68**	11	3	12	9	6	24	6	12	6	18	9	9	30	9	9	12	12	12
GR_0094	8/21/2012	0	0	**66**	19	9	12	12	9	30	12	9	9	12	6	6	19	6	3	12	6	12
GR_0096	7/18/2012	1	1	**46**	12	9	3	3	3	21	6	9	6	9	6	3	14	3	3	9	9	6
GR_0097	6/26/2012	1	1	**64**	18	12	9	3	6	21	6	12	3	12	6	6	26	6	9	12	12	9
GR_0104	8/20/2012	0	0	**74**	22	12	12	9	9	30	12	12	6	12	6	6	25	6	9	12	6	12
GR_0106	8/20/20	0	0	**71**	22	12	12	12	9	27	12	9	6	12	9	3	24	6	9	12	3	12

					---------- Raw Scores ----------																	
Site Code	Visit date	Is Urban	District Owned	**Overall Score**	**Buffer and Landscape Context**	Aquatic Area Abundance Score	Percent of AA with Buffer	Average Buffer Width	Buffer Condition	**Hydrology**	Water Source	Hydroperiod or Channel Stability	Hydrologic Connectivity	**Physical Structure**	Structural Patch Richness	Topographic Complexity	**Biotic Structure**	Interspersion and Zonation	Vertical Biotic Structure	Number of Plant Layers Present	Number of Co-dominant Species	Percent Invasion
	12																					
GR_0109	8/21/2012	0	0	**77**	22	12	12	9	9	27	12	9	6	18	12	6	23	6	6	12	9	12
GR_0110	7/2/2012	1	1	**62**	18	12	12	3	6	30	9	9	12	9	3	6	19	6	6	9	6	6
GR_0112	6/25/2012	1	1	**61**	15	9	9	3	6	24	6	6	12	12	6	6	23	6	9	12	9	3
GR_0128	7/25/2012	1	1	**34**	6	3	3	3	3	15	6	3	6	6	3	3	15	3	6	6	6	6
GR_0129	6/25/2012	1	1	**55**	15	12	3	3	3	24	6	12	6	9	6	3	19	6	6	6	6	9
GR_0132	7/17/2012	1	1	**62**	15	12	3	3	3	24	6	12	6	12	6	6	25	6	9	12	12	6
GR_0144	7/18/2012	1	1	**80**	16	9	12	6	6	30	6	12	12	21	9	12	29	9	9	12	12	9
GR_0149	7/2/2012	1	1	**44**	15	12	3	3	3	15	6	6	3	9	6	3	12	3	3	6	3	9
GR_0152	7/23/2012	1	0	**62**	13	9	3	3	6	21	6	12	3	15	6	9	26	9	9	12	9	3
GR_0158	7/17/20	1	0	**61**	22	12	12	12	9	24	12	9	3	6	3	3	22	6	6	12	6	12

					---------- Raw Scores ----------																	
Site Code	Visit date	Is Urban	District Owned	**Overall Score**	**Buffer and Landscape Context**	Aquatic Area Abundance Score	Percent of AA with Buffer	Average Buffer Width	Buffer Condition	**Hydrology**	Water Source	Hydroperiod or Channel Stability	Hydrologic Connectivity	**Physical Structure**	Structural Patch Richness	Topographic Complexity	**Biotic Structure**	Horizontal Interspersion and Zonation	Vertical Biotic Structure	Number of Plant Layers Present	Number of Co-dominant Species	Percent Invasion
	12																					
GR_0160	7/17/2012	1	1	**45**	16	12	3	3	6	15	6	3	6	9	3	6	11	3	3	6	6	3
GR_0165	7/17/2012	1	0	**76**	20	12	12	9	6	24	6	12	6	18	9	9	28	9	9	12	12	6
GR_0101	8/21/2012	0	0	**69**	20	12	12	12	6	27	12	12	3	9	6	3	28	9	9	12	6	12