ARROYO SECO WATERSHED MANAGEMENT AND RESTORATION PLAN

APPENDICES TO FINAL REPORT

03-01-06

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Council of Arroyo Seco Agencies (CASA) Meeting Schedule

11/13/03	01/08/04	02/12/04
03/11/04	04/08/04	05/13/04
06/10/04	07/08/04	08/12/04
09/09/04	10/14/04	01/13/05
03/10/05	05/12/05	07/14/05
09/08/05	11/10/05	

Partial list of organizations attending CASA meetings over the project period:

- Arroyo Seco Foundation
- Audubon California
- California Department of Transportation (CalTrans)
- California State Assembly District 44 (Carol Liu)
- City of La Cañada Flintridge
- City of Los Angeles, Bureau of Sanitation
- City of Los Angeles, Department of Recreation and Parks
- City of Pasadena, Parks and Natural Resources Division
- City of Pasadena, Department of Public Works
- City of Pasadena, Department of Water and Power
- City of South Pasadena
- County of Los Angeles Department of Public Works
- Los Angeles / San Gabriel Rivers Watershed Council
- National Park Service, Rivers Trails and Conservation Assistance Program
- North East Trees
- Raymond Basin Management Board
- Regional Water Quality Control Board – Los Angeles
- Rose Bowl Operating Company
- University of Southern California
- U.S. Army Corps of Engineers
- U.S.D.A. Forest Service, Angeles National Forest

Council of Arroyo Seco Organizations (CASO) Meeting Schedule

05/22/04	09/07/04	12/11/04
03/12/05	06/30/05	09/30/05
12/15/05		

Partial list of organizations attending CASO meetings

- Altadena Foothills Conservancy
- Arroyo Seco Gardens
- Arroyo Seco Journal
- Arroyo Seco Neighborhood Council
- Audubon Center at Debs Park
- California Cycleways
- Equestrian Trails, Inc.
- Foothill Bicycle Initiative
- Franklin High School Transportation Academy
- Friends of Debs Park
- Friends of Echo Park
- Friends of the Los Angeles River
- Friends of the Southwest Museum
- Goodwill Industries
- Heritage Square Museum
- Highland Park Heritage Trust
- Historic Highland Park Neighborhood Council
- Kidspace Children's Museum
- La Cañada Flintridge Trails Council
- Latino Urban Forum
- National Parks Rivers, Trails, and Conservation Assistance Program
- Northeast Democrats
- Northeast LA Open Space Coalition
- Occidental College, Urban and Environmental Policy Institute
- October Surprise
- Pasadena Arts Council
- Pasadena Audubon Society
- Pasadena Heritage
- Pasadena Museum of Natural History
- Pasadena Roving Archers
- Rock Rose Gallery
- Rose Bowl Riders

- Sequoya School
- Sierra Club
- Trust for Public Lands
- West Pasadena Residents Association

Appendix 2: Water Quality Data Summary

Arroyo Seco Watershed Management and Restoration Plan Project

Summary of Baseline Water Quality Data

Agreement Number 02-138-254-0

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Background

The Arroyo Seco is one of the main tributaries of the Los Angeles River, beginning high in the San Gabriel Mountains above Pasadena and ending at its confluence with the Los Angeles River 22 miles downstream. Historically, the Arroyo was a verdant natural stream that provided refuge to both wildlife and humans alike.

Today, the Arroyo Seco is heavily impacted by human activities. Several dams and structures alter its flow within the otherwise natural confines of the Angeles National Forest (ANF). South of the ANF, the Arroyo Seco is blocked by the Devil's Gate Dam, and for most of its course to the Los Angeles River is encased in concrete. Water quality is degraded by urban storm water runoff, aquatic habitat is nonexistent, and what little terrestrial habitat is left has been compromised by fragmentation and the invasion of nonnative species (NET & ASF 2002).

From a water quality perspective, the Arroyo Seco is considered a major tributary of the Los Angeles River. As TMDLs are developed for the Los Angeles River, compliance strategies will extend to the Arroyo Seco. In addition, the Arroyo is also listed separately on California's Section 303(d) list for algae, high coliform counts, and trash (LARWQCB 2002).

Identifying strategies to meet future water quality objectives will require a solid understanding of existing Arroyo Seco water quality. This understanding does not exist today. While much water quality data has been collected in the Arroyo Seco watershed, it hasn't previously been compiled or evaluated as a whole. This document is the first step in this process. It outlines the steps taken as part of this project to consolidate existing data into one source and presents an assessment of the consolidated dataset's usefulness in making water quality improvement decisions.

Objectives

This first stage of the Water Quality Technical Study involves the assembly of a water quality database that can be used as the basis for the more advanced analyses required by future tasks of this project. Specifically, NET hoped to achieve the following objectives:

- Identify all existing water quality data for the Arroyo Seco watershed, and consolidate it into one comprehensive database;

- Review relevant point source discharge permits;
- Coordinate with local agencies and governments to gain an understanding of their water quality monitoring programs and/or TMDL implementation efforts;
- Assess the assembled data set, and
- Provide a base of information to be used in future tasks of this project.

The remainder of this document presents our findings, their implications on future phases of this project, and preliminary recommendations for how to improve water quality data collection in the Arroyo Seco Watershed.

Overview of Data Sources

NET carried out a broad outreach campaign to secure the data needed to begin this study. In the process, we identified at least seven different organizations that collect or maintain distinct sets of water quality data related to the Arroyo Seco watershed. These sources are described in Table 1.

Table 1. Sources of Arroyo Seco Water Quality Data

Data source	Description of dataset	Rationale for collecting data
RWQCB (LARWQCB 2004b)	Comprehensive set of parameters, collected over a long time and at multiple locations	Unknown
Los Angeles County DPW (2003)	Comprehensive parameters, collected since 2002, one sampling location	NPDES permit compliance
City of Los Angeles (2004)	Monthly bacteria sampling at confluence with Los Angeles River	TMDL preparations
City of Pasadena (2004)	Historical sampling of limited parameters above Hahamongna	Operation of treatment plant treating Arroyo Seco surface water (closed in 1993)
Southern California Coastal Waters Research Program (2004)	Three sampling events in 2000-2002, comprehensive parameters	Collaboration with US EPA in preparing TMDL standards for the Los Angeles River watershed
Jet Propulsion Laboratory (2002	Storm-event sampling at outfall of JPL storm drains	Compliance with JPL storm water permit
Friends of the Los Angeles River (Wang, 2004)	Recent sampling event(s) performed by citizen volunteers & FoLAR staff	Ongoing FoLAR LA River water quality monitoring

NET also carried out a review of all point source discharge permits for the watershed. Our research indicated that permitted discharges are not likely to be major sources of contamination in the watershed. There is only one facility with an active individual NPDES permit for discharge to the Arroyo Seco, the Lincoln Avenue Water Company's South Coulter Surface Water Treatment Plan in Altadena (LARWQCB, 2003). This facility consists of a small municipal water treatment plant that is used as a backup water supply for the community of Altadena. It operates intermittently during the winter when there is surface flow to its intake in Millard Canyon. The permitted discharge occurs when the plant back-flushes its filters. The resulting water is discharged to the Arroyo Seco. A review of this facility's permit information indicated that the plant has been in compliance with past permit requirements and is unlikely to affect the water quality of the Arroyo Seco due to its limited and intermittent discharge and the nature of its processes.

The Jet Propulsion Laboratory also is governed under a general NPDES permit, the *General National Pollutant Discharge Elimination System and Waste Discharge Requirements for Discharges of Groundwater from Construction and Project Dewatering to Surface Waters in Coastal Watersheds of Los Angeles and Ventura Counties*, adopted by the LA-RWQCB on August 7, 2003 (LARWQCB 1997). This discharge is associated with a shallow groundwater dewatering system designed to stabilize a JPL structure. This water is not pumped from the larger JPL subsurface contaminant plume. Reviews of previous monitoring reports from this site, the newly issued general permit, and materials describing the JPL groundwater cleanup effort suggest that this discharge is not likely to have a material impact on Arroyo Seco water quality (LARWQCB 1997, Foster Wheeler 1999, LARWQCBa 2004).

There are a number of facilities within the watershed that are also covered under the State's Industrial and Construction Storm Water general permits. Due to the large number of such facilities, the lack of spatial information with which to determine whether they fall within the watershed, and staffing limitations in the RWQCB's Storm Water Program, most of these facilities were not reviewed in time to be included in this report. However, NET did review the Jet Propulsion Laboratory's storm water annual reports, for this facility is large and is in the naturalized portion of the upper watershed. These results will be discussed as necessary in the document below.

Water Quality Standards

The starting point of NET's approach to evaluating the data is based on comparing it to relevant water quality objectives. Comparisons to objectives allow us to identify those parameters most likely to indicate water quality impairments in the Arroyo Seco watershed. Once these potential impairments are identified, further analysis can be performed to assess whether the data can be used to identify trends in contamination through time, spatial differences throughout the watershed and identification of key source areas, and differences between wet and dry season contaminant concentrations.

Three sets of objectives were considered for this effort: water quality objectives from the LA RWQCB's *Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties* (LARWQCB, 1994) and revisions, water quality objectives from the *California Ocean Plan* (SWRCB, 2001), and water quality standards from the US EPA's *Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California – 40 CFR Part 131* (CTR) (EPA, 2000). Where available, the objectives set in the Basin Plan were used. For certain parameters, Ocean Plan limits exist for parameters not covered in the Basin Plan. Because the Arroyo Seco is a tributary of the Los Angeles River, which discharges to the Pacific Ocean, the Ocean Plan limits were deemed relevant in these situations. Finally, CTR-based limits were not employed in this study since their derivation is based on accompanying hardness data (EPA, 2000) that was not available for many of the priority pollutant results.

Table 2 displays the water quality objectives used in this study. Only objectives for parameters where there were at least four results above the detection limit are shown.

Table 2. Water Quality Objectives
(note: only displayed for contaminants which were detected in the Arroyo Seco)

Parameter	Source	Sample Type	Value	Units	Notes
Aldrin	Ocean Plan	30-day mean	0.000022	ug/L	No instantaneous objectives
Aluminum	Basin Plan	Instantaneous	1.0	Mg/L	MCL
Ammonia (as N)	LA River TMDL	One-hour Average	8.7	Mg/L	
Antimony	Basin Plan	Instantaneous	0.006	mg/L	MCL
Arsenic	Basin Plan	Instantaneous	0.05	Mg/L	MCL
Barium	Basin Plan	Instantaneous	1.0	Mg/L	MCL
Beryllium	Basin Plan	Instantaneous	0.004	Mg/l	MCL
Cadmium	LA River	Instantaneous	0.0031 (W)	Mg/l	MCL

	TMDL				
Chloride	Basin Plan	Instantaneous	150	Mg/l	LA River above Figueroa
Coliform, Fecal	Basin Plan	Instantaneous	400	MPN/100mL	Triggers resampling
Coliform, Total	Basin Plan	Instantaneous	10,000	MPN/100mL	Triggers resampling
Copper	LA River TMDL	Instantaneous	0.022 (D) 0.017 (W)	Mg/L	
Cyanide	Basin Plan	Instantaneous	0.2	Mg/L	MCL
Diazinon	CA Dept Fish & Game	Instantaneous	0.00008	Mg/L	From LA County DPW NPDES reports
E.coli	Basin Plan	Instantaneous	235	MPN/100mL	Triggers resampling
Enterococcus	Basin Plan	Instantaneous	104	MPN/100mL	Triggers resampling
Lead	LAR TMDL	Instantaneous	0.011 (D) 0.062 (W)	Mg/L	
Mercury	Basin Plan	Instantaneous	0.002	Mg/L	MCL
Nickel	Basin Plan	Instantaneous	0.1	Mg/L	MCL
Nitrate (as N)	LA River TMDL	30-day Average	8	Mg/L	
Nitrate (as NO3)	Basin Plan	Instantaneous	45	Mg/L	MCL
Nitrate + Nitrate (as N)	LA River TMDL	30-day Average	8	Mg/L	
Nitrite (as N)	Basin Plan	Instantaneous	1	Mg/L	
Nitrogen (Nitrate + Nitrite)	Basin Plan	Instantaneous	8	Mg/L	LA River above Figueroa
Oil & Grease	Ocean Plan	Instantaneous	75	Mg/L	
Silver	Ocean Plan	Instantaneous	0.007	Mg/L	
Sulfate	Basin Plan	Instantaneous	300	Mg/L	LA River above Figueroa
Total Dissolved Solids	Basin Plan	Instantaneous	950	Mg/L	LA River above Figueroa
Turbidity	Ocean Plan	Instantaneous	225	Mg/L	
Zinc	LAR TMDL	Instantaneous	0.016 (W)	Mg/L	

Overview of Data

NET secured data from seven different agencies for this study. This data represents analyses carried out between 1976 and 2004, from at least six different sampling points along the Arroyo Seco, for over 225 different analytes, and comprising at least 1,950 discrete samples. Table 3 displays the different data sets analyzed as part of this study.

This data was compiled into one comprehensive database and checked for uniformity. NET compared analytical methods, ensured that units were consistent and added spatial information to be used in a GIS system to all sample results.

Table 3. Quantitative Description of Data Sources

Agency	Date Range	Locations	Parameters	# Events	# Samples
RWQCB (2004b)	1986 – 1997	Devil's Gate, mid-Arroyo, confluence	Comprehensive(1)	17	1,100
LA County DPW (2003)	2002 – 2003	Mid-Arroyo (Debs Park)	Comprehensive(1)	6	132
City of Los Angeles (2004)	2002 – 2004	Confluence	Bacteria	36	111
SCCWRP (2004)	2000 – 2002	Confluence	Comprehensive(1)	3	75
City of Pasadena (2004)	1976 – 1989	Upper Hahamongna	Comprehensive(1)	15	169
Jet Propulsion Laboratory (2002)	1993 – 2002	JPL site storm drains	Conventional(1) and metals	5	384
Friends of the Los Angeles River (Wang, 2004)	2003 – 2004	Lower Arroyo	Conventional / Field(1)	??	??
Total				**82+**	**1,971+**

(1) Comprehensive contaminant suite consists of basic water quality indicators (pH, conductivity, etc), priority pollutants, organics, and other analyses needed to fully characterize water quality. Conventional / field suite consists of field-based measurements such as pH and conductivity, and basic laboratory measurements such as various nutrients and common metals.

Because the JPL data is from storm drain outlets and not from the Arroyo main channel, it is withheld from analysis unless otherwise noted.

Comparison to Water Quality Standards

After consolidating and cleaning the data, NET identified all analytes that had measured above the detection limit in Arroyo Seco surface water. Table 4 presents a list of these detected analytes. NET then compared each detected sample result to the corresponding limit and calculated the frequency with which each chemical fell above the regulatory standard. Table 5 summarizes all of the chemicals found to have exceeded regulatory limits.

Table 4. Chemicals Detected in Arroyo Seco Surface Water

Parameter	Parameter
1-METHYLNAPHTHALENE	ENTEROCOCCUS
1-METHYLPHENANTHRENE	FLUORANTHENE (IDRYL)
2, 4, 5-TP	FLUORENE (ALPHA-DIPHENYLENEMETHANE)
2, 4-D	FLUORIDE
2,6-DIMETHYLNAPHTHALENE	HARDNESS (AS CACO3)
2-METHYLNAPHTHALENE	INDENO(1,2,3-C,D)PYRENE
ACENAPHTHENE	IRON – TOTAL
ACENAPHTHYLENE	LEAD – DISSOLVED
ALKALINITY (AS CACO3)	LEAD – TOTAL
ALKALINITY (AS CACO3), TOTAL	MAGNESIUM
ALUMINUM – TOTAL	MAGNESIUM (SAME AS MAGNESIUM DISSOLVED)
ANTHRACENE	MANGANESE
ARSENIC	MBAS (DETERGENTS) (SURFACTANTS)
BARIUM	NAPHTHALENE (TAR CAMPHOR)
BENZ(A)ANTHRACENE	NICKEL
BENZO(A)PYRENE	NITRATE (AS NITROGEN)
BENZO(B)FLUORANTHENE	NITRATE (AS NO3)
BENZO(E)PYRENE	NITRATE + NITRITE (AS NITROGEN)
BENZO(G,H,I)PERYLENE	NITRITE (AS NITROGEN)
BENZO(K)FLUORANTHENE	NITROGEN, AMMONIA (AS NITROGEN)
BICARBONATE	NITROGEN, TOTAL ORGANIC
BICARBONATE (HCO3)	OIL AND GREASE
BIPHENYL	PERYLENE
BIS(2-ETHYLHEXYL)PHTHALATE	PH
BOD 5 DAY (BIOCHEMICAL OXYGEN DEMAND)	PHENANTHRENE

BORON	PHOSPHATE
CADMIUM	PLANKTON
CALCIUM (SAME AS DISSOLVED CALCIUM)	POTASSIUM
CHLORIDE	PYRENE
CHROMIUM – TOTAL	SETTLEABLE SOLIDS, TOTAL
CHRYSENE (1,2-BENZPHENANTHRENE)	SILVER
COLIFORM RATIO	SODIUM
COLIFORM, FECAL	SPECIFIC CONDUCTANCE (UMHO/CM X 10-6)
COLIFORM, TOTAL	STREPTOCOCCUS
COLOR UNITS	SULFATE
COPPER – DISSOLVED	TKN
COPPER – TOTAL	TOTAL DISSOLVED SOLIDS
CYANIDE	TOTAL HARDNESS (AS CACO3)
DIAZINON	TOTAL ORGANIC CARBON
DIBENZ(A,H)ANTHRACENE	TOTAL PETROLEUM HYDROCARBONS
DISSOLVED ORGANIC CARBON	TOTAL SUSPENDED SOLIDS
DISSOLVED OXYGEN	TURBIDITY
DISSOLVED OXYGEN	ZINC – DISSOLVED
E.COLI	ZINC – TOTAL

Table 5. Results of Comparisons to Water Quality Objectives

Parameter	# Samples	Average Concentration	Water Quality Objective	Source	# Samples Over WQ Objective	% of Samples Over WQ Objective
Enterococcus	46	21,500	104	Basin Plan	42	91
Fecal Coliform	18	46,100	400	Basin Plan	14	78
E.coli	38	9,600	235	Basin Plan	29	76
Total Coliform	57	102,400	10,000	Basin Plan	40	70
Diazinon	6	0.00059	0.00008	CA DF&G	2	33
Copper – Total	16	0.0178	0.022 (D) 0.017 (W)	LAR TMDL	4	25
Aluminum	6	1.75	1	Basin Plan	1	17
Lead	19	0.0103	0.011 (D) 0.062 (W)	LAR TMDL	2	11
Cyanide	9	0.004	0.0052	CTR	1	11
Zinc – Total	17	0.0783	0.16 (W)	LAR TMDL	1	6
Nitrite	19	0.209	1	Basin Plan	1	5
Chloride	20	88.7	150	Basin Plan	1	5

The conclusions from this review are the following:

- From a water quality standpoint, elevated bacteria levels in the Arroyo Seco appear to present the most significant water quality problem. Concentrations far exceeded limits known to indicate risks to human health, and indicate that the Arroyo Seco does not meet the beneficial uses criteria for which it is classified.

- Other parameters for which water quality problems potentially exist are for several metals (aluminum, copper, lead and zinc), the pesticide diazinon, and nitrite. However, the low number of samples for these parameters and/or the low frequency with which samples exceeded the objectives suggests that greater examination is needed to determine the extent of any problem. Along with the four primary bacteria measures (total coliform, fecal coliform, enterococcus, and e.coli), these contaminants will be referred to as the **contaminants of concern** throughout the remainder of this study.

- Chloride also exceeded a water quality objective for the upper Los Angeles River. However, the low frequency of this occurrence coupled with the limited consequences of moderately elevated chloride levels suggests that this parameter is not likely to be an issue in the near future.

- In general, the water quality issues suggested by this data are consistent with nonpoint source pollution from other heavily urbanized and exploited Southern California watersheds (Stein et al., 2003). The lack of significant point sources contributing to water quality problems further supports this conclusion.

Water Quality Trends Through Time

The NET project team hoped to identify trends in water quality in the Arroyo Seco watershed through time. We grouped the data by contaminant and sampling location and generated graphs to identify trends. This approach proved problematic. For most contaminants, there were a maximum of 2-4 samples at any given location, often over widely spaced time periods. This made it impossible to calculate meaningful trends.

For a limited set of contaminants (mainly bacteria and some metals), there appeared to be sufficient data to evaluate trends for the sampling locations in the lower watershed. Once again, we generated graphs and attempted to calculate numerical trends. This approach was not successful either, for the inter-year seasonal variation in results masked any longer-term trends.

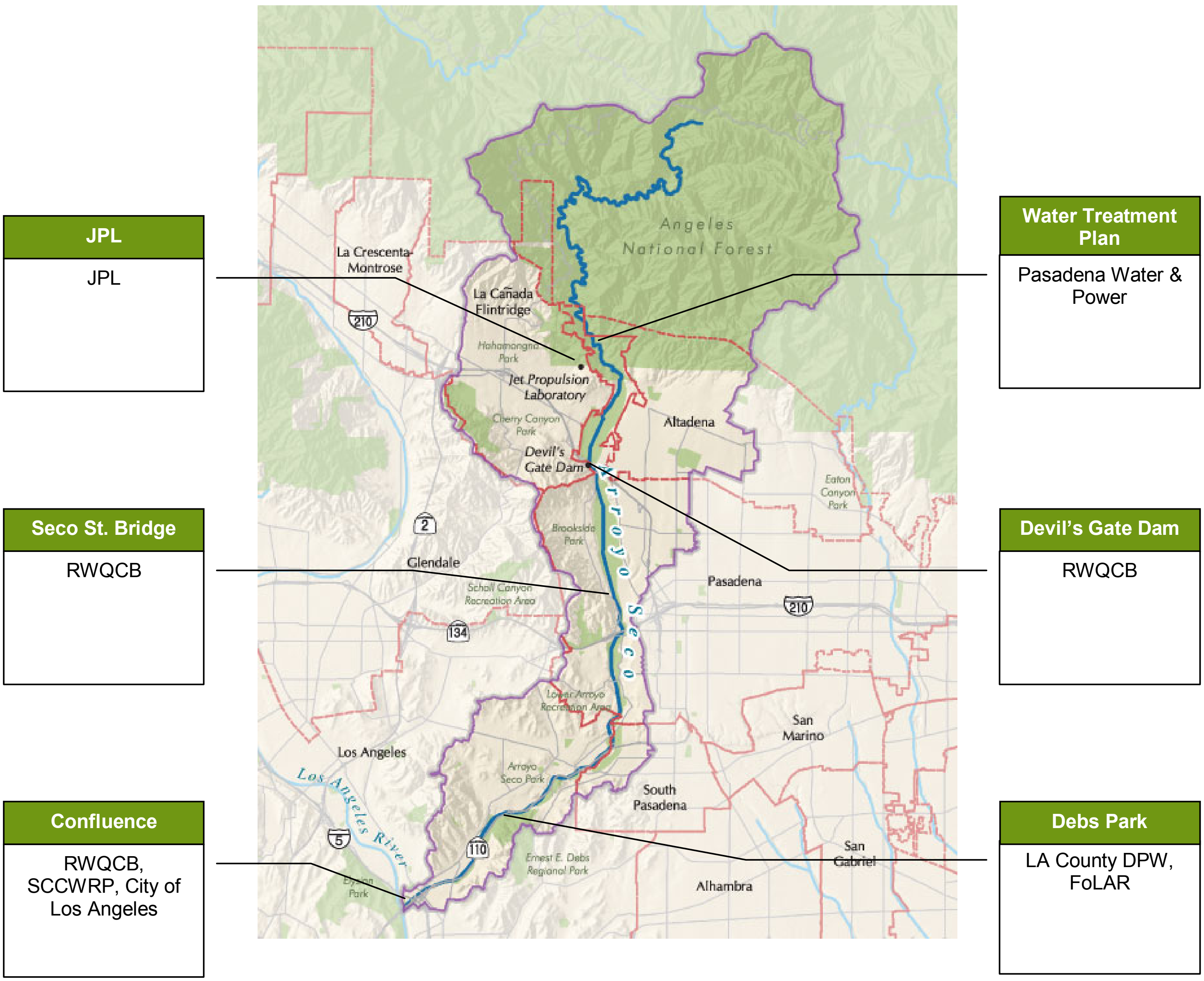
As a result, NET will be unable to determine whether changes in land use, pollution control, public awareness, etc., that have occurred over the sampling time period have had an impact on water quality to date.

Spatial Trends in Contaminant Concentrations

The objective of this analysis was to determine whether any trends in the spatial distribution of particular contaminants across the watershed could be discerned. Specifically, NET hoped to identify particular areas of the watershed where concentrations varied in some systematic way (in particular, from north to south). Our hypothesis was that concentrations would likely increase in general from north to south, as water descended from the relatively clean conditions of the northern watershed down to the more urbanized southern section. In addition, we had hoped to find sampling locations that might have shed light on the impacts of large storm drains or other features that could contribute higher contaminant loads.

As mentioned previously, samples had been collected by various organizations at six different points in the Arroyo watershed. These points are shown on the map in Figure 1. At several of the sampling sites, data for the contaminants of concern (bacteria, metals, and diazinon) did not exist, or existed in such small quantities (i.e., 1-2 discrete samples) that no meaningful conclusions could be drawn. Even for contaminants with the highest number of samples (e.g, Total Coliform n=45, Enterococcus n=34), the vast majority of the samples were collected at or near the Arroyo Seco confluence with the Los Angeles River, making watershed-wide analysis impossible.

Figure 1. Sampling Points in the Arroyo Seco Watershed



NET then decided to divide the watershed into northern and southern halves, and to pool the sampling results from each half and compare the resulting sets against one another. Once again, there was insufficient data to draw any meaningful conclusions, even for the contaminants with high sample counts. Simply too little data had been collected for the contaminants of concern north of the Los Angeles / South Pasadena city line. Statistics describing the north/south distribution of each contaminant of concern are presented in Table 6.

Table 6. Distribution of Contaminants Above WQ Objectives in AS Watershed

	North		South	
Contaminant	**# Samples**	**Average Concentration**	**# Samples**	**Average Concentration**
Aluminum (Total)	0		6	1.75
Chloride	5	88.8	15	88.6
Coliform – Fecal	2	265	16	51,800
Coliform – Total	2	765	55	106,000
Copper (Total)	2	0.0075	14	0.0203
Diazinon	0	N/A	6	0.000593
E.coli	0	N/A	38	9,630
Enterococcus	0	N/A	46	21,500
Lead (Total)	5	0.015	14	0.00992
Nitrite (as N)	2	0	17	0.209
Zinc (Total)	3	0.016	14	0.0836

The conclusion to be drawn from this analysis is that most historical sampling efforts where significant quantities of data were generated were performed at or near the LA River confluence – sampling was done in the Arroyo to characterize its impact on the Los Angeles River, **not** to characterize the water quality along the Arroyo itself. Data collection efforts in the northern watershed to date have either been too few in number or for parameters that don't aid in defining the major water quality problems observed in the lower Arroyo.

Wet vs. Dry Season Contaminant Concentrations

NET next performed analyses to determine the impact of rain-related runoff on water quality in the Arroyo Seco. Tables 7 and 8 present the results of this analysis.

First, NET calculated the average concentration of the contaminants of concern for rainfall-related and non-rainfall-related sampling events. These events were defined to be those completed during 24-hr periods where rainfall was measured in the project area. In addition, NET also calculated the mean concentrations for the more broadly defined wet vs. dry seasons (10/1 – 3/31 and 4/1 – 9/30 respectively).

The mean concentrations shown in Tables 7 and 8 show that the rainfall-related and wet season averages for all contaminants are significantly higher. However, due to the high concentration variability of each set of values, and the small number of results in one of the two groupings for many contaminants, the project team decided to employ statistics to evaluate these differences in means. NET performed a simple statistical t-test for each pair of mean values to see if these differences in mean concentration were statistically significant.

The results of these tests are shown in the last column of each table. A "Y" means that the difference between the mean concentrations is statistically significant at the 95% confidence level. These results demonstrate that despite the seemingly higher concentrations in the rain-related and wet season categories, the variability in the data and/or the small number of samples introduces uncertainty into the comparisons. For most contaminants, we are not able to conclude that the shown concentration differences are due to rainfall or wet seasonal runoff. Given the current data sets, these differences could in theory be due to random chance or variability in the results.

The comparisons were conclusive, however, for several contaminants. We can safely say that total coliform, fecal coliform, enterococcus, lead and zinc are significantly higher during rain events, and that enterococcus and zinc are higher during the wet season.

Table 7. Rainfall Impact on Average Contaminant Concentrations

Contaminant	Units	Not related to rainfall		Rainfall-related		Statistically significant difference?
		# Samples	Mean Concentration	# Samples	Mean Concentration	
Coliform – Total	MPN/100mL	36	41,100	9	394,000	Y
Coliform – Fecal	MPN/100mL	11	6,480	7	108,000	Y
Enterococcus	MPN/100mL	25	5,080	9	90,300	Y
E.coli	MPN/100mL	24	12,200	2	16,400	N

Aluminum	mg/L	1	0.117	5	2.16	N/A
Copper	Ug/L	8	9.13	8	21.5	N
Diazinon	Ug/L	1	0.026	5	0.706	N/A
Lead	Ug/L	11	2.64	8	16.9	Y
Nitrite	mg/L	14	0.0533	5	0.488	N
Zinc	Ug/L	9	12.7	8	135	Y

Table 8. Seasonal Impact on Average Contaminant Concentrations

Contaminant	**Units**	**Dry season**		**Wet season**		**Statistically significant difference?**
		# Samples	Mean Concentration	# Samples	Mean Concentration	
Coliform – Total	MPN/100mL	23	62,900	22	163,000	N
Coliform – Fecal	MPN/100mL	8	10,500	10	74,500	N
Enterococcus	MPN/100mL	17	5,530	17	49,800	Y
E.coli	MPN/100mL	15	1,950	11	26,900	N
Aluminum	mg/L	1	0.117	5	2.16	N/A
Copper	ug/L	6	10.2	10	22.8	N
Diazinon	ug/L	1	0.026	5	0.706	N/A
Lead	ug/L	7	6.34	12	12.1	N
Nitrite	mg/L	9	0.0617	10	0.319	N
Zinc	ug/L	7	40.0	10	95.4	Y

The overall conclusion, though, is that more frequent and better-designed sampling programs are needed to conclude that rain and wet season creates higher contaminant concentrations for all of the contaminants of concern.

However, it may *not* be critical to demonstrate this difference for several reasons. First, the higher flows during the wet season will produce much higher contaminant loadings even if the contaminant concentrations are equal to dry season values, with the implication that reducing wet-season concentrations should take top priority even at equal levels. Second, the levels for some contaminants (e.g., bacteria) are so much higher than relevant objectives that even the lower values during the dry season are highly problematic. These evaluations will be carried out in subsequent stages of this project.

Implications

The key implications of this data review are presented in the following list:

- The high concentration of indicator bacteria throughout the year is the most significant water quality problem in the Arroyo Seco watershed. Average bacteria concentrations across many sampling events were hundreds of times over the relevant water quality objectives. Diazinon and several metals also exceeded respective water quality objectives and warrant future attention as well.

- With existing data, we are unable to draw conclusions about changes in water quality through time – the time periods of sampling, the contaminants sampled for, and the spatial distribution of contaminants were not consistent enough to draw out any long-term trends.

- While samples have been collected from many points along the Arroyo Seco, the significant majority of all sampling has occurred in the southern portion at the confluence with the Los Angeles River. The existing set of data is not sufficient to identify major sources of contamination, nor is it adequate to assess trends in water quality from north to south in the watershed.

- As one would expect, higher levels of all forms of contamination were witnessed in rain-related flows and during the wet season. However, more data is needed to draw strong conclusions due to the relative scarcity of data for some parameters and the high variability in concentrations that is found throughout the year.

Tentative Recommendations

- New and improved water quality sampling programs are needed in the Arroyo Seco watershed. Current efforts are not sufficient to close the data gaps identified in this report. Several proposed sampling programs may address some of the observed limitations (Brick 2003, LACPDW 2004), but will still benefit from greater coordination between agencies / organizations involved in Arroyo Seco water quality sampling. Specific recommendations will be made at a later stage of this planning effort.

- NET will be unable to identify specific water quality problem areas or to aid in identifying attractive locations for BMPs using existing data alone. As a result, NET will perform simple water quality modeling to refine current proposals and ideas. This modeling will make use of existing water quality models, hydrologic information, land use data, and buildup / washoff models to estimate contaminant contributions of sub-watersheds within the Arroyo Seco watershed (USEPA 2001, Collins 2004, Fleming 2004, Stein 2004).

- The analysis of water quality and contaminant concentrations alone is not sufficient to develop effective mitigation measures, for contaminant loadings are not considered. In order to fully understand wet vs. dry season contaminant contributions and the impact of Arroyo Seco water quality on the Los Angeles River, concentration information must be combined with flow data. We will attempt to find this data and consider it as part of this study.

Personal Communications

Collins, Rod. 2004. TMDLs and Standards, Los Angeles Regional Water Quality Control Board.

Fleming, Terry. 2004. United States Environmental Protection Agency, Region IX.

Stein, Eric. 2004. Principal Investigator, Watershed Group, Southern California Coastal Water Research Project.

Wang, Thea. 2004. RiverWatch Coordinator, Friends of the Los Angeles River.

Bibliography

Brick, Tim. 2003. *Developing a Citizen Water Quality Monitoring Program for the Arroyo Seco*. Arroyo Seco Foundation.

City of Los Angeles (Los Angeles). 2004. Arroyo Seco Bacteria Monitoring Sampling Results, 2002 – 2004.

City of Pasadena. 2004. Water Quality Sampling Results at the Intake of the Behmer Treatment Plant 1976 – 1989.

Foster Wheeler. 1999. *Final Remedial Investigation Report for Operable Units 1 and 3: On-Site and Off-Site Groundwater at the National Aeronautics and Space Administration Jet Propulsion Laboratory*. Prepared for National Aeronautics and Space Administration Jet Propulsion Laboratory.

Jet Propulsion Laboratory. 2002. *Annual Stormwater Monitoring Reports*, *1993 – 2002.*

Los Angeles Regional Water Quality Control Board (LARWQCB). 1994. *Basin Plan for the Coastal Waters of Los Angeles and Ventura Counties*.

Los Angeles Regional Water Quality Control Board (LARWQCB). 1997. *General National Pollutant Discharge Elimination System Permit and Waste Discharge Requirements for Groundwater Discharges From Construction and Project Dewatering to Surface Waters In Coastal Watersheds of Los Angeles and Ventura Counties, Order No. 97-045, General NPDES Permit No. CAG994001*.

Los Angeles County Department of Public Works (LACDPW). 2003. *Los Angeles County 2003 Stormwater Monitoring Report*.

Los Angeles County Department of Public Works (LACDPW). 2004. Proposed Arroyo Seco Water Quality Sampling Program.

Los Angeles Regional Water Quality Control Board (LARWQCB). 2002. *2002 CWA Section 303(d) List of Water Quality Limited Segment*.

Los Angeles Regional Water Quality Control Board (LARWQCB). 2003. *NPDES Permit and Waste Discharge Requirements for Lincoln Avenue Water Company South Coulter Surface Water Treatment Plant.*

Los Angeles Regional Water Quality Control Board (LARWQCB). 2004a. *Letter to JPL RE: Continuation Of Coverage Under General National Pollutant Discharge Elimination System And Waste Discharge Requirements Jet Propulsion Laboratory*.

Los Angeles Regional Water Quality Control Board (LARWQCB). 2004b. *Arroyo Seco Surface Water Monitoring Results, 1986 – 2003.*

North East Trees and Arroyo Seco Foundation (NET & ASF). 2002. *Arroyo Seco Watershed Restoration Feasibility Study.*

Southern California Coastal Water Research Program (SCCWRP). 2004. Arroyo Seco Water Quality Monitoring Data 2000 – 2002.

State Water Resources Control Board (SWRCB). 2001. *California Ocean Plan.*

Stein, Eric, Drew Ackerman, and Kenneth Schiff. 2003. *Watershed-based Sources of Contaminants to San Pedro Bay and Marina Del Rey: Patterns and Trends*. Southern California Coastal Water Research Project.

United States Environmental Protection Agency (EPA). 2000. *40 CFR Part 131, Water Quality Standards; Establishment of Numeric Criteria for Priority Toxic Pollutants for the State of California; Rule.*

United States Environmental Protection Agency (EPA). 2001. *PLOAD Version 3.0 – An ArcView GIS Tool to Calculate Nonpoint Sources of Pollution In Watershed and Stormwater Projects*.

Appendix 3: Water Quality Modeling & Results

Arroyo Seco Watershed Management and Restoration Plan Project

Pollutant Input Areas Map

Agreement Number 02-138-254-0

Submitted by:

North East Trees
570 W. Ave. 26, Suite 200
Los Angeles, CA 90065

Funding for this project has been provided in full or in part through a contract with the State Water Resources Control Board (SWRCB) pursuant to the Costa-Machado Water Act of 2000 (Proposition 13) and any amendments thereto for the implementation of California's Nonpoint Source Pollution Control Program. The contents of this document do not necessarily reflect the views and policies of the SWRCB, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

Background

North East Trees is completing the Arroyo Seco Watershed Management & Restoration Plan under a State of California Proposition 13 grant, administered by the State Water Resources Control Board (SWRCB). A key interim deliverable of this project is a Pollutant Input Areas Map (Map), which identifies key sources of non-point source pollution in the watershed and the specific drains and/or channels that deliver this pollution to the Arroyo Seco from surrounding areas.

As proposed, the original scope of work (SOW) states that these areas will be identified through an analysis of historical water quality data from throughout the Arroyo Seco watershed. As mentioned in the Summary of Baseline Water Quality Data (NET, 2004), submitted to the RWQCB on 3/25/04, it was not possible to complete this analysis due to inadequate historical data.

As a result, NET decided to complete limited watershed modeling using the GIS-based water quality model PLOAD (EPA, 2001). This selection was based on consultations with a number of local water quality experts (Stein 2004, Fleming 2004, Collins 2004). PLOAD is a simple screening model that uses an average annual rainfall rate, land use characteristics, permeability estimates, and topography (in the form of sub-watershed delineation) to determine total annual flow rates, contaminant loading, and average concentrations for each sub-watershed. Due to the limited amount of data available for the Arroyo, NET decided that such a screening model rather than a more complicated transient flow model would be appropriate. With this model, we will be able to perform rough calibrations of the model to reality, and to prioritize sub-watersheds and storm drain networks for future action. More sophisticated predictions would require much greater water quality data, significantly more financial resources, and a more complex understanding of the Arroyo Seco hydrologic system than can be delivered by the current project.

In the Summary of Baseline Water Quality Data NET identified eleven contaminants for which concentrations exceeded water quality objectives. However, the data needed to model all eleven contaminants using PLOAD is not available; specifically, the Los Angeles County Department of Public Works only calculates event mean concentrations (EMC) for seven of the eleven parameters: fecal coliform, total coliforms, fecal enterococcus, copper, lead, zinc, and nitrite. In addition, of the bacteria parameters, only fecal coliform is relevant for freshwater environments. Therefore, modeling calculations and the identification of priority watersheds and storm drains will be based on the following five contaminants:

- Fecal coliform;
- Lead;
- Zinc;
- Copper;
- Nitrite.

As mentioned earlier, PLOAD estimates the annual load and concentration for each modeled parameter. These two measures are not equal; although most existing water quality objectives are concentration-based, many of the most important standards are being replaced by TMDLs, which rely on load-based calculations. Therefore, both load and concentration comparisons were performed to identify high priority subwatersheds, as described below in the Results section.

Overview of Approach

The creation of the Pollutant Input Areas Map will be completed in the following steps:

1) Collect and check input data needed for the PLOAD model.

2) Run model using input parameters.

3) Check contaminant concentrations and watershed flow volumes with measured values from the Arroyo Seco watershed.

4) Identify priority sub-watersheds based on the following criteria, based on comparisons to load- and concentration-based water quality objectives.

5) Divide this group into high-priority and medium-priority watersheds by identifying those that are top contributors of both bacteria and metals

6) Using GIS maps and field surveys, identify key storm drain networks and the outlets that drain them in the priority watersheds.

7) Generate a map that displays the sub-watersheds and drains on relevant geographical context.

Results

NET ran PLOAD for the five pollutants mentioned above. Of the five, we concluded that only nitrite didn't warrant further consideration; predicted nitrite concentrations were less than 20% of the 1.0 mg/L standard for nitrite as mentioned in the Nutrient TMDL for the Los Angeles River.

Fecal coliform presented a different issue: of the 71 sub-watersheds, only 29 did not exceed the basin plan limit of 400 MPN / 100mL for fecal coliform. This wasn't unexpected given the high levels of bacteria observed in Arroyo waters, but it also doesn't help in identifying priority sub-watersheds.

An examination of load estimates for fecal coliform painted a different picture. Over 90% of the estimated annual load for the entire watershed came from five sub-watersheds. Accordingly, these five sub-watersheds were assigned the highest priority for reducing bacteria in the watershed.

The metals modeling results were not as clear as either fecal coliform or nitrite. In the concentration estimates, most of the urbanized sub-watersheds displayed a level higher than a water quality objective for one of lead, copper or zinc (13 sub-watersheds in total). And, the load estimates were not as concentrated as those for bacteria: for all three metals parameters, the top nine sub-watersheds generated only 50% of the annual load. For bacteria, 90% of the load came from five sub-watersheds; for the most limiting of metals (lead), 28 sub-watersheds were needed before the 90% level was passed.

A more detailed examination of the metals predictions did reveal trends of use in prioritizing sub-watersheds. For concentration, only two sub-watersheds exceeded two of the three metals LA River TMDL standards: basin ARRSC8, where the Jet Propulsion Laboratory sits, and basin BI5210A, which drains a nearly 100% impermeable area of industrial and commercial facilities in the southeastern-most corner of the watershed. Another eleven exceeded only one of the three metals standards.

For metals annual loads, nine sub-watersheds contributed 50% of the total watershed load for each metal; across all three metals, this set represented twelve sub-watersheds. Of these twelve, six were in this top 50% for all three metals, and another three were in the top 50% for at least two of the metals.

The entire goal of this modeling exercise is to identify pollutant input areas in the Arroyo Seco in the absence of empirical data. These pollutant input areas should be those where an investment in water quality improvement will return the greatest benefits. Based on the analysis presented in the Baseline Water Quality Data Summary (Appendix B), empirical data suggests that bacteria pollution is the most significant water quality issue in the Arroyo Seco, with metals a borderline concern. NET used these conclusions, along with the observations listed above, to develop the following criteria for identifying the highest-priority regions of the Arroyo Seco watershed:

1. **High Priority** – Sub-watershed is one of the five contributing 90% of the Arroyo Seco annual fecal coliform load, OR sub-watershed is in the top 50% of load-generating watersheds for copper, lead AND zinc (eight sub-watersheds).
2. **Medium Priority** – Sub-watershed is in top 50% of load-producing areas for two of three metals, OR sub-watershed EMC exceeds water quality objectives for all three metals (three sub-watersheds).
3. **Low Priority** – All others (sixty sub-watersheds).

The following table presents these results:

Sub-Watershed Designation	**Location Description**	**Priority**	**Fecal coliform 90% load?**	**In top 50% of load for all three metals?**	**In top 50% of load for two of three metals?**	**EMC > water quality objectives for all three metals?**
ARRSC8	Pasadena, JPL area	**H**	**Y**	**Y**	**Y**	N
BI5210A	Los Angeles, southeast corner of watershed	**H**	**Y**	N	N	**Y**
BI192	Pasadena, east of Central Arroyo Park	**H**	**Y**	**Y**	**Y**	N
ARRSC17	Los Angeles, W & E banks of AS S of Debs Park & SW Museum	**H**	**Y**	**Y**	**Y**	N
WALTA	Altadena / Pasadena, N of Figueroa Drive	**H**	N	**Y**	**Y**	N
BI560	Pasadena, between	**H**	**Y**	N	N	N

	Figueroa Dr. and Montana St.					
EALTA	Altadena / Pasadena, E of WALTA basin	**H**	N	**Y**	**Y**	N
BI5202	Los Angeles, W bank of AS between Mt. Washington & Eagle Rock hills	**H**	N	**Y**	**Y**	N
ARRSC11	Pasadena, Annandale Estates E to 210 / 134 interchange	M	N	N	**Y**	N
FLINT1	La Canada Flintridge, S of Flint Wash	M	N	N	**Y**	N
BI668	Los Angeles Along N. Figueroa St.	M	N	N	**Y**	N

Key input data:

- Estimated average annual rainfall in the Arroyo Seco watershed: 20" (NET & ASF, 2002)
- Figure 1. Overall Map of the Arroyo Seco Watershed
- Figure 2. Map of Arroyo Seco sub-watersheds
- Figure 3. Map of Generalized Land Use
- Figure 4. Map of Estimated Permeabilities (based on land use)
- Table 1. Permeability estimates for land use categories (estimated / interpolated based on LA County DPW estimates, LACDPW 2000)
- Table 2. Event mean concentrations of contaminants by land use category (LACDPW 2000)

Model output results (EMC and Annual Load) by Contaminant

- Figure 5. Fecal Coliform Model Output
- Figure 6. Copper Model Output
- Figure 7. Lead Model Output
- Figure 8. Zinc Model Output
- Figure 9. Nitrite Model Output

Cumulative Model Output Results

- Figure 10. Summary of Priority Sub-Watersheds

- Figure 11. Priority Storm Drains / Streams and Outlets w/ Topography

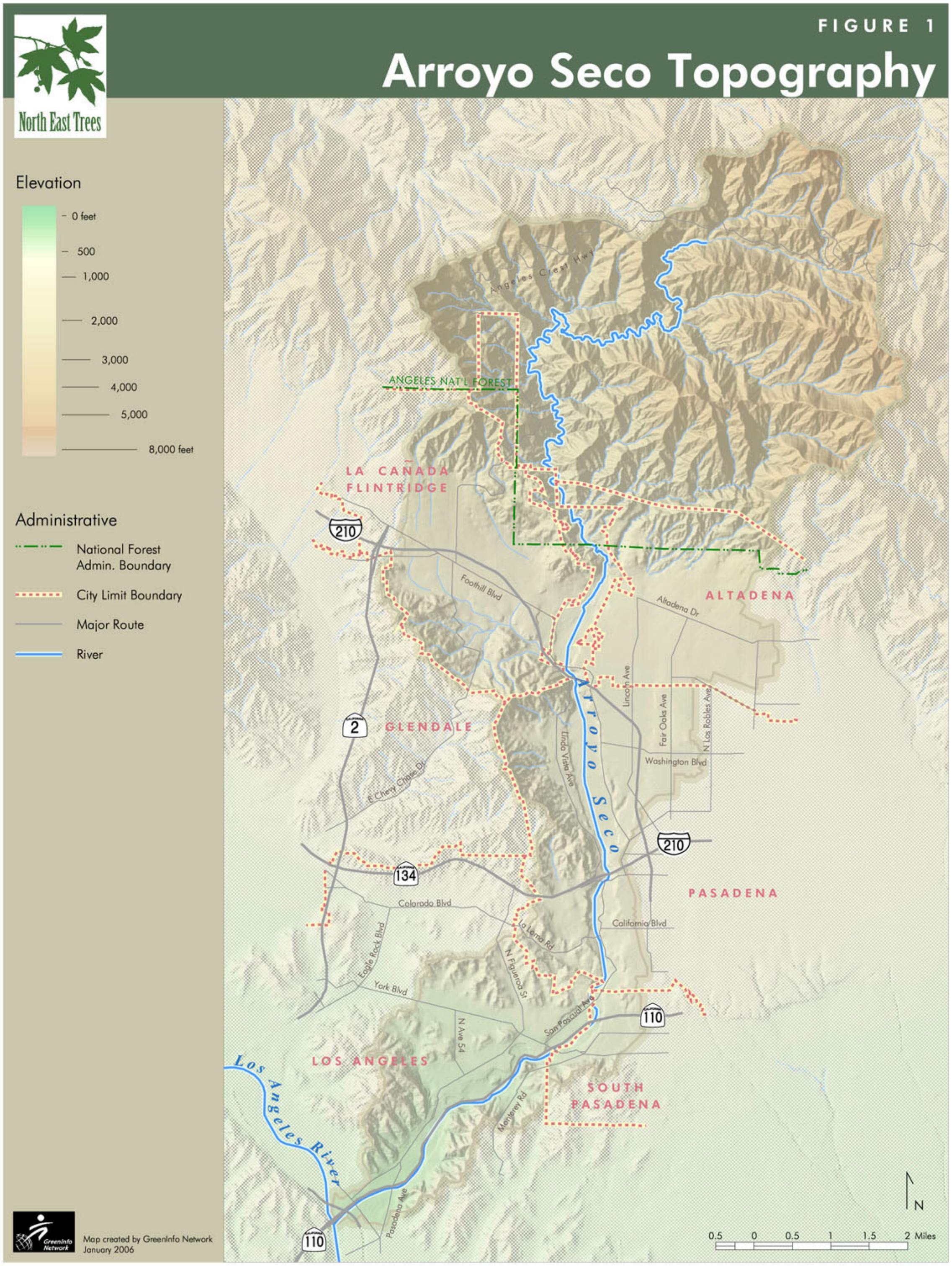


FIGURE 1
Arroyo Seco Topography

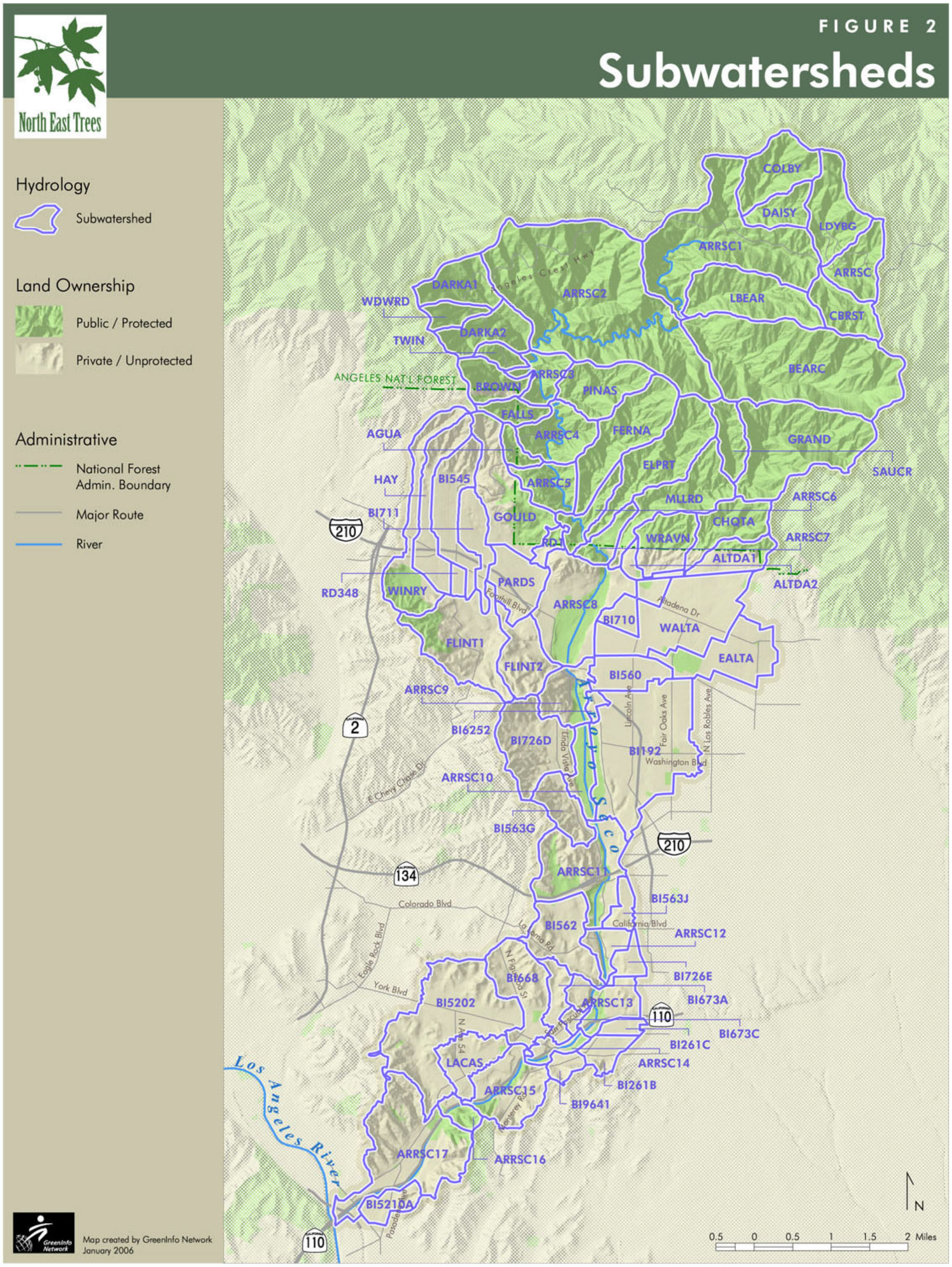


FIGURE 2
Subwatersheds

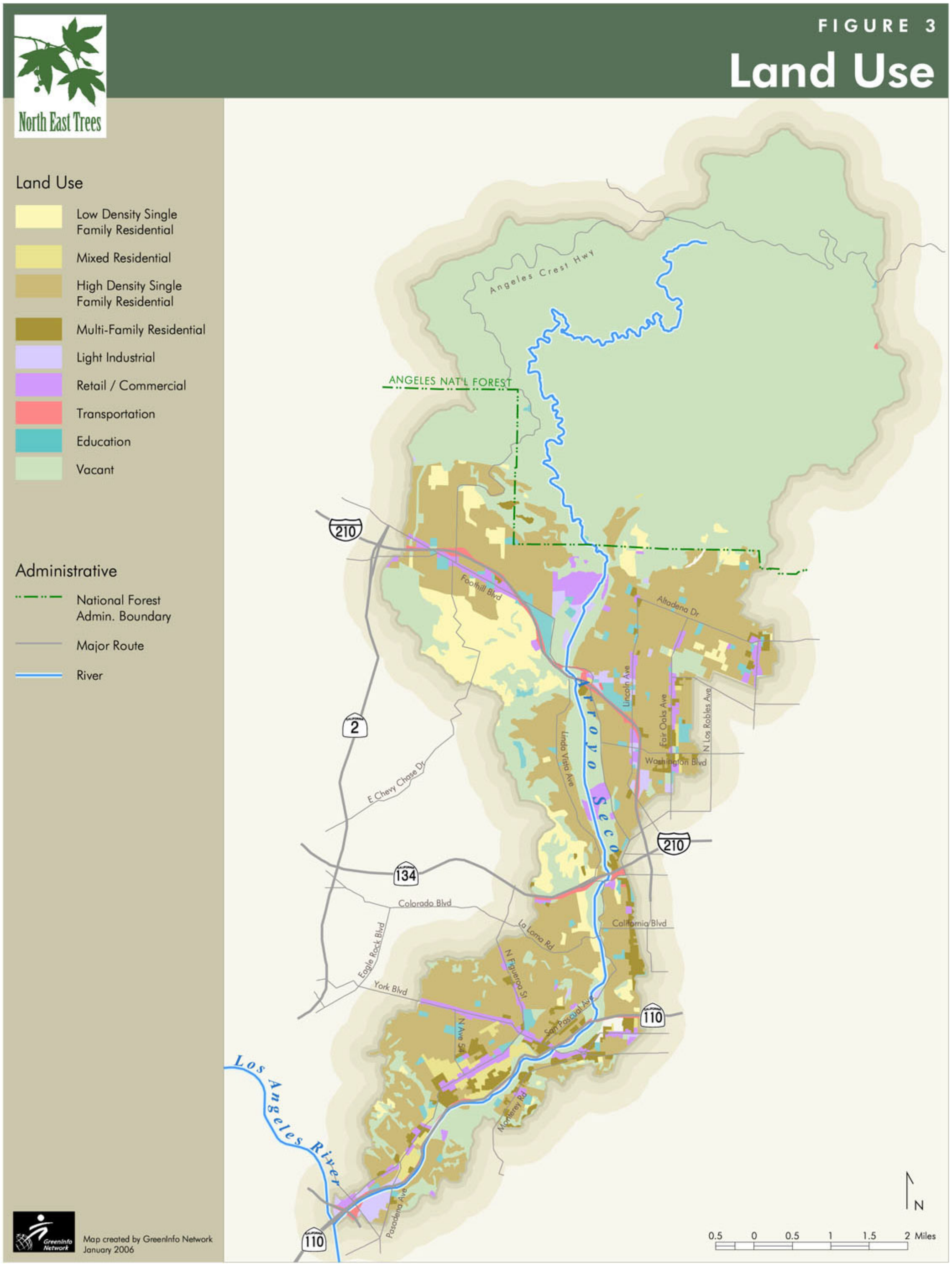


FIGURE 3
Land Use
North East Trees
Land Use
Low Density Single Family Residential
Mixed Residential
High Density Single Family Residential
Multi-Family Residential
Light Industrial
Retail / Commercial
Transportation
Education
Vacant
Administrative
National Forest Admin. Boundary
Major Route
River
Map created by GreenInfo Network January 2006
Angeles Crest Hwy
ANGELES NAT'L FOREST
210
Foothill Blvd
Altadena Dr
Lincoln Ave
Fair Oaks Ave
N Los Robles Ave
Washington Blvd
Linda Vista Ave
Arroyo Seco
2
E Chevy Chase Dr
134
Colorado Blvd
California Blvd
La Loma Rd
Eagle Rock Blvd
N Figueroa St
York Blvd
N Ave 50
San Pascual Ave
110
Monterey Rd
Los Angeles River
Pasadena Ave
N
0.5 0 0.5 1 1.5 2 Miles

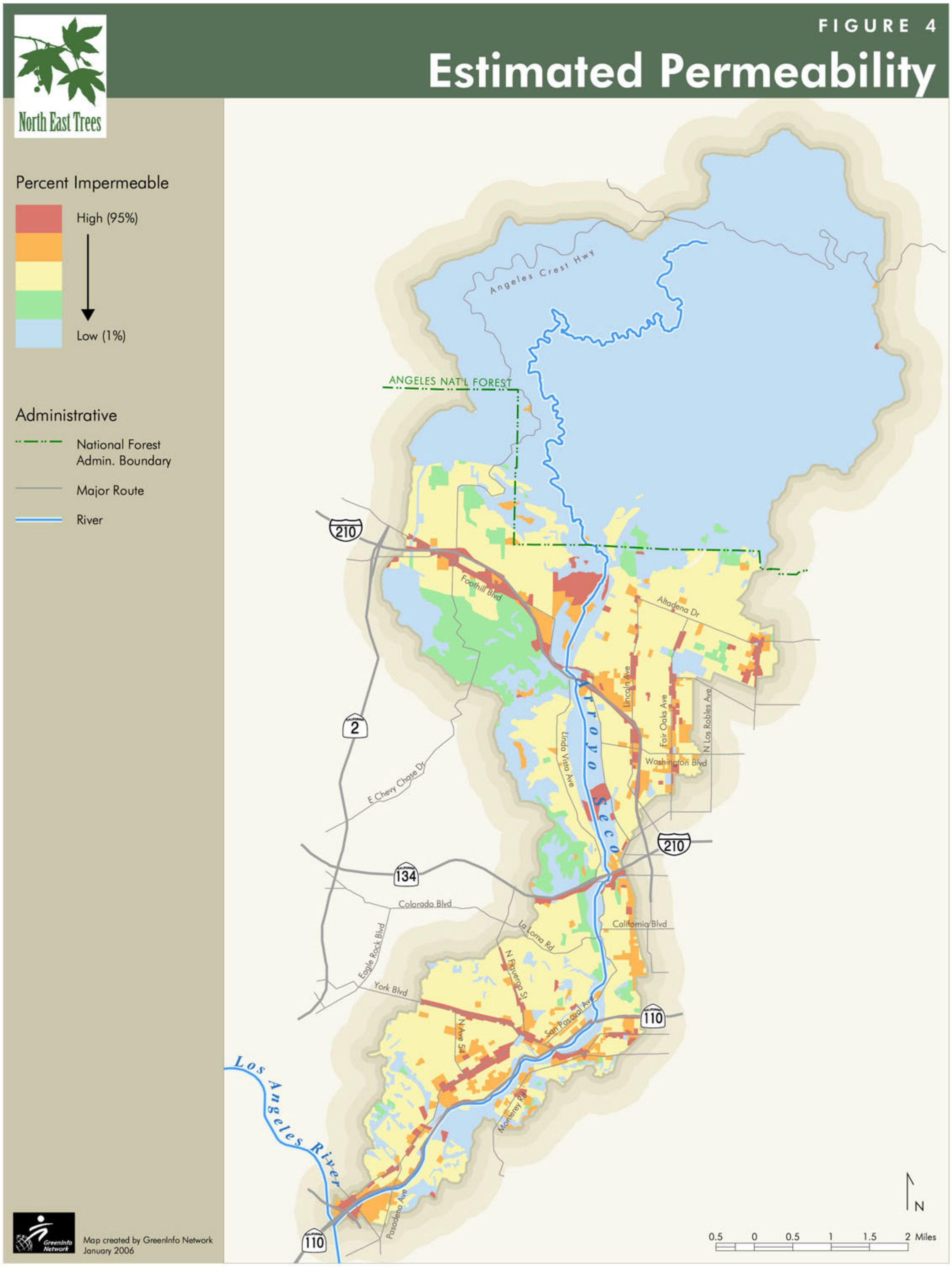


FIGURE 4
Estimated Permeability
North East Trees
Percent Impermeable
High (95%)
Low (1%)
Administrative
National Forest Admin. Boundary
Major Route
River
ANGELES NAT'L FOREST
Angeles Crest Hwy
210
Foothill Blvd
Altadena Dr
Lincoln Ave
Fair Oaks Ave
N Los Robles Ave
Washington Blvd
Linda Vista Ave
Arroyo Seco
2
E Chevy Chase Dr
134
Colorado Blvd
California Blvd
La Loma Rd
Eagle Rock Blvd
N Figueroa St
York Blvd
San Pascual Ave
110
N Ave 54
Monterey Rd
Los Angeles River
Pasadena Ave
N
0.5 0 0.5 1 1.5 2 Miles
GreenInfo Network
Map created by GreenInfo Network
January 2006

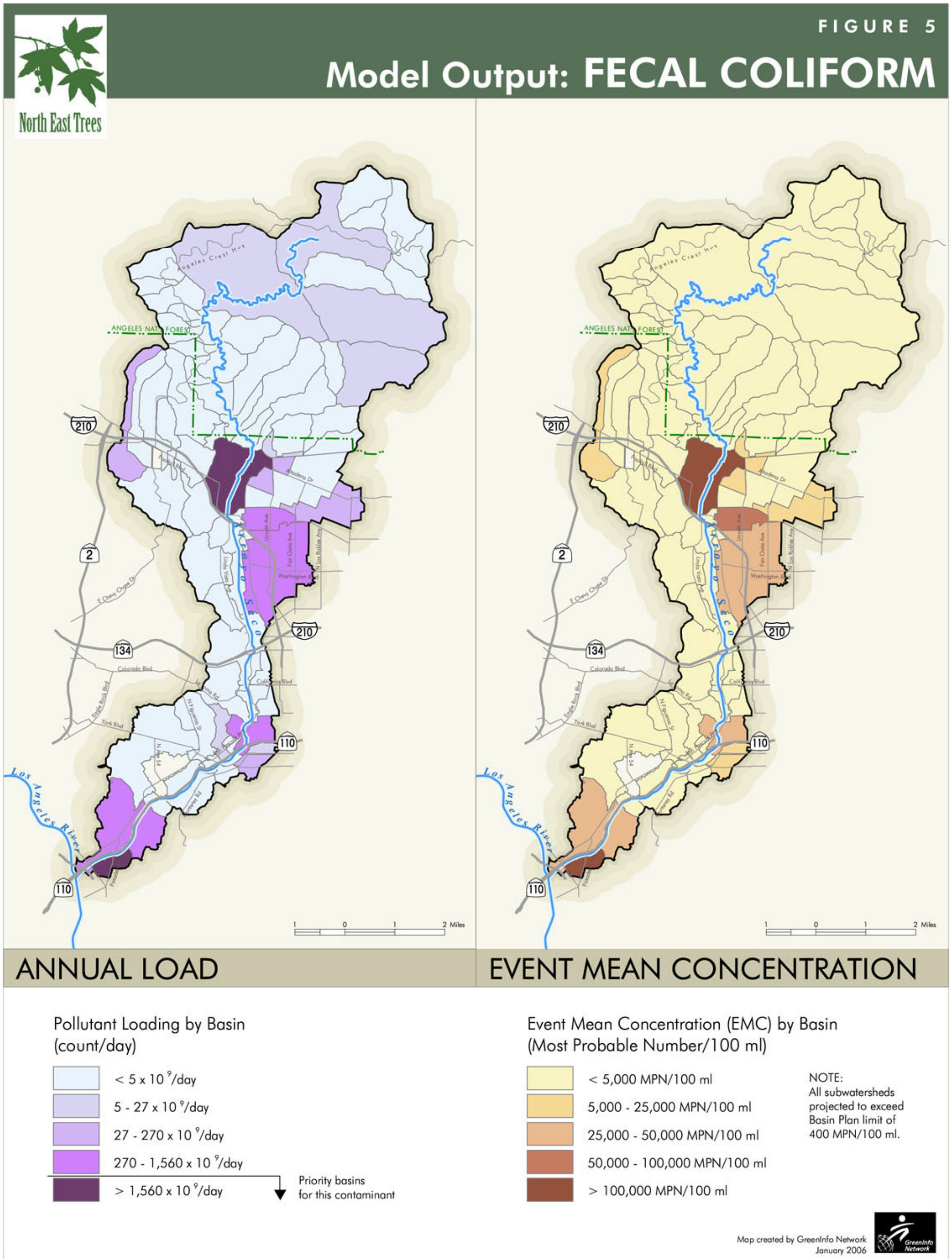


FIGURE 5
Model Output: FECAL COLIFORM
North East Trees
ANGELES NAT'L FOREST
210
2
134
110
Los Angeles River
Arroyo Seco
ANNUAL LOAD
EVENT MEAN CONCENTRATION
Pollutant Loading by Basin
(count/day)
< 5 x 10 ⁹/day
5 - 27 x 10 ⁹/day
27 - 270 x 10 ⁹/day
270 - 1,560 x 10 ⁹/day
> 1,560 x 10 ⁹/day
Priority basins
for this contaminant
Event Mean Concentration (EMC) by Basin
(Most Probable Number/100 ml)
< 5,000 MPN/100 ml
5,000 - 25,000 MPN/100 ml
25,000 - 50,000 MPN/100 ml
50,000 - 100,000 MPN/100 ml
> 100,000 MPN/100 ml
NOTE:
All subwatersheds
projected to exceed
Basin Plan limit of
400 MPN/100 ml.
Map created by GreenInfo Network
January 2006

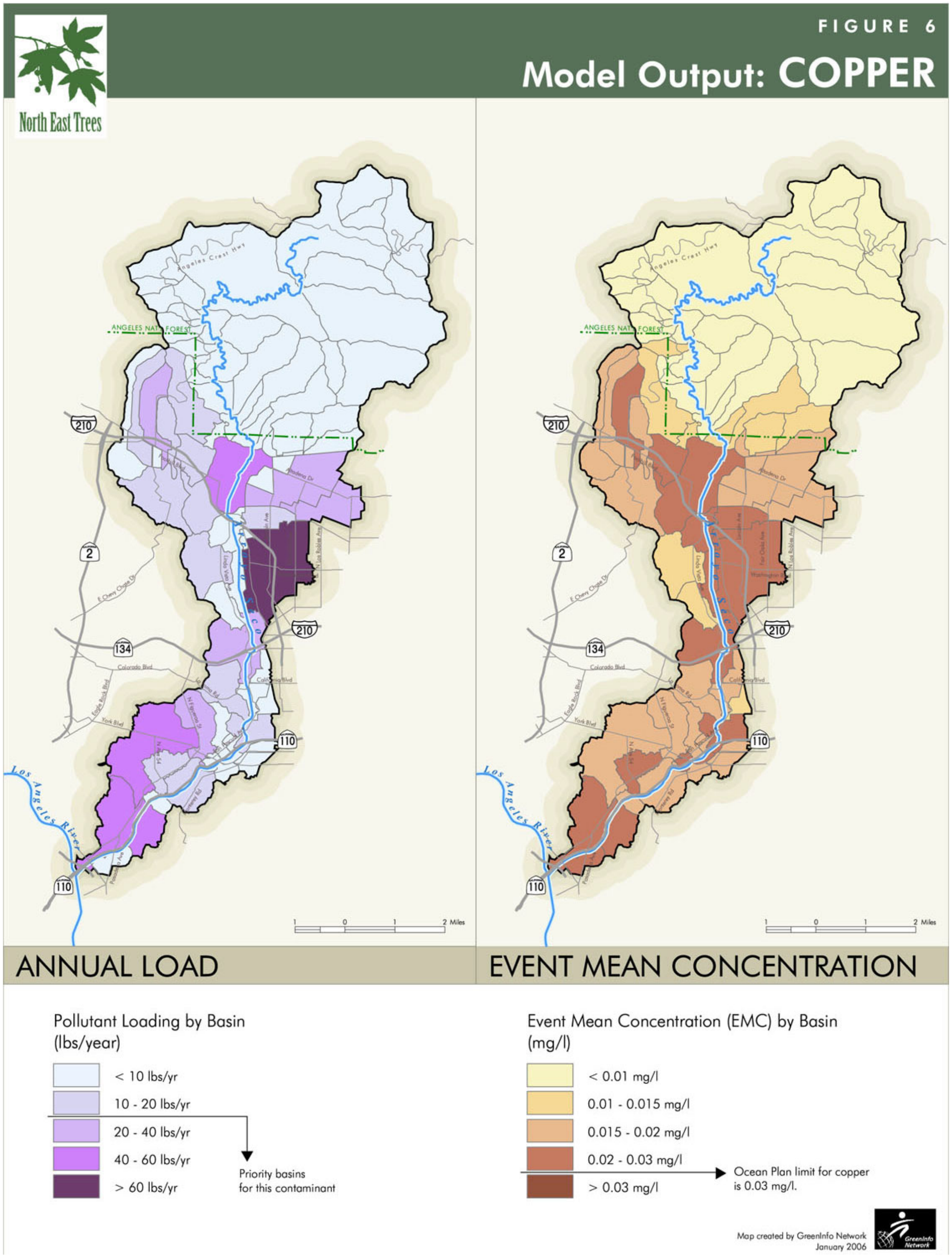
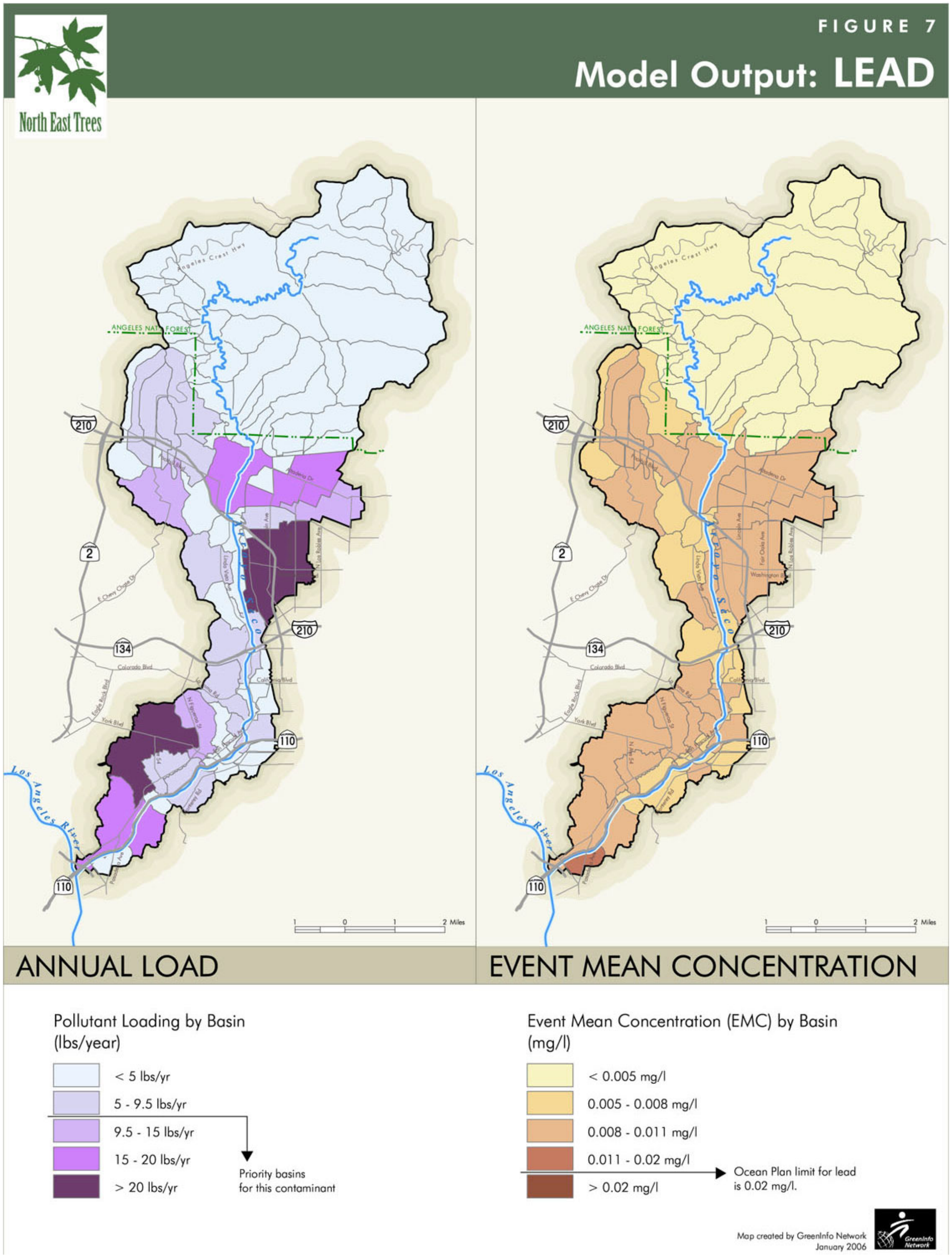
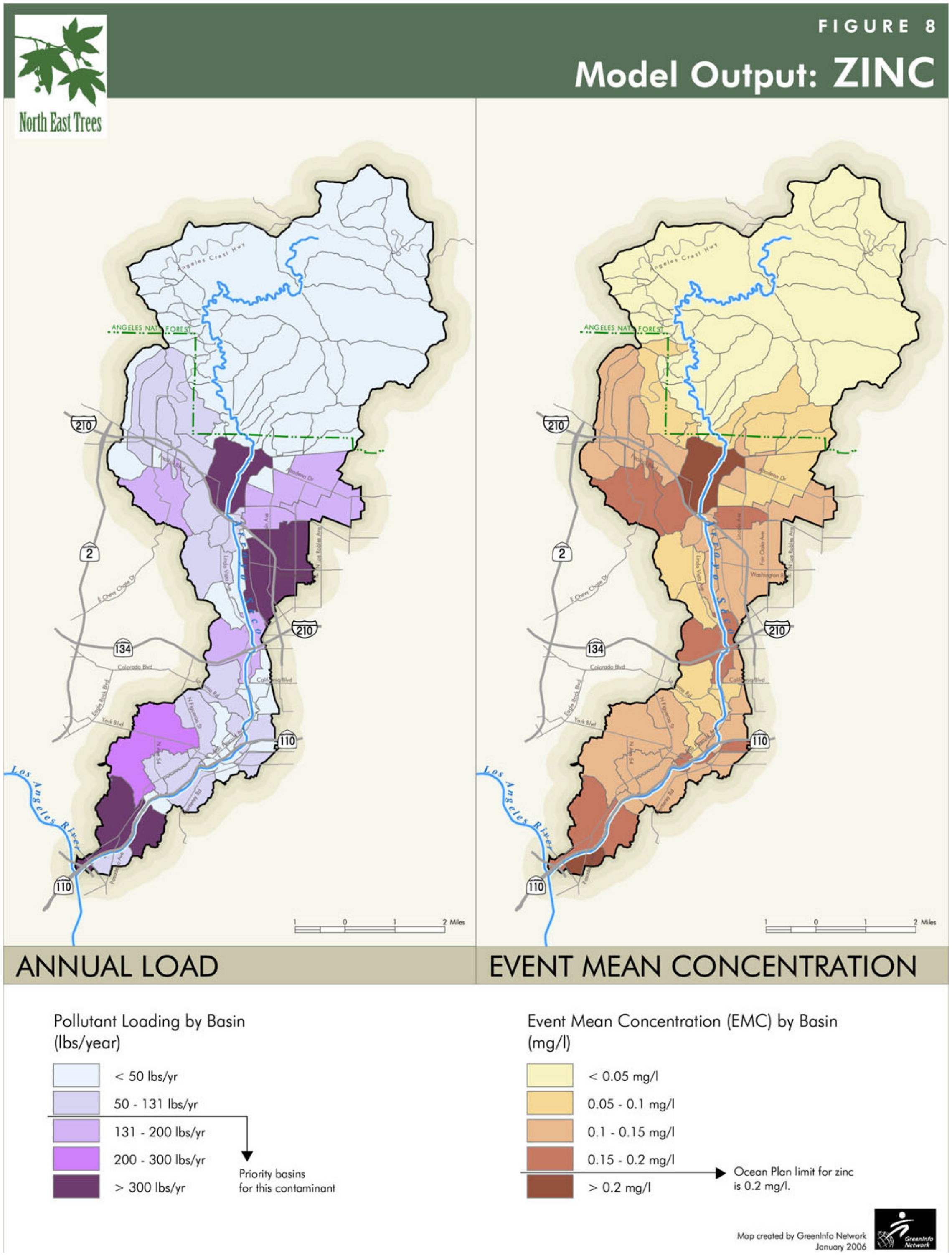


FIGURE 6
Model Output: COPPER
North East Trees
ANNUAL LOAD
EVENT MEAN CONCENTRATION
Pollutant Loading by Basin
(lbs/year)
< 10 lbs/yr
10 - 20 lbs/yr
20 - 40 lbs/yr
40 - 60 lbs/yr
> 60 lbs/yr
Priority basins
for this contaminant
Event Mean Concentration (EMC) by Basin
(mg/l)
< 0.01 mg/l
0.01 - 0.015 mg/l
0.015 - 0.02 mg/l
0.02 - 0.03 mg/l
> 0.03 mg/l
Ocean Plan limit for copper
is 0.03 mg/l.
Map created by GreenInfo Network
January 2006

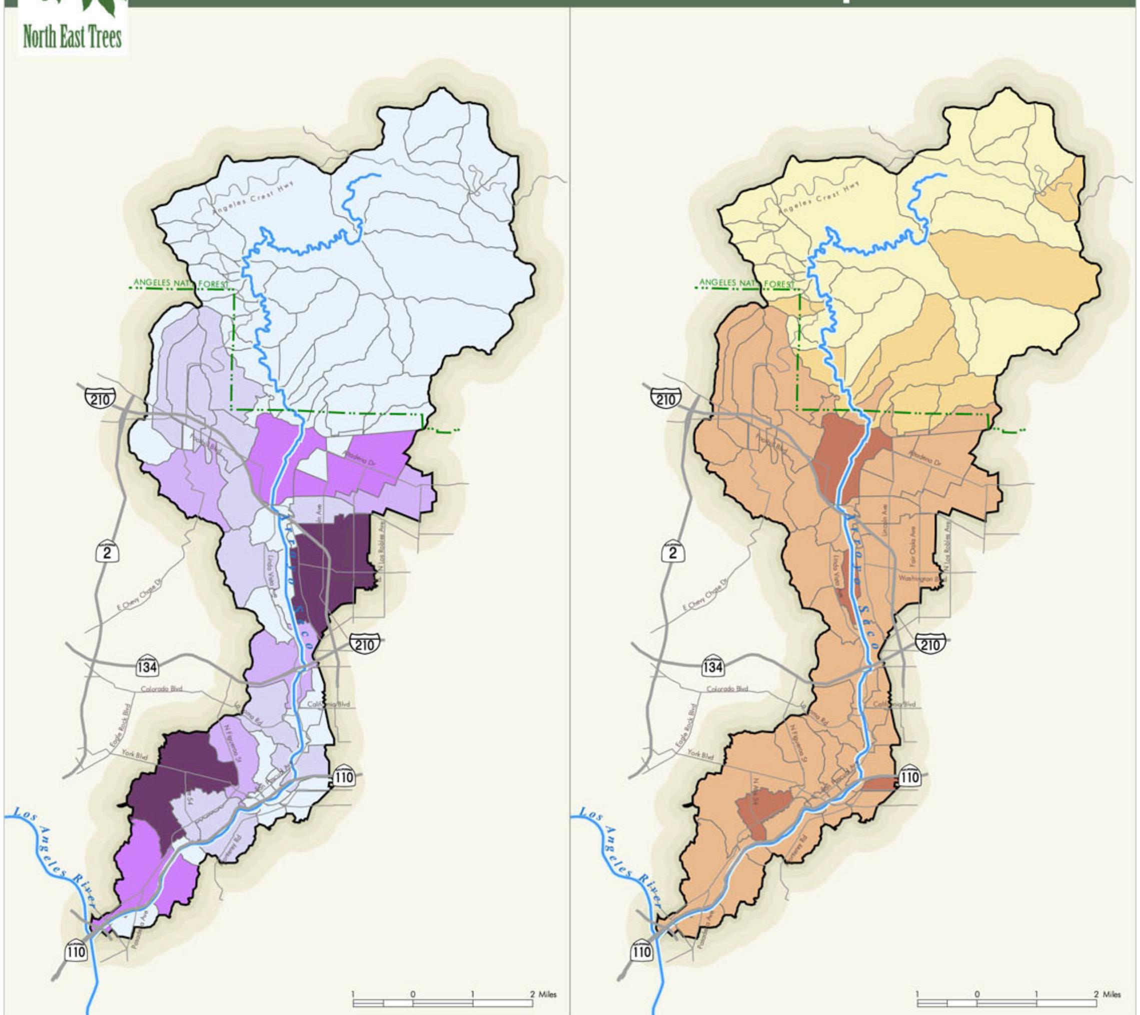

North East Trees
FIGURE 7
Model Output: LEAD
ANGELES NATL FOREST
Angeles Crest Hwy
210
2
134
110
Colorado Blvd
York Blvd
Los Angeles River
Arroyo Seco
1 0 1 2 Miles
ANNUAL LOAD
EVENT MEAN CONCENTRATION
Pollutant Loading by Basin (lbs/year)
< 5 lbs/yr
5 - 9.5 lbs/yr
9.5 - 15 lbs/yr
15 - 20 lbs/yr
> 20 lbs/yr
Priority basins for this contaminant
Event Mean Concentration (EMC) by Basin (mg/l)
< 0.005 mg/l
0.005 - 0.008 mg/l
0.008 - 0.011 mg/l
0.011 - 0.02 mg/l
> 0.02 mg/l
Ocean Plan limit for lead is 0.02 mg/l.
Map created by GreenInfo Network
January 2006
GreenInfo Network


North East Trees
FIGURE 8
Model Output: ZINC
ANGELES NATL FOREST
210
2
134
110
Los Angeles River
1 0 1 2 Miles
ANNUAL LOAD
EVENT MEAN CONCENTRATION
Pollutant Loading by Basin (lbs/year)
< 50 lbs/yr
50 - 131 lbs/yr
131 - 200 lbs/yr
200 - 300 lbs/yr
> 300 lbs/yr
Priority basins for this contaminant
Event Mean Concentration (EMC) by Basin (mg/l)
< 0.05 mg/l
0.05 - 0.1 mg/l
0.1 - 0.15 mg/l
0.15 - 0.2 mg/l
> 0.2 mg/l
Ocean Plan limit for zinc is 0.2 mg/l.
Map created by GreenInfo Network
January 2006
GreenInfo Network

North East Trees

FIGURE 9

Model Output: NITRITE



ANNUAL LOAD

Pollutant Loading by Basin (lbs/year)

- < 50 lbs/yr
- 50 - 90 lbs/yr
- 90 - 150 lbs/yr
- 150 - 200 lbs/yr
- > 200 lbs/yr

Priority basins for this contaminant

EVENT MEAN CONCENTRATION

Event Mean Concentration (EMC) by Basin (mg/l)

- < 0.05 mg/l
- 0.05 - 0.075 mg/l
- 0.075 - 0.1 mg/l
- 0.1 - 1.0 mg/l
- > 1.0 mg/l

Basin Plan limit for nitrite (as N) is 1.0 mg/l.

Map created by GreenInfo Network January 2006

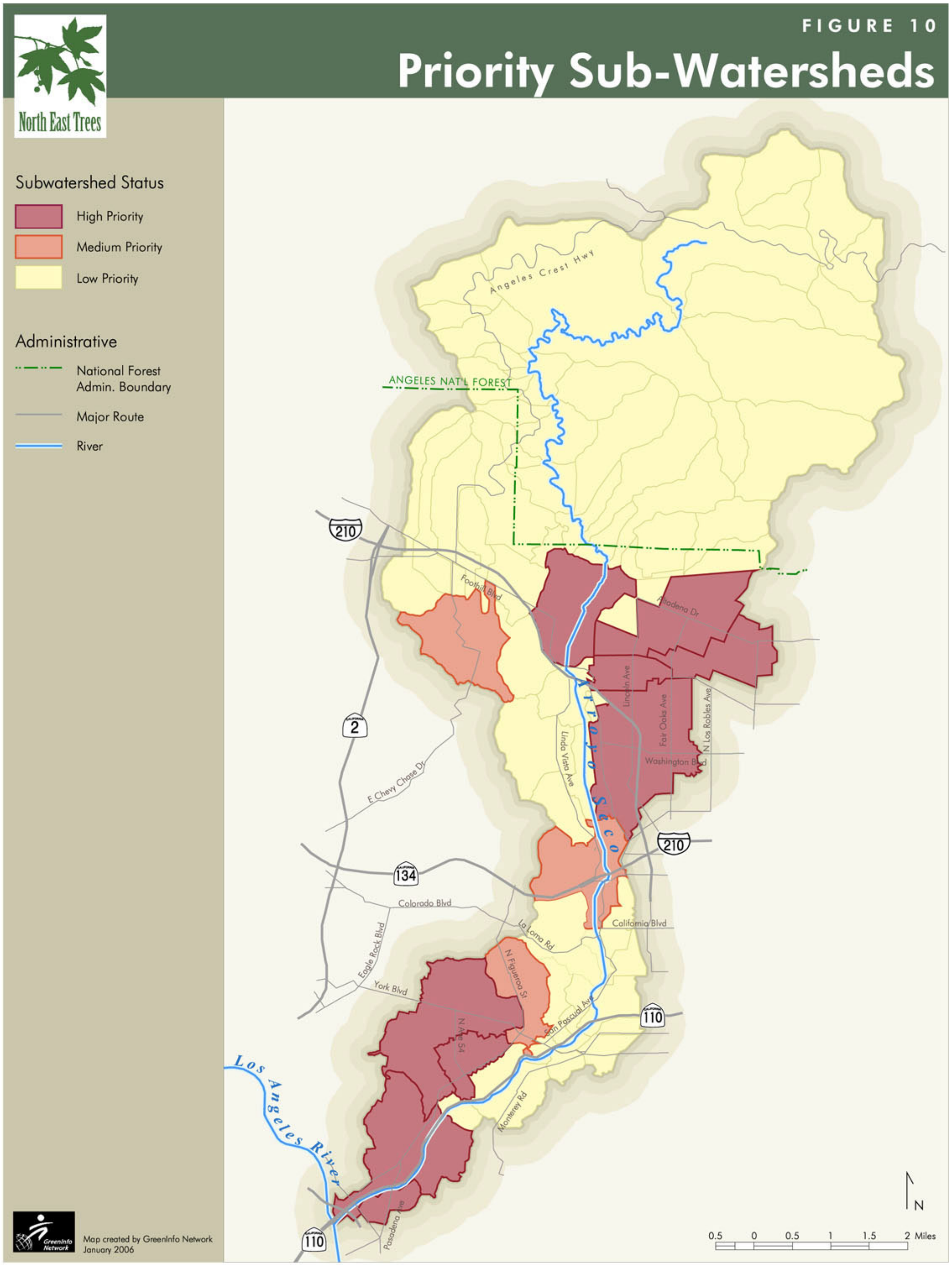


FIGURE 10
Priority Sub-Watersheds
North East Trees
Subwatershed Status
High Priority
Medium Priority
Low Priority
Administrative
National Forest Admin. Boundary
Major Route
River
Angeles Crest Hwy
ANGELES NAT'L FOREST
210
Foothill Blvd
Pasadena Dr
Lincoln Ave
Fair Oaks Ave
N Los Robles Ave
Washington Blvd
Linda Vista Ave
Arroyo Seco
2
E Chevy Chase Dr
134
210
Colorado Blvd
California Blvd
La Loma Rd
Eagle Rock Blvd
N Figueroa St
York Blvd
San Pascual Ave
110
N Ave 64
Los Angeles River
Monterey Rd
Pasadena Ave
110
N
0.5 0 0.5 1 1.5 2 Miles
Map created by GreenInfo Network
January 2006

FIGURE 11

Critical Drains

North East Trees

Hydrology

Priority Outlet:

- Small 24 - 36"
- 36 - 48"
- 48 - 72"
- Large >72"
- Other Outlet
- Priority Drain
- Other Drain

Priority Basin:

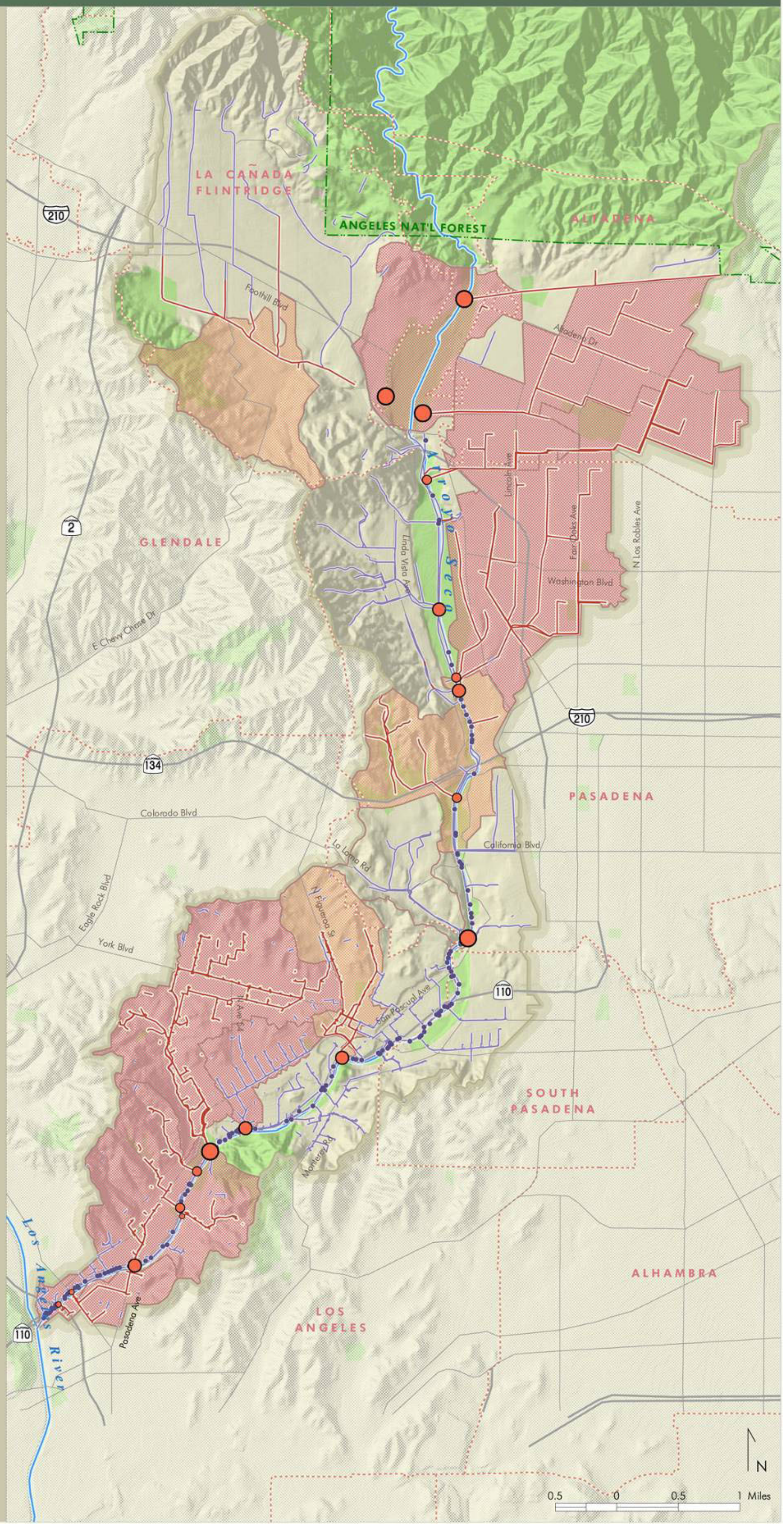
- High Priority
- Medium Priority

Land Ownership

- Public / Protected
- Private / Unprotected

Administrative

- National Forest Admin. Boundary
- City Limit
- Major Route
- River



NOTE:
Drains north of the Los Angeles and South Pasadena city boundaries are estimated based on Los Angeles County Department of Public Works drain maps and field surveys.

Map created by GreenInfo Network
January 2006

Bibliography

Personal Communications

Collins, Rod. 2004. TMDLs and Standards, Los Angeles Regional Water Quality Control Board.

Fleming, Terry. 2004. United States Environmental Protection Agency, Region IX.

Stein, Eric. 2004. Principal Investigator, Watershed Group, Southern California Coastal Water Research Project.

Bibliography

Los Angeles County Department of Public Works (LACDPW). 2000. *1994-2000 INTEGRATED RECEIVING WATER IMPACTS REPORT*.

North East Trees (NET). 2004. *Summary of Baseline Water Quality Data.*

North East Trees and Arroyo Seco Foundation (NET & ASF). 2002. *Arroyo Seco Watershed Restoration Feasibility Study.*

United States Environmental Protection Agency (EPA). 2001. *PLOAD Version 3.0 – An ArcView GIS Tool to Calculate Nonpoint Sources of Pollution In Watershed and Stormwater Projects*.

Appendix 4: BMP Overview & Ranking Tables

Prepared with assistance from:

GEOSYNTEC CONSULTANTS
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Los Angeles, California 90045

M E M O R A N D U M

TO: Jason Pelletier, North East Trees
FROM: GeoSyntec Consultants
DATE: March 17, 2005

SUBJECT: **Task 2: BMPs for Bacteria**

1.0 Introduction

The Arroyo Seco Watershed Management Plan will include specific BMP projects – including both structural and non-structural measures – recommended for implementation at various prioritized drainage areas in the watershed. These prioritized BMP type/location combinations have been selected initially based on their potential to provide measurable bacteria load reduction benefits, and thereby bring the watershed closer toward the ultimate goal of achieving REC-1 objectives on a more consistent basis, or more specifically, matching an estimated background bacteria objective exceedance frequency.

The primary purpose of this Task 2 analysis is to identify and describe those *structural* measures that have demonstrated capability to provide water quality benefits specific to *bacteria* (i.e., measures which have the potential to achieve REC-1 bacteria objectives). Also identified in this analysis are non-structural and non-bacteria-specific structural measures, however these measures are only briefly mentioned here for reference purposes. Eventually various measures may be recommended for general application across the watershed, while others will be recommended for specific prioritized drainage areas (Task 4). This memorandum is intended to be utilized in the context of other task deliverables in support of the Watershed Management Plan.

North East Trees originally developed their preliminary list of BMPs in what has been referred to as their "BMP matrix". This memo builds off that BMP matrix concept by describing those runoff retention and bacteria-specific treatment structural measures which can be applied as part of a larger comprehensive and integrated water quality, water resources approach. NET's original BMP matrix then forms the basis for the final BMP summary tables included at the end of this memorandum.

2.0 Identification of Options

Three categories are distinguished here for potential runoff management options. These options were chosen because they not only manage runoff volume, but they also specifically help to reduce bacteria concentrations in the runoff. Many of these options help to reduce concentrations of other pollutants as well. The intended purpose and types of options for each of these three categories in the overall implementation plan are generally:

1) Non-structural (i.e., institutional) Source Control Options

This suite of options is not discussed in detail here but reference is made to the previously-developed North East Trees matrix. These options are intended to prevent/reduce levels of bacteria, or bacteria sources (e.g. garbage/trash) from initially being picked up by runoff whether on-site, in the curb/street, or in the storm drain system. They generally do not reduce the amount of flow or volume to be managed, but may reduce bacteria levels. These non-structural options probably would help the most with dry weather runoff and would be only minimally effective in actually reducing any bacteria exceedances, but they should be part of an integrated solution, and could be early implementation steps. Examples of these options are pet waste programs and restaurant education/inspection programs.

2) On-site Structural Source Control Options

These options include cisterns, on-site storage/reuse, onsite capture and infiltration, and septic-related BMPs; they are intended to reduce the total volume and flow rate of runoff leaving properties and entering the storm drain system, including any bacteria that might be picked up in the runoff on-site. They directly reduce the amount of runoff that enters the downstream storm drain system, thereby reducing the amount that needs to be managed downstream. Studies conducted for the Santa Monica Bay TMDL Draft Implementation Plans demonstrated that only a relatively small fraction of the amount of runoff required to meet water quality objectives can be managed through these options, so these options will not represent a total solution for any of the major subwatershed. The presumption is that no treatment would be required for any bacteria/pathogens since water would either be infiltrated or applied with subsurface irrigation or otherwise locally managed techniques with minimal unrestricted public contact. Some limited pre-treatment might be required for a larger system to minimize operational problems.

3) Regional Structural Options

The following are potential regional options:

- Divert to regional wastewater treatment – This option is intended to divert dry and wet weather runoff to a local wastewater collection system where it receives equivalent to secondary treatment (no disinfection required) and is discharged to the ocean. Diverting runoff eliminates discharge of that quantity of water downstream, thereby potentially reducing the number of exceedance days, especially at lower flows. This option can only be done when capacity exists in the collection and treatment system, and therefore short-term operational storage would likely be required to balance the rainfall hydrograph with available capacity.

- Capture, store, treat and discharge – This "end of pipe" solution treats runoff either in-line or off-line to reduce bacteria to levels that presumably would not cause an exceedance of water quality objectives. To minimize peak capacity of treatment, short-term operational storage will be required to balance the rainfall hydrograph with capacity. It is likely that some level of treatment and discharge will have to be considered in most jurisdictions, as most of the other options may not be able to achieve full compliance with TMDL quantitative targets by themselves.

- Capture, store and beneficially reuse for irrigation or similar non-potable uses – This option is intended to divert wet-weather runoff to beneficial use with appropriate treatment for the intended use. The capture and reuse of runoff eliminates discharge of that quantity of water downstream, thereby potentially reducing the number of exceedance days, especially at lower flows. To minimize capacity of treatment and/or off-stream diversion pumping to storage, short-term operational storage will likely be required to balance the hydrograph, and longer-term storage may be required to balance water availability with seasonal demand. It is assumed that treatment objective would be equivalent to Title 22 standards for unrestricted irrigation with recycled water.

- Capture, store, treat and inject – This option is intended to divert runoff to be a source of regional groundwater injection with appropriate treatment for the intended use. The capture and injection of runoff eliminates discharge of that quantity of surface water downstream, thereby potentially reducing the number of exceedance days. To minimize capacity of treatment and/or off-stream diversion pumping to storage, short-term operational storage will likely be required to balance runoff hydrographs, and longer-term storage may be required to balance water availability with seasonal demand.

This analysis is intended to focus exclusively on the *structural* (on-site and regional) options only. It should also be recognized that the structural storm water BMPs presented here focus on *bacteria-specific* options, and that in most cases, pre-treatment BMPs are required. These BMPs could include some combination of biofilters, extended detention basins, filters, and/or proprietary BMPs. These pre-treatment BMPs are not discussed in detail in this technical memorandum, but the cumulative effect of pre-treatment as part of a treatment train is summarized in Section 2.2.6. For further information see the California BMP Handbook (www.cabmphandbooks.com) or the Los Angeles County SUSMP Manual (www.ladpw.org/wmd/NPDES/SUSMP_MANUAL.pdf).

2.1 On-Site Options

On-site options provide an important step in managing wet weather runoff. This Technical Memorandum focuses on several treatment control BMPs that will reduce runoff volumes and improve runoff quality prior to entering the storm water collection system. Of these, four options have been identified as providing source control at the individual lot level: 1) residential cisterns, 2) on-site storage and reuse, 3) capture and infiltration, and 4) alternative on-site treatment systems. Since runoff would be retained and not discharged, bacteria and other pollutants would not be discharged and would therefore be effectively removed.

It should be recognized that on-site options, like non-structural options options, may not fully mitigate the impacts of pollutant loading, but their implementation could contribute to integrated water quality solutions, and could contribute to the reduction of the magnitude and extent of downstream (regional) options.

2.1.1 Residential Cisterns

Cisterns are low-cost water conservation devices that could be used to reduce runoff volume and, for smaller storm events, delay and reduce the peak runoff flow rates. They store and divert runoff from impervious roof areas on residential properties. This stored runoff could provide a source of chemically untreated 'soft water' for gardens and compost, free of most sediment and dissolved salts. Because residential irrigation could account for up to 40 percent of domestic water consumption, water conservation measures such as cisterns could be used to reduce the demand on the municipal water system, especially during the hot summer months. Photos of cisterns (one attached to a roof drain system) are presented in Figure 2.

Figure 1. Cisterns (Source: **www.lid-stormwater.net** and www.watertanks.com)

Individual cisterns could be located above ground and beneath each downspout, or the desired storage volume could be provided in one large, common cistern that collects rainwater from several sources. Pre-manufactured residential-use cisterns are available in sizes ranging from 100 to 10,000 gallons.

Although the cistern option would not manage sufficient quantities of runoff to eliminate the need for other runoff management options, it should be encouraged due to its positive effect from a water conservation standpoint, and its ability to eliminate low flow runoff from very small storm events. Table 1 provides a summary of selected information.

Table 1 . Cistern Data	
Control Measure	Cisterns
TMDL compliance method and performance	Reduces volumes of runoff potentially contributing to increased discharge/exceedance days. Not feasible for implementation as the primary BMP for TMDL compliance.
Cost-related data	Product cost: $1 to $2/gallon for cistern sizes ranging from 50 to 10,000 gallons
Site-related data	BMP is contained on site and does not require additional right-of-way
References	www.watertanks.com www.cleanairgardening.com www.lid-stormwater.net

2.1.2 On-site Storage and Reuse Projects

This option involves capturing runoff from areas other than, or in addition to, rooftops and storing it for subsequent reuse on-site. These other areas include driveways, parking lots, and paved sports areas. This option could also include some treatment (such as chlorination) and would require careful management, and consideration of water distribution systems.

The potential sites for this type of system would be public parks, government facilities, or schools at which the runoff could be reused for irrigation without meeting full Title 22 treatment Standards (requiring filtration and disinfection). They would be installed underground since they would need to be big enough to storage large volumes of runoff. The landscape maintenance could involve a controlled subsurface distribution system (i.e., no sprinkler system) so that direct public contact is essentially eliminated. The opportunities for these types of projects would have to be identified and developed on a case-by-case basis.

In addition to chlorination, treatment options could include trash/gross solids removal and removal of oil and grease where needed to minimize operational problems. Wet weather runoff would be directed to the underground system by either conveyance piping or through infiltration of the surface soil, or a combination of both. The runoff would be stored in the underground system and could be pumped and used for on-site irrigation. Each system would be designed and sized to collect and treat runoff (from either on-site or additional street areas) and stored underground in a system sized to appropriately supply a percentage of the irrigation demand.

Examples

The Open Charter School Demonstration Project in the Ballona Creek Watershed is an example of this option. It is being built in cooperation between government and non-profit agencies in the creation of an environmentally sustainable school. Funded by County Proposition A (Safe Neighborhood Parks Act), and financed by the City of Los Angeles Bureau of Sanitation, the project is designed to reduce the amount of polluted runoff to Ballona Creek and Santa Monica Bay.

Working in conjunction with the Los Angeles Department of Water and Power's (DWP's) Cool Schools Program and the Los Angeles Unified School District, TreePeople supervised the installation of an integrated set of BMPs at the site. The system consists of a runoff collection system, pipes to route the runoff to a small-footprint treatment unit, a cistern, an automatic chlorinator, and a pump. The treatment unit is designed to remove trash, grit, and oil from the collected runoff. It consists of an inlet, a grit chamber, an oil-water separator, and flow control. The cistern stores 110,000 gallons of captured storm water for reuse as irrigation supply. It consists of an excavated area, an impermeable liner, and subsurface storm water storage "blocks" to store the runoff. A photo of this installation during construction is presented in Figure 2. An agreement on monitoring the performance of the site's BMPs is currently being negotiated. Table 2 summarizes the on-site storage and reuse option.

Figure 2. Subsurface Storage Blocks for On-site Storage and Reuse

Table 2 On-Site Storage and Reuse Summary	
Control Measure	On-site Storage and Reuse
TMDL compliance method and performance	Reduction of runoff contributing to potential TMDL discharge exceedances and treatment of captured volumes. Multiple pollutants addressed.
Cost-related data	Approximately $4/gallon Based on Open Charter School Construction Costs $435,000 Treated volume = 110,000 gal
Site-related data	Underground site
References	TreePeople (O'Donnell, 2004)

2.1.3 Small Scale Infiltration Projects

Many on-site options have been identified that capture storm water and allow it to infiltrate into the ground at rates that would provide water quality treatment and reduce the downstream flow. The options porous pavement, retention grading, infiltration pit, bioretention, and infiltration culverts are discussed. As with any infiltration option, the pre-design considerations include the following:

- Soil types and groundwater depths
- Presence of contaminated groundwater/subsurface soils, and the potential impacts of introducing pollutants into the subsurface system.
- Proximity to potentially impacted structures
- Maintenance to prevent long-term clogging

2.1.3.1 Porous Pavement

Areas such as roadways, driveways and parking areas covered with impermeable (non-porous) pavement are one of the largest contributors to wet weather urban runoff. Porous pavement is a special type of material that allows water to pass through yet is strong enough to structurally support vehicular traffic.

Concrete block pavement is one type of porous pavement that has been available for many years and has been used primarily as aesthetic treatments to parking areas and low volume roadways. In the last 20 years, high-density plastic grids have also entered the market place. There are many configurations and applications that have been developed for both of these materials. Most of the systems are supported by a stone base that has large pore spaces. This base acts both as pavement support and as a reservoir to store water so that it can be infiltrated, if the soil conditions allow, or detained and slowly released to the storm drain system. Supplemental storage facilities, such as underground vaults or drainage blankets, can be used in conjunction with these systems. Each pavement type is generally described below.

Porous Concrete: This pavement has stable air pockets encased within it that allow water to drain uniformly through into the ground below, where it can be naturally filtered (See Figure 3). The material becomes stronger and more stable when it gets wet, so it does not deteriorate as fast as other paving materials. Its use should be restricted to parking lots and local roads since it supports lighter loads than standard concrete. Since it is cement based, it will not release harmful chemicals into the environment such as with oil-based asphalt. It has been in use throughout Europe for about fifty years, and a domestic formula known as the Portland Cement Pervious Pavement has been used successfully since the 1970s in the U.S., particularly in Florida. The pavement is a special blend of Portland cement, sand-free coarse aggregate rock, and water. Several vendors provide this material in the Lo sAngeles area, including the following:

- http://www.perviousconcretecalifornia.com/
- http://www.graniterock.com/tnperviousconcrete.html

Figure 3. Porous Pavement Section
(www.gcpa.org/pervious_concrete_pavement.htm)

Grass Pavers: Plastic rings in a flexible grid system or concrete pavers are placed on a base of blended sand, gravel and topsoil, then filled with topsoil such as sandy loam and planted with vegetation (see Figure 4) . This pavement provides an alternative to asphalt or concrete for low-traffic areas such as firelanes, overflow and event parking, golf cart paths, residential driveways, and maintenance and utility access lanes. The support base and the rings' walls prevent soil compaction and reduce rutting and erosion by supporting the weight of traffic and concentrated loads, while the large void spaces in the rings allow a strong root network to develop. The end result is a load-bearing surface covered with natural grass and which is typically around 90 percent pervious, allowing for storm water pollution filtration and treatment. Ancillary benefits include airborne dust capture and reductions in the urban heat island effect. Most manufacturers also produce the paver rings from post-consumer recycled plastic materials. It should be noted, however, that this approach involves installing grass that will require irrigation and could increase the potable water demand.

Figure 4. Grass Paver Example

Gravel Pavers: This pavement option is intended for high frequency, low-speed traffic areas (see Figure 5). The same ring structure as with the grass paver is used, but the voids are filled with gravel to provide greater load bearing. Manufacturers provide specifications on the sieve analysis that should be used to generate the clean gravel fill for the rings, and a geotextile fabric is used to prevent the gravel infill from migrating to the soil subbase. Gravel pavers can be used for automobile and truck storage yards, high-throughput parking lots, service and access areas, loading docks, boat ramps, and outdoor bulk storage areas. It should be noted, however, that this approach does not require irrigation and therefore does not increase the potable water demand.

Figure 5. Gravel Paver Example

Interlocking Paving Blocks: The shape of these interlocking pre-cast units leaves drainage openings that typically comprise approximately 10 percent of the paver surface area (See Figure 6). They are made of concrete or plastic. When properly filled with permeable material, the voids allow for movement of storm water through the pavement surface into the layers below. The system is a highly durable, yet permeable pavement capable of supporting heavier vehicular loads than grass or gravel pavers and it offers the most flexibility in widespread application. Interlocking concrete paving blocks are resistant to heavy loads and both concrete and plastic ones are easy to repair, require little maintenance, and are of high quality. These systems, however, have the highest materials and construction costs.

Figure 6. Permeable Paving Blocks

Pervious Crushed Stone: Parking stalls and low-traffic areas can be covered or surrounded with a pervious crushed stone. The pervious stone surface would allow storm water and auto-related contaminants to be absorbed and trapped in the soils.

Figure 7. Pervious Crushed Stone

2.1.3.2 Retention Grading

Residential front and backyard retention grading is a concept whereby a site is graded to create a "sunken garden" that holds runoff and rainwater until it can be absorbed into the ground. This type of grading works best in highly permeable soils. While in some locations, mini retention structures are capable of handling a flash flood that could occur during a 100-year storm event, this is not expected to be needed. The depressed area, however, could retain small storms and could also be placed over coarse aggregate rock to achieve a higher infiltration rate to prevent nuisance and vector-breeding conditions. In all cases precautions must be taken during design to ensure that standing water could either be infiltrated or evapotranspirated within three days and that County requirements for sump conditions are met.

2.1.3.3 Infiltration Pits

Infiltration pits are a common means of storm water management in many areas of the United States. They involve adding a grate with a rock pit below at the lowest end of paved areas such as driveways and parking lots. Alternately, a rock pit can be constructed at a roof downspout (see Figure 8).They are designed to capture and store storm water until the water percolates into the subsurface soils. They serve the dual purpose of retaining and cleansing runoff and rainwater, giving the water within it time to percolate into the ground rather than carrying pollutants into the storm drain system.

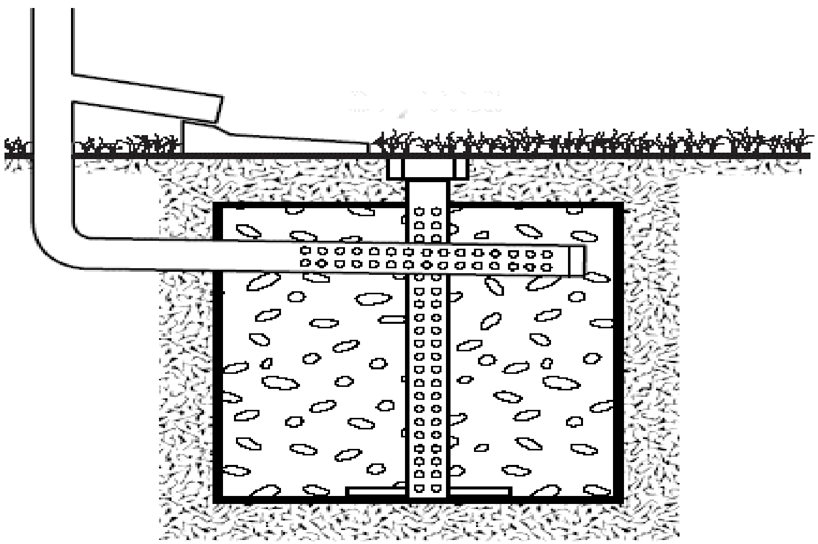

Figure 8. Infiltration Pit

2.1.3.4 Bioretention Areas

With bioretention, runoff is directed into shallow landscaped depressions (see Figure 9). It is applicable to large areas. These depressions and the surrounding areas are designed to provide onsite treatment, incorporating many of the pollutant removal mechanisms that operate in forested ecosystems. They are commonly located in parking lot islands, median strips, swales or within small pockets of residential land uses.

The bioretention area is commonly graded so that excess flow is conveyed as sheet flow to the treatment area, which consists of a grass buffer strip, sand bed, ponding area, organic layer or mulch layer, planting soil, and plants. Runoff first passes over or through a sand bed, which slows the runoff's velocity and distributes it evenly along the length of the ponding area; this area consists of a surface organic layer and/or ground cover and the underlying planting soil. The ponding area is graded and its center area is depressed. Water is impounded to a depth of about six inches and gradually infiltrates the bioretention area or is evapotranspired. The design can be modified to include an underdrain within the sand bed to collect the infiltrated water and discharge it to a downstream storm drain system. This modification is needed in areas where impervious subsoil could prevent complete infiltration in the soil system. In the case of this modification, the bioretention area would act more as a filter that discharges treated water than as an infiltration device.

These installations could provide as high as 90 percent removal of suspended solids and bacteria. (www.lid-stormwater.net). Innovations in the designs of bioretention areas could include both aerobic and anaerobic treatment zones in the treatment bioretention area to promote nitrogen removal if a nitrogen TMDL were added to water quality objectives. The anaerobic zone will promote denitrification. Testing of installations has shown removal of between 93 and 98 percent of metals, between 68 and 80 percent of total Kjeldahl nitrogen, and between 70 and 83 percent of total phosphorus.

Figure 9. Bioretention

2.1.3.5 Infiltration Culverts

The runoff from a small area could be routed to a treatment system to remove grit and oil and then be routed to an infiltration system located in an area with well draining soils. A typical treatment system would consist of an inlet, a grit chamber, an oil wall separator, and flow control. The infiltration system would consist of a perforated culvert under the boardwalk that could store the runoff until it is infiltrated. An example is provided in Figure 10.

Figure 10. Infiltration Culvert (www.cultec.com)

2.1.3.6 Analysis of Capture and Infiltration

Regional environmental factors, such as the amount, intensity, and frequency of rainfall, local soil permeability, groundwater levels, and subsurface soil quality (i.e., absence of contaminants) will determine the ability of the these systems to pass storm water through the top soil layers and then store and release the water in a timely manner into the underlying soil.

Infiltrating runoff requires that the soils be permeable enough to allow percolation into the groundwater basin. If it is unlikely that there is opportunity for groundwater recharge through on-site infiltration projects on a large scale, there could be potential, for some runoff to infiltrate into the top layers of soil, where it will reduce the overall runoff volume leaving the site. Sandy or sandy loam soils have the highest percolation rates (infiltration capacity), while clay soils tend to have the lowest infiltration capacity. The clay in poorly draining soils quickly expands when wet and holds water almost immediately when exposed to moisture.

In addition to the need for permeable soils, an infiltration system requires that the soil be uncontaminated to avoid degradation of the underlying aquifer. This is particularly true given the presence of some septic systems within the Arroyo Seco. One additional concern about the use of infiltration pits is that unmaintained or unmonitored installations could be a risk to groundwater quality (e.g. from illegal dumping). Specific installation requirements and monitoring could be developed to mitigate this risk. As with all the options maintenance of these installations is important to provide consistent treatment. For porous pavement, limits must be placed on the weight of the vehicles that can be used. A summary of On-Site Capture and Infiltration options is presented in Table 3.

Table 3
On-Site Capture and Infiltration

Control Measure	On-Site Capture and Infiltration
TMDL compliance method and performance	Reduction of runoff volumes and full treatment when fully functional. Performance: Irregular (EPA estimates 75% failure for pavement)
Cost-related data	Porous Pavement ($6-8/sf) Permeable (grass and gravel) Pavers ($1.50-$3/sf + surface treatment ~ $10/sf)1

[1] Referenced Presto and Invisible Structures products

Table 3 On-Site Capture and Infiltration	
	Bioretention estimate: $2.50/sf Infiltration Culvert: ($42/ft materials , estimate $100-200/ft)
Site-related data	Varies; if properly designed, could have no impact on usable areas
References	USEPA, 1999

2.2 Regional Options

Regional options are treatment control practices that capture, store and treat runoff before releasing it back into the environment. This section discusses the different treatment requirements and technologies available for the potential options that have been identified for the Arroyo Seco: diversion to regional wastewater treatment facilities; capture, storage, treatment and then either discharging, beneficially reusing (i.e., for irrigation), or injecting runoff; direct discharge of the runoff using an extended outfall; and regional wastewater treatment.

Wet weather events result in high flows over a relatively short duration. Designing a system to accommodate all of the flows as they are generated would be prohibitively expensive. Therefore, all options for storm water treatment or direct discharge would involve the capture and storage of storm water runoff. Storage costs for all options are on the order of $1 - $1.5 M/mgd, and these costs are in addition to the treatment options discussed below. It should be noted that costs associated with any significant conveyance facilities, and land acquisition are not included in the cost discussion below.

The collected runoff would then be pumped from the storage facilities at a lower rate over a period of hours or days. The hydrologic analyses conducted as part of the Implementation Plan describes target runoff volumes and storage requirements anticipated for treatment.

2.2.1 Divert to Regional Wastewater Treatment

This option involves storing wet weather runoff and then routing it to a new Wastewater Treatment Plant (WTP) for treatment. The WTP unit processes would include grit removal, primary sedimentation, secondary treatment using high purity oxygen and secondary sedimentation, disinfection using chlorine, and ocean discharge. Treatment facilities would be designed to meet ocean discharge requirements for collected wastewater and are assumed to meet these standards for discharging treated wet weather runoff.

2.2.2 Capture, Store, Treat and Discharge

Capture, store, treat and discharge, or treatment and discharge, refers to diverting runoff from the storm drain system to a dedicated runoff treatment facility. The runoff would be captured and diverted, held in temporary storage for a maximum of 24 hours, pumped to new facilities for treatment, and discharged.

As discussed in the hydrologic analyses (section 2.2.1), required storage volumes would be significant. The proposed number and capacity of each treatment facilities will depend upon the siting analysis and development of alternatives.

Treatment would depend on target constituents (in this case, primarily bacteria). Trash and suspended solids would also be present in wet weather flow, and pretreatment of flows would therefore be required to remove these constituents before treatment to remove bacteria is implemented. This level of treatment, however, would be substantially below the level of treatment required to beneficially reuse the runoff.

This section discusses traditional as well as candidate treatment technologies that could potentially be utilized for treatment of bacteria, where discharges are released. Traditional treatment methods would probably be most applicable with high wet weather runoff flowrates. The candidate treatments technologies have not been proved for this application but could possibly provide treatment on small-scale in localized drainage areas. The treatment technologies examined consist of the following:

- Traditional treatment
- Storm water Filtration Units
- Advanced Oxidation
- Peracetic Acid (PAA) and Other Bactericides
- Subsurface Constructed Wetlands

It should be noted that many of the information related to new and proprietary technologies were provided by vendors and manufacturers, and implementation should be carefully monitored and considered in the context of adaptive management practices.

2.2.2.1 Traditional Treatment

Constructing wet weather runoff treatment facilities is a relatively new concept. For this study, wastewater treatment facilities designed to treat dilute wastewater at high rates on an intermittent and as-needed basis will be used as the treatment model. Plants designed for the East Bay Municipal Utility District in Oakland, California are described below. The results of research by the National Science Federation are also presented below. These data will be used to develop an assumed treatment scheme and plant area per mgd of design capacity.

EBMUD Case Studies

The primary purpose of the East Bay Municipal Utility District Wet Weather Facilities Program is to reduce the frequency and volume of overflows during wet weather events when the wastewater flows are very high (EBMUD, 2004). They operate three wet weather treat plants to maximize the volume of wastewater delivered to their main wastewater treatment plant and to assure that all wastewater entering the interceptor receives some treatment prior to discharge (floatable removal, disinfection and dechlorination). These three plants are the Oakport Wet Weather Treatment Plant, the San Antonio Creek Wet Weather Treatment Plant, and the Point Isabel Wet Weather Treatment Facility. The San Antonio Creek Plant, however, will not be presented as a model facility. It includes only grit removal and chlorination/ dechlorination facilities because it is at a site that is too small to accommodate sedimentation basins.

The overall design criteria for the Wet Weather Facilities Program is handling the wastewater flows during a 5-year rainfall event when the soil is saturated and the wastewater interceptors are at capacity. It is estimated that all of these conditions occurring simultaneously has a 13 year return period. The current permit allows a discharge limit of 100 MG per year.

The treatment goal is to reduce the solids and pathogen load in the discharged effluent. The discharge permits for the wet weather facilities could be modified in the future. It may be that metals removal and other criteria will be added to the permit.

The Oakport plant is rated for 158 mgd and has a storage capacity of 2.85 million gallons. The plant consists of a diversion structure, influent pump station, ten sedimentation basins, a chlorination/dechlorination system, standby diesel engine generator, control building and associated inlet, outlet and effluent channels and outfall. If the volume of wet weather flow at Oakport exceeds 2.85 million gallons (the storage capacity of sedimentation basins) prior to the restoration of local interceptor capacity, the flow is treated and disposed via outfall.

This plant does not have solids handling facilities. Accumulated solids within the sedimentation basins are washed into the local wastewater interceptor when capacity is available.

The ten Oakport sedimentation basins are 20 feet wide by 200 feet long for a total area of 40,000 square feet and a surface loading rate of about 4,000 gallons per day per square foot. This is a very high surface loading rate when compared to plants treating a more typical wastewater. The recommended primary sedimentation tank surface loading rate for untreated wastewater is 600 to 1,200 gallons per day per square foot (Metcalf and Eddy, 1972). For the purposes of this study, it was assumed that these basins comprised half of the total land area for the plant. Thus, an 80,000 square foot plant was assumed for the entire plant (about 500 square feet per mgd).

The total construction cost for this plant in 1990 was about $25 M. This cost does not include land acquisition. At an assumed escalation rate of 5 percent per year, this corresponds to a current cost of $50M. At a design flowrate of 158 mgd, the unit capital cost for this plant is $0.3 M/mgd.

The operations and maintenance cost for this plant is about $200,000. This is for materials only and does not include labor costs. No personnel are assigned solely to the facility. District staff members operate the site only during and after a wet weather event. In addition, maintenance crews visit all of the wet weather facilities on a regular basis but are also assigned to the District's main wastewater treatment plant.

Because of the proposed operating scenario (passive diversion) and the variability of storm events and soil moisture, the actual pattern and magnitude of flows is difficult to predict. On the average, the plant is expected to be operated approximately 10 times per year and discharge an average of 2.5 times per year. Correspondingly, the average yearly discharge volume is approximately 38 million gallons (MG) while the maximum is estimated to be 272 MG. The plant discharges for relatively short periods. The average discharge is 8 hours/event and 21 hours per year and the maximum expected discharge is expected to be 38 hours per event and 102 hours per year. Based on these data, it is estimated that the unit O&M cost for this facility is about $5,300/MG for materials only.

The Point Isabel Wet Weather Treatment Facility provides dry weather pumping of wastewater, up to 14 million gallons per day (mgd), to the main treatment and also provides treatment of wet weather flows up to 100 mgd with a storage capacity of 3.0 million gallons. The facility is equipped with a dry weather wet well that normally collects and pumps wastewater to the treatment plant, but will overflow passive weirs into the wet weather wet well and begin activation of the wet weather treatment facility for storm operation when flows in the local interceptor reach capacity.

When the wet weather influent pump station is activated, pumps lift the diluted wastewater through bar screens and then grit removal chambers. Flows then enter into eight sedimentation basins from near the bottom of the influent channel so that scum and floatables are removed. The sedimentation/storage basins provide primary sedimentation, chlorine contact time and storage. Sodium hypochlorite for disinfection is injected into the wastewater at the suction of each operating pump. Wet weather flows that exceed the capacity of the sedimentation/storage basins flow into the effluent channel and are dechlorinated with sodium bisulfite before discharging into San Francisco Bay through a 72-inch outfall. Solids and stored wastewater are returned to the dry weather wet well and then pumped to the District's main wastewater treatment plant.

The eight Pt. Isabel sedimentation basins are 20 feet wide by 210 feet long and for a total area of 33,600 square feet and a loading rate of about 3,000 gallons per square foot. For the purposes of this study, it was assumed that these basins comprise half of the total land area for the plant. Thus, a 67,000 square foot plant was assumed for the entire plant (about 670 square feet per mgd).

The total construction cost for this plant in 1993 was about $25 M. This cost does not include land acquisition. At an assumed escalation rate of 5 percent per year, this corresponds to a current cost of $43M. At a design flowrate of 100 mgd, the unit capital cost for this plant is $0.4 M/mgd.

A high degree of variability is expected from storm to storm and within each storm event. The variability is also reflected in constituent characteristics of the wastewater. As a result, the facility design emphasis was based on flexibility and passive flow control. The actual pattern and magnitude of flows to the Point Isabel WWTF is difficult to predict because of the proposed operating scenario and the high variability of storm events and soil moisture. The reported O&M cost for materials only for this plant is $32,200 per year. If the average O&M cost of $5,300/MG for the Oakport plant is similar for this plant, this would correspond to an average discharge of about 6 MG.

Small Packaged Systems

Small packaged systems using traditional treatment methods are also available to handle flows from small watershed areas. An example of these systems treats dry weather runoff in the creek upstream of the Paradise Cove area in Malibu. This system operates at flows at flows ranging from 60 to about 160 gpm. It consists of an 8,000-gallon pond to equalize flow, a multimedia filter to remove solids; an organic clay filter to remove oil, grease, and pesticides; and an ultraviolet disinfection system. Similar systems are in operation in the City of Encinitas and on Aliso Creek in Orange County.

Figure 11 – Aliso Creek Small Packaged System

The capital cost of a system to treat about 150 gpm ranges from $150,000 to $250,000 depending on factors such as the level of automation. This corresponds to a unit cost of $700,000 to $1.2M/mgd. The labor for these systems involves visiting the site a few times a week to ensure that it is operating correctly and routine maintenance. Electricity is the only operating expense as no consumable chemicals are used.

Summary

The National Science Federation conducted the Environmental Technology Verification (ETV) testing program for Urban Wet Weather Technologies in 1999. The goal of this program was to verify the operational performance of technologies applicable to the treatment of effluents generated by wet weather conditions in urban areas - storm water discharges, combined sewer overflows, or sanitary sewer overflows resulting from infiltration into the separate sanitary sewer system. High rate sedimentation and ultraviolet disinfection were found to meet many design goals (NSF. 1999). Their conclusion that high rate sedimentation appears feasible is consistent with the high surface loading rates for the EBMUD plants. Using UV for disinfection would eliminate the need for dechlorination and the potential for chlorinated organics in the plant discharge.

Based on the design criteria presented above, it is assumed that traditional treatment would consist of storage, influent pumping, bar screens to remove trash, sedimentation basins to remove settleable solids such as grit and organic material, and disinfection. A sedimentation tank surface loading rate on the order of 3,000 to 4,000 gpd/SF will be assumed. The assumed footprint area for the treatment facilities would range up to about 700 square feet per mgd. Grit removal and fine screening would be considered in lieu of sedimentation if a site is very constrained. UV disinfection should also be considered.

The option of treating wet weather runoff could be coupled with a reuse project either initially or in the future. All or a portion of the effluent could be routed to a plant that would provide filtration and disinfection to meet Title 22 requirements. Traditional treatments are summarized in Table 7.

Table 4 Traditional Treatment	
Control Measure	Traditional Treatment
TMDL compliance method and performance	No reduction in storm water volumes. Performance may not be good enough for non-bacteria applications such as metals removal.
Cost-related data	\$0.3 to 0.4M/mgd plus land acquisition cost | \$5,300 / MG for materials cost \$1.2M/mgd for small systems
Site-related data	Requires a significant footprint on the order of 700 square feet per mgd
References	EBMUD (2004) Clear Creek (2004)

2.2.2.2 Storm Water Filtration Units

Storm water filtration units (see Figure 12) are available as proprietary filtration systems equipped with vertical filter media that utilize filtration media specifically chosen to treat a particular site's pollutants of concern. In this case, the main constituent of concern is bacteria.

The performance of storm water filtration units is highly dependent on filter media. The units alone have not been proven to reduce pollutant concentrations of flows with bacteria loads to TDML discharge standards (requiring some 99.9% removal). They could potentially, however, be used in combination with other methods (such as biocides) to improve performance. Effectiveness for bacteria applications is still undergoing testing.

Manufacturers have indicated that two media technologies currently being researched may provide some level of bacteria control without creating residuals with toxicity characteristics that would prohibit their use for surface water applications. These media are not currently available for purchase, and estimated removal rates are not available. They have; however, been used as pretreatment for suspended solids TSS, removals on the order of 80% and higher are achievable, depending on the media used.

Typical placement of these devices includes catch basins, manholes, and pre-cast underground vaults that can be placed wherever space is available on-site and hydraulics allow. A typical pre-cast structure measures 8′ x 16′ in area. Filter cartridges have a treatment flow of 15 gpm, and a typical pre-cast structure can house approximately 35 cartridges, allowing for a flow of 525 gpm. This corresponds to a unit size of about 200 square feet/mgd.

A capital cost of $30,000 per mgd of flow to be treated is typical. Maintenance costs for cleaning and/or replacement of cartridges on an annual basis are on the order of $2,000 - $5,000 for a typical system depending on number of cartridges and frequency of maintenance and cell replacement (Harris, 2004). If the unit operated five times per year at a rate of 525 gpm for a duration of one day (3.8 MG/year), this O&M cost corresponds to a unit rate of $500 to $1,300/MG. A summary of storm water filtration is provided in Table 8.

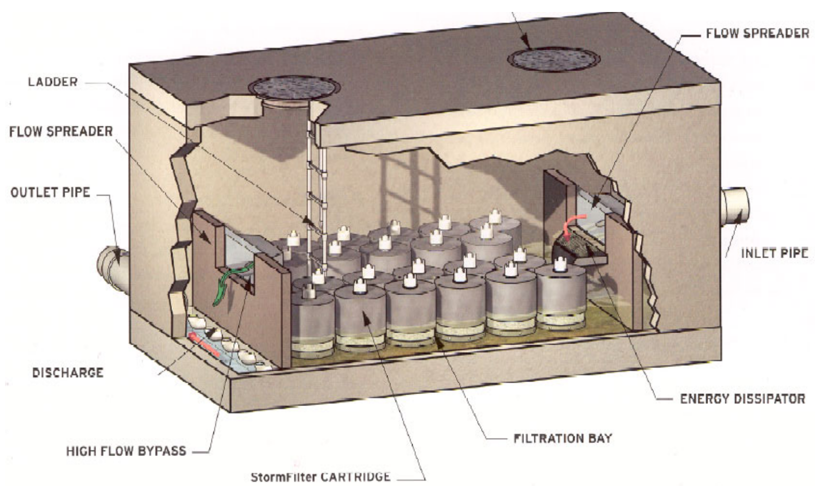

Figure 12. Storm Water Filter schematic (from Stormwater Management, Inc)

Table 5 Storm Water Filtration	
Control Measure	Storm water filtration
TMDL compliance method and performance	No reduction in storm water volumes. Performance: good for non-bacteria applications. Further testing needed; cannot meet bacteria standards without additional treatment.

Cost-related data	$30,000 per MGD $500 to $1,300/MG. (O&M) Costs not fully developed for bacteria treatment. Only typical filter costs available.
Site-related data	Requires either detention or expanded vault. Requires an underground footprint on the order of 200 square feet/mgd.
References	Harris (2004)

2.2.3.3 Advanced Oxidation

This technology uses fully fluidized biofilm carrier elements to provide attached-growth aerobic treatment. It has typically been used to treat wastewater, but could be considered for storm water applications as it has been shown to control fecal coliform to levels that are safe for discharge. Removal efficiencies for fecal coliform are on the order of <2 MPN/100 ml.

Hydroxyl Systems™ is a yet untested proprietary system that provides this biological treatment technology (see Figure 14 and Table 9). The system could treat storm water flows prior to discharge to the receiving waters. The treatment system is modular and may be installed in new or existing systems.

Typical placement is in above or below-ground tanks wherever space is available on-site and hydraulics allow, as shown in Figure 13. While system footprint varies with flowrate and target contaminants, a housing size of 8′ x 40′ is typical.

The process includes the use of air, ozone or other oxidants as both positive flotation mechanism (PFM) and as an oxidant of pollutants. The pollutant oxidation takes place in a oxidation cell that contains the fluidized biofilm carrier elements. This technology is accepted by some permitting agencies for groundwater contamination applications; the fact that this technology is chlorine-free makes it more likely to be accepted by project regulatory agencies for storm water treatment applications.

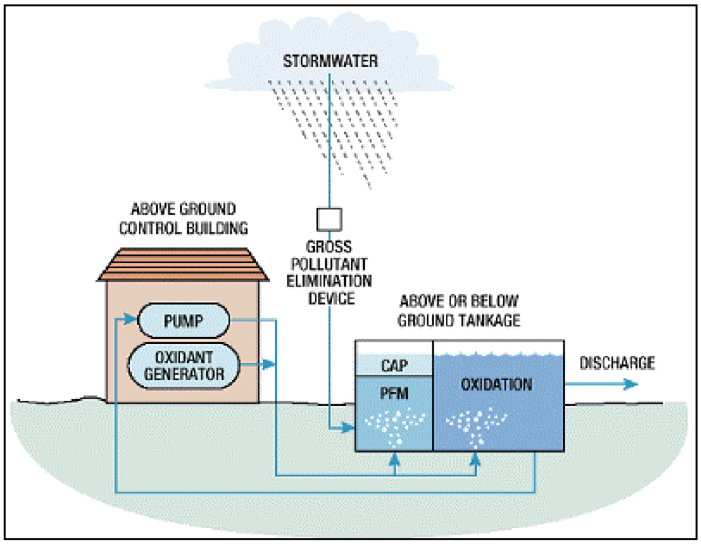

Figure 13. Hydroxyl Treatment System for Storm Water Applications

Table 6 Advanced Oxidation	
Control Measure	Advanced Oxidation
TMDL compliance method and performance	Should meet TMDL discharge requirements. No applications/data to confirm for storm water usage.
Cost-related data	Estimated capital cost for a 1,000 gpm (1.4 mgd) system was about $825,000 in 2002. Based on an assumed 10 percent escalation rate since that time and 25 percent for engineering, this would correspond to a current total cost of $1.1 M. ($780K/MGD) These costs include initial purchase and installation, as well as maintenance.
Site-related data	This system would include a 60,000 gallon tank and would require an area of 24 feet by 54 feet (1,300 square feet).
References	Featherstonhaugh (2002)

2.2.3.4 Peracetic Acid (PAA)

PAA is an emerging product that can be used in storm water treatment. PAA is a stabilized equilibrium solution concentrate that is a mixture of peracetic acid, acetic acid, and hydrogen peroxide. It is primarily used as a disinfectant that acts through oxidation. PAA is more effective than chlorine dioxide and has virtually no odor at end-use concentrations. It degrades to water, carbon and oxygen. It does not have disinfection byproducts like chlorine, but does have a residual concentration. These features make PAA a good alternative to common disinfectants such as chlorine, potassium permanganate, or hydrogen peroxide alone. PAA is primarily used in the food and beverage industry, but it also has potential wastewater and storm water treatment applications. Removal efficiencies for bacteria depend on % PAA, dosage, length of contact and bacteria type.

Placement of PAA treatment systems depends on application; such systems are most likely to be placed in underground treatment tanks wherever space is available on-site and hydraulics allow. Manufacturers indicate that application rates should run less than 20 mg/L and typically between 5 mg/L and 10 mg/L. PAA systems generally see removals on the order of 90% and higher for 1-3 hours of contact time.

Costs depend on concentration of PAA (either 6% or 15%), method of application, and include initial purchase and installation of treatment system, purchase of PAA, and maintenance requirements.

PAA has been approved for discharge to land; discharge to surface waters will require obtaining a permit from the applicable project regulatory agency. Residual PAA concentrations and additional permitting requirements remain a concern. See Table 10 for a summary of Peracetic Acid.

Table 7 Peracetic Acid (Biocide)	
Control Measure	Biocide (PAA)
TMDL compliance method and performance	Requires controlled storage and post-application facilities to remove residual.
Cost-related data	The cost of application is estimated to be between $150 and $300 per million gallons of storm water treated **(Chemical cost only)**
Site-related data	Footprint to depend on storage facility size.
References	Harvey (2004)

2.2.3.5 Subsurface Flow Constructed Wetlands

Constructed wetlands provide an effective means of treating surface water, urban runoff and wastewater. Free-water-surface constructed wetlands (FWSCWs) are characterized by open water, a variety of submerged and emergent aquatic plants and varying degrees of depth. In sub-surface flow constructed wetlands (SSFCWs), water flows beneath the surface through a gravel matrix out of which wetland plants grow. The gravel provides an approximate thousand-fold increase in surface area for the growth of bacterial biofilms that increase the rate of contaminant degradation. Within the gravel matrix there are distinct oxygen rich (aerobic) and oxygen free (anaerobic) zones where specific microbial processes take place. In both cases, the majority of water treatment is a function of microbial processes on the FWSCW bottom or the biofilm covering the gravel in the SSFCW. The SSFCWs have gained popularity, because the water level is maintained below the media surface thus controlling odor and there is less likelihood of avian nutrient loading (bird droppings). In addition, there are fewer vector (mosquito) issues associated with SSFCW.

Constituents Targeted

SSFCWs have been studied for over 25 years and showed that they are highly effective in the removal of nitrogen (ammonium, nitrate and nitrite), phosphorus (organically bound-P and orthophosphate), suspended solids, biochemical oxygen demand (BOD), heavy metals and pathogenic microorganisms including protozoans (e.g. Giardia), bacteria (coliforms, fecal coliforms and other pathogens) and viruses (bacterial and human). The degree of constituent removal is most often a function of the loading rate, residence time and available carbon (BOD) to drive the microbial processes. Nitrogen is removed via microbial denitrification where the nitrate is converted to nitrogen gas. Phosphorus is taken up by plants and bacteria for metabolic purposes and also precipitates as calcium phosphate on the gravel. Heavy metals either adsorb to the biofilm or form insoluble metal sulfides. The pathogenic organisms often adsorb to the biofilm and are inactivated by the bacterial enzymes, viruses, and plant secretions or eaten by grazing protozoans.

The general range of nitrogen removal is 85-99% for a 4-8 day residence time. Similar percent removals were found heavy metals such as copper, zinc and cadmium in SSF with a 5-day residence time. Indicator bacteria such as total coliform bacteria had a two-log or 99% reduction, fecal coliform bacteria had a three-log or 99.9% reduction and human/bacterial viruses had a 99% reduction with a 5-day retention time.

SSFCW Design

As currently tested by the Orange County Water District (personal communication with Stephen Lyon, OCWD,). The SSFCWs typically are three feet deep and rectangular with the influent applied across the shorter axis. The gravel matrix can use 3/8" or 3/4" pea gravel (see Figure 19). The smaller gravel provides more surface area, but if the application is for non-point source surface waters there can be substantial deposition of non-degradable suspended solids that could lead to clogging. The 3/4" gravel would allow greater porosity and less likelihood of clogging . Construction of a

SSFCW begins with cutting into the ground and putting in either a base such as concrete or bentonite clay or some form of impermeable liner such as Hypolon or PVC sheeting. The base has a 1% slope to facilitate the flow and the plumbing is standard schedule 40 PVC tubing.

One group of local plants that has been very successful is bulrushes (genus *Scirpus*). They have a deep root system that allows for the transport of oxygen to the anaerobic zone to allow for nitrification of the ammonium and subsequent denitrification of the nitrate. The sequential aerobic and anaerobic zones throughout the wetland improve the possibility of removing/oxidizing/reducing any contaminant in the influent.

A residence time of at least 48 hours would be necessary to impart a partial treatment of the influent. The values on constituent removal listed above were from studies using primary, secondary and dairy farm wastewater. Surface runoff should have far lower levels of contaminants as so should require shorter treatment times.

A typical system configuration would be a cell that is 3.5 feet deep by 100 feet wide by 162 feet long. With an estimated porosity of 0.45 this cell would accommodate a flow of up to 121,000 gallons per day. This corresponds to an area of 7.6 gpd/SF, 131,600 SF/mgd, 3 acres/mgd.

Initial costs for subsurface wetlands are estimated at $26,000 to $55,000 per acre of wetland constructed; excavation and plants make up the bulk of this cost. Maintenance costs are usually a percentage of the capital cost. Specific cost data was not available for this study.

Operation and Maintenance

Once constructed, the SSFCWs need relatively little maintenance. The flow rates should be checked on a weekly basis and the plants should be harvested each year prior to the spring growth cycle. The mulched plants could go into digester tanks to act as a carbon-rich feed source to drive denitrification and other microbial activities. The SSFCW is constructed such that if there is no inflow, the subsurface water level will be maintained save for losses due to evapotranspiration. If there is no inflow for more that two weeks, water should be added to keep the plants from drying out. Prior to the rainy season, the accumulated silt should be flushed out and removed.

Advantages

Since this is a built structure it is far easier to control the physical/chemical/biological processes that occur within the wetland without having to deal with issues such as endangered species habitat, vector control or other aspects of permitting. It also offers the possibility of controlling the residence time that has a direct impact on the quality of the effluent. This technology is accepted by all project permitting agencies.

See Table 8 for a summary of Subsurface Flow Constructed Wetlands.

Table 8 Subsurface flow Constructed Wetlands	
Control Measure	Sub-surface flow constructed wetlands
TMDL compliance method and performance	Should meet TMDL discharge requirements. No applications/data to confirm for storm water usage.
Cost-related data	No specific data available, estimated $50-400K/MGD
Site-related data	Requires an area of about 3 acres/mgd
References	Lyon (2002) and Susilo (2003)

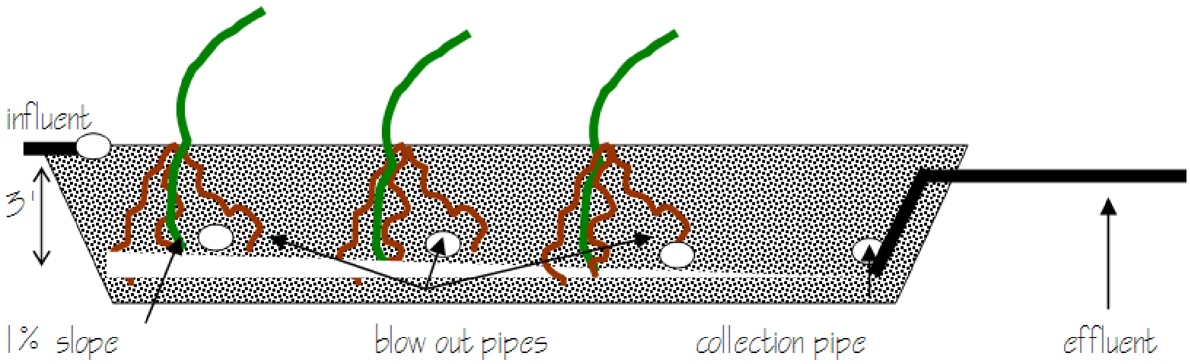

Figure 14. Typical SSF Constructed Wetland Configuration based on OCWD Research

This option involves diverting collected urban runoff, storing it as necessary, treating it, and beneficially reusing it as irrigation supply. Reuse options include landscape irrigation, industrial use, toilet flushing in buildings with dual piping systems, and other non-potable water uses. The Santa Monica Urban Runoff Recycling Facility (SMURRF), formerly the Santa Monica Dry-Weather Runoff Reclamation Facility (DWRRF), can be used as a model for the treatment plant that would be required to treat the runoff. It must be recognized that the SMURRF was designed to collect and treat dry weather runoff from two storm drains in the City of Santa Monica (the Pico-Kenter and Santa Monica Pier Storm Drains). Thus, it was designed to accommodate a relatively small and constant flow.

The SMURRF has an average capacity of 500,000 gallons per day (gpd) and a peak capacity 750,000 gpd (Antich, 2002). It employs a rotating drum screen and cyclone-type grit chamber to remove grit, small particles and debris, a dissolved air floatation (DAF) system to remove oil and grease, microfiltration and ultraviolet (UV) disinfection. A simplified schematic flow diagram of the SMURRF is presented in Figure 20.

The finished water is used for landscape irrigation at various sites. Since there are no water reclamation regulations dealing with storm drain runoff, the SMURRF was designed to produce California Department of Health Services (DHS) Title 22 effluent for biological oxidation (CH2M HILL et al. – 1997). This means that the effluent will meet the turbidity and disinfection criteria for irrigation in unrestricted access areas. The SMURRF does not include facilities to remove total dissolved solids (TDS). However, treatment processes that do not increase TDS were selected. For example, ultraviolet (UV) disinfection was selected instead of chlorine disinfection because the chlorination equipment requires the addition of chlorine and sulfur dioxide, which result in increased TDS levels. The SMURRF was designed to achieve a TDS limit of 1,000 mg/L. Space has been allocated for the future installation of reverse osmosis (RO) facilities should the need arise.

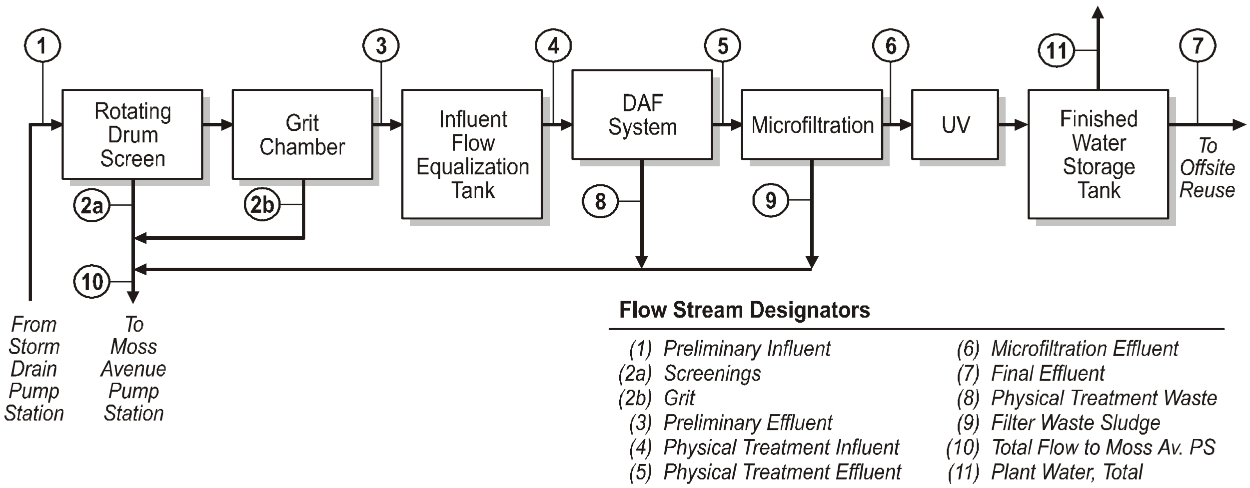

Figure 15. SMURRF Schematic Flow

The total capital costs for the SMURRF were $9 million. Of this, about $6.3 million was for treatment, and $2.7 million was for the distribution system. Approximately 12% of the plant cost, or $750,000, was related to architectural components specifically designed to incorporate public art and education. A 500,000-gallon tank for the raw and treated water was designed to accommodate tight site conditions. One side of the tank is a retaining wall for a highway on/off ramp (Pacific Coast Highway) The estimated cost of storm water treatment is estimated at $2.9 million ($5.80/gal. or $5.8M/MGD)

A similar facility to treat wet weather runoff would be much larger and would require large storage volumes upstream and downstream of the plant. The treatment process, however, would probably be similar. See Table 9 for a summary of the Capture, Store, Treat and Beneficially Reuse option.

Table 9 Capture, Store, Treat, and Beneficially Reuse	
Control Measure	Capture, Treat & Reuse (SMURFF)
TMDL compliance method and performance	Should meet TMDL discharge requirements. No applications/data to confirm for wet weather runoff usage.
Cost-related data	$5.8M/mgd
Site-related data	No data available
References	Antich (2002)

2.2.4 Capture, Store, Treat and Inject

This option deals with disposal by injection back into the groundwater table on a large scale.

2.2.5 Regional Wastewater Treatment

Although beyond the scope of wet weather TMDLs for stormwater, should septic systems be identified as a primary source of bacterial exceedances regional wastewater treatment may be an alternative to septic systems. Technically this alternative is similar to to both sections 2.2.1 and 2.2.2.

2.2.6 Summary

The following tables summarize the BMP approaches described above, as well as others listed in NET's original BMP matrix. It should be noted that different BMPs have different pre-treatment options (which can provide removal of multiple pollutants) and different integrated uses.

Table 10. BMP Type, Effectiveness, Benefit, and Cost Summary Table

	Design Basis			Treatment Effectiveness							Multipurpose Benefits			Cost**
	Flow-Based	Treatment Volume	Management Volume	***Bacteria***	Nutrients	Metals	Organics	Trash	Sediment	Oil & Grease	Reuse	GW Recharge	Open Space / Aesthetic	Relative Cost
Non-Structural Options														
Misc. Institutional Options [See list in table below]		N/A		U	U	U	U	U	U	U				$
On-Site Structural Options														
a) Cisterns			✓	U	U	U	U	U	U	U	✓			$
b) Storage and Reuse		✓	✓	3	3	3	3	3	3	3	✓			$$$
c) Small Scale Infiltration		✓	✓	3	3	3	3	3	3	3	✓	✓		$
d) On-site Wastewater				3	U	U	U	U	U	U				U
e) On-site StormTreat system	✓			2	3	3	3	3	3	3				$$$
f) Non-bacteria specific options [See list in table below]	✓	✓	✓	1-2	1-3	1-3	1-3	1-3	1-3	1-3	✓	✓	✓	$-$$$
Regional Structural Options														
1. Divert to Regional Facility	✓			3	3*	3*	3*	3*	3*	3*				$$$
2. Capture, Store, Treat, and Discharge		✓*	✓*	3	3*	3*	3*	3*	3*	3*				U
3. Capture, Store, Treat, and Reuse		✓*	✓*	3	3*	3*	3*	3*	3*	3*	✓			U
4. Capture, Store, Treat and Inject		✓*	✓*	3	3*	3*	3*	3*	3*	3*		✓		U
5. Wastewater Treatment	✓			3	U	U	U	U	U	U				$$$
6. Non-bacteria specific options [See list in table below]	✓	✓	✓	1-2	1-3	1-3	1-3	1-3	1-3	1-3	✓	✓	✓	$-$$$
Treatment options (subgroup of 2, 3, 4) recommended for bacteria treatment														
- Traditional Treatment/Small Package	N/A	N/A	N/A	3	U	U	U	1	1	1	N/A	N/A	N/A	varies
- Storm Water Filtration	N/A	N/A	N/A	U/2 exp	2	3	3	3	3	3	N/A	N/A	N/A	$$$
- Advanced Oxidation	N/A	N/A	N/A	U/3	U	U	U	1	1	1	N/A	N/A	N/A	$$

Table 10. BMP Type, Effectiveness, Benefit, and Cost Summary Table

	Design Basis			Treatment Effectiveness							Multipurpose Benefits			Cost**
	Flow-Based	Treatment Volume	Management Volume	***Bacteria***	Nutrients	Metals	Organics	Trash	Sediment	Oil & Grease	Reuse	GW Recharge	Open Space / Aesthetic	Relative Cost
				exp										
- Peracetic Acid/bactericides	N/A	N/A	N/A	U/3 exp	U	U	U	1	1	1	N/A	N/A	N/A	$
- SSF Wetlands	N/A	N/A	N/A	3	3	3	U	1	1	1	N/A	N/A	N/A	$

Notes:

* = Required pretreatment is included in overall treatment train and will remove many of the other constituent pollutants

** = Estimated construction costs based on current available data

1 = Least effective treatment category; negligible concentration reduction anticipated

2 = Medium effectiveness treatment category; significant/measurable concentration reduction anticipated

3 = Most effective treatment category; significant/measurable concentration reduction anticipated, with potential to meet relevant water quality standards

U = Anticipated performance unknown

U/2 exp = Anticipated performance unknown, but concentration reduction capability expected to be at category 2 or 3

Table 11. Non-Bacteria Specific BMP Options	
Non-Structural Options	
Automotive Product Disposal	Animal Waste Control
Commercial / Retail Good Housekeeping	Illicit Discharge Detection
Community Outreach & Education	Septic Inspection
Industrial Good Housekeeping	Street Sweeping
Pesticide / Herbicide Use	Parking Lot Sweeping
Fertilizer Use	Catch Basin Cleaning
Household Hazardous Material Disposal	Open Space Planning
Pet Waste Disposal	Neighborhood Incentives
Structural Options (On-site and/or Regional)	
Dry Swales	Green Parking
Bioretention	Rain Barrels
Rain Gardens	Wet Ponds
Filter Strips	Cisterns
Urban Stream Buffers	Oil/Water Separators
Catch Basin Inserts	Wastewater Treatment System
Continuous Deflective Separation (CDS)	Modular Units
Sand Filters	StormTreat
Infiltration Basins	Wet Swales
Infiltration Trenches	Constructed Wetlands
Dry Wells	Urban Trees
Porous Pavement	Green Roofs

3.0 Conclusions

A number of potential structural and non-structural BMP options are presented here. Final specific recommendations by prioritized subdrainage area (Task 4) will be based not only on technology, but on feasibility, costs, siting, permitting, reliability, and maintenance.

4.0 References

Anthony Antich, Harvey R. Gobas, and Jag Salgaonkar, 2002. "The Santa Monica Urban Runoff Recycling Facility and the Sustainable Environment" for Stormwater Journal. Forrester Communications.

Baldry, Cavador, French, et. Al. 1995. Effluent Disinfection in Warm Climates with Peracetic Acid. Wat. Sci. Tech. Vol 31. No. 5-6 pp. 161-164. IAWQ, Great Britain.

Buckminster Fuller Institute (www.bfi.org/Trimtab/fall00/living_machines.htm)

California Stormwater Quality Association. 2003. Stormwater Best Management Practice Handbook. www.cabmphandbooks.com

City of Cincinnati, 2000. Underground Treatment Facility Coming at http://www.msdgc.org/news/archives/mchighrate/. June 23, 2000.

City of Los Angeles Integrated Resources Plan Facilities Plan Interim Deliverable. Volume 3 Runoff Management, August 2003. Prepared by CH:CDM and City of Los Angeles Department of Public Works, Bureau of Sanitation

City of Los Angeles, Department of Public Works, Bureau of Sanitation. 2002. Development Handbook.

City of Los Angeles Department of Water and Power (LADWP), 2004, www/ladpw.org/wrd/publication/Engineering/online/Maps/07_Venice.pdf.

County of Los Angeles. 2002. Development Planning for Storm Water Management. September. http://www.ladpw.org/wmd/NPDES/SUSMP_MANUAL.pdf

Dharma Living Systmes. (www.dharmalivingsystems.com/water_systems/index.php)

EBMUD, 2004. Phone conversation and e-mail from Vince DeLange, East Bay Municipal Utility District to Bob Kemmerle, E2 Consulting Engineers, Inc.

Envrio Tech Chemicals. Tech Data BioSide(tm) HS15% (Peroxyacetic Acid Solution) Modesto, CA

Featherstonhaugh, David, Hydroxyl Systems, 2002, Proposal to Ken Susilo, Psomas, December 10, 2002.

Georgia Concrete & Products Association. www.gcpa.org. (http://www.gcpa.org/pervious_concrete_pavement.htm)

Gartland,Lisa._http://www.cleanaircounts.org/resource%20package/A%20Book/Paving/other%20pavings/coolpave.htm#porous

Harvey, Mike, Enviro-Tech, 2004. Phone conversation with Bill Whittenberg, Psomas, April 14, 2004.

Harris, Will, Stormwater Management, Inc. 2004. Email to Ken Susilo, Psomas, April 11, 2004.

Kramer, JF. 1997. Peracetic Acid: A New Biocide for Industrial Water Applications. Corrosion 97. NACE International, Houston TX.

Metcalf and Eddy, 1972. Wastewater Engineering: Collection, Treatment, and Disposal. McGraw- Hill Book Company.

National Science Federation, 1999. Regulatory World, TWO ETV PILOTS UNDERWAY at http://www.nsf.org/business/newsroom/regworld99-2/source.html

O'Donnell, David TreePeople, 2004. Phone conversation with Bob Kemmerle, E2 Consulting Engineers ,April 14, 2004

O'Donnell, David, TreePeople, 2004. Email to Bob Kemmerle, E2 Consulting Engineers, April 20, 2004.

Pounders, Brad. Hancor. 2004. Personal communication with Myles Harrold. April 29.

Scnaidt, Mark (Clear Creek Systems, Inc.), 2004. Telephone conversation with Bob Kemmerle, E2 Consulting Engineers, Inc. on May 3, 2004.

Susilo, Ken 2003. Storm Water Strategies for Mitigating Bacteria And Nutrient Loads in Highly Sensitive Receiving Waters with Complex Hydrologic Conditions A Case Study In Malibu, CA. American Water Resources Association National Conference, San Diego, CA.

Susilo, Ken; Kemmerle, Bob; Dekermenjian, Hampik; Jones, Dave. 2004. Santa Monica Bay Beaches Wet Weather Bacteria TMDL Implementation Plan Technical Memorandum Task 6: Treatment and Management Options. August 30.

Susilo, Ken. 2004 Santa Monica Bay Beaches Wet Weather Bacteria TMDL Implementation Plan Jurisdictions 1 and 4 Technical Memorandum Task 3.1: Structural Best Management Practices. November 17.

USEPA, 1999. United States Environmental Protection Agency Office of Water Washington, D.C. EPA 832-F-99-023. Storm Water Technology Fact Sheet Porous Pavement, September.

USEPA 2002. Wastewater Technology Fact Sheet. The Living Machine. Office of Water EPA 832.F-02-025. October

Watersave (www.watersave.uk.net/Presentations/index4.html)

Table 12. Example of BMP Scoring Matrix: Regional BMP Site

Area Name: BI5202-1
Management Solution Type: Regional

Ranking	Potential Fatal Flaw?	Weight	Score (1=worst - 5=best, FF)		
			Infiltration	Detention w/ SSF wetlands	Disinfection Treatment
Cost		**30.0%**			
– Capital	N	20.0%	5	3	1
– Operations and Maintenance	N	10.0%	4	3	1
Effectiveness		**30.0%**			
– Treatment levels	N	20.0%	5	4	5
– Multiple Pollutants	N	2.5%	5	4	4
– Volume mitigation	N	2.5%	5	3	2
– Reliability	N	5.0%	3	3	3
Implementation		**30.0%**			
– Implementation Issues					
– – Engineering/Siting Feasibility	Y	15.0%	FF	4	2
– – Ownership/Right-of-Way/Jurisdictions	Y	5.0%	3	3	3
– – Environmental Clearance	N	5.0%	4	4	2
– – Permitting, Water Rights	Y	2.5%	5	5	2
– Safety	Y	2.5%	3	3	4
Environment/Other Factors		**10.0%**			
– Other Beneficial Uses (e.g., conservation)	N	5.0%	5	4	1
– Other potential consequences	Y	5.0%	3	3	3
Weighted Score		**100.0%**	FF	3.525	2.5

Table 13. Example of BMP Scoring Matrix: Localized BMP Site

Area Name: ARRSC11-3
Management Solution Type: Distributed

Ranking	Potential Fatal Flaw?	Weight	Score (1=worst - 5=best, FF)			
			Cisterns	Bioretention	Porous Pavements (grasspave)	
Cost		**30.0%**				
– Capital	N	20.0%	3	4	2	
– Operations and Maintenance	N	10.0%	2	3	3	
Effectiveness		**30.0%**				
– Treatment levels	N	20.0%	3	3	3	
– Multiple Pollutants	N	2.5%	4	4	4	
– Volume mitigation	N	2.5%	4	4	4	
– Reliability	N	5.0%	4	4	3	
Implementation		**30.0%**				
– Implementation Issues						
– – Engineering/Siting Feasibility	Y	15.0%	3	3	3	
– – Ownership/Right-of-Way/Jurisdictions	Y	5.0%	5	5	5	
– – Environmental Clearance	N	5.0%	5	5	5	
– – Permitting, Water Rights	Y	2.5%	5	5	5	
– Safety	Y	2.5%	4	4	3	
Environment/Other Factors		**10.0%**				
– Other Beneficial Uses (e.g., conservation)	N	5.0%	5	4	3	
– Other potential consequences	Y	5.0%	2	3	3	
Weighted Score		**100.0%**	3.325	3.625	3.1	0

Appendix 5: Habitat Restoration Analysis

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Section A5-1: Selection of Focal Species

Arroyo Seco Watershed Restoration Feasibility Study Conclusions

The Arroyo Seco Watershed Restoration Feasibility Study (ASWRFS) concluded that elements of watershed and habitat restoration are feasible, and will enhance recreational prospects, based on that initial evaluation of opportunities and constraints on the land, along with indications of agency and general public interest that can ultimately generate policy and funding opportunities. A number of conceptual projects and studies were recommended to cumulatively advance watershed restoration. The projects were ranked according to their potential contributions to the five components of stream and habitat restoration, water supply, water quality and recreation/open space.

As a means of focusing habitat restoration planning throughout the watershed the ASWRFS proposed an initial suite of focal species to serve as the subjects for structuring restoration efforts. The ASWRFS identified focal species as follows:

***Fish Species**:* **Steelhead (Wild Rainbow Trout)**: flagship/umbrella species – encompasses requirements for **Pacific Lamprey**, as well as for lower elevation focal fish species [following]; **Unarmored Threespine Stickleback**: umbrella species – encompasses requirements for lower elevation **Arroyo Chub, Santa Ana Sucker** and **Santa Ana Speckled Dace**.

Terrestrial Species: **Arroyo Toad**: ecosystem health indicator for "fluctuating hydrological, geological, and ecological processes operating in riparian ecosystems and adjacent uplands" (USFWS 1999); **Southwestern Pond Turtle**: ecosystem health indicator for upper watershed tributaries; **Yellow Warbler**: umbrella species for high quality riparian habitat, shaped by natural fluvial processes; **Arboreal Salamander**: umbrella species for high quality oak, walnut and sycamore woodland habitats, including connectivity to riparian areas; **Oak Titmouse**: umbrella species for woodlands that may be somewhat fragmented, but still offer significant habitat value for species less effected by loss of terrestrial connectivity; **Coast Horned Lizard**: ecosystem health indicator for certain aspects of alluvial fan and coastal sage scrubs; **Lesser Nighthawk**: umbrella species for certain aspects of alluvial fan sage scrub, especially area requirements; **Plummer's Mariposa Lily**: ecosystem health indicator and tentative flagship species for alluvial fan sage scrub and chaparral; **Cactus Wren**: flagship species for alluvial fan and coastal sage scrub – stands of *Opuntia* species; **Greater Roadrunner**: flagship species for coastal and alluvial fan sage scrub and grassland habitat connectivity; **California Gnatcatcher**:

tentative umbrella species for restoration of coastal sage scrub quantity, quality and habitat connectivity; **Grasshopper Sparrow**: umbrella species for grassland habitats; **California Quail**: flagship species for upland habitat connectivity; **Behr's Metalmark & Square-spotted Blue Butterflies**: these butterflies may serve as umbrella species for the restoration of smaller patches of alluvial fan and coastal sage scrub, potential flagship species for restoration of these habitats in the Lower Arroyo; **Bobcat**: population health indicator for viability of prey species and their ecological relationships; potential umbrella species for landscape-scale connectivity and may serve some of the functions of Mountain Lions, the likely Keystone species, which is essentially excluded from the urbanized portions of the watershed; **Gray Fox**: possible population health indicator for viability of prey species and their ecological relationships, as well as indicator of habitat connectivity at possibly finer scales than Bobcat.

While they were received too late to be integrated into that document, comments provided by Scott Harris, California Department of Fish and Game, included the proposal of **Coast Range Newt** as a focal species (primarily for the upper watershed) since, like Arroyo Toad and Southwestern Pond Turtle, it requires upland, as well as wetland habitat, and also like the others “range[s] surprisingly far from drainages for feeding, breeding and/or aestivation, and to escape flooding”. We agree with that proposal.

Retrospective Withdrawal of Two ASWRFS Focal Species

The initial effort to identify focal species for the ASWRFS included brainstorming among a group of knowledgeable contributors, including agency personnel, as well as research by the authors of the Habitat Restoration technical report. Unfortunately, in the expansive effort to bring it all into consideration on a tight budget a couple issues fell through the cracks. This section serves as errata regarding the initial list of focal species.

Cactus Wren & the Historic Character of Alluvial Scrub in the Watershed

During the course of the current study Mickey Long, Natural Areas Administrator for the Los Angeles County Department of Parks and Recreation, brought to our attention that there are apparently no historic records of Cactus Wren in the Hahamongna area, a fact that effectively negates it as a focal species for habitat restoration.

This knowledge fit with V. Jigour’s observations in more intact (at least in the early 1990s) alluvial scrub areas throughout the region, including Big Tujunga and Santa Ana Washes in particular, of Cactus Wren nests preferentially in snake cholla (*Opuntia parryi*), rather than coastal prickly pear (*Opuntia littoralis*), which is also present in those washes. In contrast to the flattened oval pads of coastal prickly pear, snake cholla grows cylindrical branches whose bifurcations, left undisturbed over decades, create well-defended fortresses with lots of interior open space for nests and lots of prickles on the outside to thwart potential predators. Other logical reasons for Cactus Wren's apparent preference may include the much taller statures ultimately reached by snake cholla in undisturbed alluvial scrub – sometimes reaching heights of six feet or more – while coastal prickly pear tend to remain much lower growing in alluvial scrub habitats, along with its probably more effective prickles (similar to the infamous "jumping cholla" of Anza Borrego State Park's low desert). Cumulatively these features seem to provide the perfect combination of prospect and refuge.

Snake cholla does not presently occur in the Arroyo Seco watershed – more specifically Hahamongna where it might be expected. Since it has not been a focus of our current effort we have not learned whether this cactus species was documented as historically present. This detail would provide helpful insight into the appropriate character for alluvial scrub restoration efforts in the Arroyo Seco. While coastal prickly pear occurs in both coastal sage and alluvial scrub associations, snake cholla does not occur in coastal areas but tends to be prominent in the hottest, driest alluvial scrub environments.

A notorious alluvial scrub species that we know was **not** documented as historically present in the Arroyo Seco watershed is the federally Endangered species slender-horned spineflower (*Dodecahema leptoceras*), whereas it was known to occur at Big Tujunga Wash, Rubio Canyon, Santa Anita Canyon and the West Fork of the San Gabriel River, among other regional occurrences.

Such distinctions cause us to consider that certain features of canyon structure, such as orientation to reception of desert climatic influences, especially so-called Santa Ana Winds, likely influence the patterns of alluvial scrub species distribution specific to each of the historic canyons. For example, in contrast to the broader structure and relatively gentle descent of Big Tujunga Canyon that facilitates the formation of Santa Ana Winds, Arroyo Seco Canyon descends sometimes steeply on a narrow, more winding path that becomes downright twisting through the gorge area – possibly defying the formation of hot, desiccating winds that might otherwise be nurtured there and leaving Hahamongna's climate less extreme than other historic alluvial scrub occurrences in the region. A related observation is the presence of numerous white alders (*Alnus rhombifolia*) and a few big-leaf maple (*Acer macrophyllum*) as far downstream as the soft-bottom sections of the stream in Pasadena's Central Arroyo Park. These typically mesic species tend to decrease in frequency, or in the case of the maple, drop out completely in areas downstream of the drier, more desert-like alluvial washes.

Related to the apparent absence of Cactus Wren from historic Hahamongna, one must wonder whether there was once enough alluvial scrub habitat there to support Lesser Nighthawk, which requires large areas for foraging. Future research into its historic presence/absence in the Hahamongna area will help to refine expectations and aims of alluvial scrub habitat restoration there.

Gray Fox – A Mesopredator

Gray Fox may arguably be a charismatic native mammal species with some potential public appeal. However, it was documented as among the mesopredators (predators smaller than those considered to regulate food webs in top-down fashion like mountain lions) that can take heavy tolls on scrub-dwelling bird species in one of the first studies of its kind on the ecological effects of coastal sage scrub habitat fragmentation in San Diego County, along with follow-up studies.[2] Since those reports have been staples of our education in conservation biology, the appearance of Gray Fox as a suggested focal species for habitat restoration was an erroneous oversight that simply escaped the ASWRFS team's attention. Therefore, Gray Fox is hereby withdrawn from consideration as a focal species for habitat restoration efforts.

Arroyo Seco Watershed Restoration & Management Plan

Focal Species Selection

With its emphasis on restoring water quality, this project is geographically focused on the urbanized area, rather than the mountainous watershed. Correspondingly, we have chosen a selection of focal wildlife species applicable to the urbanized portion of the watershed, including one bird species that was not identified as a focal species in the ASWRFS.

Arroyo Seco Watershed Restoration & Management Plan Focal Species

- Arroyo Chub (*Gila orcutti)*
- Yellow Warbler (*Dendroica petechia brewsteri*)
- Oak Titmouse (*Baeolophus inornatus affabilis*)
- California Quail (Callipepla californica)
- Spotted Towhee (Pipilo maculates megalonyx)

Criteria for ASWRMP Focal Species Selection

Species were selected for the ASWRMP based on the following criteria:

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[2] Crooks, K. R. & M. E. Soulé. 1999. Mesopredator release and avifaunal extinctions in a fragmented system. *Nature* **400**:563 566.

Crooks, K. R., A. V. Suarez, D. T. Bolger, M. E. Soulé. 2001. Extinction and colonization of birds on habitat islands. *Conservation Biology* **15**: 159-172.

Soulé, M. E., D. T. Bolger, A. C. Alberts, J. Wright, M. Sorice, S. Hill. 1998. Reconstructed dynamics of rapid extinctions of chaparral-requiring birds in urban habitat islands. *Conservation Biology* **2**: 75-92.

- Represent important habitats to be restored in the lower watershed (downstream of the San Gabriel Mountains)
- Habitat restoration for the species feasible and potentially measurable within the next ten to twenty years given existing opportunities, including officially adopted planning directives
- Restoration of habitat for the species will support the cumulative watershed restoration essential to restoring the full range of ASWRFS focal species

We chose two of the species for their potential relationship to water quality goals – Arroyo Chub and Yellow Warbler. As a fish species the Arroyo Chub is dependent on relatively good water quality, and the Yellow Warbler inhabits riparian vegetation that is necessarily dependent on watershed processes. Based on our initial research, including consultation with noted fish biologist Camm Swift, we chose Arroyo Chub over the Unarmored Threespine Stickleback proposed in the ASWRFS as an umbrella species for low elevation fish species upon. Issues we considered included concern that restoration of the species itself (as opposed to simply habitat restoration) may be more feasible since Arroyo Chub does not have the regulatory restrictions of the federally listed endangered Unarmored Threespine Stickleback. And, restoration of Arroyo Chub habitat would also provide habitat for future populations of Unarmored Threesping Stickleback.

For Oak Titmouse and Spotted Towhee, the relationship to water is less obvious, but the oak woodland and dense shrub habitats they require for breeding are important habitats in the southern watershed. While Arboreal Salamander would be an excellent indicator for connectivity of oak and other high quality woodlands with riparian areas, little is known about its present distribution in the watershed, whereas Oak Titmouse is obviously easier to spot and work with. Consideration of the salamander's needs should be built into woodland protection and restoration programs aimed at Oak Titmouse, reinforcing the connection to watershed functions. If it proves possible to restore sufficient habitat connectivity that California Quail may someday scurry through the scrub of Pasadena's Lower Arroyo Seco Park they will need fresh water to sustain them through the dry months. For the most densely urbanized parts of the lower watershed, Spotted Towhee is among the few native scrub species that we may reasonably expect to restore to isolated habitat fragments of relatively small size, but again, serving watershed functions. For that reason, it serves as a more suitable focal species for scrub restoration than would California Gnatcatcher, whose needs are more demanding and whose potential return to the watershed likely depends on factors outside, as well as within the watershed.

With a larger budget we might have considered additional focal species. However, we note the likely synergistic effects of habitat restoration aimed at this suite of five species in supporting restoration of other ASWRFS focal species in the following section.

Habitat Restoration Synergies: Connections Among ASWRMP & ASWRFS Focal Species

While this project focuses habitat restoration on five species germane to the urbanized lower watershed (generally below the San Gabriel Mountains /Angeles National Forest), implementation of the proposed projects will cumulatively benefit the ecosystem and watershed, including several of the ASWRFS Focal Species.

Habitat restoration for the aquatic focal species, Arroyo Chub, necessitates reconnection of the Arroyo Seco mainstem with tributaries and floodplains that can offer refuge from the high velocities of storm events that can exceed 15,000 cubic feet per second (cfs). When Camm Swift generously donated time for brief reconnaissance of lower Flint Canyon and the Low Flow Wetlands at Pasadena's Lower Arroyo Seco Park, we learned that the gentle riffles of the low flow features could currently support an introduced population of Unarmored Threespine Stickleback, whereas the artificial flow regime cannot duplicate the structure of undercut banks and pools required by Arroyo Chub. Such habitat structuring in nature occurs through the interplay of strong hydraulic forces with rocks, roots and woody debris lining the banks of the stream. So in this case, the requirements for Arroyo Chub may actually encompass the requirements of the stickleback and the other low elevation species, and the chub may actually be the better umbrella species.

Moreover, restoration of the connected stream and floodplain system required by Arroyo Chub will establish conditions more favorable to the eventual upstream passage of Steelhead or Wild Rainbow Trout, identified in ASWRFS as the focal species for restoration of higher elevation, cold water habitat. These cold-water fish cannot muscle their way upriver against the unmitigated force of channelized flows. In addition to providing the shade needed to maintain cold water temperatures, the protection and restoration of high quality riparian habitat for both Arroyo Chub and Yellow Warbler will support restoration of aquatic food webs required by Steelhead/ Rainbow Trout, as well as the chub, since leaf and insect drop from riparian vegetation form the basis for aquatic food webs.

Overall aquatic habitat connectivity is where the directives of this current effort admittedly fall short of addressing the eventual use of the entire Arroyo Seco by Steelhead or Wild Rainbow Trout. At present the most immanently foreseeable scenarios for stream restoration in the urbanized areas involve only **segments** of the watershed that are addressed herein for Arroyo Chub. The problems inherent to restoring the salmonid are well beyond the scope of this study, including the need to assess and address barriers in the mountains, as well as the urban portion of the watershed, along with connectivity to the ocean in the case of Steelhead. However, restoration efforts aimed at restoring the stream and floodplain systems needed by Arroyo Chub over segments of the watershed will only complement future efforts aimed at restoring passage for Steelhead/Wild Rainbow Trout.

With projects proposed for both Arroyo Chub and Yellow Warbler habitat reaching upstream into the mountains, those efforts will certainly provide localized benefits for Southwestern Pond Turtle and Coast Range Newt, as well as for Arroyo Toad if it is indeed present or returns to the watershed. The connected stream/floodplain systems required by Arroyo Chub will also restore suitable habitat for Arroyo Toad.

Protection and restoration of oak, walnut and sycamore woodlands in the northern portion of our study area for Oak Titmouse can benefit many other species, including Arboreal Salamander. Where applicable, the connectivity to riparian areas needed by the salamander should be considered a corollary objective in planning and designing woodland restoration projects.

Efforts to restore habitat connectivity for California Quail may provide some potential movement linkages for Bobcat, which can serve as an ecosystem regulating stand-in for Mountain Lion in residential areas of the watershed that still retain significant open space. If California Quail are to ever return to Pasadena's Lower Arroyo Park and potentially beyond, public collaboration will be needed, including control of pets in natural areas as well as provision of backyard habitat and other measures. Such measures on behalf of the public could be synergistic for an array of wildlife species yet to be enumerated.

In the lower watershed Spotted Towhee provides a directive for restoration of scrub habitats even though they may be fragmented. If California Gnatcatchers ever return to the general area of the Arroyo Seco watershed, they will be supported by habitat restoration efforts aimed at Spotted Towhee. Whereas Spotted Towhee especially favors the dense scrub that develops on more protected north-to-eastern exposures, the more open scrub that will develop on certain associated south-to-western exposures, as well as alluvial scrub areas, could favor the return of Behr's Metalmark and Square-spotted Blue Butterflies to the lower watershed.

Behr's Metalmark and Square-spotted Blue Butterflies, along with Coast Horned Lizard are among the species that would benefit from restoration of alluvial scrub habitat, which is not covered by the focal species we selected for this project. The only suitable area of the watershed for large-scale alluvial scrub restoration is Hahamongna, and the park master plan for that area specified extremely limited restoration of alluvial scrub. Therefore, little was to be gained by including an alluvial scrub focal species in this study. However, pockets of alluvial scrub habitat will be appropriate in certain restoration projects aimed at California Quail and Spotted Towhee that will hopefully entice the butterflies.

Section A5-2: Habitat Restoration Models/Objectives for Focal Species

Overview

The relationship between restoration of habitats and restoration of water quality may not always be obvious. We can speculate that water quality was better when wildlife habitats were abundant throughout the watershed, partly because those intact habitats helped sustain good water quality. Unfortunately the strongest correlation may be that abundant wildlife habitats were associated with a smaller human population, since we are collectively the source of our own water quality problems. But habitat restoration can provide direct and indirect benefits to water quality and certain wildlife species can serve as indicators of water quality. So habitat restoration is a natural component of a watershed restoration plan.

Because the word has been enjoying increasing popularity, it is appropriate to begin with a definition of *habitat* – even better to get that definition in context from an illustrious source in the field of ecological restoration, Michael Morrison.

> I define *habitat* as the resources and conditions present in an area that affect occupancy by a species. Habitat is organism-specific: it relates the presence of a species, population, or individual (animal or plant) to an area's physical and biological characteristics. Habitat involves more than vegetation or vegetation structure; it is the sum of the specific resources needed by a species. Whenever an organism is provided with resources that affect its ability to survive, that is habitat. Migration corridors, dispersal corridors, and the land that animals occupy during breeding and nonbreeding seasons – all are habitat. Thus, habitat is not equivalent to *habitat type*, a term coined by Daubenmire (1968:27-32) that refers only to the type of vegetation association in an area or the potential of vegetation to reach a specific climax stage. Habitat is much more than an area's vegetation (such as pine-oak woodland). The term *habitat type* should not be used when discussing wildlife/habitat relationships. When we want to refer only to the vegetation that an animal uses, we should say *vegetation association* or *vegetation type* instead.
>
> The confusion between habitat and habitat type has led to a general misconception about how to restore an area for wildlife. If habitat is species-specific, then any plot of land has numerous habitats; each habitat corresponds to specific species. As you gaze across an area,

> therefore, you area viewing numerous habitats of likely different quality. Thus the definition of habitat as species-specific is an absolutely critical concept. It means that restoring vegetation, regardless of how well it matches some desired condition, can easily fail to restore the desired assemblage of wildlife. Failure to plan simultaneously for plant and animal restoration results in a hit-or-miss strategy for animals and it clearly falls under the Field of Dreams hypothesis – "if you build it they will come" (Palmer et al. 1997: 295). Restoring vegetation restores wildlife habitat for *some* species, but not necessarily the species desired. Poor planning for wildlife may create an ecological trap in which an undesired species kills or harasses a desired species or its young. (Morrison 2002: 44)

Morrison goes on to define a series of other terms concerning habitat and the interested reader is encouraged to obtain that text.

Now that we share the common understanding that habitat is species-specific, our approach of selecting focal wildlife species for habitat restoration may be more meaningful. In order to achieve habitat restoration we must have one or more wildlife species in mind. We need to understand how that species relates to its environment – how it responds to physical processes and how it accesses resources. So we select focal species whose habitat needs we can begin to home in on. It makes sense to select focal species that serve as indicators of some kind. They could be indicators of physical conditions, such as water quality. Ideally they will serve as physical environment indicators and also serve as stand-ins or representatives for other wildlife species with similar habitat needs. This may be sort of a hybrid Field of Dreams approach – "if we build it for species *x*, then *y* and *z* may come". At least they'll have a better chance. But, assuming we learn as much as we can about the habitat needs of species *x*, with this focal species strategy we stand a better chance of achieving habitat restoration for at least one native wildlife species than if we just began planting native plants.

We selected a suite of focal wildlife species potentially applicable to the urbanized portion of the watershed. Appropriate to the scope of the current project we selected a subset of the focal species proposed for the Arroyo Seco Watershed Restoration Feasibility Study (ASWRFS). For this effort we stepped down in scale to focus on the lower portion of the watershed. Accordingly, we have added a focal bird species with habitat requirements plastic enough to be restorable to the finer-grained opportunities present in the urban matrix. The set of species chosen for this study met the following criteria:

- Represents important habitats to be restored in the lower watershed (downstream of the San Gabriel Mountains)

- Habitat restoration feasible and potentially measurable within the next ten to twenty years given existing opportunities, including officially adopted planning directives
- Restoration of habitat for the species will support the cumulative watershed restoration essential to restoring the full range of ASWRFS focal species

We chose two of the species for their potential relationship to water quality goals – Arroyo Chub and Yellow Warbler. As a fish species the Arroyo Chub is dependent on relatively good water quality, and the Yellow Warbler inhabits riparian vegetation that is necessarily dependent on watershed processes. For Oak Titmouse and Spotted Towhee, the relationship to water is less obvious, but the oak woodland and dense shrub habitats they require for breeding also serve watershed functions. If it proves possible to restore sufficient habitat connectivity that California Quail may someday scurry through the scrub of Pasadena's Lower Arroyo Seco Park they will need fresh water to sustain them through the dry months. For the most densely urbanized parts of the lower watershed, Spotted Towhee is among the few native scrub species that we may reasonably expect to restore to isolated habitat fragments of relatively small size, but again, serving watershed functions. And where restoration opportunities exist that may not lend themselves to habitat restoration for this selection of focal species, especially likely in the lower watershed, such sites may serve as habitats for native plant associations whose animal constituents will be learned only with observation over time. But these sites can also serve cumulatively significant watershed functions.

To help us understand the specific habitat requirements of our suite of focal species we have identified ecological reference sites where the focal species occur and breed. We sought reference sites with conditions that could be emulated within the Arroyo Seco watershed and have summarized salient features of those sites as they apply to our understanding of the focal species' habitat needs. We then developed simple models of those needs to serve as general objectives for habitat restoration projects. A caveat is appropriate to distinguish our qualitative "rapid assessment" approach from quantitative assessment and modeling. The reference from which our introductory quote was taken provides an excellent overview of the types of measurements that may be taken to develop quantitative assessments of habitat features.

Examples of such measurements include evergreeness of overstory or shrubs, overstory tree dispersion, canopy closure, ground level and ground cover vegetation, woody stem density, herbaceous stem density, fallen log size, % leaf litter cover, litter-soil depth and compactibility, distance to rocks, soil temperature, soil relative humidity and ambient relative humidity (Morrison 2002). These examples represent just a few of the extensive measurements that have been taken in habitat assessment sampling and modeling. Morrison notes that wildlife researchers have historically been less concerned about identifying specific plant species comprising habitats than they perhaps should have been and he also notes that all these observations must be understood within their temporal (time) and spatial scale contexts. Usually such extensive sampling is done on behalf of endangered or threatened wildlife species whose habitat needs may be very specific, or conducted as part of graduate student research. Such time-consumptive assessment is beyond the means of this project and likely beyond what is necessary in our case, at least at this point. We intentionally selected focal species that are not endangered or threatened, and the bird species especially tend to be somewhat generalized in their habitat needs, within certain parameters. So we have set out to articulate a “vision” for habitat restoration for each of the species that can be used to evaluate restoration opportunities within the watershed – a first step the process of restoring those sites to once again support our wildlife heritage.

Arroyo Chub (*Gila orcutti)*

Introduction

We chose Arroyo Chub as a focal fish species for habitat restoration in the Arroyo Seco watershed because, among the historically indigenous low elevation, relatively warm water fish species, its habitat requirements appear most readily achievable through focused habitat restoration efforts. In the Arroyo Seco Watershed Restoration Feasibility Study, Unarmored Threespine Stiickleback (*Gasterosteus aculeatus williamsoni*) was designated an “umbrella species” for low elevation fish habitat restoration on the Arroyo Seco because fulfilling its habitat requirements would incidentally meet the needs of other low elevation fish species, including Arroyo Chub and Santa Ana Sucker (*Catostomus santaanae*). In the current study we have selected Arroyo Chub as a focal species whose habitat restoration not only seems most readily achievable, but whose potential reintroduction may more readily be implemented through collaboration of public and private organizations because it does not have the regulatory status of the federally listed endangered Unarmored Threespine Stickleback or the threatened Santa Ana Sucker. Arroyo Chub is a California state listed Species of Special Concern. The restoration of habitat for, and potential reintroduction of Arroyo Chub would constitute a step toward restoration of the entire system that we hope may once again support Steelhead. Achievement of that goal will require the cumulative restoration of watershed function that we hope our entire suite of focal species sets in motion.

Further supporting the choice of Arroyo Chub as a focal species for the current effort, while any of the native fish species would naturally require relatively good water quality, laboratory studies have revealed that Arroyo Chub are tolerant of the temperature fluctuations common to the region's low elevation streams (higher temperatures occur under low water conditions), and that they are physiologically adapted to survive hypoxic conditions (Moyle et al. 1995 citing Castleberry and Cech 1986). So they appear a good species to begin the transition back to watershed conditions that will support other native fish species.

Previously referred to as the California Minnow (Culver and Hubbs 1917), the Arroyo Chub is a relatively small fish that can reach lengths of 120 mm (4.7 in.) but typical adult lengths are 70-100 mm (2.8-3.9 in.). The body color is silver or grey to olive-green dorsally, white ventrally, and there usually is a dull grey lateral band (Moyle et al. 1995 citing Moyle 1976). Arroyo Chub have chunky bodies, fairly large eyes, and small mouths.

> Arroyo Chub are fractional spawners that breed more or less continuously from February through August, although most spawning takes place in June and July (Tres 1992). Most spawning occurs in pools or in quiet edge water, at temperatures of 14- 22° C. During spawning, males follow a ripe female while actively rubbing the upper part of their snouts against the area below the female's pelvic fins. The rubbing and chasing leads to egg release and the eggs may be fertilized by more than one male (Tres 1992). The embryos adhere to the bottom and hatch in 4 days at 24 C. The fry spend their first few days after hatching clinging to the substrate but rise to the surface once the yolk sac has been absorbed (Tres 1992). The next 3-4 months are spent in quiet water, in the water column and usually among vegetation or other flooded cover. . . . Females first reproduce after reaching one year of age. After their second year, females generally grow larger than males. Arroyo chubs rarely live beyond four years. . . .
>
> They are omnivorous, feeding on algae, insects, and small crustaceans. However, most (60-80%) of the stomach contents consist of algae (Greenfield and Deckert 1973). They are also known to feed extensively on the roots of a floating water fern (*Azolla* sp.) infested with nematodes (Moyle 1976). (Moyle et al. 1995)

Typical Arroyo Chub habitat consists of slow-moving or backwater sections of warm to cool (10-24° C; 50-75° F) streams with mud or sand substrates, and with depths typically greater than 40 cm. (16 in.) (Wells and Diana 1975). The tiny chub need side channels or tributaries to escape to when high velocity flows occur (Swift pers. com.). Such escape routes would have been more common on the braided floodplains of pre-development river basins.

As summarized in the Arroyo Seco Watershed Restoration Feasibility Study (with slight modifications) the habitat requirements of Arroyo Chub include the following:

Water Temperature – below 31° C (87.8° F)

Dissolved Oxygen – 7.22 ppm "normal for clean, natural streams in southern California" (Feldman, Baskin) 2.0 ppm lowest tolerance limit.

Nesting Sites – Areas of gentle flow and near or within aquatic vegetation (filamentous algae). Nesting velocity 0 -.08 m/second

Rearing –Young fish seek cover from predators in aquatic vegetation.

Favorable Habitat Conditions – Mild water velocities, some circulation, and moderate algal cover; sand dominated substrate or mud with low amount of cobbles and deposited silt.

Flow – Portions of stream can be dry part of the year.

(Adapted from Stoecker in Jigour et al. 2002)

During the 1970s measurements were taken of stream attributes throughout coastal southern California. The following are the metrics associated with the portion of upper Big Tujunga Creek that supported Arroyo Chub at that time. (Wells and Diana 1975)

	Reported	English Equiv.
Elevation (m)	975	3198 ft
Mean Width (m)	3.3	10.8 ft
Mean Depth (cm)	14.8	5.8 in
Flow Velocity (cm/s)	2.6	2 in/s
Volume Flow (m^3/s)	0.011	0.388 cfs
Gradient (degrees)	0.10	
Date	12.VI.75	June 12, 1975
Time (P.S.T.)	1400	2 pm
Air Temperature (°C)	29	84.2° F
Water Temperature (°C)	28	82.4° F
Dissolved Oxygen (ppm)	7	
CO_2 (ppm)	15	
Total Hardness (ppm)	171	
PH	8.1	
Salinity (0/00)	0.0	
Turbidity (J.U.)	16	
Invertebrate Fauna		

Coleoptera	+
Dipterea	+
Ephemeroptera	+
Hemiptera	+
Odonata	+
Tricoptera	+
Hydracrina	
Crayfish	

Wells and Diana (1975) did provide these metrics for two points on the upper Arroyo Seco but since the conditions there were more applicable to Rainbow Trout than to Arroyo Chub we have not included them here. Note that the above Big Tujunga Creek data was taken at a montane elevation but the conditions were similar to low elevation sites in contrast with the data recorded at the same elevation on the Arroyo Seco.

The historic distribution of Arroyo Chub included the Los Angeles, San Gabriel, San Luis Rey, Santa Ana, and Santa Margarita rivers and Malibu and San Juan creeks (Wells and Diana 1975). Historic locations included the Arroyo Seco (Culver and Hubbs 1917). It is currently common at only three localities within its native range: 1.) upper Santa Margarita River and its tributary De Luz Creek, 2.) San Juan Creek and its tributary Trabuco Creek, downstream of O'Neill Regional Park, and 3.) Malibu Creek (Swift et al. 1993), although the authors noted that the Malibu Creek population may have been introduced because elsewhere Arroyo Chubs always occurred with Unarmored Threespine Stickleback. As of 1993 it was present but scarce in: Big Tujunga Canyon, Pacoima Creek above Pacoima Reservoir and Sepulveda Flood Control Basin in the Los Angeles River watershed; San Gabriel River, primarily in the West Fork below Cogswell Dam where the gradient is lower than the other forks; and the middle Santa Ana River tributaries between Riverside and the Orange County border (ibid.).

The species has been successfully introduced into the Santa Ynez, Santa Maria, Cuyama, Santa Clara and Mojave river systems, along with other smaller coastal streams. "If arroyo chubs had not been introduced into a number of waters outside their native range and had they not thrived in those waters, they would qualify for listing as a threatened species. . . . Recently, red shiner (*Cyprinella lutrensis*) have been introduced into arroyo chub streams and may competitively exclude chubs from many areas (C. Swift, pers. comm.). Chubs generally decline when the shiners become abundant (T. Haglund, pers. comm.). The potential effects of introduced species, combined with the continued degradation of the urbanized streams that constitute much of its habitat, mean that this species is not secure despite its wide range.” (Moyle et al. 1995).

Arroyo Chub is scarce within its native range because it does best in the lower gradient streams of the flatter lands that have succumbed to land development and channelization. An ideal gradient for Arroyo Chub is 1% and it does best in relatively low flows (Swift pers. com.). For example, the species is surviving in the West Fork of the San Gabriel where typical flow volumes may range between 10-20 cubic feet per second (cfs). During the relatively dry years between 1986 and 1990 the species did well on the West Fork due to low water conditions there. Then, after the rains of the winter of 1991-1992 increased the flows, Arroyo Chub became scarcer there relative to Santa Ana Sucker and Speckled Dace (*Rhinichthys osculus*). (Swift et al. 1993) In 1993 Arroyo Chub again became common there.

Populations of Arroyo Chub, Santa Ana Sucker and Speckled Dace were recently identified in a portion of Haines Canyon Creek where it joins Big Tujunga Wash, downstream of the 210 Freeway and upstream of Hansen Dam (Harris pers. com.). This stream segment bubbles up (apparently due to a high water table) from the ponds that lie just downstream of the freeway (Swift pers. com.), and runs a course alongside of the main Tujunga channel for 3-4 kilometers (1.9-2.5 miles) along the wash. When water backs up behind Hansen Dam the stream becomes temporarily shorter as impounded water converges with the stream. The upper 1.75 kilometers (1 mile) of this stream lie within the area purchased in 1998 by the Los Angeles County Department of Public Works for their Big Tujunga Wash Mitigation Bank (LADPW undated). Thus, this part of the stream was surveyed for freshwater fishes, resulting in the discovery of the chub and sucker there in 2001.

Ecological Reference Site

Upon consultation with Camm Swift (pers. com.) we selected the Haines Canyon Creek / Big Tujunga Wash Mitigation Bank site as an ecological reference site with conditions closest to what might be achievable on the Arroyo Seco downstream of the canyon mouth near the Jet Propulsion Laboratory. The gradient and other environmental conditions there are closer to those within the urbanized portion of the Arroyo Seco watershed than the West Fork of the San Gabriel. The site is far from pristine, but habitat restoration efforts implemented there as mitigation have included the removal from the stream vicinity of the invasive giant reed (*Arundo donax*) that compromises the habitat integrity for the low elevation fish species, along with removal of water hyacinth (*Eichhornia crassipes*) from the ponds that feed the stream. Mitigation efforts have also included removal of exotic pest animal species from the ponds, as well as from the stream itself, including: Largemouth Bass (*Micropterus almoides*), Mosquitofish (*Gambusia affinis*), Fathead Minnow (*Pimephales promelas*), Green Sunfish (*Lepomis cyanellus*), Bluegill (*Lepomis* macrochirus), Red Shiner (*Cyprinella lutrensis*), Bullfrog (*Rana catesbeiana*) and Red Swamp Crayfish (*Procambarus clarkii*) (Chambers Group 2002a,b,c). These exotic pest species impact the native fish species either through predation or competition for available resources. They apparently sometimes colonize the stream from the ponds and sometimes reach the stream when the water impounded behind Hansen Dam backs up toward the stream.

The Haines Canyon Creek gradient at this site averages the desirable 1% favored by Arroyo Chub and the typical flow volume ranges from 5-7 cfs (Swift pers. com.). The stream exemplifies the meander pattern, along with the pool and riffle sequences, including undercut banks, that support Arroyo Chub habitat. The width of the steam varies from just a few feet at points constricted by sand bars, vegetation and/or woody debris, to more than twenty-five feet in some locations. At some points the stream forks as it passes around vegetated sandbar islands. While we did not measure the dissolved oxygen and that measure was apparently not reported for the mitigation bank studies (Chambers Group 2002a,b,c and 2003), there are numerous locations along the stream where water passes over rocks or woody debris that help aerate it as it bubbles up and over these obstructions. Since three of the low elevation species occur in this stream we may assume that the water temperature falls within the acceptable range for Arroyo Chub. The tree canopy is relatively continuous, although we did observe some breaks in the canopy cover.

Tree species that shade this portion of Haines Creek include arroyo and red willows (*Salix lasiolepis* and *S. laevigata*), possibly other willow species, white alder, (*Alnus rhombifolia)*, Fremont cottonwood (*Populus fremontii*) and velvet ash (*Fraxinus velutina*). While the stream conditions have clearly been improved by the removal of *Arundo donax*, the remaining understory is dominated by eupatory (*Ageratina adenophora*), which does not appear on the list of exotic species to be removed (Chambers Group 2002a: p. 3-1). So we cannot consider the understory to exemplify ideal riparian habitat conditions, but that apparently hasn't prevented the chub and other native fish species from living in the stream. Still, it is possible that this nonnative understory subtly impacts the aquatic food web since riparian vegetation is the source for much of the organic matter and insects that drop into the stream. The Haines Creek riparian corridor is flanked by the alluvial scrub vegetation of the greater Big Tujunga Wash – this is one place where chaparral yucca (*Yucca whipplei*) and prickly-pear (*Opuntia littoralis*) are neighbors with red willow.

Unfortunately we did not observe any of the native fish species during our field reconnaissance, although we did observe some fish activity that day. In a broad, deep pool, estimated at about 30 in. (155 cm) deep, a group of at least thirteen fish, some nearly 1 foot (30 cm) long – too large to be any of the native low elevation species – congregated across the stream above a light colored sand bed that rendered them more visible. Apparently aware of our presence they huddled above the sand on the far side of the stream until rain pelted the pool with intersecting ripples. With water visibility thus obscured, the fish ventured into the center of the pool, where the dark organic-looking surface probably would not have revealed their silhouettes anyway, to feed on some unseen substance. As the rain subsided they moved back to the far side of the stream where they were once again visible, albeit at a distance. To an uneducated eye these fish resembled trout, but the dark on their tails especially put that in question. Struggling to discern from our not-quite-clear emailed photos of the fish, Camm Swift said that if he had to guess he thinks they are Largemouth Bass. This was disconcerting news to us all, in light of the efforts Swift and others have made to remove these and other exotic animal species from the stream.

On the day of our field reconnaissance of Haines Canyon Creek, February 25, 2004, an intense storm was approaching with high winds that buffeted southern California through that night and dropped 4-6 inches of rain in the mountains. As we talked by cell phone with Michele Chimienti, Los Angeles County Department of Public Works, she advised us that we needed to be out of the wash area before the expected dam releases were to begin around 4 pm that day in expectation of the heavy rainfall predicted for the mountains. Flows of 60 cfs were expected to course through Big Tujunga Wash as a result (Chimienti pers. com.). This probably would not have been enough water to cause the main channel to converge with Haines Canyon Creek. However, examination of aerial photos of the area (LADPW undated; Chambers Group 2002, 2003), along with our field observations, suggest that during past floods, breakout channels typical of the braided stream patterns of alluvial plains have reached over from the main channel to converge with Haines Canyon Creek. This pattern is likely illustrative of the historic floodplain dynamics the Arroyo Chub coevolved with.

Simple Model for Arroyo Chub Habitat Restoration

Based on review of the pertinent literature, communications with expert Camm Swift, and our observations of the Haines Canyon Creek ecological reference site, objectives for restoring Arroyo Chub habitat to the Arroyo Seco downstream of the canyon mouth include the following:

- Stream channel with a low gradient, approaching 1%, with seasonal connectivity to the main flow but access to backwaters or tributaries to escape high flood flows – e.g., attributes of an historic braided floodplain.

- Meanders, pool and riffle sequences, including undercut banks, similar to those on lower Haines Canyon Creek within the Big Tujunga Wash Mitigation Bank; at least some pools with depths of 40 cm. (16 in.) or more, and with sand or mud bottoms.

- Cover of riparian vegetation to keep the stream waters below 31° C (87.8° F), ideally between 10-24° C (50-75° F), and to provide organic matter, nutrients and insects to support the aquatic food web.

- Aquatic dissolved oxygen content of 7 ppm or greater.

- Filamentous algae and other aquatic vegetation – the conditions necessary to support such growth remain to be understood but may coincide with many of the physical parameters of Arroyo chub habitat.

- Freedom from exotic animal predators such as Largemouth Bass, Green Sunfish, Red Shiners, Bullfrogs, and crayfish, among others.

- Once the habitat requirements have been met arrangements must be made to reintroduce the species to the new habitat.

Yellow Warbler (*Dendroica petechia brewsteri*)

Introduction

The Yellow Warbler is the most strikingly yellow of the North American wood warblers (Lowther et al. 1999). A Neotropical migrant, the summer breeding range of Dendroica petechia extends from the limits of shrub vegetation south of the tundra in Alaska southward to Baja California Norte and the Sierra Madre Occidental in Mexico. The species' winter range extends from southern Baja California Sur and the Mexican coastlines southward to South America. Subspecies D.p. brewsteri occurs along the Pacific Coast from Washington through southern California. (ibid.)

In southern California Yellow Warbler breeds in wet deciduous thickets composed of willows in particular, along with cottonwoods, sycamores and alders (Dunn and Garrett 1997), characteristic of riparian environments. The species' territory often includes tall trees for singing and foraging and a heavy brush understory for nesting. The open cup nest is typically placed 0.6 to 5 meters (2-16 feet) above ground in a deciduous sapling or shrub. [Green (undated) citing

Ficken and Ficken 1966.] During spring and fall migrations environments similar to the breeding habitats are favored. Primarily an insectivore and foliage gleaner, meaning that it picks its food off foliage while perched, Yellow Warbler also captures insects while sallying (flying out after airborne prey) and hovering (picking foods from a surface while in flight) (Lowther et al. 1999), and occasionally eats wild fruits (ibid.) including berries [Green (undated) citing Bent 1953, Ehrlich et al. 1988]

While the loss of lowland riparian habitats has been an obvious factor in the decline of Yellow Warbler throughout California, a major and more insidious threat is posed by nest parasitism by Brown-headed Cowbirds over recent decades (Bent 1953, Garrett and Dunn 1981, Remsen 1978). For these reasons Yellow Warbler is a California Species of Special Concern. In areas where cowbird-trapping programs have been implemented, usually on behalf of listed endangered and threatened species, Yellow Warbler populations have benefited greatly. At the Kern River Preserve cowbird control programs have resulted in 100-fold increases in the Yellow Warbler population (Cooper in Jigour et al. 2002). Similarly, at Hansen Dam Yellow Warbler has likely benefited from the cowbird control program implemented by the U.S. Fish and Wildlife Service on behalf of Least Bell's Vireo (Garrett pers. comm.). However, cowbird trapping is expensive and somewhat controversial and should be implemented in the Arroyo Seco only if indicated by monitoring results (Cooper and Long pers. com. 2004).

Locally, Yellow Warbler is fairly common in the white alder riparian forests of the San Gabriel Mountains, including the Arroyo Seco (Garrett 1993 b, Cooper in Jigour et al. 2002), but downstream of the canyon mouth occurs only sparingly at Hahamongna (Cooper pers. comm., Cooper citing W. Principe pers. comm. in Jigour et al. 2002) and not downstream of there at present due to the limited occurrence of riparian vegetation. Yellow Warblers have also bred along the soft-bottomed stretch of the Los Angeles River in Glendale (Cooper pers. comm.), suggesting a fairly high tolerance for urbanization, provided suitable habitat is present. It has not been documented as summering in Pasadena's Lower Arroyo restoration site just south of the Colorado Street Bridge (Cooper pers. comm.), which provides some of the vegetative characteristics of a naturally-occurring riparian forest, though we may begin to observe Yellow Warblers there in the future.

Ecological Reference Sites

Based on recommendations from Kimball Garrett and Dan Cooper (pers. comm.) the ecological reference sites selected as achievable models for Yellow Warbler habitat restoration in the Arroyo Seco watershed are: 1.) the riparian forest above Hansen Dam on the Tujunga Wash tributary of the Los Angeles River, and 2.) the soft-bottomed section of the Los Angeles River that terminates just upstream of its confluence with the Arroyo Seco.

The willow riparian forest behind Hansen Dam covers approximately 1,463 acres (Contreras et al. 2003). The February 25, 2004 timing of the field reconnaissance precluded ground-level investigations of the forest as a storm was just beginning and releases from the upstream dams along Big Tujunga were imminent, meaning that Hansen Dam was about to be inundated. However, the overview available from the banks above may offer even more telling views of some of the significant features of this area with respect to habitat.

Among the more noteworthy characteristics of the forest is the foliage height diversity that appears evident from above. The forest displays a mosaic of tree and shrub heights. Apparently, despite the regulation conferred by the upstream dams, fairly high volume flows reach Hansen Dam, resulting in some of the fluvial structuring of the vegetation that might be expected of an untamed river system. That is, as floods course through the vegetation, tearing out some trees and shrubs while others remain, the result is different age classes of vegetation, with corresponding differences in foliage heights. As sediment aggrades (builds up) on this flood plain, new floods may take different paths across the built-up sediments, resulting in a braided stream pattern that confers a mosaic distribution to the vegetation age classes.

This appearance is hypothetically also conferred by the distribution of the different willow species and cottonwoods in response to patterns of sediment deposition. For example, Goodding's black willow (*Salix gooddingii*) is the tallest of the regional willows, reaching to 20 meters (65 feet) or more, and seems to prefer finer-grained particles. In contrast, arroyo willow (*S. lasiolepis*) is a small tree that seldom reaches 10 meters (25-30) feet and prefers rocky or gravelly substrates. Each willow species has it's own characteristic structure and substrate affinities, although there is some overlap. As flood waters flow through the Hansen Dam basin sediment deposition occurs according to the different velocities of water moving through a given area, which is in turn influenced by the vegetation growing there. Coarser sediments remain in areas with faster moving water, while finer sediments drop out in calmer areas. In that sense the basin likely mimics historic riparian zones, with the primary difference being that this floodplain may be broader than those that occupied the same area prior to human modification of the hydrology and fluvial geomorphology.

The knowledge that Least Bell's Vireo (*Vireo bellii pusillus*) is successfully breeding in the Hansen Dam basin further substantiates the observation that at least some of the willow-riparian forest mosaic there is maintained at an early successional stage, since that species has a documented preference for early seral vegetation (USFWS 1998).

The soft-bottomed section of the Los Angeles River in the vicinity of the Glendale Narrows provides an excellent contrast to the Hansen Dam basin as an ecological reference site for restoration of Yellow Warbler habitat to the Arroyo Seco. Here, only a relatively narrow strip of riparian vegetation has emerged on the sediment bars within the channel, supported by treated wastewater, urban runoff and the high groundwater table in that area (the reason that section of the river remained soft-bottomed in the first place Dwyer, pers. comm.). However, as that vegetation has matured over time it has attracted Yellow Warblers. They were documented as present, but not breeding, in 1993 (Garrett 1993 b). But in 2002 and 2003, Garrett writes [pers. (email) comm. Feb. 11, 2004] "there have been several Yellow Warbler territories along the main Los Angeles River channel from just upstream of Los Feliz Ave. to the downstream end of the soft-bottom reach, about 0.5 km upstream from the Arroyo Seco confluence. There were three singing birds along the lowermost 0.5 km of this reach alone in summer 2003. Whether birds bred successfully I cannot say, but the presence of stable territories with singing males suggests that breeding was at least attempted in some of these territories. I would not expect breeding success to be high along the L. A. River here because of the abundance of Brown-headed Cowbirds."

Thus, the structure of the vegetation in that river reach has apparently assumed the characteristics favored by Yellow Warbler for breeding. This is clearly good news with respect to habitat restoration goals for the Arroyo Seco since, while it may be difficult to achieve near the expanse of riparian habitat present behind Hansen Dam, the conditions in the soft-bottom reach of the Los Angeles River seem potentially more attainable.

Garrett (1993a) documented current biological attributes in that section of the river, along with references to historic conditions, and Wallace (1993) documented the specific plant species present. The soft-bottomed reach is referred to in that report as the Newell Street site. Along with the presence of willows and cottonwoods, the most obvious feature of the vegetation there that is shared with the Hansen Dam basin is the foliage height diversity. Some of the trees along this reach of the river now exceed 12 meters (40 feet), while shrubby willows and mulefat are also present. And although flood flows are controlled along the river relative to historic conditions, high enough velocities are reached to result in some fluvial structuring of the vegetation. Another attribute shared by both sites that should not be overlooked when considering habitat restoration objectives is the fact that the vegetation patterns have arisen adventitiously, presumably according to environmental conditions, rather than by human design.

Simple Model for Yellow Warbler Habitat Restoration

As indicated by comparison of the two local ecological reference sites for Yellow Warbler breeding habitat, attributes to be aspired to in restoring suitable habitat for the species along the Arroyo Seco include:

- Plant species composition including an array of willow (*Salix*) species, cottonwood (*Populus* sp.), mulefat (*Baccharis salicifolia*) and associated understory species – implying sufficient year-round moisture to support this riparian association.

- Sufficient maturity of the overall vegetation. For example, Yellow Warbler apparently did not attempt breeding in the soft-bottomed reach of the Los Angeles River until 2002. Kimball Garrett (pers. comm.) estimated this as approximately 25 years since the vegetation was allowed to grow there.

- Foliage height diversity. As discussed previously, this occurs in nature through the differential effects of fluvial structuring. This could be the key component lacking at Pasadena's Lower Arroyo site. As such the site should be an excellent place to test the importance of this attribute. Ideally, the site should be monitored for breeding bird occupancy over time. We might expect this site to eventually attract Yellow Warblers, but if fluvial habitat structuring is as important to breeding Yellow Warblers as we deduce from the ecological reference sites, we might expect the site to become unsuitable habitat for the species after some length of time, with the suitability eventually falling off as the vegetation matures without exposure to fluvial structuring.

- Monitoring program to enable adaptive management.

- Potential: Cowbird control program to enable successful breeding – if indicated by monitoring program

Oak Titmouse (*Baeolophus inornatus affabilis)*

Introduction

It is probably appropriate to state at the outset that, no, Oak Titmouse is not a mouse, although the plural is "titmice". Oak Titmouse is a diminutive non-migratory bird species, about 5 inches long, of the family Paridae, which the titmice share with the chickadees (National Geographic 1999). Their heads capped with a short crest, male and female Oak Titmice share the same plumage colors – olive-brownish gray on upper-parts and medium-gray or grayish-white on under-parts (Cicero 2000). Until recently Oak Titmouse and Juniper Titmouse were considered a single species, Plain Titmouse (*Parus inornatus*) but their different geographic ranges, combined with genetic evidence lead to their reclassification into the new genus *Baeolophus*, with Oak Titmouse keeping the species name *inornatus*, while Juniper Titmouse was assigned the name *B. ridgwayi*. As their common names suggest, Oak Titmouse occurs primarily in oak (*Quercus* sp.) or oak-pine woodlands throughout much of California's warm, dry foothill regions, whereas Juniper Titmouse inhabits juniper and piñon-juniper woodlands of the intermountain, or Great Basin region. Other morphological, color, ecological and vocal differences distinguish the two species, whose songs and calls produce strikingly different sonogram patterns. Four subspecies of Oak Titmouse are recognized, with the cordial-sounding name *B. i. affabilis* assigned to the population of primarily cismontane southern California that is the darkest and largest of the subspecies. (*Ibid. – unless otherwise noted Cicero 2000 is the primary reference source for this introduction*.)

The dependence of Oak Titmice on oak woodlands arises foremost from their habit of building nests in natural tree cavities, along with woodpecker-excavated holes. Such natural cavities occur in main branches, secondary branches and trunks of mature oak trees, along with dying or dead oaks. Oak Titmice will use holes in stumps and may alter or further excavate existing cavities. They will also use nest boxes and other artificial sites (ibid., Cooper pers. com.), but adequate roosting cover is an important habitat requisite. Roost sites include natural or artificial cavities – females may use the nest site for roosting up to a month before egg laying – and branches or twigs surrounded by dense evergreen foliage. Oak Titmice also use scrub oaks, chaparral (Cicero 2000, Garrett pers. com.), riparian woodlands (Cicero 2000, Cooper in Jigour et al. 2002.), pure walnut woodlands (Cooper 2000, Cooper in Jigour et al. 2002.) and even exotic trees (Garrett pers. com.) for nesting as well as roosting, as long as there are oaks nearby.

Foraging habitat is another requirement. Considered a member of the "foliage gleaning guild" Oak Titmouse actually consumes more than 50% of its diet as plant foods and gleans more of its animal food on bark, with foliage being a secondary source. Its principal plant foods include: seeds – primarily acorns and various wild seeds including poison oak (*Toxicodendron diversilobum*); oak and willow (*Salix* sp.) catkins, leaf buds and galls; and berries. It is reasonable to assume that the species of seeds consumed differed prior to the import of exotic plant species into California. Oak Titmouse is a common visitor to bird feeders in areas close to oak woodlands. While it does have a taste for cultivated fruits, especially cherries, Oak Titmice are not considered agricultural pests. In fact, at least some of their animal prey might be considered agricultural pests, while some are welcome. Animal foods they consume include leafhoppers, treehoppers, jumping plant lice, aphids, scales, bees, caterpillars, ants, wasps and spiders (Cicero 2000).

In pursuing their meals Oak Titmice use their stout bills to hammer acorns and other seeds against branches to open them. They also use it to peck and probe into crevices and chip away bark in search of animal prey, as well as to pull apart leaf galls, flowers, curled dead leaves and lichen. They are known to eat grubs out of acorns and may often be seen hanging upside down from branches to search their undersides for insects (Cicero 2000 citing Dixon 1954; National Geographic 1999).. They occasionally perform aerial maneuvers such as hovering and chasing to capture flying insects. They then carry larger prey to a branch where they will hold it down with their feet while hammering the item or prying it apart with that sturdy bill. ["Nature, red in tooth and claw" – Alfred Lord Tennyson.] They do capture some food on the ground but typically carry it to an elevated perch to consume it. Most food is consumed at vegetation heights under 9 meters (30 feet) and they store some seeds for later consumption. (Cicero 2000)

The primary conservation concern for Oak Titmouse statewide is the ongoing loss of oak woodlands through clearing for agriculture, rangelands and urbanization, along with harvesting of oaks for fuelwood (ibid.) The species experienced a 1.9% decline per year throughout California from 1980-1996 and a 1.6% annual decline in the California foothills from 1966-1996 [Flannery (undated) citing Sauer et al. 1997).

Locally, Oak Titmice occur in mature riparian forest and even pure walnut woodlands in the Puente Hills (Cooper 2000, Cooper in Jigour et al. 2002). They are fairly common in some parts of the Arroyo Seco watershed, including La Cañada Flintridge (ibid.) and the canyons of the San Rafael Hills area as a whole (Garrett pers. com.). But, while they have been recorded as far south as the Pasadena Freeway overcrossing of the Arroyo during summer and visit Debs Park during fall and winter they do not reside in the more urban parts of the watershed. Hopes of returning the species to the most urban portions of the watershed may be futile because of their need for a fairly extensive core area of woodland (Garrett pers. com.). For example, on a statewide basis, the minimum oak woodland management units recommended for the species are 50 to 100 hectares (Wilson et al. 1991) (124 to 247 acres). However, habitat enhancement in the mid- watershed areas could benefit the Oak Titmouse.

Ecological Reference Sites

The two sites recommended and selected as appropriate ecological reference sites for habitat restoration for Oak Titmouse are: 1.) the oak grove at Hahamongna (Cooper pers. com.) and 2.) the vicinity of Cherry Canyon Open Space/ Descanso Gardens (Garrett pers. com.). These two sites likely constitute the core woodland areas that enable the species to be sustained throughout the residential areas of La Cañada Flintridge, the rest of the San Rafael Hills and into the Arroyo Seco watershed.

The most noteworthy feature of the Hahamongna oak grove is the presence and expanse of mature coast live oaks (*Quercus agrifolia*). The number of both natural and excavated tree cavities suitable for nesting has been shown to increase significantly with tree diameter (Cicero 2000 citing Wilson 1992). Perhaps less obvious is the fact that this grove exists in close proximity to both scrub and riparian vegetation, including willows and the canyon live oaks (*Quercus chrysolepis*) of the Arroyo Seco canyon, that enhance the foraging opportunities for Oak Titmice who nest and roost in the oak grove.

The coast live oak woodland of the Cherry Canyon Open Space differs from the Hahamongna grove in topography, in that it clothes the canyon and primarily north facing slopes of the hills, and also in its diversity of plant species that interdigitate with the coast live oaks, including Mexican elderberry (*Sambucus mexicana*), chaparral currant and fuchsia-flowered gooseberry (*Ribes malvaceum* var. *viridfolium* and *R. speciosum*), white sage (*Salvia apiana*), and a host of other chaparral and coastal sage scrub species. Another noteworthy feature is the spacing of coast live oaks, many of which are relatively crowded together in the canyon area, and interspersed with the scrub species in more exposed locations. Yet another feature of this general area that likely enhances its suitability for Oak Titmouse is the presence of mature coast live oaks that were planted as street trees – obviously many years ago, as they now exhibit the nooks and crannies preferred by the species. Apparently even some of the mature exotic tree species of Descanso Gardens favor the presence of Oak Titmice here (Garrett pers. com.).

The diversity of plant species associated with the oak woodlands in the vicinity of Cherry Canyon Open Space is especially noteworthy in that tree species richness, particularly where multiple oak species co-occur in a general area, has been highlighted as important for maintaining a variety of cavity nesting opportunities (Wilson et al. 1991), as well as for accommodating the interspecific and annual variability in acorn production (Koenig et al. 1991, Cicero 2000 citing Koenig et al. 1994, 1996). “Mast seeding” refers to the annually intermittent seed production exhibited by oaks (Koenig and Knops undated). “Mast years” are those in which acorn production is particularly high, in contrast with other years when acorn production may be limited to nearly nonexistent. Coast live oaks typically exhibited three-year masting cycles on the central coast of California, although mast years were observed to sometimes occur consecutively (Koenig et al. 1991). Furthermore, acorn production within a species has been observed to be highly synchronous over broad geographic areas (Koenig and Knops undated). Thus, while coast live oaks are the predominant native oak species over the populated, lower elevation portions of the Arroyo Seco watershed, the presence of Engelmann oaks (*Quercus engelmannii*) or California walnuts (*Juglans californica*), along with a diversity of other native (and even exotic) plant species in nearby areas may be important for supporting Oak Titmice through lean years of coast live oak acorn production.

Simple Model for Oak Titmouse Habitat Restoration

As illustrated by the two ecological reference sites, along with pertinent references, objectives for restoring Oak Titmouse habitat in the Arroyo Seco watershed include the following:

- Core areas of mature oak or walnut woodland of significant size: 50 –100 hectares (125-250 acres)

- Adjunct plantings in nearby urban areas where Oak Titmice do not occur, of plant species that will enhance foraging and even nesting opportunities for the species. Such supportive plantings may be implemented in the form of oaks as street trees or in residential landscapes.

- Provision of some diversity of tree species in addition to coast live oak, including Engelmann oak, California walnut, and willows.

- Inclusion of large shrub species that may provide alternative nesting sites such as scrub oak (*Quercus berberidifolia*), and other scrub species that may provide alternative foraging opportunities.

California Quail (*Callipepla californica)*

Introduction

We have included California Quail as a focal indicator species of habitat connectivity rather than as an indicator for restoration of a specific habitat type. California Quail are widely recognized as our State Bird. These plump ground birds with distinctive teardrop-shaped top-knots, are made even more memorable by the image of a trail of chicks bobbing after their parents as they run for cover. Their ground-dwelling nature has rendered their short legs powerfully adapted for land locomotion. While they can fly rapidly if necessary, it is only for short distances. “When alarmed they prefer to run, flying only as a last resort.” (McIlvaine 2000)

California Quail are permanent residents of low and middle elevations throughout most of cismontane California. They inhabit a variety of shrub, scrub and brush vegetation types, as well as open areas of coniferous and deciduous woodlands, and the margins of grasslands and agricultural fields [Ahlborn (undated) citing Leopold 1977], as well as desert washes, stream valleys (McIlvaine 2000) and some suburban areas but only adjacent to large habitat reserves (Cooper pers. com.). They are generalists and opportunists so their diet varies by location.

They feed primarily on legumes and other seeds that comprise as much as 82% of their diet, along with green vegetation at 18% (McIlvaine 2000 citing Duncan and Shields 1966). They forage on the ground and among the low vegetation that typifies their habitat, scatching, gleaning, grazing, browsing and jumping to pick off seeds, blossoms and fruits. They also search for and pounce upon arthropods (insects and spiders) [Ahlborn (undated)].

During cool weather California Quail are believed capable of meeting their water needs through consumption of succulent plants, arthropods and dew (ibid.) But during hot weather they require fresh water daily. While they can tolerate mildly salty water (ibid.) their tolerance for other water quality problems is not known. They will gather near water during dry weather and disperse over broader areas when green vegetation and water are abundant. (ibid.) But they also exhibit more complex social patterns, some influenced by the reproductive cycle, as summarized in the following:

> During the fall and winter, California quail are highly gregarious birds, gathering into groups, called coveys. In most situations, covey size averages about 50 birds, but under intensive management and protection, coveys can get as large as 1000 birds (Leopold 1977). In the covey, the quail tend to imitate one another and exhibit cooperative behavior. For example, when one bird finds a good supply of food it often calls the others to it. Likewise, when a member of the covey perceives danger it will warn the group with the appropriate call (Sumner 1935). California quail communicate with 14 different calls (Leopold, 1977). This includes courtship, re-grouping, feeding, and warning calls. The most frequently heard location call has been described as “cu-ca-cow” or “chi-ca-go.”
>
> At the start of nesting season in early spring the coveys break up, as quail pairs spread themselves out into different habitat areas to nest and rear their young. At the end of summer each new quail family rejoins the others to form a new covey where they will remain until the next breeding season. (McIlvaine 2000 – *refer to the web site for further discussion of this subject*).

California Quail nest in a small depression in the ground, hidden by herbage among shrubby vegetation. “Brush and trees provide cover for feeding, escape, movement and roosting” [Ahlborn (undated)]. Thus, the overall pattern of California Quail habitat is “a mosaic of low, brushy vegetation, with grass/forb openings, taller shrubs, and trees, interspersed with water” (ibid.). Illustrating the generalist nature of California Quail, as well as their ubiquity in a broad variety of coastal sage scrub environments, this species occurred at all 16 sites sampled in Orange, Riverside and San Diego Counties (as did Spotted Towhee) in a study aimed at identifying species that could be serve as indicators of biodiversity

(Chase et al. 2000). In other words, the presence of California Quail doesn't tell us that much about the relative biodiversity of a given site.

However, in a study that returned to examine the distribution of scrub-requiring birds in fragmented coastal sage scrub habitats in San Diego County that were originally assessed in 1987 (Soulé et al. 1988), California Quail were among the three species most likely to have dropped out of urban habitat fragments where they had been present ten years earlier (Crooks et al. 2001). The length of time since habitat fragmentation was found significant for the presence of California Quail, with only a 50% chance of their occurring in a habitat fragment 13 years after it had become isolated. But an even greater factor is apparently the size of the habitat area. The estimated area at which there is a 50% probability of California Quail being present is 37 hectares (91 acres). Multiple logistic regression models predicted that after 100 years of isolation the estimated habitat fragment size at which there is a 95% probability of California Quail being present is 173 hectares (427 acres). (ibid.) This may be a tough figure to match in the urban part of the watershed, but the problem might be partially resolved by habitat connectivity that could enhance the effective size of existing or restored habitat fragments.

Locally, California Quail "is probably found in maximum numbers within Hahamongna Watershed Regional Park, where mulitple broods of chicks were observed during 2001 (Cooper pers. obs.) It is abundant along the southern base of the San Gabriel Mountains." (Cooper in Jigour et al. 2002). California Quail have retreated from most, if not all portions of the lower Arroyo Seco watershed, similar to the pattern observed in the San Diego habitat fragments (Crooks et al. 2001). They disappeared from the area of Debs Park in the mid-1980s. The following excerpt from the Arroyo Seco Watershed Restoration Feasibility Study is worth repeating here.

> Quail were found on the Pasadena/Los Angeles border on the west side of the Arroyo (vic. Figueroa Blvd.) as recently as the mid-1990s (R. Jillson, pers. comm. to D. S. Cooper), but are now believed to be confined to the hills north of the 134 Fwy./Colorado Blvd. South of here, they are either absent or only rarely encountered. Strangely, this includes the "BFI restoration area" just south of Colorado Blvd. [Lower Arroyo Seco Park], which appears to have excellent habitat. It is possible that high use by people, and especially dogs, discourages their persistence here. Along the main stem of the Arroyo, quail may occur no farther south than Devil's Gate Dam, with occasional birds coming down into the Arroyo, presumably east out of the San Raphael Hills.
>
> Locating remnant populations of California Quail should be a top priority for this study, as they seem to be a good indicator of habitat attributes important to urban conservation projects, including low levels of disturbance from pets, connectivity with larger open space, etc. Natural

> movement corridors for quail, Mule Deer, and other terrestrial species may include washes, culverts, and utility rights-of-way. These should be located and treated as prime candidates for conservation easements and potential habitat restoration. Examples include Flint Wash, which enters Hahamongna from the San Raphael Hills underneath the 210 Fwy. The search for these features should focus on the interface between the San Raphael Hills and the Arroyo (vicinity of Brookside Golf Course/Rose Bowl). Since so much habitat has been lost or is ecologically isolated within the lower Arroyo Seco, the habitats within the San Raphael Hills should be considered an important link between the upper and lower Arroyo Seco watershed. This is a prime example of why conservation and ecological restoration efforts for the Arroyo must extend beyond the watershed boundaries. Protecting habitat adjacent but outside of those boundaries may prove as important for certain species as restoring habitat within the watershed per se. (Cooper in Jigour et al. 2002)

Clearly the Arroyo Seco offers the greatest potential conduit for movement of quail to the lower parts of the watershed, especially with the availability of water throughout much of the year. There is one location, pointed out to us by Lynne Dwyer (pers. com.) where a relatively intact drainage from the Linda Vista area brings scrub cover close to similar vegetation sloping down into Pasadena's Central Arroyo Park (north of Washington), separated only by the curved section of Linda Vista Ave. The Linda Vista drainage is believed to connect with other scrub remnants that rise over the San Rafael Hills to connect with Flint Canyon, which provides the only clear passage below the 210 Freeway to Hahamonga. (Dwyer pers.com.)

But even within the Arroyo there are potential choke points in habitat connectivity. In Pasadena's Central Arroyo Park, between the Holly Street bridge and the 134 Freeway on the west side of the park, where the relative absence of people might otherwise favor quail movement, the parkland becomes narrowly constricted as some fenced residential properties meet the edge of the Arroyo Seco stream channel, potentially discouraging some wildlife movement that might otherwise occur there. Downstream of this choke point lies what appears to be "excellent habitat" (Cooper in Jigour et al. 2002) in Pasadena's Lower Arroyo Seco Park and the City has plans for a habitat restoration program in the Central Arroyo Seco Park that should also favor quail movement through that area. With restoration of suitable scrub vegetation along the Arroyo from Pasadena to Debs Park, California Quail might someday return to Debs Park. A California quail population reportedly resides in the vicinity of Elysian Park Reservoir (Haun 1999), giving hope that habitat connectivity efforts along the Arroyo could someday reconnect this population with others upstream.

If California Quail returned to the lower watershed they might serve as a reminder to some residents, at least, of the importance of restoring habitat and watershed functions of the Arroyo for our feathered friends. That this species can attract the attention of urban population centers has been demonstrated by the San Francisco Board of Supervisors' designation of California Quail as the Official Bird of the City and County of San Francisco, as well as its endorsement of the Golden Gate Audubon Society's "Save the Quail Campaign" in 2000 (Golden Gate Audubon 2000). No less commitment might be asked of the residents and neighbors of the Arroyo Seco watershed.

Objectives for California Quail Habitat Restoration

Based upon our current knowledge of the distribution of California Quail in the urbanized portions of the Arroyo Seco watershed, along with applicable references, the following objectives must be met in an effort to restore the State Bird to its rightful place in the community:

- Promote and arrange for conservation easements and/or other means for protecting the remaining California Quail habitats that are not currently under public protection.
- Establish the specific locations and generalized movement patterns of remaining California Quail populations in the San Rafael Hills through focused surveys.
- Identify factors that contribute to or impinge upon California Quail movement patterns and occupation of otherwise apparently suitable habitat (e.g., predation by domestic pets) within the watershed through focused study.
- In locations where quail and other wildlife must cross roads to access otherwise suitable habitats (e.g., Linda Vista Ave. where it curves adjacent the north end of Central Arroyo Seco Park), implement measures to favor wildlife passage such as reduced night lighting, lower traffic speed zones with speed bumps and signage.
- Ensure that scrub habitats and brushy areas with surface water are included in habitat restoration programs, as appropriate.
- Based upon the results of the study of California Quail movement patterns implement additional measures that will favor their movement to suitable habitat areas.

Spotted Towhee (*Pipilo maculates megalonyx)*

Introduction

We selected Spotted Towhee as a focal species for whom habitat restoration in the most urbanized parts of the Arroyo Seco watershed is a realistic goal. The species is doing well in other parts of the watershed, but in the downstream, most urbanized area, its center of abundance is 300-acre Ernest E. Debs Park.

The dark-hooded Spotted Towhee gets its common name from the white spots on its otherwise black wings and scapulars that form wing bars and distinguish it from its relative, the Eastern Towhee. The white abdomen is set off by reddish brown sides and flanks.

A primarily ground-dwelling species, Spotted Towhee is a year-round resident in our region. While they do fly as may be necessary, they spend much of their time hopping along on the ground or from branch to branch. (Greenlaw 1996) Subspecies *Pipilo maculates megalonyx* is distributed throughout coastal southern California, along with Santa Rosa and Santa Cruz Islands. Among the features that distinguish populations of the species at several geographic scales is the variability of their songs, which also vary among individuals. (ibid.) The species has a fairly diverse repertoire to begin with, so it is especially thought provoking to consider that the vocalizations of Spotted Towhee may be as unique as human voice patterns. For subspecies *P. m. megalonyx* singing is seasonal, beginning between January 15th and February 15th, with the last songs of the season heard in early August (Greenlaw 1996 citing Davis 1958).

The species as a whole forages primarily on the ground, favoring sites with well developed leaf litter/duff that provides habitat for their favorite foods. Adults consume a variety of beetles that are the chief component of their insect diet, along with some crickets, grasshoppers, true bugs, stink bugs, ants, wasps, caterpillars, moths, scales, spiders, millipedes and sowbugs. They eat all insect developmental stages including larva, pupa and adults. They supplement that diet with arboreal foraging primarily during spring through summer. Seed and fruit food sources in California include wild cherries (*Prunus* sp.), elderberry (*Sambucus* sp.), snowberry (*Symphoricarpos* sp.), honeysuckle (*Lonicera* sp.), tarweed (*Madia* sp.), sumac (*Malosma* and *Rhus* sp.), poison oak (*Toxicodendron diversilobum*), amaranth (*Amaranthus* sp.), oak acorns (*Quercus* sp.), miner's lettuce (*Montia perfoliata*), coffeeberry and redberry (*Rhamnus* spp.), gooseberry (*Ribes* sp.), toyon (*Heteromeles arbutifolia*), and manzanita (*Arctostaphylos* sp.). (Greenlaw 1996 citing Davis 1957)

Spotted Towhee breed in a "wide variety of plant associations, all characterized by dense, broadleaf shrubby growth (variously described as brush, thickets, or tangles) only a few meters tall, with or without emergent trees that provide deep sheltered, semi-shaded litter and humus on [the] ground, and [a] screen of twigs and foliage close overhead." (Greenlaw 1996) Generalists in their habitat requirements with respect to plant species composition, optimum Spotted Towhee habitat is best described as "so dense you can't walk through it" (Cooper pers. com.). They build their nests primarily into litter on the ground, "often in relatively exposed situations (although usually well concealed by adjacent plants)" (Greenlaw 1996) or sometimes elevated in the shrubs (ibid.). In a study aimed at identifying biodiversity indicator species in 16 coastal sage scrub environments in Orange, Riverside and San Diego County, Spotted Towhee, along with California Quail, occurred in all sixteen of them (Chase et al. 2000), only enhancing their reputation as habitat generalists. Furthermore, in a study that examined the distribution of scrub-requiring bird species in fragmented San Diego County coastal sage scrub patches Spotted Towhee were one of three species, along with Bewick's Wren and California Gnatcatcher, whose presence actually increased over the ten year interval from 1987 to 1997 (Crooks et al. 2001). This increase amounted to recolonizations of only two sites where the species had not been present in 1987, but they were among the smallest size fragments and the species did occur within the urban matrix. Both of these correlations are encouraging with respect to hopes for restoring habitat for the species in urban areas of the Arroyo Seco watershed.

However, the presence of Spotted Towhee was found related to the age of the fragment – that is, the time since fragmentation (isolation from surrounding habitat areas by land development) first occurred. Not as sensitive to time since fragmentation as most other species, Spotted Towhee were found in all but the oldest habitat fragments. The estimated fragment age at which there is a 50% probability of Spotted Towhee occurring is 41 years. (ibid.) A variety of factors may be tied to the decline of species over time since fragmentation, as Crooks et al. enumerated:

> The loss and degradation of habitat certainly contributes to extinctions within fragments. Native vegetative cover declines closer to the urban edge (Suarez et al. 1998), fragments with proportionally more urban edge have an increased diversity of ruderal and ornamental plant species (Alberts et al. 1993), and the proportion of native shrub cover declines with fragment age (Soulé et al. 1988; Suarez et al. 1998). . . .
>
> In addition to overt habitat degradation or other physical changes in the fragments, other factors likely contribute to extirpations of scrub birds. For

> example, the matrix surrounding habitat islands may support competitors and predators whose interactions with species within islands may alter population persistence and community structure (Wilcove 1985; Andren & Angelstram 1988). Exotic carnivores (opossums, domestic cats) and native carnivores (gray foxes, striped skunks, and raccoons) occur within the developed matrix and are predators on birds and bird nests in this system (Soulé et al. 1988; Langen et al. 1991; Crooks & Soulé 1999) and elsewhere (Wilcove 1985; Churcher & Lawton 1987; Leimgruber et al. 1994). Numbers and activities of these opportunistic "mesopredators" increase with the disappearance of the dominant predator, the coyote, in the fragments, a process termed *mesopredator release* (Soulé et al. 1988; Crooks & Soulé 1999). In turn, the species richness of scrub-breeding birds was lower in fragments with more mesopredators and fewer coyotes, even after we accounted for the positive effect of fragment area and the negative effect of fragment age on scrub bird persistence (Crooks & Soulé 1999).
>
> (Crooks et al. 2001)

In the same study, the estimated habitat size correlated with a 50% probability of occurrence of Spotted Towhee was 4 hectares (10 acres) (ibid.). However, the territory defended by a male may be as small as 20 x 20 meters (approx. 22 x 22 yards, or 0.04 hectare, 0.09 acre) (Cooper pers. com.), so the species may be attracted to much smaller patches of restored habitat. And one recent study found a paradoxical advantage of habitat fragmentation for Spotted Towhee and another ground nesting bird species in the decrease in snake predators in isolated patches, which otherwise impact the reproductive success of ground nesting bird species (Patten and Bolger 2003). While this decline in snakes may be a boon to Spotted Towhee it does represent the unraveling of the ecosystem. We don't really know how much can become unraveled before the structure ceases to function as a self-sustaining system. Perhaps a new ecosystem will arise in restored urban habitat islands. We will only learn for certain by making the effort and monitoring the results.

Ecological Reference Site

The ecological reference site suggested by Dan Cooper (pers. com.) as a model for Spotted Towhee habitat restoration efforts is the area behind the Audubon Center at Debs Park, described as "sumac scrub". This description caused some confusion when we arrived at the site to find what appeared to be relatively shrub-free walnut woodland on the more or less north-facing slopes. We learned that this area had probably been clothed with dense stands of shrubs such as lemonadeberry (*Rhus integrifolia*) and toyon (*Heteromeles arbutifolia*), as well as the emergent walnuts prior to a recent fire. But this only serves to illustrate the importance of restoring multiple habitat patches, if a large area of habitat is no longer available. In fact, in the study of San Diego habitat fragments it was concluded that Spotted Towhee, which was able to persist in relatively isolated habitat patches, was among those species that likely depend on metapopulation dynamics, "in which the overall persistence of a species across the landscape is a function of recolonizations of populations from nearby habitat patches" (Crooks et al. 2001). Since habitats within the urban matrix may be more subject to fires caused by human influences, this places additional emphasis on the importance of multiple habitat islands, to which resident wildlife can emigrate at times of natural and/or human influenced catastrophes.

Debs Park is among the examples of increasing fire frequency due to human influence. But fortunately the park is large enough that when one area – like the area behind the Audubon Center – burns, another may be recovering. Indeed, another north facing slope at Debs, to the north of the Audubon Center, has been developing the shrub density favored by breeding Spotted Towhee. It is characterized by laurel sumac (*Malosma laurina)*, lemonadeberry, toyon, California black walnut (*Juglans californica* var. *californica),* blue elderberry (*Sambucus mexicana*), golden currant *(Ribes aureum* var. *gracillimum),* california coffeeberry *(Rhamnus californica* ssp. *californica)* and holly-leaved redberry *(Rhamnus. ilicifolia*), among other species. But, as mentioned previously, Spotted Towhee are not particular about the specific plant species, nor slope aspect comprising their breeding habitat.

Simple Model for Spotted Towhee Habitat Restoration

Based upon the descriptive detail provided by avian conservation biologist Dan Cooper, our review of the literature, and evaluation of the ecological reference site, the following considerations should be applied to habitat restoration efforts for Spotted Towhee in the urbanized parts of the Arroyo Seco watershed:

- Provision of multiple habitat patches near existing populations of Spotted Towhee that will ideally help reestablish a metapopulation structure for Spotted Towhee and other species with similar habitat requirements within the urbanized matrix.

- Dense shrublands with or without emergent trees. "So dense you can't walk through it." On north facing slopes the plant association might look something like the Debs Park north facing slopes, although it may benefit from going through an ecological succession as it matures. Favorable habitat on northerly slope aspects could be achieved through restoration of walnut woodlands with a dense shrubby understory, and with or without emergent coast live oak, or simply "sumac scrub". On less protected slopes the overall canopy may be lower with fewer moisture- or shade-loving plant species and more drought-tolerant coastal sage scrub species. But restored riparian areas can also support scrub-dependent species like Spotted Towhee, provided that they are buffered by the scrublands that would flank them under natural conditions.

- Restored habitat patches may be small if there are larger patches with Spotted Towhees nearby, but size should be maximized in all instances.

- Monitoring will be necessary to determine the effectiveness of habitat restoration efforts aimed at Spotted Towhee and to enable adaptive management.

Native Plant Associations

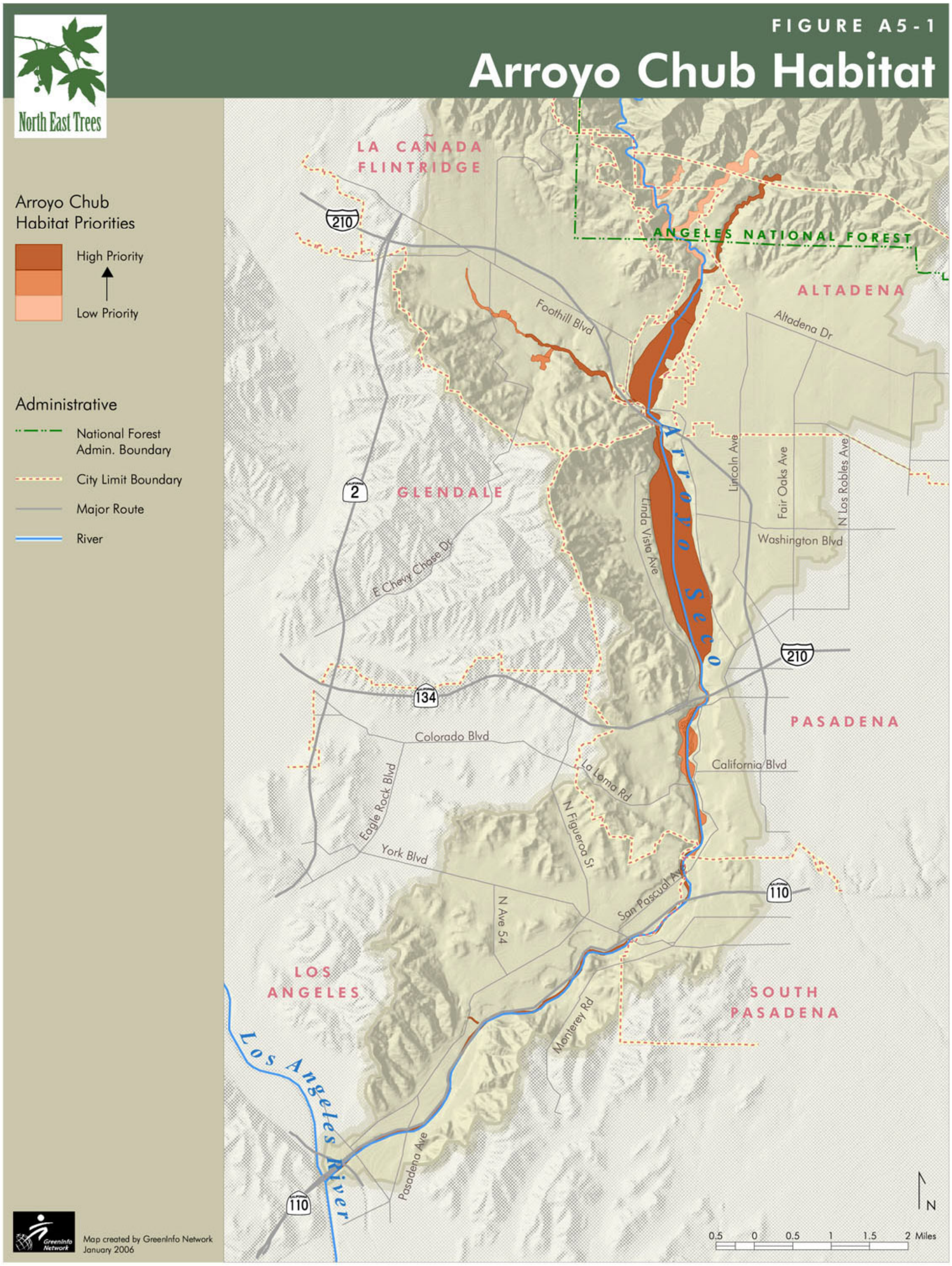
We added the objective of native plant associations to apply to ecological restoration opportunities that have merit but may not be applicable to habitat restoration for the suite of focal animal species we selected for this plan. Especially for some of the most urban sites of the lower watershed this may be the only option, due to the sensitivity of many native wildlife species to urbanization. We all observe wildlife in urban environments, but those observations are typically confined to a few urban generalist, introduced species – European Starlings, Rock Doves (city pigeons) and House Sparrows, for example. We can't necessarily guarantee that restoring native plant associations in small urban patches will elicit the return of more sensitive and/or discriminating native animal species, but if we build it we can watch to see who will come.

The concept behind the native plant association objective is that habitat restoration for plant species should consider the ecological relationships they exhibit under natural conditions. Such relationships include soil type, slope aspect, plant species and their relative representation (distribution), and proximity to other plant associations.

For example, if one were designing a riparian species habitat restoration project that might not be applicable to Yellow Warbler habitat restoration, one would want to emulate relationships observed in another ecological reference site. For example, the proposed resurrection of the North Branch creek is not likely to bring Yellow Warblers, although it could support Spotted Towhee. But in this case a more appropriate ecological reference site than those we evaluated for Yellow Warbler or Spotted Towhee is Sennett Creek that descends from Griffith Park through Forest Lawn to the Los Angeles River. Some applicable observations include the way that the riparian tree species change from California sycamores to willows as the stream descends and moisture becomes more concentrated, the transition of associated understory species, and the fact that, where the plant associations have not been altered by the cemetery, the riparian plant species are closely flanked by scrub vegetation.

This general objective will become more meaningful as it is applied to specific restoration opportunities.

Appendices
Appendix A5-3: Species-Specific Restoration Priorities



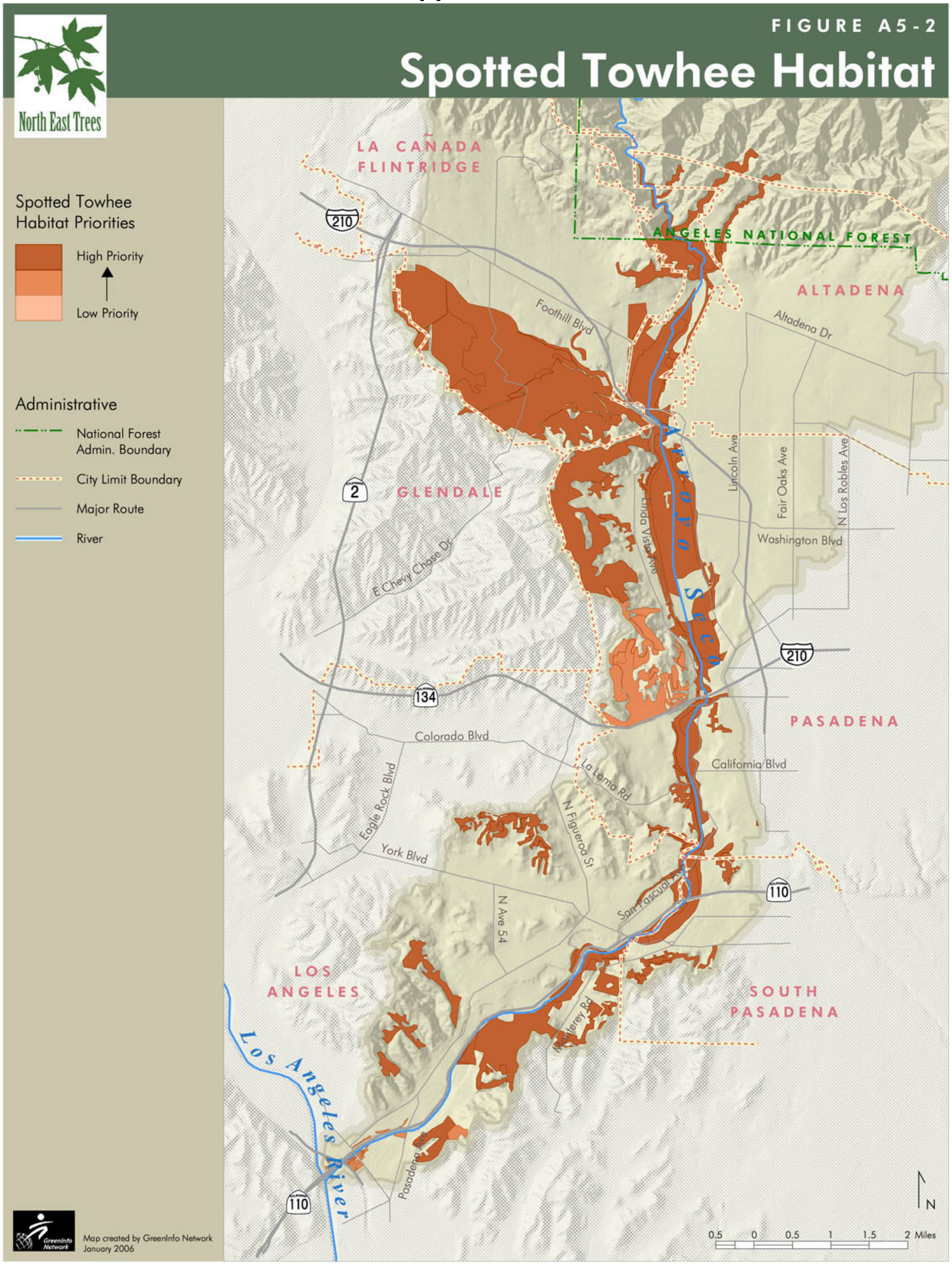


FIGURE A5-2
Spotted Towhee Habitat
North East Trees
Spotted Towhee Habitat Priorities
High Priority
Low Priority
Administrative
National Forest Admin. Boundary
City Limit Boundary
Major Route
River
LA CAÑADA FLINTRIDGE
ANGELES NATIONAL FOREST
ALTADENA
GLENDALE
PASADENA
LOS ANGELES
SOUTH PASADENA
Arroyo Seco
Los Angeles River
Foothill Blvd
Altadena Dr
Lincoln Ave
Fair Oaks Ave
N Los Robles Ave
Washington Blvd
Linda Vista Ave
E Chevy Chase Dr
Colorado Blvd
California Blvd
La Loma Rd
Eagle Rock Blvd
York Blvd
N Figueroa St
San Pascual Ave
N Ave 54
Monterey Rd
Pasadena Ave
210
2
134
110
N
0.5 0 0.5 1 1.5 2 Miles
Map created by GreenInfo Network January 2006

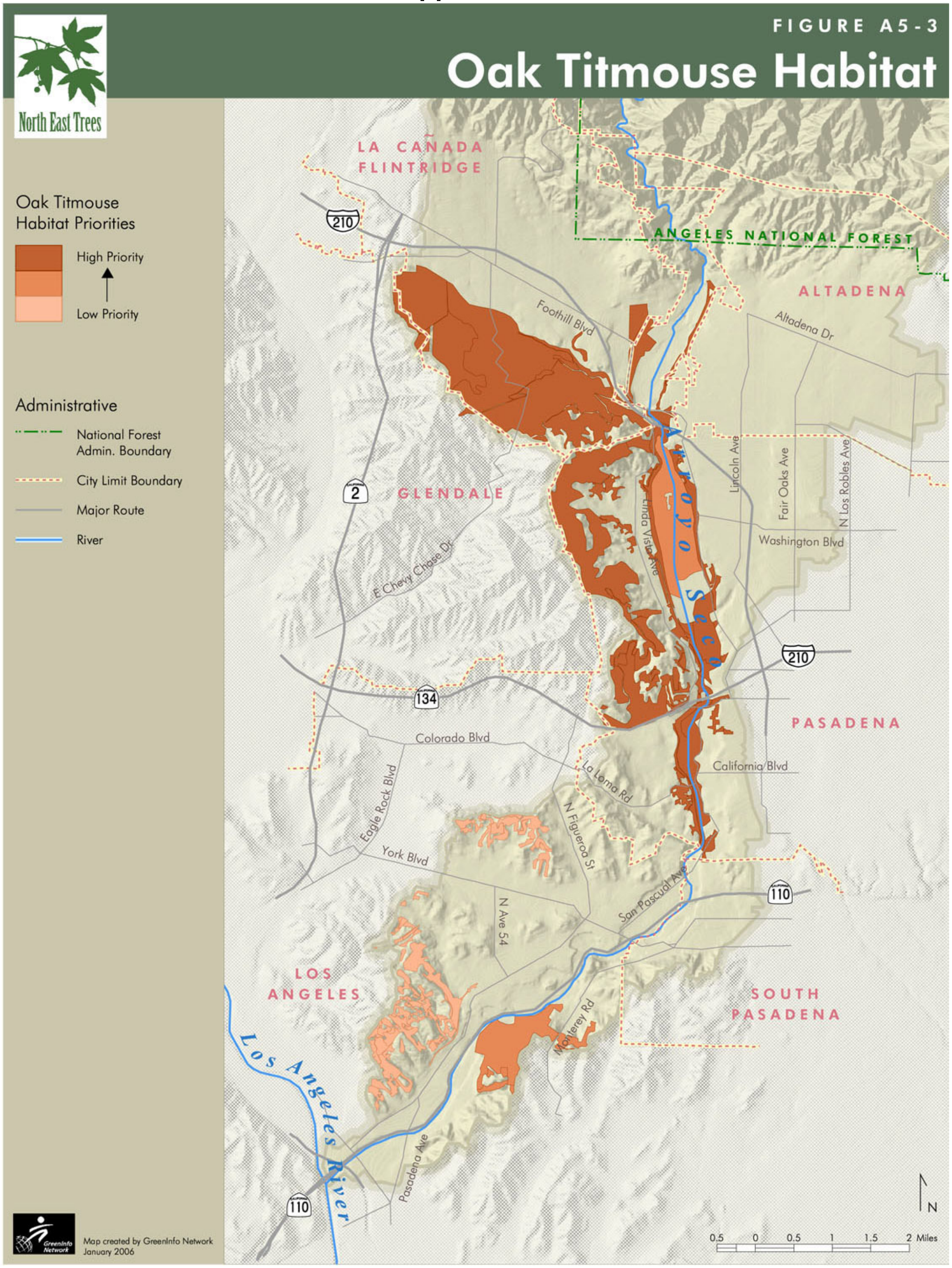


FIGURE A5-3
Oak Titmouse Habitat
North East Trees
Oak Titmouse
Habitat Priorities
High Priority
Low Priority
Administrative
National Forest
Admin. Boundary
City Limit Boundary
Major Route
River
LA CAÑADA
FLINTRIDGE
ANGELES NATIONAL FOREST
ALTADENA
GLENDALE
PASADENA
LOS
ANGELES
SOUTH
PASADENA
Arroyo Seco
Los Angeles River
Foothill Blvd
Altadena Dr
Lincoln Ave
Fair Oaks Ave
N Los Robles Ave
Washington Blvd
Linda Vista Ave
E Chevy Chase Dr
Colorado Blvd
La Loma Rd
California Blvd
Eagle Rock Blvd
N Figueroa St
York Blvd
San Pascual Ave
N Ave 54
Monterey Rd
Pasadena Ave
210
2
134
110
N
0.5 0 0.5 1 1.5 2 Miles
Map created by GreenInfo Network
January 2006

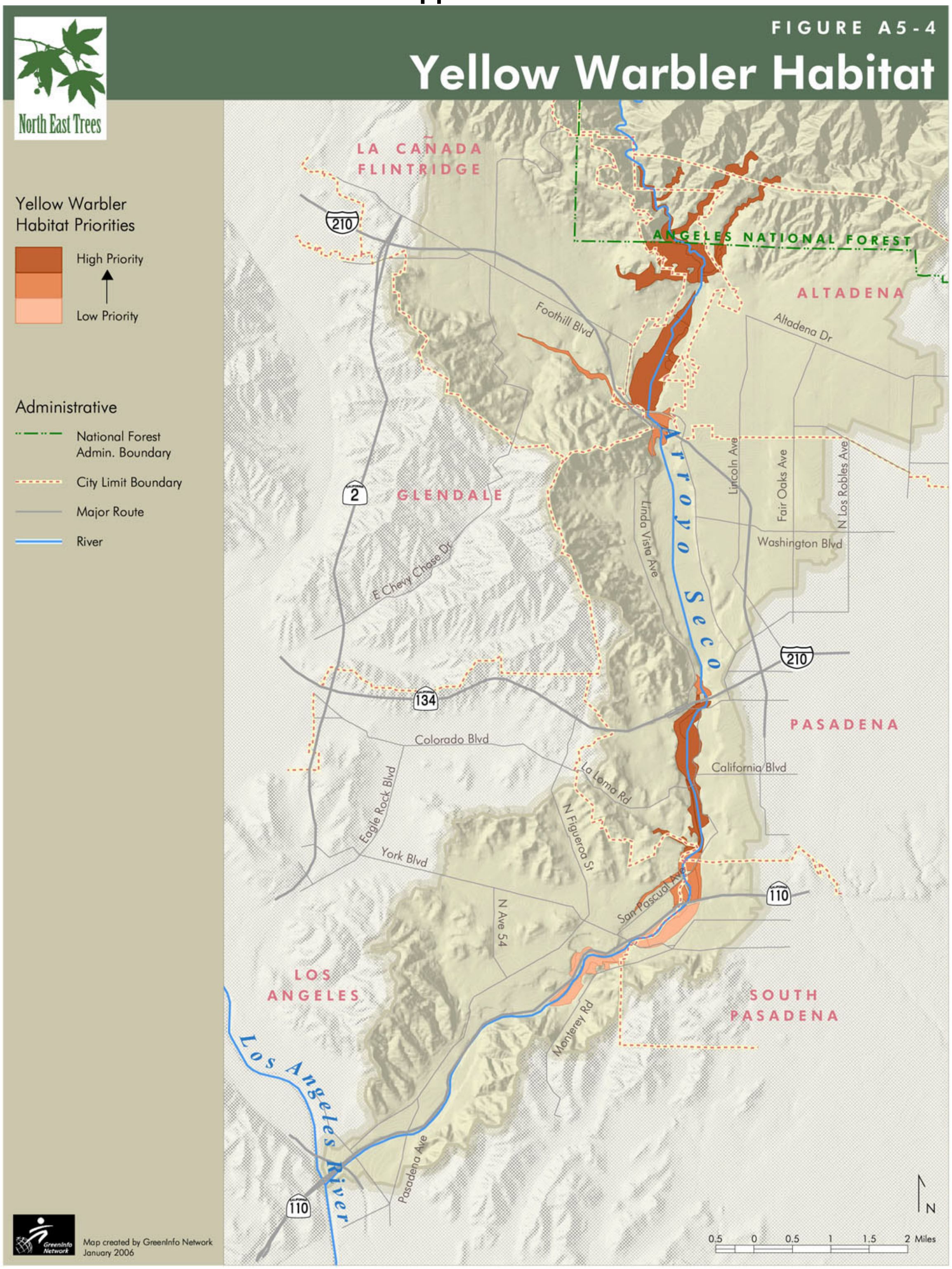


FIGURE A5-4
Yellow Warbler Habitat
North East Trees
Yellow Warbler Habitat Priorities
High Priority
Low Priority
Administrative
National Forest Admin. Boundary
City Limit Boundary
Major Route
River
LA CAÑADA FLINTRIDGE
ANGELES NATIONAL FOREST
ALTADENA
GLENDALE
PASADENA
LOS ANGELES
SOUTH PASADENA
Arroyo Seco
Los Angeles River
Foothill Blvd
Altadena Dr
Lincoln Ave
Fair Oaks Ave
N Los Robles Ave
Linda Vista Ave
Washington Blvd
E Chevy Chase Dr
Colorado Blvd
California Blvd
La Loma Rd
Eagle Rock Blvd
York Blvd
N Figueroa St
San Pascual Ave
N Ave 54
Monterey Rd
Pasadena Ave
210
2
134
110
N
0.5 0 0.5 1 1.5 2 Miles
Map created by GreenInfo Network January 2006

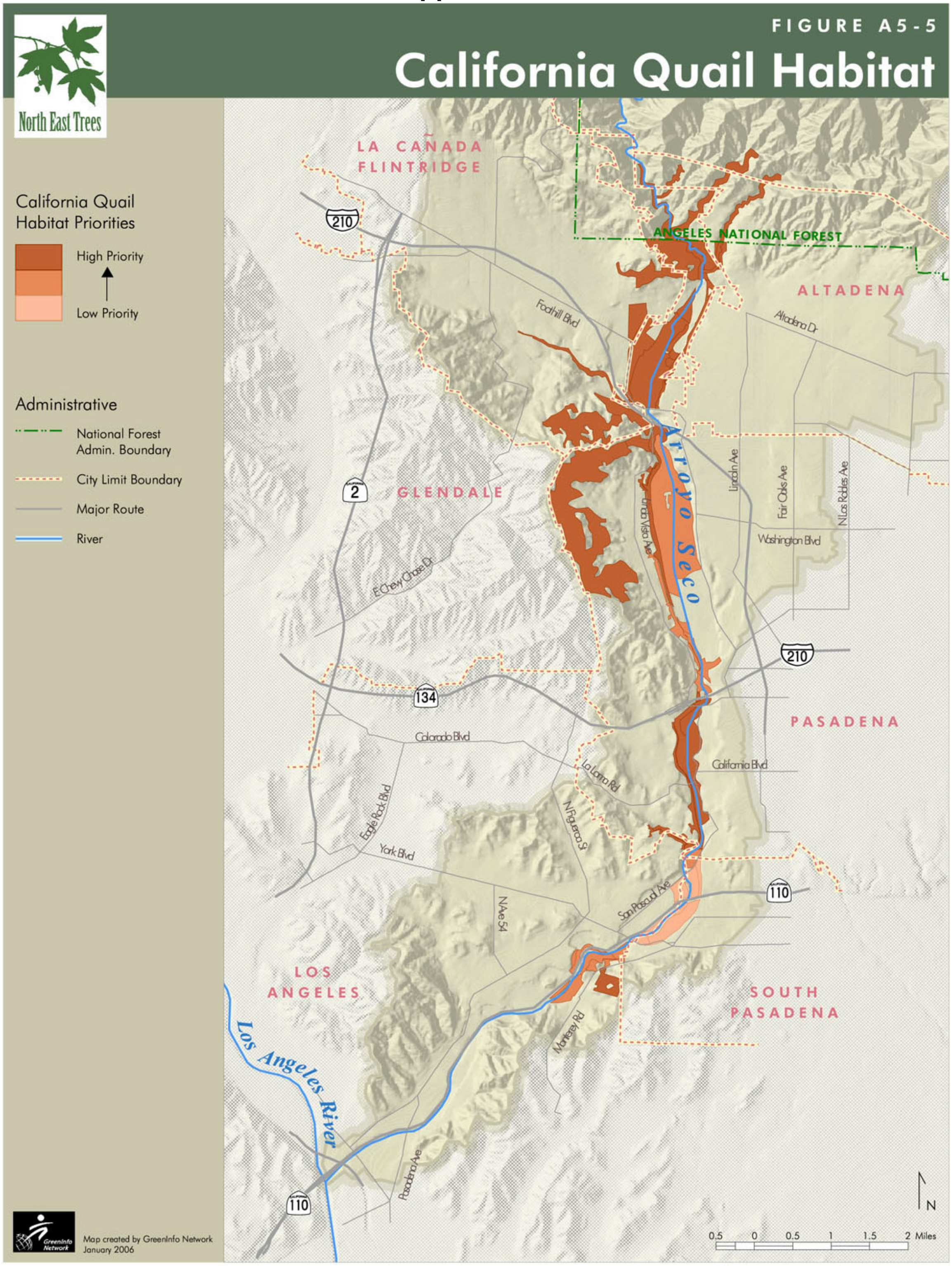


FIGURE A5-5
California Quail Habitat
North East Trees
California Quail
Habitat Priorities
High Priority
Low Priority
Administrative
National Forest
Admin. Boundary
City Limit Boundary
Major Route
River
Map created by GreenInfo Network
January 2006
LA CAÑADA
FLINTRIDGE
ANGELES NATIONAL FOREST
ALTADENA
GLENDALE
PASADENA
LOS
ANGELES
SOUTH
PASADENA
Arroyo Seco
Los Angeles River
Foothill Blvd
Altadena Dr
Lincoln Ave
Fair Oaks Ave
N Los Robles Ave
Washington Blvd
E Chevy Chase Dr
Colorado Blvd
California Blvd
La Loma Rd
N Figueroa St
Eagle Rock Blvd
York Blvd
San Pascual Ave
N Ave 54
Monterey Rd
Pasadena Ave
210
2
134
110
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0.5 0 0.5 1 1.5 2 Miles

Overview Bibliography

Daubenmire, R. 1968. *Plant Communities: A Textbook of Plant Synecology*. Harper and Row, New York.

Morrison, M. L. 2002. *Wildlife Restoration: Techniques for Habitat Analysis and Animal Monitoring.* Island Press, Washington, D. C.

Palmer M. A., R. F. Ambrose, and N. L. Poff. 1997. Ecological theory and community restoration ecology. *Restoration Ecology* **5**: 291-300.

Arroyo Chub - References

Personal Communications

Chimienti, Michele. 2004. Senior Civil Engineering Assistant, Los Angeles County Department of Public Works. Michele provided copies of the Big Tujunga Wash Mitigation Bank annual reports.

Harris, Scott. 2001. California Department of Fish and Game. Email communication to North East Trees regarding the Arroyo Seco Watershed Restoration Feasibility Study.

Swift, Camm. 2004. Senior Project Scientist, ENTRIX, Inc., Irvine, CA and consultant to Chambers Group, Inc. on the Big Tujunga Wash Mitigation Bank project.

Bibliography

Castleberry, D. T. and J.J. Cech, Jr. 1986. Physiological responses of a native and an introduced desert fish to environmental stressors. *Ecology* **67**: 912-918.

Chambers Group, Inc. 2002a. *Big Tujunga Wash Mitigation Bank Annual Report – 2000*: Preliminary Draft. Prepared for Los Angeles County Department of Public Works. February, 2002.

Chambers Group, Inc. 2002b. *Big Tujunga Wash Mitigation Bank Annual Report – 2001*: Final. Prepared for Los Angeles County Department of Public Works. December, 2002.

Chambers Group, Inc. 2002c. *Functional Analysis of the Big Tujunga Wash Mitigation Bank for 2001, Los Angeles County* (Appendix A). Prepared for Los Angeles County Department of Public Works. January, 2002.

Chambers Group, Inc. 2003. *Big Tujunga Wash Mitigation Bank Annual Report – 2002*: Draft and Appendices. Prepared for Los Angeles County Department of Public Works. June, 2003.

Culver G. B. and C. L. Hubbs. 1917. The fishes of the Santa Ana system streams in southern California. *Lorquina* **1**: 82-83.

Jigour, V., D. Cooper and M. Stoecker. 2002. Habitat restoration in the Arroyo Seco watershed. Appendix F in *Arroyo Seco Watershed Restoration Feasibility Study* Volume II. North East Trees and Arroyo Seco Foundation, Los Angeles.

Los Angeles County Department of Public Works (LADPW). Undated. *Big Tujunga Wash Mitigation Bank*. Brochure published by the department.

Moyle, P. B. 1976. *Inland Fishes of California.* University of California Press, Berkeley, CA.

Moyle, P. B., R. M. Yoshiyama, J. E. Williams, and E. D. Wikramanayake. 1995. *Fish Species of Special Concern in California.* Department of Wildlife & Fisheries Biology, University of California, Davis. Prepared for the State of California, The Resources Agency, Department of Fish and Game, Inland Fisheries Division, Rancho Cordova; Contract No. 21281F.

Swift, C.C., T. Haglund, M. Ruiz and R. Fisher. 1993. The status and distribution of the freshwater fishes of southern California. *Bulletin of the Southern California Academy of Sciences* **92**: 101-167.

Tres, J. 1992. *Breeding Biology of the Arroyo Chub, Gila orcutti (Pisces: Cyrpindae)*. Unpublished M. S. Thesis, California State Polytechnic University, Pomona. 73 pp.

Wells, A. W. and J. S. Diana. 1975. *Survey of the Freshwater Fishes and Their Habitats in the Coastal Drainages of Southern California*. Report submitted to California Department of Fish and Game, Inland Fisheries Branch by Los Angeles County Museum of Natural History. 360 pp.

Yellow Warbler - References

Personal Communications

Cooper, Dan. Audubon California, Pasadena.

Dwyer, Lynne. Landscape Architect, Friends of Los Angeles River, Los Angeles.

Garret, Kimball. Ornithology Collections Manager, Natural History Museum of Los Angeles County, Los Angeles.

Bibliography

Bent, A. C. 1953. Life histories of North American Wood warblers. *U.S. National Museum Bulletin* 203. 734pp.

Contreras, Y., I. Gonzalez, R. Haro, M. Mancilla, J. Ramirez, Y. Rivas, M. Varga, L. Zuniga. 2003. Draft Hansen Dam informational brochure. San Fernando High School: Project GRAD Scholars. www.tujungawatershed.org/images/TWY_PG_2003_broch.pdf

Dunn, J. L. and K. L. Garrett. 1997. *A Field Guide to the Warblers of North America*. Houghton Mifflin Co., Boston.

Ehrlich, P. R., D. S. Dobkin, and D. Wheye. 1988. *The Birder's Handbook*. Simon and Schuster, New York. 785pp.

Ficken, M. S., and R. W. Ficken. 1966. Notes on mate and habitat selection in the yellow warbler. *Wilson Bulletin* 78:232-233.

Garrett, K., and J. Dunn. 1981. *Birds of Southern California*. Los Angeles Audubon Society. 408pp.

Garrett, K. ed. 1993 a. *The Biota of the Los Angeles River*. Natural History Museum of Los Angeles County Foundation: California Department of Fish and Game Contract No. FG 0541.

Garrett, K. 1993 b. The avifauna of the Los Angeles River: an historical overview and current analysis. F1-90 in *The Biota of the Los Angeles River*. (K. Garrett ed.) Natural History Museum of Los Angeles County Foundation: California Department of Fish and Game Contract No. FG 0541.

Green, M.; R. Duke and D. Winkler eds. (Undated.) Yellow Warbler *Dendroica petechia* B430. *California Wildlife Habitat Relationships System Volume II: Birds*: Updates from Zeiner, DC, WF Laudenslayer Jr., KE Mayer, and M White, eds. 1988 – 1990. California Department of Fish and Game: California Interagency Wildlife Task Group. http://www.dfg.ca.gov/whdab/html/B430.html

Jigour, V., D. Cooper and M. Stoecker. 2002. Habitat restoration in the Arroyo Seco watershed. Appendix F. in *Arroyo Seco Watershed Restoration Feasibility Study Volume II*. North East Trees and Arroyo Seco Foundation, Los Angeles.

Lowther, P.E., C. Celada, N. K. Klein, C. C. Rimmer and D. A. Spector. 1999. Yellow Warbler (*Dendroica petechia*). In *The Birds of North America* No. **454** (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Remsen, J. V., Jr. 1978. Bird species of special concern in California. California Department of Fish and Game, Sacramento. Wildlife Management Administrative Report No. 78-1. 54 pp.

United States Fish and Wildlife Service (USFWS). 1998. *Draft Recovery Plan for Least Bell's Vireo*. U. S. Fish and Wildlife Service, Portland OR. 139 pp.

Wallace, G. 1993. Vascular plants of the Los Angeles River. B1-16 in *The Biota of the Los Angeles River*. (K. Garrett ed.) Natural History Museum of Los Angeles County Foundation: California Department of Fish and Game Contract No. FG 0541.

Oak Titmouse - References

Personal Communications

Cooper, Dan. Director of Bird Conservation, Audubon California, Pasadena

Garret, Kimball. Ornithology Collections Manager, Natural History Museum of Los Angeles County, Los Angeles.

Bibliography

Cicero, C. 2000. Oak Titmouse (*Baeolophus inornatus*) and Juniper Titmouse (*Baeolophus ridgwayi).* In *The Birds of North America* No. **454** (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Cooper, D. S. 2000. Breeding Landbirds of a Highly Threatened Open Space: The Puente-Chino Hills, California. *Western Birds* **31**: 213-234.

Dixon, K. L. 1954. Some ecological relationships of chickadees and titmice in central California. *Condor* **52**: 140-141.

Flannery, M. (Undated.) Bird Conservation Plan: Oak Titmouse *Baeolophus inornatus,* synonym: *Parus inornatus.* California Partners in Flight. http://www.prbo.org/calpif/htmldocs/species/oak/oatiacct.html

Jigour, V., D. Cooper and M. Stoecker. 2002. Habitat restoration in the Arroyo Seco watershed. Appendix F in *Arroyo Seco Watershed Restoration Feasibility Study* Volume II. North East Trees and Arroyo Seco Foundation, Los Angeles.

Koenig, W. D., W. J. Carmen, M. T. Stanback, and R. L. Mumme. 1991. Determinants of acorn productivity among five species of oaks in central coastal California. Pages 136-142 in Standiford, R. B. *Proceedings of the Symposium on Oak Woodlands and Hardwood Rangeland Management*; Oct. 31 – Nov. 2, 1990; Davis CA. Gen. Tech. Rep. PSW-126. U. S. Deprtment of Agriculture, Forest Service, Pacific Southwest Research Station, Berkeley. 376 pp.

Koenig, W. D., J. M. H. Knops, W. J. Carmen, M. T. Stanback, and R. L. Mumme. 1996. Acorn production by oaks in central coastal California: influence of weather at three levels. *Canadian Journal of Forest Research* **26**: 1677-1683.

Koenig, W. D. and J. M. H. Knops. Undated. Geographical ecology of acorn production by California oaks. Integrated Hardwood Range Management Program. Fact Sheet 68. http://danr.ucop.edu/ihrmp/oak68.htm

Koenig, W. D., R. L. Mumme, W. J. Carmen, and M. T. Stanback. 1994. Acorn production by oaks in central coastal California: variation within and among years. *Ecology* **75**: 99-109.

National Geographic. 1999. *Field Guide to the Birds of North America*. Third edition. National Geographic Society, Washington, D. C.

Sauer, J. R, J. E. Hines, G. Gough, I. Thomas, and B. G. Peterjohn. 1997. The North American Breeding Bird Survey results and analysis. Version 96.4 Patuxent Wildlife Research Center, Laurel, MD.

Wilson, R. A. 1992. *Nesting Success of the Plain Titmouse, Parus inornatus, as an Indicator of Habitat Quality in Blue Oak Woodlands*. Master's thesis, Humboldt State University, Arcata, CA.

Wilson, R. A., P. Manley, and B. R. Noon. 1991. Covariance patterns among birds and vegetation in a California oak woodland. Pages 126-135 in Standiford, R. B. *Proceedings of the Symposium on Oak Woodlands and Hardwood Rangeland Management*; Oct. 31 – Nov. 2, 1990; Davis CA. Gen. Tech. Rep. PSW-126. U. S. Deprartment of Agriculture, Forest Service, Pacific Southwest Research Station, Berkeley. 376 pp.

California Quail - References

Personal Communications

Cooper, Dan. 2004. Director of Bird Conservation, Audubon California, Pasadena.

Dwyer, Lynne. 2004. Landscape Architect, Friends of Los Angeles River, Los Angeles.

Bibliography

Ahlborn, G.. (Undated.) California Quail *Callipepla californica* B140. California Wildlife Habitat Relationships System Volume II: Birds: Updates from Zeiner, DC, WF Laudenslayer Jr., KE Mayer, and M White, eds. 1988 – 1990. California Department of Fish and Game: California Interagency Wildlife Task Group. http://www.dfg.ca.gov/whdab/html/B140.html

Chase, M. K., W. B. Kristan III, A. J. Lynam, M. V. Price, and J. T. Rotenberry. 2000. Single species as indicators of species richness and composition in California coastal sage scrub birds and small mammals. *Conservation Biology* **14**: 474-487.

Crooks, K. R., A. V. Suarez, D. T. Bolger, M. E. Soulé. 2001. Extinction and colonization of birds on habitat islands. *Conservation Biology* **15**: 159-172.

Duncan, Don A. and Paul W. Shields. 1966. Fall and winter food of California quail in dry years. *California Fish and Game* **52** (4): 275-282.

Golden Gate Audubon Society. 2000. Quail becomes official bird of San Francisco. http://www.goldengateaudubon.org/Conservation/archives/quailofficialbird.htm

Haun, Larry. 1999. Birds and flowers of Elysian Park (tied to comment on Pg 117

Leopold, A. S. 1977. *The California Quail*. University of California Press. Berkeley. 281pp.

McIlvaine, J. 2000. The biogeography of California Quail (*Callipepla californica*). Paper prepared for Geography 316: Biogeography, San Francisco State University Department of Geography. http://bss.sfsu.edu:224/courses/Fall00Projects/Quail.html

Soulé, M. E., D. T. Bolger, A. C. Alberts, J. Wright, M. Sorice, S. Hill. 1988. Reconstructed dynamics of rapid extinctions of chaparral-requiring birds in urban habitat islands. Conservation Biology 2: 75-92.

Spotted Towhee - References

Personal Communications

Cooper, Dan. Director of Bird Conservation, Audubon California, Pasadena.

Bibliography

Alberts, A. C., A. D. Richman, D. Tran, R. Sauvajot, C. McCalvin, D. T. Bolger. 1993. Effects of habitat fragmentation on native and exotic plants in southern California coastal scrub. Pages 103-110 in J. E. Keeley, editor. *Interface Between Ecology and Land Development in Southern California.* Southern California Academy of Sciences, Los Angeles.

Andren, H. & P. Angelstram. 1988. Elevated predation rates as an edge effect in habitat islands: experimental evidence. *Ecology* **69**:544 547.

Greenlaw, J. S. 1996. Spotted Towhee (*Pipilo maculatus*). In *The Birds of North America* No. **454** (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Chase, M. K., W. B. Kristan III, A. J. Lynam, M. V. Price, and J. T. Rotenberry. 2000. Single species as indicators of species richness and composition in California coastal sage scrub birds and small mammals. *Conservation Biology* **14**: 474-487.

Churcher, J. B. & J. H. Lawton. 1987. Predation by domestic cats in an English village. *Journal of Zoology, London* **212**:439 456.

Crooks, K. R. & M. E. Soulé. 1999. Mesopredator release and avifaunal extinctions in a fragmented system. *Nature* **400**:563 566.

Crooks, K. R., A. V. Suarez, D. T. Bolger, M. E. Soulé. 2001. Extinction and colonization of birds on habitat islands. *Conservation Biology* **15**: 159-172.

Davis, J. 1957. Comparative foraging behavior of the Spotted and Brown towhees.

Auk **74**: 129-166.

Davis, J. 1958. Singing behavior and the gonad cycle of the Rufous-sided Towhee. *Condor* **60**: 308-336.

Langen, T. A., D. T. Bolger, T. J. Case. 1991. Predation on artificial bird nests in chaparral fragments. *Oecologia* **86**:395-401.

Leimgruber, P., W. J. McShea, J. H. Rappole. 1994. Predation on artificial nests in large forest blocks. *Journal of Wildlife Management* **58**:254-260.

Patten, M. A. and Bolger, D. T, 2003. Variation in top-down control of avian reproductive success across a fragmentation gradient. *Oikos* 101: 479-488.

Soulé, M. E., D. T. Bolger, A. C. Alberts, J. Wright, M. Sorice, S. Hill. 1998. Reconstructed dynamics of rapid extinctions of chaparral-requiring birds in urban habitat islands. *Conservation Biology* **2**: 75-92.

Suarez, A. V., D. T. Bolger, T. J. Case. 1998. The effects of habitat fragmentation and invasion on the native ant community in coastal southern California. *Ecology* 79:2041-2056.

Wilcove, D. S. 1985. Nest predation in forest tracts and the decline of migratory songbirds. Ecology 66:1211-1214.

Appendix 6: Detailed Project Profiles

PROJECT: LA-1: Lincoln Heights Freeway Interchange Restoration and BMP

PROJECT LOCATION

City: Los Angeles

Neighborhood: Lincoln Heights

Site Identification: Vacant land along Arroyo Seco channel and adjacent to / underneath Interstate 5 & Arroyo Seco Parkway interchange.

Site Owner: California Department of Transportation

PROJECT DESCRIPTION

Project Type: BMP installation and habitat restoration

Project Scope: Water Quality, Habitat Restoration

Project Overview: This site, located just northwest of where Avenue 26 crosses the Arroyo Seco, is currently used for material storage. Much of it exists in a natural albeit disturbed state. In addition, a storm drain draining an industrial sector of the watershed empties through the site directly to the Arroyo Seco. Project Component Letters would include an infiltration gallery or subsurface flow wetland to treat the storm drain discharge, habitat restoration consistent with historical conditions, and limited provision of public access to the site.

Project Rationale: Habitat Restoration: The site if restored could be a critical link between the more naturalized open space areas to the north including Debs Park, and the confluence of the Arroyo Seco with the Los Angeles River.

PROJECT DETAILS

Project Component	Component Letter	Type	Size (acres)	Score (max possible)	Cost
Restore riparian and coastal sage scrub habitat	A	HR	6.5	2 (15)	$100,000 - $250,000
Install infiltration gallery or subsurface flow wetland at end of Ave 26 storm drain	B	WQ	3+	3.75 (5)	$500,000 - $1,000,000
Open site to public access	C	MISC	< 1	N/A	$50,000 - $100,000
Total			**6.5**		**$650,000 - $1,350,000**

HABITAT DETAILS

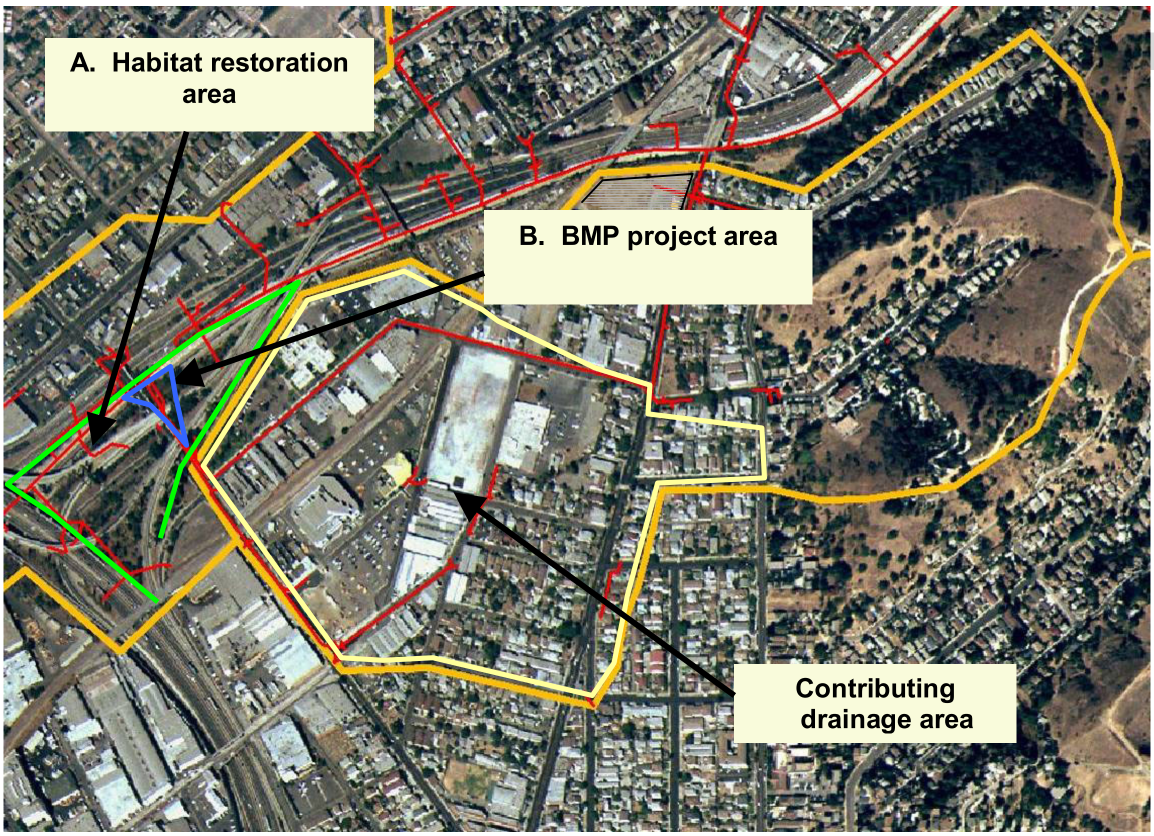
	AC	CQ	OT	ST	YW	Total Score
Restoration scores	0	0	0	2	0	2

Rank (out of 22 projects): Tied for 17th
Rank in Los Angeles (out of 11 projects): Tied for 9th

WATER QUALITY DETAILS

Tributary area: 65 acres
Project area: 1-3 acres
BMP Type: Infiltration basin / trench (or subsurface flow wetland if infiltration rates not sufficient)
Score (out of 5): 3.75
Rank (out of 48): 11 (Tied)
Rank in Los Angeles (out of 26): 3 (Tied)

PROJECT AREA PHOTOGRAPH



PROJECT: LA-2: Sycamore Grove Park Stream Restoration

PROJECT LOCATION

City: Los Angeles

Neighborhood: Highland Park

Site Identification: Sycamore Grove Park.

Site Owner: City of Los Angeles Department of Recreation and Parks

PROJECT DESCRIPTION

Project Type: BMP installation

Project Scope: Water Quality

Project Overview: Prior to the channelization of the Arroyo Seco and the installation of subsurface storm drains, a large tributary called the North Branch ran through Highland Park and Mt. Washington before joining the Arroyo Seco at the present-day location of Sycamore Grove Park. Today, this drain carries runoff from over 1,000 acres of densely developed Los Angeles, and is estimated to contributed substantial quantities of metals and bacteria to the Arroyo Seco.

This project's aim is to daylight and naturalize the southern end of the North Branch tributary of the Arroyo Seco through existing Sycamore Grove Park. The park is located south of Avenue 50 between Figueroa Street and the Arroyo Seco. Additional project Component Letters include installing subsurface BMPs under Arroyo Seco Alternative School on the west side of Figueroa, and daylight the existing storm drain or install BMPs in the easement north of the school.

Project Rationale:

This project would create a naturalized stream through Sycamore Grove Park, adding to the natural character of the park and bringing a small portion of the North Branch back to its historical state. Because this naturalized stream would be unlined, most dry seasons and some wet season runoff would infiltrate into the ground and be treated by natural processes in the soil. This, combined with the BMP proposed for the Arroyo Seco Alternative School and a BMP or naturalized stream in the storm drain right of way just north of the school, would improve water quality entering the Arroyo Seco.

PROJECT DETAILS

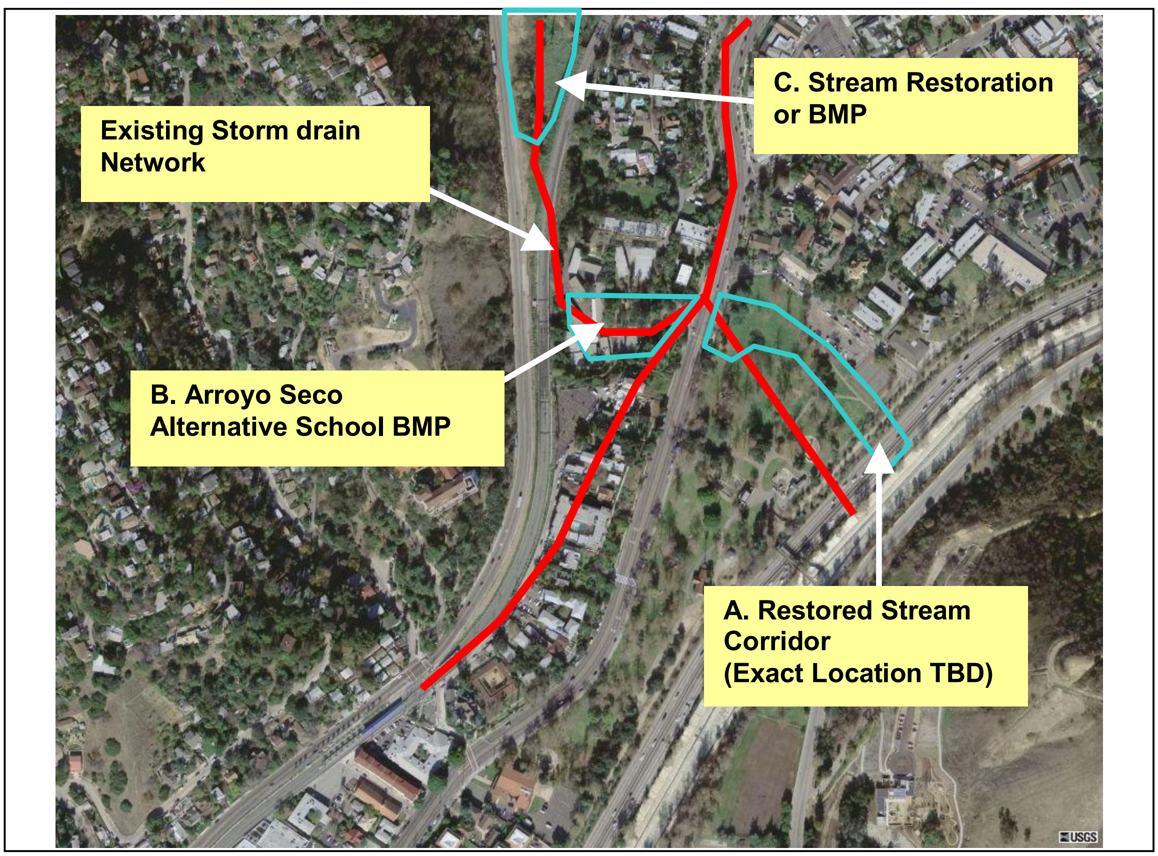
Project Component	Component Letter	Type	Size (acres)	Score (max possible)	Cost
Daylight North Branch storm drain, create a natural stream channel	A	WQ	3-5	4.6 (5)	$1M - $5M

through Sycamore Grove Park.					
Install subsurface Best Management Practices in open areas of the Arroyo Seco Alternative School.	B	WQ	1	4.6 (5)	$1M - $5M
Daylight North Branch in storm drain easement, or install additional BMPs	C	WQ	1	4.6 (5)	$500K - $1M
Total			**5-7**		**$2.5M - $10M+**

WATER QUALITY DETAILS

Tributary area:	1,100+ acres
Project area:	5-7 acres
BMP Type:	Natural stream channel, infiltration galleries
Score (out of 5):	4.6
Rank (out of 48):	1
Rank in Los Angeles (out of 26):	1

PROJECT AREA PHOTOGRAPH



PROJECT: LA-3: Welch Site BMP and Habitat Restoration

PROJECT LOCATION

City: Los Angeles

Neighborhood: Lincoln Heights

Site Identification: Welch Property.

Site Owner: Unknown - private

PROJECT DESCRIPTION

Project Type: BMP installation and habitat restoration

Project Scope: Water Quality, Habitat Restoration

Project Overview: The Welch Property is adjacent to the Arroyo Seco on Pasadena Avenue, a block east of Figueroa Street. This three acre parcel is privately owned and it is currently vacant and unused. Component Letters of this project include acquisition of the property by a public agency, investigation of subsurface soil and groundwater and cleanup if necessary, installation of an infiltration gallery or subsurface flow wetland for the Pasadena Avenue storm drain, and conversion of the property to public open space and planting with coastal sage scrub and riparian vegetation.

Project Rationale: Similar to Project LA-1, this project would provide for the treatment of discharge from a storm drain draining an industrial / commercial sector of the watershed, and would also provide a core Component Letter of a wildlife corridor in the southern watershed. This site would also be a valuable additional of open space to one of LA's most densely populated areas.

PROJECT DETAILS

Project Component	Component Letter	Type	Size (acres)	Score	Cost
Acquisition of property by a public agency.	A		3.4		$1M - $5M
Investigation and cleanup of any subsurface contamination.	B		3.4		???
Install infiltration gallery or subsurface flow wetland (depending on soil properties) to treat storm drain discharge.	C	WQ	1	3.8	$500K - $1M
Convert to public open space with areas of coastal sage scrub and riparian habitat.	D	HR	3.4	2	$100K - $250K
Total			**3.4**		**$1.6M - $6.3M**

HABITAT DETAILS

	AC	CQ	OT	ST	YW	Total Score
Restoration scores	0	0	0	2	0	2

Rank (out of 22 projects): 20th
Rank in Los Angeles (out of 11 projects): 9th

WATER QUALITY DETAILS

Tributary area: 90 acres
Project area: 3.4 acres
BMP Type: Infiltration trenches or subsurface flow wetland
Score (out of 5): 3.8
Rank (out of 48): 11 (Tied)
Rank in Los Angeles (out of 26): 3 (Tied)

PROJECT AREA PHOTOGRAPH

PROJECT: LA-4: Garvanza Elementary / Luther Burbank Middle Schools BMP Implementation

PROJECT LOCATION

City: Los Angeles

Neighborhood: Highland Park

Site Identification: Garvanza Elementary and Luther Burbank Middle Schools

Site Owner: Los Angeles Unified School District

PROJECT DESCRIPTION

Project Type: BMP installation

Project Scope: Water Quality

Project Overview: Garvanza Park, Garvanza Elementary and Luther Burbank Middle schools, located in Highland Park, sit on two major storm drains which convey runoff from nearly 400 acres of highly impervious, densely populated neighborhoods. It is likely that these drains contribute significantly to pollutant-laden stormwater runoff into the Arroyo Seco.

Given the size of these sites, the large areas of parking lots and playing fields that are compatible with subsurface stormwater best management practices, and their proximity to major storm drains, they are ideal locations to install BMPs to treat stormwater originating upstream of the schools. Water quality would be greatly improved by installing infiltration galleries under playing fields and open space areas at the northeast and southwest edges of campus, thereby treating discharges from the storm drains running along Avenue 63 and Figueroa.

If installing these BMPs proves infeasible, an alternative would be to install biorentention areas and cisterns to retain parking lot and roof top runoff from the site itself. Although this would not produce the same benefits as installing regional BMPs, it would reduce runoff from one of the larger facilities in the Los Angeles portion of the watershed.

Project Rationale: This site is an ideal regional BMP location: it has open space / parking zones compatible with the installation of large subsurface BMPs that would not affect uses, and it lies adjacent to major storm drains carrying runoff from highly urbanized areas.

PROJECT DETAILS

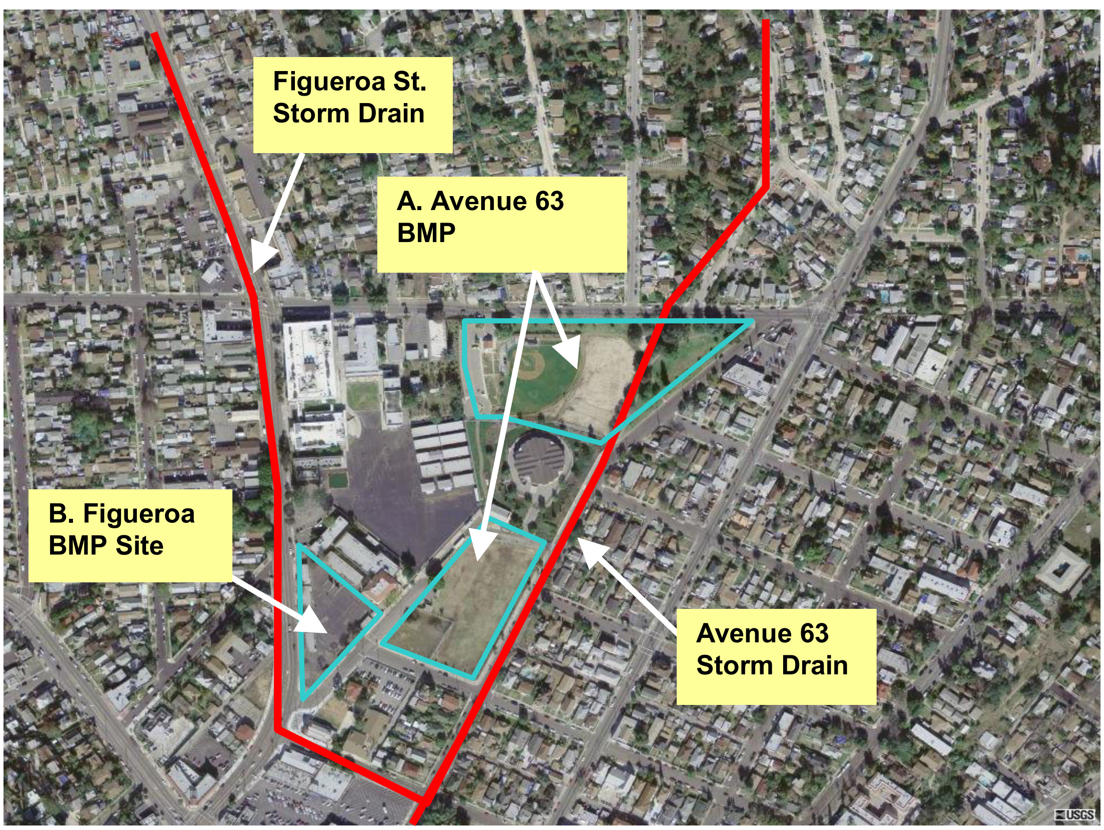
Project Component	Component Letter	Type	Size (acres)	Score	Cost
Install BMPs underneath east side of campus to treat discharge from Avenue 63 storm drain.	A	WQ	9	4.2	$1M - $5M
Install BMPs underneath	B	WQ	1	4.2	$500K - $1M

southwest corner of campus to treat discharge from Figueroa storm drain.					
If regional BMPs infeasible, install onsite bioretention areas and cisterns to eliminate parking lot and rooftop runoff.	C	WQ			$100K - $250K
Total			**10**	**4.2**	**$1.5M - $6M** ($100K - $250K if onsite treatment only)

WATER QUALITY DETAILS

Tributary area:	400+ acres
Project area:	10 acres
BMP Type:	Infiltration
Score (out of 5):	4.2
Rank (out of 48):	8 (Tied)
Rank in Los Angeles (out of 26):	2 (Tied)

PROJECT AREA PHOTOGRAPH



PROJECT: P-1: Lower Arroyo Park Habitat Restoration and BMP Implementation

PROJECT LOCATION

City: Pasadena

Neighborhood: N/A

Site Identification: Lower Arroyo Park

Site Owner: City of Pasadena

PROJECT DESCRIPTION

Project Type: BMP installation and habitat restoration

Project Scope: Water Quality, Habitat Restoration

Project Overview: Lower Arroyo Park is a critical habitat link between the central Arroyo and sites farther north, the San Rafael Hills to the northeast, and the lower Arroyo in Los Angeles and South Pasadena. In addition, Lower Arroyo Park also contains many areas of moderate to high quality habitat – the riparian habitat of the low flow diversions and the area underneath the Colorado Street Bridge, the scrub habitat in the floodplains, the oak woodlands along the hillsides, and one of the few places where the Arroyo isn't lined with concrete under the Colorado Street and 134 Freeway bridges.

This project is itself an assembly of several projects that would be major ones in and of themselves. There is substantial riparian vegetation, but it could be strengthened by restoring natural hydrologic processes that could lead to periodic thinning. Scrub habitat in the flatlands and oak woodland habitat on the hillsides are often fairly extensive and of good quality, but in many places are heavily impacted by unsanctioned footpaths and other encroachments. Finally, Lower Arroyo Park, with its natural character and ample floodplain areas, offers perhaps the best opportunity to remove the concrete lining of the Arroyo channel and restore natural hydrologic function and aquatic ecosystems.

Project Rationale: Lower Arroyo Park is a critical habitat linkage between the northern and southern areas of the watershed. It also contains many areas of existing native habitat that, with some improvement, could serve as core areas for all of the terrestrial indicator species. And, the character and extent of the Park's protected lands are suitable for full restoration of the Arroyo Seco. This would not only have important habitat benefits, but would also infiltrate large volumes of water from farther north, thereby serving as an important water quality improvement mechanism.

PROJECT DETAILS

Project Component	**Letter**	**Type**	**Size**	**Score**	**Cost**

			(acre s)		
Remove Arroyo concrete lining, or expand and improve low flow wetlands if full restoration infeasible.	A	WQ/HR	40	14 (15) HR 4.35 (5) WQ	$10M+
Restore aquatic habitat in naturalized stream channel, and reintroduce low elevation native fish species.	B	HR	40	See above	$1M - $5M
Protect and restore existing riparian corridors.	C	HR	60+	See above	$500K - $1M
Restore scrub and oak woodland habitat, with focus on establishing a strong north-south corridor and on reducing human impacts on existing habitat.	D	HR	80+	See above	$500K - $1M
Total			**120+**	**14 (HR)** **4.35 (WQ)**	**$10M+**

HABITAT DETAILS

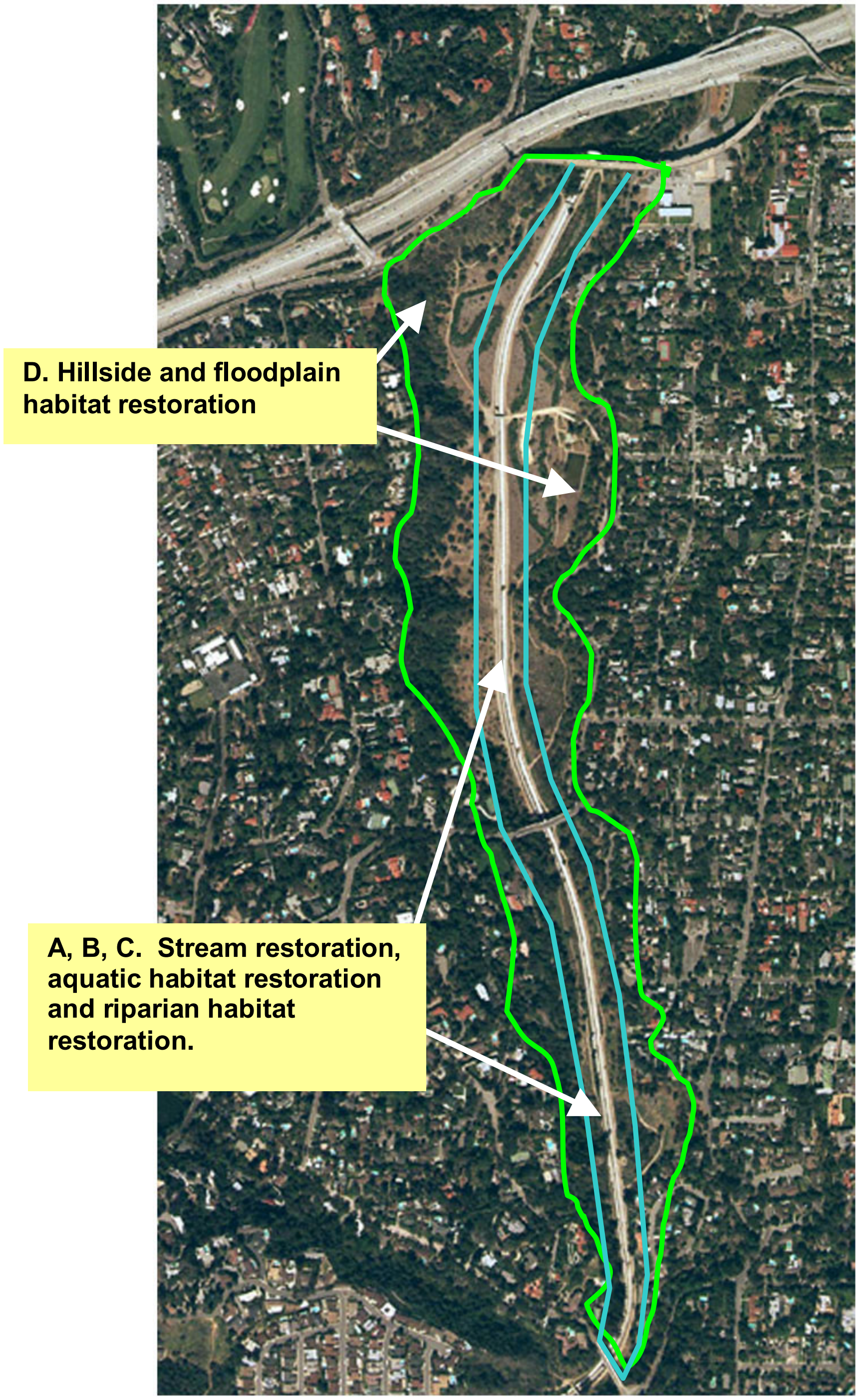
	AC	CQ	OT	ST	YW	Total Score
Restoration scores	2	3	3	3	3	14

Rank (out of 22 projects): Tied for 2nd
Rank in Pasadena (out of 6 projects): Tied for 2nd

WATER QUALITY DETAILS

Tributary area: 25,000 acres
Project area: 40 acres
BMP Type: Infiltration through natural stream process, restoration of natural biological processes
Score (out of 5): 4.35
Rank (out of 48): 6
Rank in Pasadena (out of 13): 5

PROJECT AREA PHOTOGRAPH



PROJECT: P-2: Central Arroyo Park Habitat Restoration and BMP Implementation

PROJECT LOCATION

City: Pasadena

Neighborhood: N/A

Site Identification: Central Arroyo / Brookside Park

Site Owner: City of Pasadena

PROJECT DESCRIPTION

Project Type: BMP installation and habitat restoration

Project Scope: Water Quality, Habitat Restoration

Project Overview: The Central Arroyo Park encompasses the area south of the Devil's Gate Dam and north of the 134 Freeway. This portion of the Arroyo contains major recreational facilities for Pasadena and the Arroyo region, including the Rose Bowl, Brookside Park and Golf Course, the Rose Bowl Aquatics Center, the Kidspace Museum, many other playing fields and courts, hiking, equestrian, and running paths, and associated parking areas.

In addition to this recreational function, the Central Arroyo Park links the more naturalized and less developed areas to the north and south: the Hahamonga Watershed Park and Angeles National Forest with the Lower Arroyo Park and beyond. Also, several very large storm drains carry stormwater runoff from heavily urbanized sections of west Pasadena. Project components include installing an infiltration gallery at the end of the Seco Street Storm Drain to treat water before it enters the Arroyo, protect and restoring hillsides for use as wildlife corridors, and naturalizing the Arroyo Seco through Brookside Golf Course.

Project Rationale: The Central Arroyo Park is a critical bottleneck in the Arroyo's function as a wildlife corridor: although technically open space, it is highly developed and very busy. Protecting and expanding existing habitat along the hillsides is perhaps the best way of connecting the more natural areas to the north and south. Storm drains expected to be among the largest contributors of pollutants to the Arroyo also run through Central Arroyo Park, and land uses at the end of these drains are compatible with the installation of large subsurface infiltration BMPs. Finally, with some restructuring of the golf course layout, it would be possible to naturalize the Arroyo through Brookside Golf Course with limited impact on golf outside of the few large storm events each year. This would also produce water quality benefits through increased infiltration.

PROJECT DETAILS

Project Component	Letter	Type	Size	Score	Cost

			(acres)		
Install infiltration gallery at the end of the Seco Street Drain, underneath existing Rose Bowl parking areas.	A	WQ	20	4.5 (5)	$1M - $5M
Protect and restore hillside habitat, focusing on the western edge of CAP.	B	HR	62	12 (15)	$500K - $1M
Naturalize the Arroyo through Brookside Golf Course	C	HR / WQ	20+	12 (15)	$5M+
Total			**100+**	**12 (15) HR 4.5 (5) WQ**	**$5M+**

HABITAT DETAILS

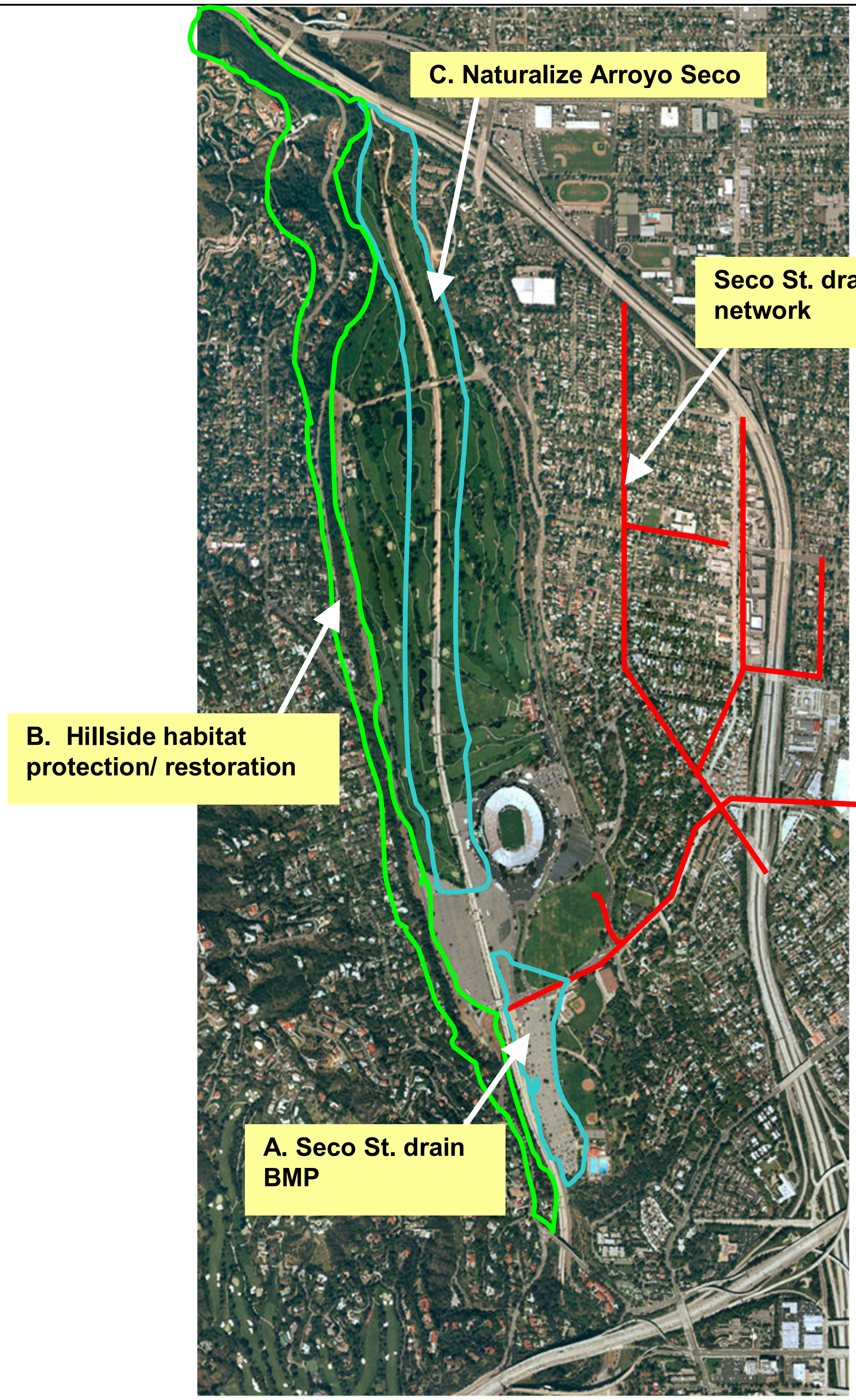
	AC	CQ	OT	ST	YW	Total Score
Restoration scores	1	3	3	3	2	12

Rank (out of 22 projects): 4
Rank in Pasadena (out of 6 projects): 4

WATER QUALITY DETAILS

Tributary area (acres): 1,300 (Seco Street Drain), 23,000 (Brookside naturalization)
Project area (acres): 100+
BMP Type: Infiltration / stream naturalization
Score (out of 5): 4.5
Rank (out of 48): 2
Rank in Pasadena (out of 13): 1

PROJECT AREA PHOTOGRAPH



PROJECT: P-3: Hahamongna Watershed Park Habitat Restoration and BMP Implementation

PROJECT LOCATION

City: Pasadena

Neighborhood: N/A

Site Identification: Hahamongna Watershed Park

Site Owner: City of Pasadena

PROJECT DESCRIPTION

Project Type: BMP installation and habitat restoration

Project Scope: Water Quality, Habitat Restoration

Project Overview: The area contained within Pasadena's Hahamongna Watershed Park is perhaps the most important habitat area of the Arroyo watershed south of Angeles National Forest. With restoration, it could support populations of all five of the indicator species discussed in this plan, and many more species reliant upon more specific habitats.

Hahamongna is also critical from a water quality perspective. Several large storm drains empty directly into the Hahamongna Basin. One of them, the Altadena Drain, has been shown to contribute large concentrations of bacteria into the Arroyo.

Key project components include installing infiltration galleries or subsurface flow wetlands at the ends of the three storm drains entering the basin from the east, and improving oak woodland, the various types of sage scrub habitat found in Hahamongna, and the healthy riparian vegetation that thrives along the braided stream channel and where Flint Wash empties into Hahamongna northwest of Devil's Gate Dam.

Project Rationale: Hahamongna is the most important potential breeding and source area (i.e., and area that could be a "source" of wildlife for Arroyo areas farther south) for all five indicator species. High quality habitat already exists, including several rare habitats not covered in detail in this plan. Large storm drains empty into Hahamongna from Pasadena and Altadena, and one of them has been shown through sampling to have high levels of indicator bacteria.

PROJECT DETAILS

Project Component	Letter	Type	Size (acres)	Score	Cost
Install infiltration gallery at end of Altadena storm drain.	A	WQ	5	4.4 (5)	$1M - $5M
Install infiltration gallery at the end of the storm drain running along Figueroa Drive.	B	WQ	9	4.4 (5)	$1M - $5M

Install infiltration gallery at the end of the storm drain running along Ventura Street.	C	WQ	3	4.4 (5)	$500K - $1M
Protect and restore oak woodlands, focusing on improving the Oak Grove area and reducing human impacts.	D.i	HR	110	15 (15)	$500K - $1M
Protect and restore riparian habitat, and maintain the vitality of the southern willow scrub habitat at the south end of Hahamongna.	D.ii	HR	60	15 (15)	$500K - $1M
Protect, restore and connect the various types of sage scrub habitat found throughout the park.	D.iii	HR	80	15 (15)	$250K - $500K
Total			**250+**		**$3.8M – 10M+**

HABITAT DETAILS

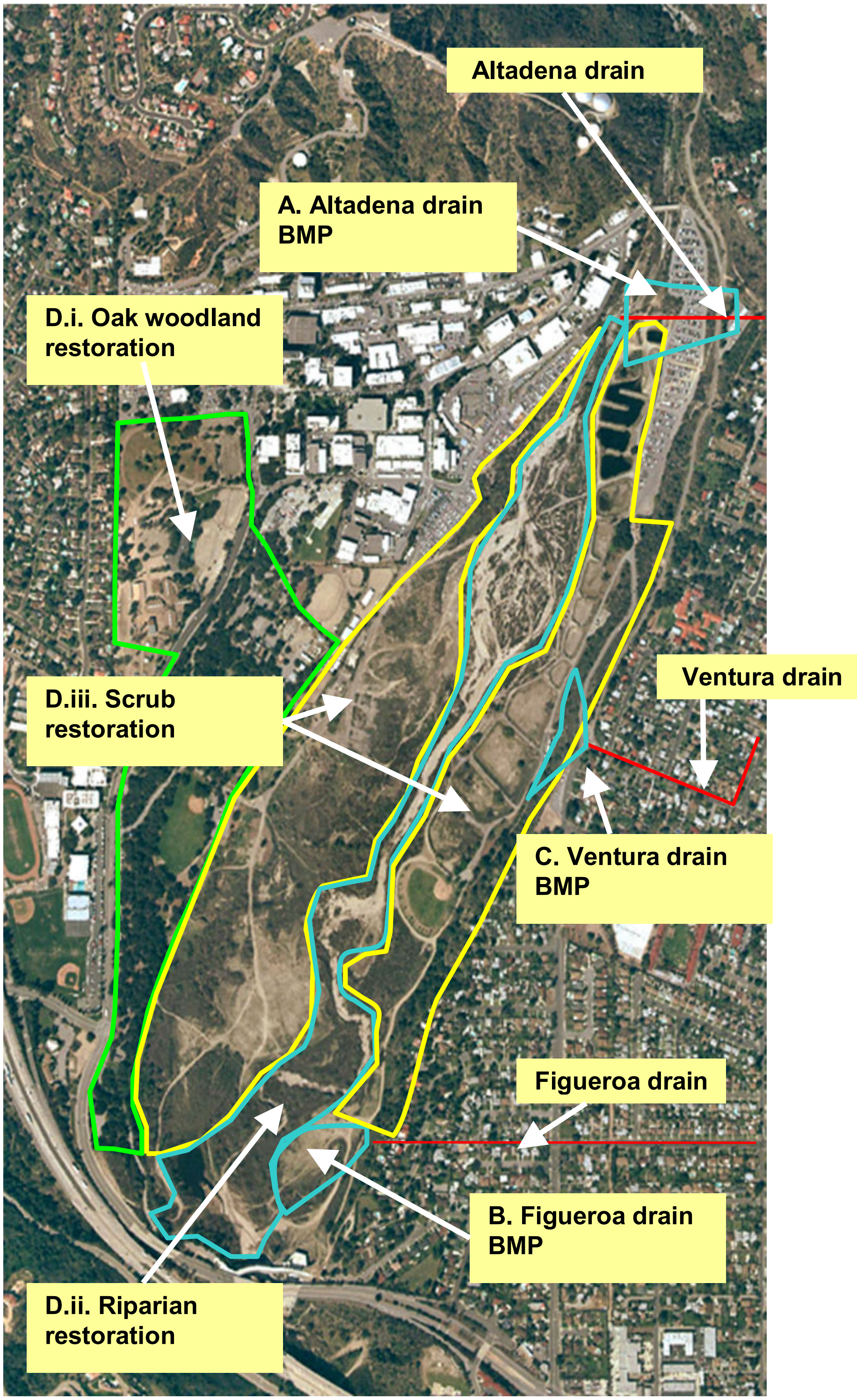
	AC	CQ	OT	ST	YW	Total Score
Restoration scores	3	3	3	3	3	15

Rank (out of 22 projects): 1
Rank in Pasadena (out of 6 projects): 1

WATER QUALITY DETAILS

Tributary area (acres): 2,500 (1,000 Altadena, 1,350 Figueroa, 150 Ventura)
Project area (acres): 17
BMP Type: Infiltration
Score (out of 5): 4.4
Rank (out of 48): 3 (Tied)
Rank in Pasadena (out of 13): 2 (Tied)

PROJECT AREA PHOTOGRAPH



PROJECT: P-4: Flint Wash Restoration

PROJECT LOCATION

City: Pasadena

Neighborhood: West Pasadena

Site Identification: Flint Wash, Along 210 Freeway W of Devil's Gate Dam

Site Owner: City of Pasadena

PROJECT DESCRIPTION

Project Type: Habitat Restoration, Stream channel restoration

Project Scope: Habitat Restoration

Project Overview: Flint Wash, which drains most of La Cañada Flintridge and far western Pasadena, empties into the Hahamongna Watershed Park just northwest of Devil's Gate Dam. The last ¾ mile of the Wash is unlined, providing an opportunity to introduce fish species. Habitat improvements would include removal of existing exotic plants, restoration of riparian habitat, removal of fish barriers, restoring natural stream channel geometry, and establishing a protected wildlife corridor through Flint Wash, up the hillside south of the 210 freeway, across Highland Drive / Linda Vista Avenue, and down into Central Arroyo Park.

Project Rationale: Flint Wash presently contains some of the last unlined sections of low elevation stream in the entire Arroyo Seco watershed. Water quality is high, and a survey by noted fishery biologist Camm Swift suggested that the stream could support native fish with minimal improvements. Also, Flint Wash provides the best route around Devil's Gate Dam for wildlife moving out of the San Gabriel Mountains and Hahamongna Basin down into the San Rafael Hills and Central / Lower Arroyo Parks.

PROJECT DETAILS

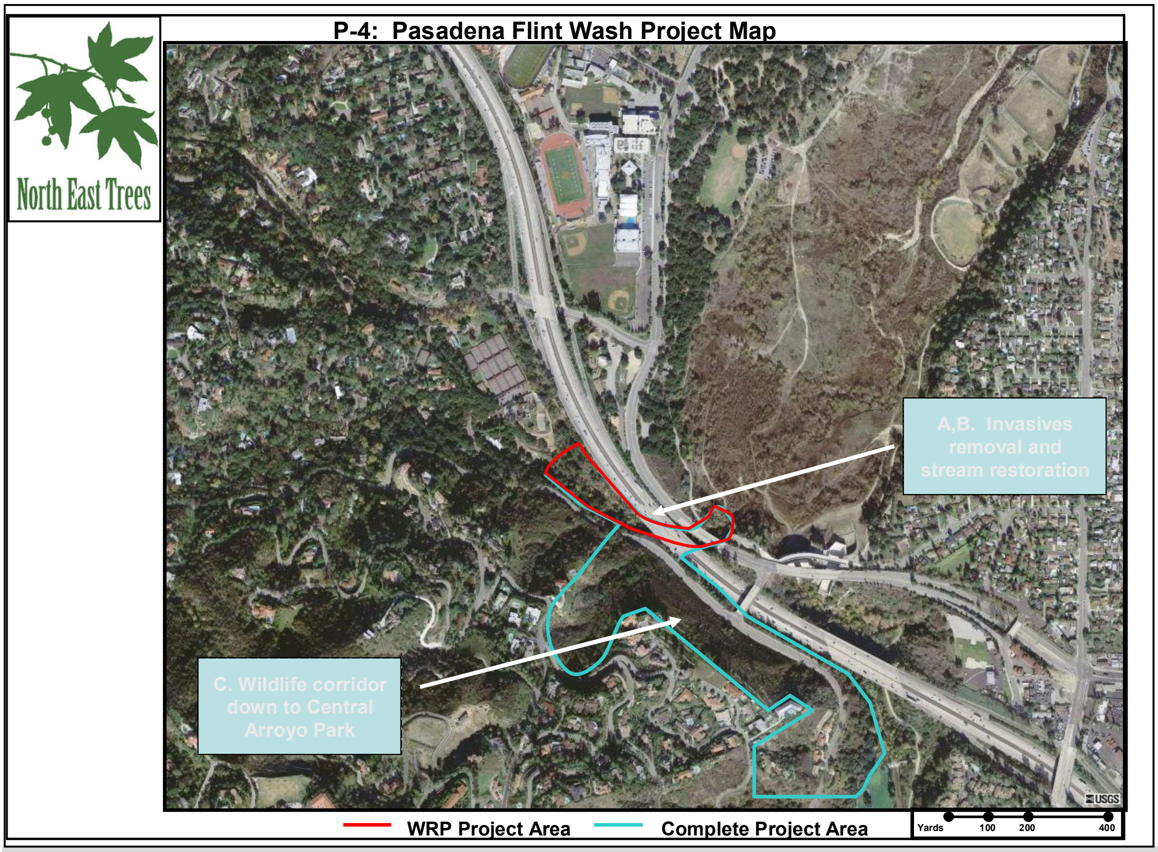
Project Component	Component Letter	Type	Size (acres)	Score	Cost
Remove invasive plants and restore riparian habitat.	A	HR	6	14 (15)	$250K - $500K
Remove fish barriers and improve stream channel geometry.	B	HR	2	14 (15)	$250K - $500K
Establish a wildlife corridor through Flint Wash into Central Arroyo Park.	C	HR	22	14 (15)	$250K - $500K
Reintroduce native fish, starting with arroyo chub.	D	HR	N/A	14 (15)	???
Total					**$750K - $1.5M+**

HABITAT DETAILS

	AC	CQ	OT	ST	YW	Total Score
Restoration scores	3	3	3	3	2	14

Rank (out of 22 projects): Tied for 2nd.
Rank in Pasadena (out of 6 projects): Tied for 2nd.

PROJECT AREA PHOTOGRAPH



PROJECT: P-5: Annandale Golf Course Habitat Restoration and Infiltration

PROJECT LOCATION

City: Pasadena

Neighborhood: Annandale Estates

Site Identification: Annandale Golf Course

Site Owner: Private – Annandale Estates

PROJECT DESCRIPTION

Project Type: Infiltration BMP and habitat improvements

Project Scope: Water Quality, Habitat Improvement

Project Overview: This golf course can be found at the southern end of the San Rafael Hills. All stormwater runoff from here and surrounding residences drains to a single storm which passes under the 134 freeway and eventually discharges to San Rafael Creek. This water likely contains nutrients, herbicides, and pesticides due to the golf course land use. Wildlife probably passes through the golf course's large expanse to and from the surrounding hills and the Arroyo. Project Component Letters include working with the golf course to reduce runoff and utilize native plants in appropriate areas.

Project Rationale: Runoff from the area increases the flow through San Rafael Creek, necessitating the concrete lining of the last several hundred yards of the creek. In addition, Annandale Golf Course is likely habitat for several of the indicator species, and could be improved by replacing exotic species with natives in golf course hazard and out-of-bounds areas.

PROJECT DETAILS

Project Component	Component Letter	Type	Size (acres)	Score	Cost
Work with golf course to increase plantings of native plants.	A	HR	230	5 (15)	$100K - $250K
Work with golf course and surrounding homeowner's association to reduce runoff from the complex.	B	WQ	230	4.3 (5)	$250K - $500K
Total			**230**		**$350K - $750K**

HABITAT DETAILS

	AC	CQ	OT	ST	YW	Total Score
Restoration scores	0	0	3	2	0	5

Rank (out of 22 projects):	Tied for 12th
Rank in Pasadena (out of 6 projects):	6

WATER QUALITY DETAILS

Tributary area (acres):	300+
Project area:	300+
BMP Type:	Rain gardens / bioretention, cisterns, infiltration.
Score (out of 5):	4.3
Rank (out of 48):	7
Rank in Pasadena (out of 12):	6

PROJECT AREA PHOTOGRAPH

PROJECT: P-6: San Rafael Creek Restoration

PROJECT LOCATION

City: Pasadena

Neighborhood:

Site Identification: San Rafael Creek south of Laguna Road

Site Owner: Multiple private property owners, outlet in City of Pasadena Lower Arroyo Park

PROJECT DESCRIPTION

Project Type: Creek and Habitat Restoration

Project Scope: Water Quality, Habitat Restoration

Project Overview: San Rafael Creek runs west to east and is directly south of Laguna Road in the Lower Arroyo portion of Pasadena. Except for the final few hundred feet which are concrete lined, the creek has remained in a fairly natural state. Project elements include removing the existing concrete bottom, removing exotic invasive plants and restoring riparian habitat.

Project Rationale: San Rafael Creek is the second-largest unlined creek in the watershed south of the Angeles National Forest (the largest being Flint Wash). Although too steep for low-elevation fish, it could provide quality riparian habitat if invasive exotic plants were removed and natives planted. In addition, naturalizing the confluence with the mainstem Arroyo Seco would be an important addition to the riparian habitat in Lower Arroyo Park.

PROJECT DETAILS

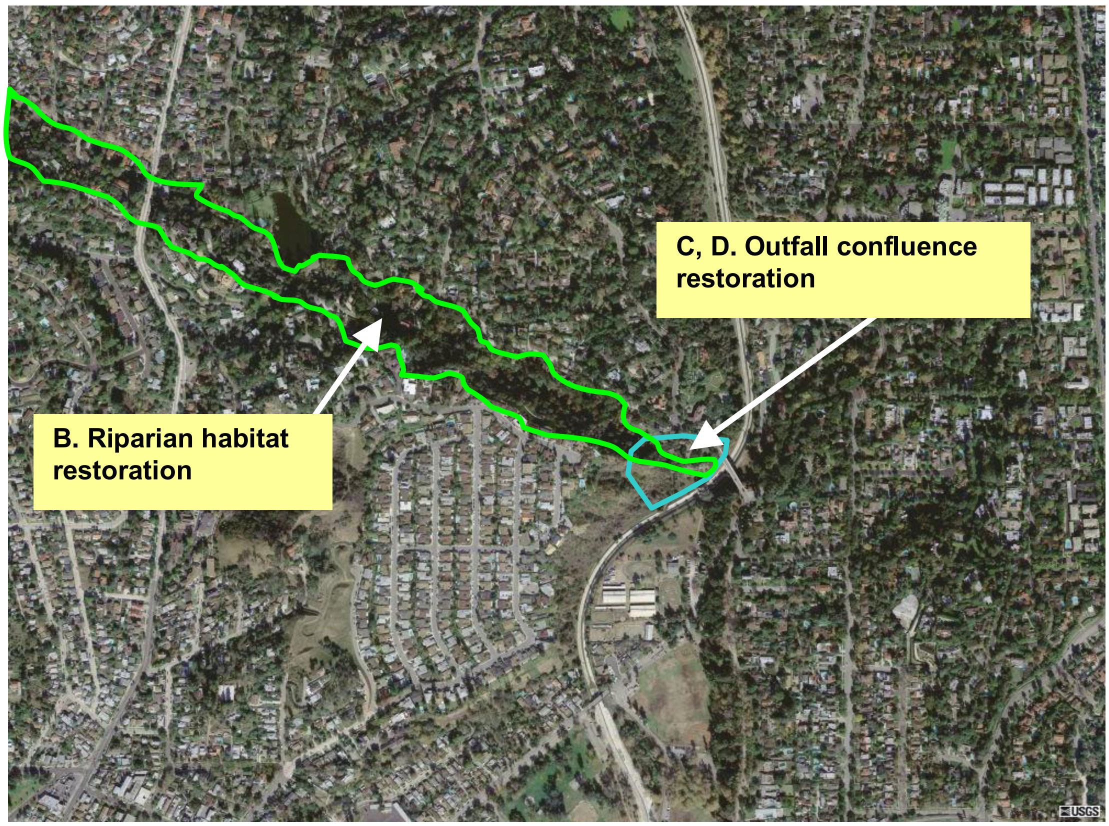
Project Component	Component Letter	Type	Size (acres)	Score	Cost
Develop working group to identify ways to protect and restore creek while respecting private property rights.	A	HR			$5K
Restore riparian habitat and remove exotic plants.	B	HR	20	9	$100K - $250K
Remove concrete lining from lower San Rafael Creek.	C	HR	1		$500K - $1M
Restore natural confluence area where SR Creek joins Arroyo Seco.	D	HR	2		$250 - $500K
Total					**$850K - $1.8M**

HABITAT DETAILS

	AC	CQ	OT	ST	YW	Total Score
Restoration scores	0	3	0	3	3	9

Rank (out of 22 projects): 6th (tied)
Rank in Pasadena (out of 6 projects): 5

PROJECT AREA PHOTOGRAPH



PROJECT: LCF-1: Flint Wash Restoration

PROJECT LOCATION

City: La Canada Flintridge

Neighborhood: N/A

Site Identification: Flint Wash

Site Owner: Multiple private property owners

PROJECT DESCRIPTION

Project Type: Habitat Restoration, Stream channel restoration

Project Scope: Habitat Restoration

Project Overview: Flint Wash, which drains most of La Cañada Flintridge and far western Pasadena, empties into the Hahamongna Watershed Park just northwest of Devil's Gate Dam. The last ¾ mile of the Wash is unlined, providing an opportunity to introduce fish species. Additional sections upstream of this point are lined with concrete.

Habitat improvements would include removal of existing exotic plants, restoration of riparian habitat, removal of fish barriers, restoring natural stream channel geometry, and removing the channel lining if feasible given flood control constraints,

Project Rationale: Flint Wash presently contains some of the last unlined sections of low elevation stream in the entire Arroyo Seco watershed. Water quality is high, and a survey by noted fishery biologist Camm Swift suggested that the stream could support native fish with minimal improvements.

PROJECT DETAILS

Project Component	Component Letter	Type	Size (acres)	Score	Cost
Secure easements to restore stream.	A	HR	10+	14 (15)	TBD
Remove exotic and invasive plants.	B	HR	10+	14 (15)	$250K - $500K
Remove fish barriers, stabilize stream banks, and improve channel geometry.	C	HR	3+	14 (15)	$250K - $500K
Reintroduce native fish, starting with arroyo chub.	D	HR		14 (15)	TBD
Work with the Corps of Engineers to investigate feasibility of removing concrete flood control channels.	E	HR	200+	14 (15)	TBD
Apply for funding to execute feasible projects.	F	HR		14 (15)	TBD
Conduct restoration efforts in newly unlined sections per B) and C).	G	HR		14 (15)	TBD

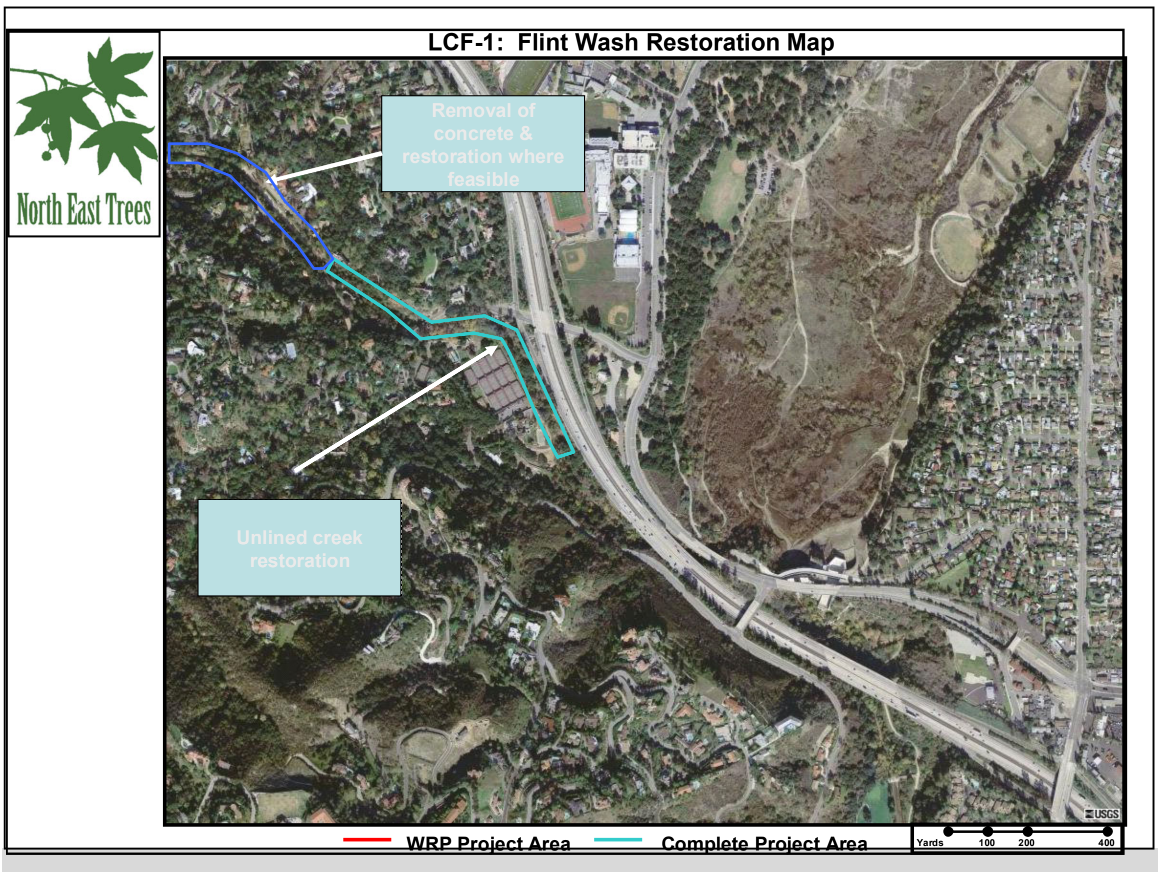
Total					**$1M+**

HABITAT DETAILS

	AC	CQ	OT	ST	YW	Total Score
Restoration scores	3	3	3	3	2	14

Rank (out of 22 projects): Tied for 2nd.
Rank in La Canada Flintridge (out of 3 projects): 1

PROJECT AREA PHOTOGRAPH



PROJECT: SP-1: Arroyo Seco Park / Golf Course Habitat Corridor

PROJECT LOCATION

City: South Pasadena

Neighborhood: N/A

Site Identification: Arroyo Seco Park, Arroyo Seco Golf Course, and South Pasadena Woodland and Wildlife Park

Site Owner: City of South Pasadena

PROJECT DESCRIPTION

Project Type: Stream restoration, improve habitat connectivity

Project Scope: Habitat Restoration

Project Overview: South Pasadena's portion of the Arroyo Seco is almost 100% protected parkland. However, little of this land is in a natural state. Playing fields and courts, parking areas, and the Arroyo Seco Golf Course occupy most of the park.

This land is a critical link in a north-south wildlife corridor. It is a bottleneck between Pasadena's Lower Arroyo Park and the relatively natural parklands lining the Arroyo in Los Angeles north of Debs Park. The focus of this project would be preserving the small existing habitat areas and expanding them as possible. In addition, the stream flowing through the golf course, which is filled with water diverted from the Arroyo Seco, presents an intriguing possibility of future restoration.

Project Rationale: South Pasadena's Arroyo Seco Park is a critical bottleneck in any north/south Arroyo wildlife movement. In addition, the stream running through the golf course could be an additional low-elevation stream segment with some restoration work.

PROJECT DETAILS

Project Component	Component Letter	Type	Size (acres)	Score	Cost
Restore, protect, and expand existing habitat along hillsides on eastern edge of park.	A	HR	25	7 (15)	$100K - $250K
Plant native plants in hazard / out-of-bounds areas of golf course.	B	HR	10	7 (15)	$50K - $100K
Naturalize diverted stream in golf course.	C	HR	4	7 (15)	$500K - $1M
Examine feasibility of reintroducing arroyo chub to a naturalized stream.	D	HR		7 (15)	TBD
Establish connectivity with open space in Los Angeles and Pasadena.	E	HR		7 (15)	TBD
				7 (15)	**$650K -**

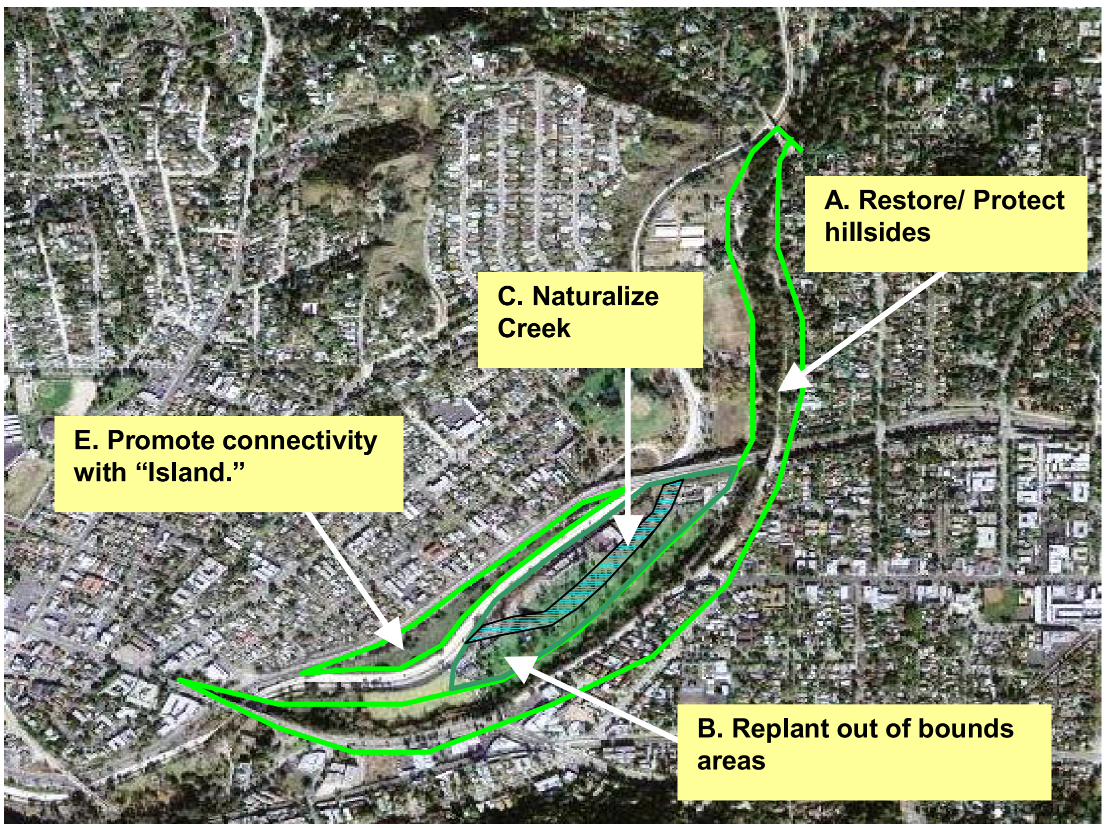
Total					$1.3M

HABITAT DETAILS

	AC	CQ	OT	ST	YW	Total Score
Restoration scores	0	2	0	3	2	7

Rank (out of 22 projects): 9
Rank in South Pasadena (out of 2 projects): 2

PROJECT AREA PHOTOGRAPH



PROJECT: SP-2: San Pasqual Stables BMPs

PROJECT LOCATION

City: South Pasadena

Neighborhood: N/A

Site Identification: San Pasqual Stables

Site Owner: City of South Pasadena, operated under lease with a private operator

PROJECT DESCRIPTION

Project Type: Implement localized BMPs to control site runoff

Project Scope: Water Quality

Project Overview: San Pasqual Stables are one of the largest equestrian facilities in the Arroyo Seco. Although the stables implement onsite practices to prevent manure from entering the channel, the level of activity in the facility and surrounding trails could lead to water quality impacts. With the installation of bioretention areas along the channel in strategic locations adjacent to the stables, this chance could be further reduced.

Project Rationale: Bacteria pollution is the single greatest water quality issue in the Arroyo Seco. To meet future water quality TMDLs for bacteria, it is imperative that concentrated non-point sources such as the stables have as high a degree of containment as possible.

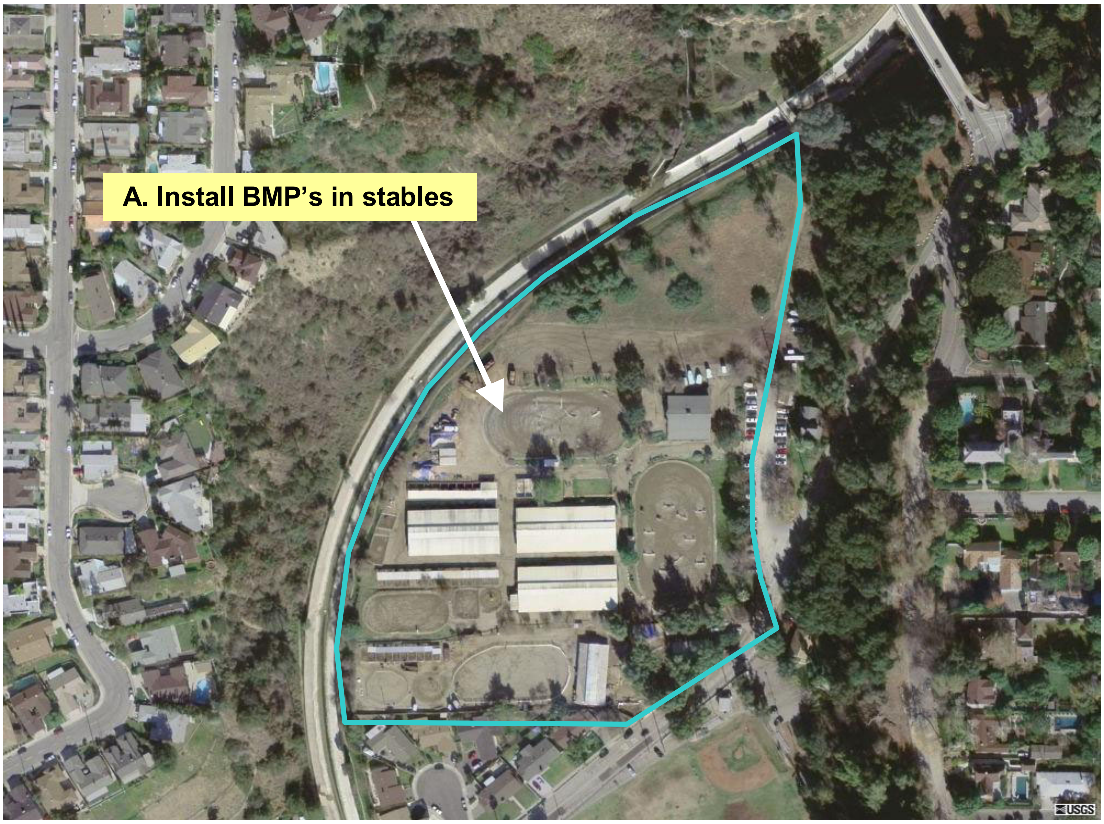
PROJECT DETAILS

Project Component	Component Letter	Type	Size (acres)	Score	Cost
Install BMPS onsite, and along the Arroyo Seco channel adjacent to the stables to control any bacteria runoff.	A	WQ	10	3.6	$100K - $250K

WATER QUALITY DETAILS

Tributary area:	10 acres
Project area:	10 acres
BMP Type:	Bioretention
Score (out of 5):	3.6
Rank (out of 48):	23 (tied)
Rank in South Pasadena (out of 1):	1

PROJECT AREA PHOTOGRAPH



PROJECT: SP-3: Arroyo Seco Channel Naturalization

PROJECT LOCATION

City: South Pasadena / Los Angeles

Neighborhood: N/A

Site Identification: Arroyo Seco Channel

Site Owner: Los Angeles County Department of Public Works

PROJECT DESCRIPTION

Project Type: Channel Naturalization

Project Scope: Habitat Restoration

Project Overview: The Arroyo Seco is wide and surrounded by open space for a small stretch between the 110 Freeway bridge to the north and the York Street Bridge to the south in South Pasadena / Los Angeles. Even during storm events, flow velocities are lower here due to the width of the channel. It may be feasible to remove the concrete channel or channel bottom in this stretch, producing a restored stream reach in the midst of urban Los Angeles / South Pasadena.

Project Rationale: High potential for Arroyo Seco naturalization, and consistent with surrounding land uses.

PROJECT DETAILS

Project Component	**Component Letter**	**Type**	**Size (acres)**	**Score**	**Cost**
Explore restoration feasibility	A	HR			$100K
Remove channel / channel bottom, restore natural conditions	B	HR	10		$1M - $5M
Explore possibility of reintroducing arroyo chub (but only in concert with restoration of golf course stream, to provide refuge from high flows)	C	HR			TBD
Total					**$5M+**

HABITAT DETAILS

	AC	**CQ**	**OT**	**ST**	**YW**	**Total Score**
Restoration scores	1	0	0	0	2	3

Rank (out of 22 projects): 8
Rank in South Pasadena (out of 2 projects): 1

PROJECT AREA PHOTOGRAPH

PROJECT: AL-7: Upper Arroyo Seco Stream Protection and Restoration

PROJECT LOCATION

City: Altadena / Angeles National Forest

Neighborhood: NA

Site Identification: Main Arroyo Seco channel N of JPL Bridge, and confluences of El Prieto, Millard and Fern Canyons with Arroyo Seco.

Site Owner: Altadena / City of Pasadena / Angeles National Forest

PROJECT DESCRIPTION

Project Type: Land / easement acquisition, exotic removal, removal of weirs, culverts and dams in streams.

Project Scope: Habitat Restoration

Project Overview: Within a mile north of the Arroyo Seco's emergence from the San Gabriel Mountains, a number of critical tributaries join the Arroyo, functioning as conduits of both water and wildlife from the higher country beyond. Moving northeast from the JPL Bridge, these streams are Millard, El Prieto, Fern, and the main channel of the Arroyo itself.

In one sense, these streams have been heavily impacted for a century. Over that time, various small dams, culverts, diversions and weirs have been constructed to supply water to the Lincoln Avenue Water Company (serving Altadena) and the City of Pasadena, as well as to enable road and trail crossings. These structures all impede the movement of fish and other aquatic creatures up and down these streams.

However, high quality terrestrial habitat still exists, and is under threat of development. Much of this land falls north of the administrative boundary of the Angeles National Forest, but is in fact privately owned (known as "in-holdings"). There are no limits on how this land is developed, and many parcels lie very near the streams and contain high quality riparian and hillside habitat, particularly in Millard Canyon. Protecting the key parcels that preserve the integrity of these north/south passages is critical..

Project Rationale: Habitat Restoration: These canyons are critical corridors for the movement of aquatic and terrestrial wildlife from the San Gabriel Mountains down to the lower Arroyo Seco watershed. Presently, terrestrial habitat corridors are threatened by encroaching development, and aquatic pathways are subdivided by numerous barriers such as weirs, diversions, culverts and dams. Their long-term protection and restoration is an important element of improving habitat farther downstream.

PROJECT DETAILS

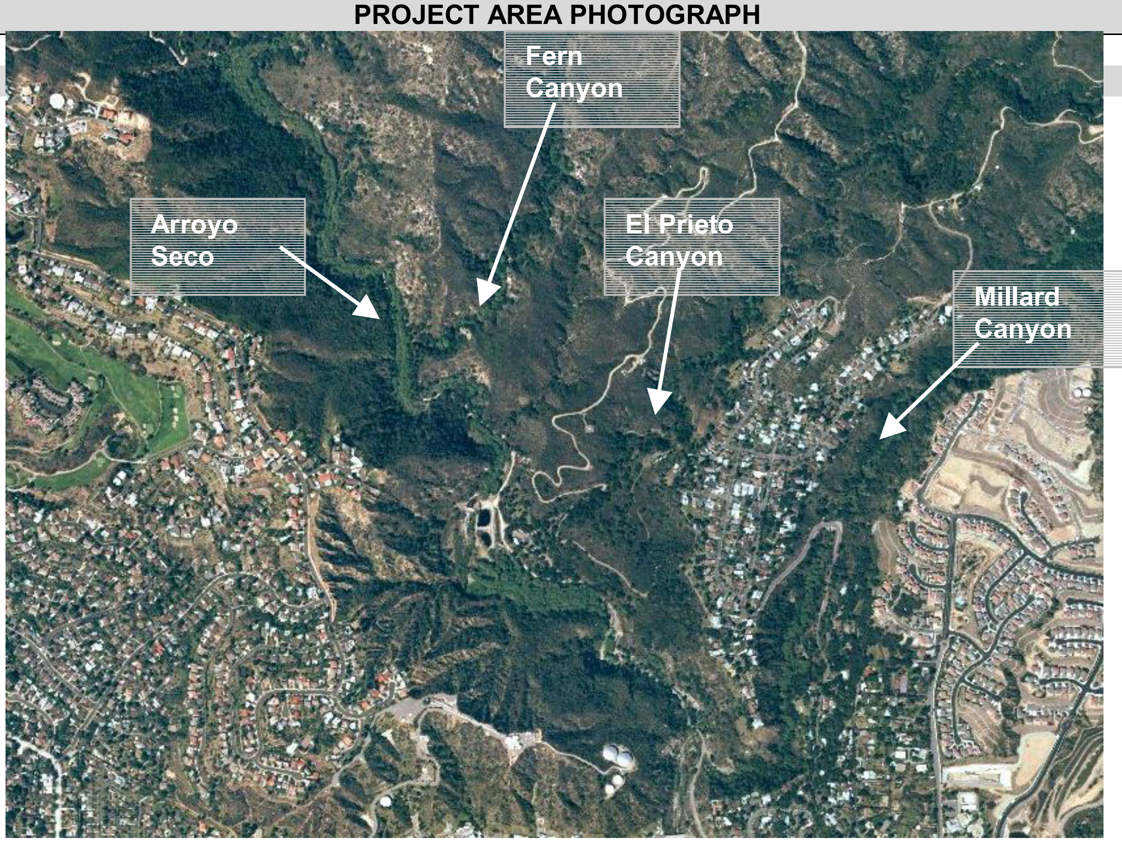
Project Component	**Component Letter**	**Type**	**Size (acres)**	**Score (max possible)**	**Cost**
Prioritize critical private parcels in need of additional protection	A	HR	N/A	8 (15)	$25,000
Protect parcels through the conservation easements or the outright purchase of the properties	B	HR	N/A	8 (15)	$1,000,000+
Collaborate with responsible agencies to develop workarounds or to remove aquatic passage barriers	C	HR	N/A	8 (15)	$1,000,000+
Launch wildlife monitoring program at southern end of upper Arroyo Seco	D	HR	N/A	8 (15)	$10,000
Total			**130+**	8 (15)	**$2.035M +**

HABITAT DETAILS

	AC	**CQ**	**OT**	**ST**	**YW**	**Total Score**
Restoration scores	3	3	0	3	3	12

Rank (out of 22 projects): 4 (Tied)
Rank in Altadena (out of 1 projects): 1

PROJECT AREA PHOTOGRAPH



PROJECT: AL-9: Woodbury Road BMP

PROJECT LOCATION

City: Altadena

Neighborhood: NA

Site Identification: Median along Woodbury Road, between Windsor and Marengo.

Site Owner: Altadena (Los Angeles County)

PROJECT DESCRIPTION

Project Type: Implement bioretention BMPs in the median along Woodbury Road.

Project Scope: Water Quality

Project Overview: Woodbury Road is one of the larger surface streets in Altadena, extending from Altadena's southwest corner near Devil's Gate Dam east along Altadena's southern border with Pasadena. Many roadways in the Arroyo were predicted to contribute significant runoff to the Arroyo, but for most this runoff would be treated via BMPs located at storm drain outlets given the limited space along the roadways.

Woodbury Road presents a unique opportunity; not only is it a significant source of runoff, but for most of its length there is a wide, paved median strip between the east- and west-bound directions. This median, if converted into planted bioretention areas, could be used to treat all of the runoff from the road itself, plus some for adjacent lots. A major County of Los Angeles Department of Public Works storm drain also runs under the median for much of its length; BMPs in the median could be employed to treat dry-weather flows from this drain, which empties directly into the Arroyo Seco south of Devils Gate Dam.

Project Rationale: Woodbury Road is one of the larger expanses of impervious surface in Altadena, and drains directly into the Hahamongna Basin. Due to its location in the midst of dense neighborhoods, and its significant auto traffic, it likely contributes nonpoint source pollutants to the Arroyo that could be treated via bioretention / infiltration.

PROJECT DETAILS

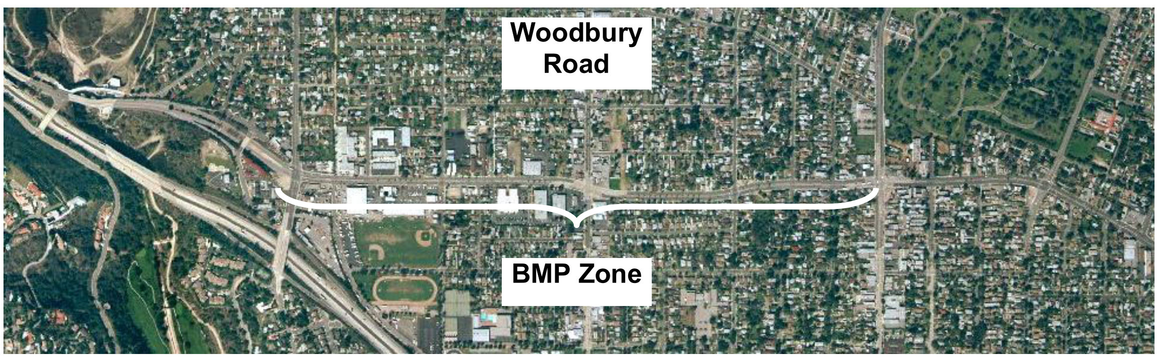
Project Component	Component Letter	Type	Size (acres)	Score (max possible)	Cost
Secure existing engineering plans for Woodbury to examine feasibility of bioretention BMPs	A	WQ	15	3.68 (5)	$25,000
Investigate feasibility of treating all dry season flows	B	WQ	15	3.68 (5)	$1,000,000+
Determine opportunities to treat wet-weather runoff through the BMPs	C	WQ	15	3.68 (5)	$1,000,000+

Design and construct BMPs	D	WQ	15	3.68 (5)	$10,000
Total			**15**	3.68 (5)	**$2.035M +**

WATER QUALITY DETAILS

Tributary area:	Unknown
Project area:	15 acres
BMP Type:	Bioretention
Score (out of 5):	3.7
Rank (out of 48):	13 (Tied)
Rank in Altadena (out of 8):	1 (Tied)

PROJECT AREA PHOTOGRAPH



Arroyo Seco Watershed Management & Restoration Plan

Appendices

Table 6A-1: Rankings of Habitat Restoration Projects
(Note: Only project NOT listed in the high priority projects section above are included in this table.)

Project #	Name	Description	Location	Size (acres)	AC	OT	YW	CQ	ST	Overall Score	Rank (in city)	Rank (overall)	Estimated Cost ($)
LCF-2	San Rafael Hills Open Space Preservation	Protect undeveloped parcels through conservation easement or acquisition, and protect connectivity through canyons	La Cañada Flintridge, Pasadena	1,500+	3	3		3		9	2	6 (tied)	
SP-1	Arroyo Seco Park / Golf Course Habitat Study	See comments under project SP-1 in Section 9.2 above.	SE Bank of Arroyo Seco through South Pasadena	200+			2	2	3	7	1	8	
LCF-3	Cherry Canyon Park & Descanso Gardens	Monitor movement of wildlife through protected open space.	La Cañada Flintridge	300+		3			3	6	3	10 (tied)	
LA-5	Arroyo Seco Park Habitat Restoration and Connectivity	Protect N/S habitat migration corridor through the area o Identify ownership of all parcels, secure easements if possible to protect a viable wildlife corridor. o Focus on area between Avenue 60 (S) and York ▪ Restore understory / scrub habitat where possible ▪ Protect and improve management of mature riparian trees for habitat value Acquire land on and around Santa Fe Hill, and restore oak / black walnut woodland habitat	Los Angeles, along SE bank of Arroyo Seco between York Blvd and Via Marisol	60+			1	2	3	6	1	10 (tied)	
LA-6	"The Island" Restoration	Restore scrub and riparian habitat, and establish connectivity with South Pasadena Woodland and Wildlife Park	Los Angeles, across from Arroyo Seco Golf Course	5			1	1	3	5	2 (tied)	12 (tied)	
LA-7	Ernest E. Debs Regional Park Restoration	▪ Continue to support ongoing restoration efforts ▪ Develop monitoring programs with	Los Angeles	200+		2			3	5	2 (tied)	12 (tied)	

		Audubon for all terrestrial indicator species ▪ Identify and protect corridors between Arroyo Seco Debs and other hillside areas of open space to the east Identify ownership of and protect corridors between Debs and Montecito Heights hillsides, including Flat Top Hill, to the south											
LA-8	Mt. Washington Open Space Restoration	▪ Protect native hillside trees ▪ Restore understory vegetation Monitor and track density and breeding presence of spotted towhees, and presence / absence of oak titmice	Kite Hill, Mt, Washington Canyon, Rainbow Canyon areas in Mt. Washington area of Los Angeles	40+		1			3	4	4 (tied)	15 (tied)	
LA-34	Eagle Rock Hillsides	Restore and protect hillside woodland habitat and existing scrub vegetation	Los Angeles, east of Occidental College	83		1			3	4	4 (tied)	15 (tied)	
LA-31	Confluence Open Space	Secure any private open space, and restore coastal sage scrub and riparian habitat where possible	Los Angeles, south of Avenue 26	5.5					3	3	6 (tied)	17 (tied)	
LA-32	Flat Top	Restore and protect hillside woodland habitat and existing scrub vegetation	Los Angeles, SE of Griffin Ave.	11					3	3	6 (tied)	17 (tied)	
LA-33	Montecito Heights Hillsides	Restore and protect hillside woodland habitat and existing scrub vegetation	Los Angeles, SE of Griffin Ave.	43					3	3	6 (tied)	17 (tied)	
LA-1	Lincoln Heights Freeway Interchange Restoration	See comments under project LA-1 in Section 9.2 above.	Los Angeles, at Interstate 5 & Arroyo Seco Parkway interchange	10+					2	2	9 (tied)	20 (tied)	
LA-2	Sycamore Grove Park Stream Restoration	See comments under project LA-2 in Section 9.2 above.	Los Angeles, in Sycamore Grove Park and Arroyo Seco Alternative School grounds	18+					2	2	9 (tied)	20 (tied)	
LA-3	Welch Site Habitat Restoration	See comments under project LA-3 in Section 9.2 above.	Los Angeles, where Pasadena Avenue crosses the Arroyo Seco	3					2	2	9 (tied)	20 (tied)	

Table 6A-2: Site-Specific Best Management Practices, Ranked By Priority (NOTE: Please read footnotes for assumptions)

Project #	Name	Description	Location	Site Size (acres)	Project Size (acres)	Estimated Treatment Volume (ft^3)[3]	Upstream Area (acres)	Total Score	Rank (in city)	Rank (overall)	Estimated Cost ($000)[4]
P-7	John Muir High School	Install infiltration gallery to infiltrate runoff from site and contents of storm drain running along W. Montana Street	Pasadena, intersection of Lincoln and Cañada Avenues	45	TBD	TBD	900+	4.4	2 (T)	3 (T)	2,500+
P-8	Army Reserve Center	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Pasadena, Arroyo Blvd and Colorado Blvd	4.2	0.3	5,700	N/A	3.8	7	9	25 – 50
P-11	Pasadena DPW HQ	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Pasadena, Mountain St. at 210 Freeway	22.0	1.4	30,000	N/A	3.78	8	10	50-100
AL-2	Edison Elementary School	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup) **Note:** This school is on Pasadena Unified School District's closure list. Any redevelopment / reuse should take into account water quality impacts.	Altadena, Glenrose Ave and Palm St	4.8	0.3	6,500	N/A	3.68	1 (T)	13 (T)	25-50
AL-4	Waldorf School	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Altadena, E. Altadena Drive at Highview Ave.	6.1	0.4	8,300	N/A	3.68	1 (T)	13 (T)	50-100

3 Estimates based on County of Los Angeles Department of Public Works Standard Urban Stormwater Mitigation Plan protocol. All sites assumed to be 50% impermeable.

4 Costs based on implementation of bioretention areas; installation of cisterns likely to be 50-100% more expensive given excavation and construction complexities. Costs assumed to be $4 / square foot of treatment area, per LA County BMP Manual.

Project #	Name	Description	Location	Site Size (acres)	Project Size (acres)	Estimated Treatment Volume (ft^3)[3]	Upstream Area (acres)	Total Score	Rank (in city)	Rank (overall)	Estimated Cost ($000)[4]
LA-17	Aldama Elementary School	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Los Angeles, Figueroa & Poppy Peak	4.4	0.3	6,000	N/A	3.68	5 (T)	13 (T)	25-50
LA-18	Annandale Elementary School	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Los Angeles, Figueroa & Pasadena Ave	3.5	0.2	4,800	N/A	3.68	5 (T)	13 (T)	25-50
LA-19	Arroyo Seco Alternative School	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Los Angeles, York & Avenue 56	3.6	0.2	4,900	N/A	3.68	5 (T)	13 (T)	25-50
LA-21	Buchanan Street Elementary School	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Los Angeles, Avenue 26 & Artesian	3.8	0.2	5,200	N/A	3.68	5 (T)	13 (T)	25-50
LA-24	Yorkdale Elementary School	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Los Angeles, San Fernando Rd & I-5	3.7	0.2	5,000	N/A	3.68	5 (T)	13 (T)	25-50
P-9	Cleveland Elementary School	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Pasadena, Palisade St and Lincoln Ave	5	0.3	6,800	N/A	3.68	9	13 (T)	50-100
AL-6	Five Acres School	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Altadena, Windsor Ave and Mountain View St	10.8	0.7	15,000	N/A	3.68	1 (T)	13 (T)	100-250
AL-1	Audubon Elementary Campus	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup) **Note:** This school is on Pasadena	Altadena, W. Altadena Drive and Casitas Avenue	5.4	0.3	7,400	N/A	3.63	5	23 (T)	50-100

Project #	Name	Description	Location	Site Size (acres)	Project Size (acres)	Estimated Treatment Volume (ft^3)[3]	Upstream Area (acres)	Total Score	Rank (in city)	Rank (overall)	Estimated Cost ($000)[4]
		Unified School District's closure list. Any redevelopment / reuse should take into account water quality impacts.									
LCF-3	Jet Propulsion Laboratory	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	La Cañada Flintridge, at northern end of Hahamongna Watershed Park	101	6.3	140,000	N/A	3.63	1	23 (T)	1,000 – 1,500
LA-10	LA DWP Substation - Pasadena Ave @ Arroyo Seco	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Los Angeles, Pasadena Ave. at Arroyo Seco	1.5	0.1	2,000	N/A	3.63	10 (T)	23 (T)	10-25
LA-11	Heritage Square Gold Line Station	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Los Angeles, Lincoln Heights	2.4	0.2	3,300	N/A	3.63	10 (T)	23 (T)	25-50
LA-12	Los Angeles Animal Services North Central Shelter	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Los Angeles, York & Avenue 53	4.7	0.3	6,400	N/A	3.63	10 (T)	23 (T)	25-50
LA-13	Super A Grocery Store (Highland Park)	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Los Angeles, Along Figueroa in Highland Park	2.5	0.2	3,400	N/A	3.63	10 (T)	23 (T)	25-50
LA-15	Ramona Hall Community Center	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Los Angeles, Figueroa & Avenue 45	1.7	0.1	2,300	N/A	3.63	10 (T)	23 (T)	10-25
LA-16	Albertson's Supermarket	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Los Angeles, Avenue 50 & Salient Dr	4.4	0.3	6,000	N/A	3.63	10 (T)	23 (T)	25-50
LA-20	Big Lots	Depending on soil infiltration rates,	Los Angeles, Buchanan	3.6	0.2	4,900	N/A	3.63	10	23 (T)	25-50

Project #	Name	Description	Location	Site Size (acres)	Project Size (acres)	Estimated Treatment Volume (ft^3)[3]	Upstream Area (acres)	Total Score	Rank (in city)	Rank (overall)	Estimated Cost ($000)[4]
	Department Store	install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	& Avenue 50						(T)		
LA-22	LA DWP Maintenance Yard - Lincoln Heights	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Los Angeles, Monte Vista & Avenue 61	27	1.7	37,000	N/A	3.63	10 (T)	23 (T)	250-500
LA-23	St. Ignacius School	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Los Angeles, Meridian & Avenue 57	2.4	0.2	3,300	N/A	3.63	10 (T)	23 (T)	25-50
LA-25	Home Depot	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Los Angeles, Lacy St & Avenue 33	9	0.6	12,300	N/A	3.63	10 (T)	23 (T)	100-250
LA-26	LA USD District Office (Lincoln Heights)	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Los Angeles, Arroyo Seco Ave & Marmion Way	3.8	0.2	5,200	N/A	3.63	10 (T)	23 (T)	25-50
LA-28	Tow Yard	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Los Angeles, Arroyo Seco Channel and Avenue 34	4.0	0.3	5,400	N/A	3.63	10 (T)	23 (T)	25-50
LA-29	Commercial District	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Los Angeles, Figueroa and Avenue 50	24.9	1.6	34,000	N/A	3.63	10 (T)	23 (T)	250-500
LA-30	York Commercial Zone	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Los Angeles, York and Figueroa	13.5	0.8	18,000	N/A	3.63	10 (T)	23 (T)	100-250
P-10	JPL Parking Area	Depending on soil infiltration rates, install bioretention areas	Pasadena, north end of Hahamongna Watershed	8	0.5	11,000	N/A	3.63	10 (T)	23 (T)	100-250

Project #	Name	Description	Location	Site Size (acres)	Project Size (acres)	Estimated Treatment Volume (ft^3)[3]	Upstream Area (acres)	Total Score	Rank (in city)	Rank (overall)	Estimated Cost ($000)[4]
		(preferable) or cisterns with on-site reuse mechanism (backup)	Park on east floodplain of Arroyo Seco								
P-13	Pasadena Commercial Areas	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Pasadena, along Washington Blvd.	12.6	0.8	17,000	N/A	3.63	10 (T)	23 (T)	100-250
AL-5	Altadena Commercial Areas	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	West Altadena south of Figueroa Drive	20.6	1.3	28,000	N/A	3.63	6	23 (T)	100-250
LA-9	Franklin High School	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Los Angeles, Pasadena Ave. at Arroyo Seco	19.8	1.2	27,000	N/A	3.53	24 (T)	43 (T)	100-250
LA-27	Loreto Street Elementary School	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Los Angeles, Pasadena Ave. at Arroyo Seco	4.3	0.3	5,900	N/A	3.53	24 (T)	43 (T)	25-50
P-12	Rose Bowl & Parking Areas	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Pasadena, Central Arroyo Park	68	4.3	93,000	N/A	3.50	12	45	500-1,000
AL-3	Lake Commercial District (Altadena)	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Altadena, Lake Avenue north of Alameda St.	33.8	2.1	46,000	N/A	3.23	7	46	250-500
AL-8	Lincoln Avenue	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site reuse mechanism (backup)	Altadena, Lincoln Avenue between Woodbury Rd. and West Loma Alta Drive.	13	0.8	18,000	N/A	3.23	8	47	100-250
LA-14	Figueroa Commercial District - Highland	Depending on soil infiltration rates, install bioretention areas (preferable) or cisterns with on-site	Los Angeles, S. of Sycamore Grove Park	52	3.3	71,000	N/A	3.18	26	48	500-1,000

Project #	Name	Description	Location	Site Size (acres)	Project Size (acres)	Estimated Treatment Volume (ft^3)[3]	Upstream Area (acres)	Total Score	Rank (in city)	Rank (overall)	Estimated Cost ($000)[4]
	Park	reuse mechanism (backup)									

Appendix 7: BMP Design Criteria Technical Memorandum

Prepared with assistance from:

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M E M O R A N D U M

TO: Jason Pelletier, North East Trees
FROM: Ken Susilo and Brandon Steets, GeoSyntec
DATE: March 16, 2005

SUBJECT: Task 3: BMP Design Criteria for Arroyo Seco Watershed

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1.0 Introduction

Both the on-site and regional variety of structural stormwater treatment BMPs for the Arroyo Seco watershed will require uniform flow or volume-based sizing standards to ensure consistency of flow retention and water quality treatment capabilities. Flow-based design criteria apply to flow-through BMPs such as swales, hydrodynamic separator systems, sand filters, and subsurface wetlands. Flow-based BMPs are typically sized to "treat" (defined via design standards rather than pollutant removal performance) a flow rate resulting from a design rainfall intensity expressed as inches per hour. Volume-based design criteria apply to retention/detention-type BMPs, such as dry detention basins, wet ponds, constructed (surface) wetlands, and bioretention areas. Volume-based treatment BMPs are designed to treat a volume of runoff, which is detained for a certain period of time to allow for settling of solids and associated pollutants.

The following sections describe various flow and volume-based BMP design criteria approaches available to (and ultimately, recommended for) NET for implementation at future BMP retrofit projects planned for the Arroyo Seco watershed.

2.0 Standard SUSMP Design Criteria Approach

The standard approach to BMP design in Los Angeles County is to apply the minimum County SUSMP (LACDPW, 2002) BMP design criteria, the simplest of which is for volume-based designs and requires treatment for runoff generated from the first 0.75″ of rainfall. However, this is an arbitrary standard (the 0.75″ is actually derived from the 85^{th} percentile average precipitation depth for Los Angeles County) and is non-bacteria specific.

The following discussion is provided for reference purposes only, and is intended to simply summarize the standard County SUSMP-based approach that is commonly used for developing project specific design criteria. While the standard SUSMP BMP sizing criteria are simple, straight-forward, standardized, and relatively easy to use, we do not recommend them for use in the Arroyo Seco watershed for the purpose of bacteria exceedance day reduction since there are no requirements regarding capture (or retention) and treatment (defined as effluent limitations). In order to control bacteria levels in receiving waters, these two conditions – hydrologic and water quality control, that is – need to be specified. Therefore, alternative site specific design criteria approaches are provided in following sections of this memo.

The County of Los Angeles' Standard Urban Stormwater Mitigation Plan (SUSMP) contains specific sizing criteria for stormwater treatment BMPs for new development and significant redevelopment projects. The SUSMP includes sizing criteria for both volume-based and flow-based BMPs. The sizing options for volume-based BMPs, such as extended detention basins, are as follows:

1. The 85th percentile 24-hour runoff event storm event determined as the maximized capture stormwater volume for the area, from the formula recommended in Urban Runoff Quality Management, WEF Manual of Practice No. 23/ASCE Manual of Practice No. 87 (WEF, 1998); or,

2. The volume of annual runoff based on unit basin storage volume, to achieve 80% or more volume treatment by the method recommended in California Stormwater Best Management Practices Handbook – Industrial/Commercial (1993); or,

3. The volume of runoff produced from a 0.75 inch storm event, prior to its discharge to a stormwater conveyance system; or,

4. The volume of runoff produced from a historical-record based reference 24-hour rainfall criterion for "treatment" (0.75 inch average for the Los Angeles County Area) that achieves approximately the same reduction in pollutant loads and flows as achieved by mitigation of the 85th percentile, 24-hour runoff event.

The "standard" and simplest (and often least conservative) volume-based sizing approach in Los Angeles County is to use SUSMP criteria 3 above.

Flow-based BMPs such as vegetated swales and hydrodynamic separation systems (e.g., CDS) units must be designed to infiltrate or treat the maximum flow rate generated from one of the following scenarios:

1. The flow of runoff produced from a rain event equal to at least 0.2 inches per hour intensity, or

2. The flow of runoff produced from a rain event equal to at least two times the 85th percentile hourly rainfall intensity for Los Angeles County, or

3. The flow of runoff produced from a rain event that will result in treatment of the same portion of runoff as treated using volumetric standards above.

3.0 Alternative Design Criteria 1: The Modified WEF Method

An alternative approach that we have applied to new development projects in Los Angeles County is a modified version of the WEF method (WEF, 1998), which is based on the concept of treating 80% of the average annual runoff volume (consistent with SUSMP volume-based criteria 2 described above), a goal that was derived from studies that showed diminishing returns (with respect to sediment removal) above this percent capture value. For these projects, minimum BMP storage volumes were then determined using a continuous simulation hydrology model, SWMM (Storm Water Management Model), with a 48-hour drawdown time. The storage-treatment block of SWMM model allows users to predict the capture efficiency of an individual BMP or to generate percent capture curves for a range of BMP sizes that can then be used to predict the average capture efficiency of the BMPs.

Flow-based BMPs that we have designed for recent new development projects in Los Angeles County have used a rainfall intensity of 0.3 inches per hour, which should provide for 80 percent capture of the annual runoff volume (based on regional rain gauge data combined with rainfall-runoff modeling), consistent with SUSMP flow-based criteria 3 described above. For these projects, the rational method with the simple method runoff coefficient equation was used, applying a design rainfall intensity of 0.3 inches per hour. This methodology results in treatment of the same portion of runoff as treated using the volumetric standard described above.

We have found that the modified WEF method results in basin volumes which significantly (by 30-40%) exceed the SUSMP-based volumes. However, given the significant cost of stormwater treatment for retrofit projects, largely due to land availability limitations, and given that bacteria is a stormwater pollutant known to occur at elevated levels even in natural or undeveloped watersheds, we recommend a less conservative sizing criteria – while setting more stringent retention and treatment requirements for the more frequent low-flow runoff events – for future BMP retrofit projects in the Arroyo Seco watershed.

4.0 Alternative Design Criteria 2: Reference-Based Approaches

The following analysis describes two proposed exceedance day reference system-based design criteria recommended for sizing volume and flow-based structural BMPs (for bacteria-specific and retrofit projects only) proposed for use in the Arroyo Seco watershed. The first is a general approach designed to be consistent with the Santa Monica Bay wet weather bacteria TMDL, and the second is a preferred watershed-specific approach that is based on the concept of matching the initial abstraction volume of undeveloped conditions.

Alternative Design Criteria 2A: general Reference-based Approach

The first alternative BMP sizing criteria that we propose is based on the precedent-setting Santa Monica Bay wet weather bacteria TMDL exceedance day reference condition approach. For the TMDL analysis, the Arroyo Sequit watershed was selected as a watershed that was representative of natural and undeveloped conditions with respect to the bacteria recreational objective exceedance frequency. Therefore, based on historic shoreline monitoring data collected at the Leo Carrillo beach located at the mouth of the Arroyo Sequit, the average annual reference winter wet weather exceedance frequency was determined to be 17 days/year. Given that historic wet weather bacteria monitoring has not occurred in the undeveloped headwaters of the Arroyo Seco (or any other watershed in coastal Southern California), this monitoring dataset may be the best analog we have for determining a background reference condition. *We should note here that this paucity of background instream water quality monitoring data demonstrates the need for wet weather monitoring in the headwaters of the Arroyo Seco.*

Based on this reference condition method, stormwater treatment BMPs would be sized to treat up to the 90th percentile (or 90% confidence value) 17th ranked 24-hour precipitation depth for the watershed. Based on the Santa Monica Bay TMDL analysis, the LAX rain gage 90th percentile is 0.41 in, with an average annual precipitation of 12.5 in. Using the Los Angeles County Eagle Rock precipitation gage (average annual precipitation of 18.4 in) as a basis for scaling, the target 24-hour capture rainfall volume would be about 0.6 in. *It should be noted that if other pollutants of concern are identified for the watershed, such as metals, this analysis and sizing approach may require further analysis since the reference condition is based on bacteria exceedance days only. It should also be noted that miscellaneous BMP design details beyond these simple sizing requirements – such as requirements pertaining to minimum or maximum side slope, hydraulic retention time, basin drain time, swale treatment depth, and/or basin aspect ratio – should continue to be based on either the SUSMP requirements or the CASQA BMP handbooks (CASQA, 2003).*

Flow-through BMPs however do not retain runoff and will therefore not prevent the frequent discharge of stormwater the more frequent smaller storm events. Therefore, treated effluent concentrations from flow-based structural BMPs in the Arroyo Seco watershed should meet the REC-1 bacteria objectives, and the systems should be sized to treat flows equal to or greater than the peak runoff flowrate resulting from a design intensity precipitation event that is consistent with the approach used to develop the volume-based criteria described above (i.e., the standard limits discharges to 17 days/year at a 90% confidence level). Peak design runoff rates should be determined using the rational method, by computing the product of this computed design precipitation intensity with the drainage area acreage and the site specific (percent imperviousness-based) runoff coefficient. This design precipitation intensity should be derived using the nearest gage (such as LA County's Devil's Gate gage), for an adequate period of record which spans both drought and flood years (i.e., at least a decade), and with a precipitation measurement frequency of hourly or better.

Requiring effluent concentrations to meet REC-1 objectives is a highly restrictive condition that will essentially restrict acceptable flow-through BMPs to the more expensive and difficult to maintain disinfection or filtration type systems. This condition should also result in the encouragement of volume-based BMPs which will result in the elimination (i.e., complete retention or capture) of all but an average of 17 discharge (or bypass) days per year. As an additional benefit, this captured water could then serve multiple uses such as water conservation/reuse (e.g., if used for landscape irrigation such as with a residential cistern, it would thereby augment municipal potable supply) and groundwater replenishment (via infiltration).

Alternative Design Criteria 2B: Watershed Specific Reference-based Approach

The alternative BMP sizing criteria that we recommend is a more watershed-specific pseudo-reference system approach that is based on the concept of matching the initial abstraction volume (i.e., the initial precipitation amount that is completely sequestered by the catchment surface prior to the creation of runoff) of undeveloped conditions rather than some predetermined reference exceedance day conditions such as criteria 2A above. The advantage of this approach is that it does not rely on a predetermined number of allowable exceedance days based on monitoring data from another watershed. A disadvantage of this approach is that it inherently assumes that by matching the estimated discharge frequency of the undeveloped condition, the frequency of bacteria exceedance days of the undeveloped condition is also matched. There are a number of key assumptions in the pseudo-reference system approaches. They are that:

1. Both naturally occurring and existing discharges result in exceedances of water quality standards preventing their beneficial uses.
2. Management of hydrology volumes to simulate frequency of discharges, coupled with treatment and release of captured discharges, is sufficient to meet TMDL standards.
3. Once water quality standards are exceeded, beneficial uses cannot be attained, but that the level of exceedance (on a concentration-based level) is not necessarily as critical as the frequency of exceedances.

For purposes of discussion, the Natural Resources Conservation Service Curve Number (CN) method is discussed. The CN method stipulates that depending on antecedent conditions, there is an initial abstraction (Ia) or initial loss of rainfall is naturally captured or discharges to the subsurface system and does not result in runoff. For Antecedent Runoff Condition II (average conditions), the following empirical equation was derived:

$$Ia = 0.2S$$

Where:

Ia is the initial loss, inches
S is storage factor, inches = 1000/CN – 10

CN is the Curve Number (dimensionless ranging effectively from 30 to 98)

The target storage would then be effectively the difference in initial losses, applied over the developed watershed area, and are highly sensitive to the native drainage conditions.

Storage/Treatment rainfall volume, ΔIa= Ia (pre-existing) - Ia (developed)
Storage/Treatment runoff volume = ΔIa * area * developed runoff coefficient

Examples are provided below:

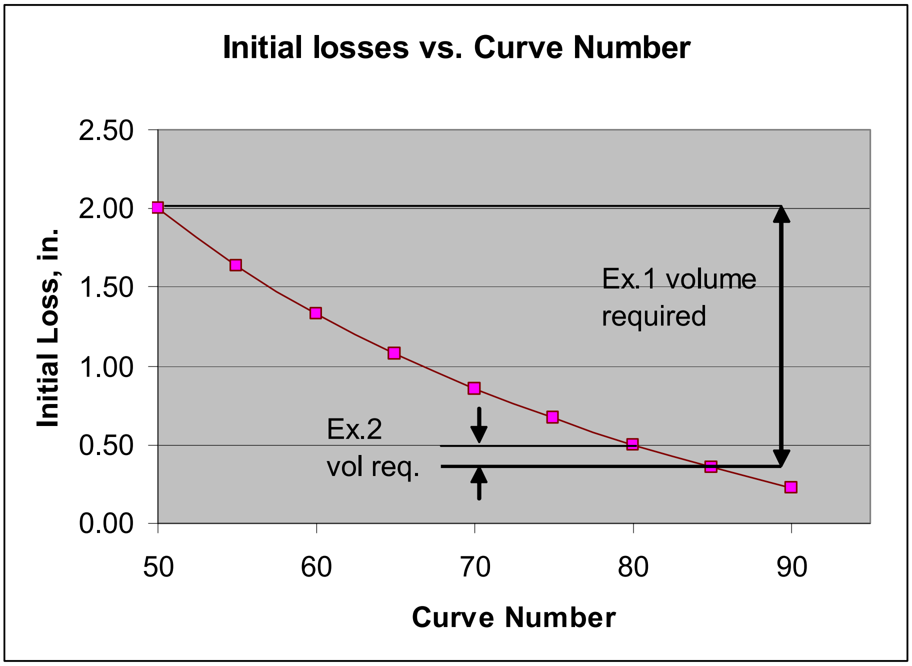
Example 1

Soil Type	A	Composite CN	Ia, in
Pre-exist	Fair Veg natural	50	2
Existing	Ind.70% imp	85	0.35
		Storage, in =	1.65

Example 2

Soil Type	D	Composite CN	Ia, in
Pre-exist	Poor Veg natural	80	0.5
Existing	Res.50% imp	85	0.35
		Storage, in =	0.15

The relationship between Ia and CN is shown below:



In general, it is expected that the pseudo-reference system approaches described herein would result in lower treatment volumes than the other potential sizing criteria.

5.0 Summary of Design Criteria Recommendations

Given that the majority of potential sites are retrofit sites with limited space and funding, we believe flow and volume-based BMPs in the Arroyo Seco watershed – which will be implemented with the primary objective of mitigating bacteria levels in the Arroy Seco – should be sized based on a reference-system approach, subject to confirmation and concurrence with the Regional Water Quality Control Board. The exceedance-days reference approach described above is consistent with the REC-1 bacteria objective exceedance frequency of the Santa Monica Bay bacteria TMDL's Arroyo Sequit reference watershed. The pseudo-reference system approach is intended to mimic the same functions with simplified analysis procedures.

It should be noted that miscellaneous BMP design details beyond these simple sizing requirements – such as requirements pertaining to minimum or maximum side slope, hydraulic retention time, basin drain time, swale treatment depth, and/or basin aspect ratio – should continue to be based on either the SUSMP requirements or the CASQA BMP handbooks (CASQA, 2003). New development and redevelopment projects in the watershed should continue to be meet County SUSMP-based sizing requirements, as required by the County.

Finally, it should be noted that these proposed alternative BMP sizing approaches are not "relaxed" design standards at all, but rather altogether different, and more innovative/site-specific, design criteria. While the SUSMP approach requires "treatment" (defined as temporary detention to encourage sedimentation) of runoff from the 0.75" precipitation event, our alternative approaches require "treatment" (defined as complete retention – or alternatively, bacteria removal to the REC-1 objectives) of runoff from a smaller precipitation event. So this proposed alternative approach should result in decreased frequency of discharges and bacteria objective exceedances from retrofitted stormdrains in the Arroyo Seco watershed.

6.0 References

California Stormwater Quality Association, January 2003, ***Stormwater Best Management Practices Handbook: New Development and Redevelopment.***

Los Angeles County Department of Public Works, September 2002, ***Development Planning for Storm Water Management: A Manual for the Standard Urban Storm Water Mitigation Plan (SUSMP).***

Water Environment Federation and American Society of Civil Engineers, 1998, ***Urban Runoff Quality Management, WEF Manual of Practice No. 23.***

Appendices

Appendix 8: Regulatory Issues Associated with Implementing Best Management Practices.

Prepared with assistance from:

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MEMORANDUM

TO: Jason Pelletier, North East Trees
FROM: Ken Susilo, GeoSyntec
DATE: May 31, 2005

SUBJECT: Task 5: Local State and Federal Regulations

1.0 Introduction

The purpose of this document is to provide an overview of the regulatory issues that need to be considered to determine the feasibility of treatment and management options currently being considered for the Arroyo Seco Watershed Restoration Plan. It does not constitute a legal opinion, and further detailed investigation is required for project implementation. The summaries presented here are based on 2005 recommendations for draft implementation of the Santa Monica Bay Beaches Bacterial TMDL Implementation Plan - Technical Memorandum 5, developed by the consulting team comprised of GeoSyntec, Psomas, CDM, and CH2MHILL.

This document includes information about specific local applicable regulations including planning, public works and zoning codes which should be considered, and state and federal regulations which cover the planning, siting and development of facilities which are under consideration.

In general, the project proponents should approach permit and regulatory agencies as soon as they have a specific project in mind. Beginning to work early with permit agencies is critical, so that CEQA or project description documentation can take into account the specific regulator's concerns, and can address issues related to codes, ordinances, regulations and laws. Actually obtaining a permit can take anywhere from three to twelve months, not including the time to plan, provide CEQA documentation, and design the facility. Therefore, to shorten the process, it is important to have early and frequent communication with the regulators.

Two types of options are considered here:

- On-site (Structural Source Control) Options: These options include cisterns, on-site storage/reuse, onsite capture and infiltration. They are intended to reduce the total volume and flow rate of runoff leaving properties and entering the storm drain system, including any bacteria that might be picked up in the runoff on-site. They directly reduce the amount of runoff that enters the downstream storm drain system, thereby reducing the amount that needs to be managed downstream. The presumption is that no treatment would be required since water would either be infiltrated or applied with subsurface irrigation or otherwise locally managed techniques with minimal unrestricted public contact. Some limited pre-treatment might be required for a larger system to minimize operational problems.
- Regional Options: Regional options refer to diversion, collection and treatment of the urban stormwater runoff from a watershed or sub-watershed. The three candidate regional treatment options include detention with subsurface wetland treatment, infiltration, and traditional disinfection (potentially including biocides or nanofiltration).

Regulatory Requirements

In general, the regulatory issues associated with the above options for management of the urban wet weather runoff are related to:

- Permitting the construction of on-site treatment systems
- Permitting the construction and operation of regional facilities, and
- Permitting of effluent, whether it be for beneficial reuse or for the discharge of the effluent.

2.1 Local Regulations

The following should be considered advisory guidance and require confirmation upon the detailed planning and implementation of potential projects.

For those on-site projects proposed for privately-owned sites, the following local regulations will apply. For those projects proposed for publicly-owned sites, each public agency will have their own internal processes to design and review projects in accordance with these codes.

The installation of on-site solutions or the construction and operation of treatment facilities must be consistent with the regulatory framework of the local member agencies, including the municipalities and the Los Angeles County Code. Only County codes are discussed in detail here. Both County and City Codes require that private property owners obtain appropriate permits from County/City departments prior to constructing structural BMPs on their property. Within unincorporated areas of the County of Los Angeles, owners will obtain permits from the County departments, and the incorporated areas' owners will obtain permits from the Cities.

Planning and Zoning Code

The purpose of the Planning and Zoning Code is to guide the growth and development of the County/City in accordance with the County/City's General Plan by regulating the location and use of buildings, structures, and land for residential, commercial, industrial, recreational, and other specified uses. This code provision requires that permits be obtained to use property in any manner that requires special consideration (e.g., due to peculiar characteristics of the use; or because of size, technological process or type of equipment; or because of its location with reference to surroundings, street or highway width, traffic generation or other demands on public services).

At the beginning of the construction approval process, the County Public Works/City Planning Division first reviews plans for development projects and new proposed uses for consistency with various standards including the Zoning Ordinance and the General Plan, and then issues planning approval.

Building Code

The Building Code regulates the design, construction, quality of materials, use, occupancy, location, and maintenance of all buildings, structures, grading and certain equipment. The provisions of this Code apply to the construction, alteration, moving, demolition, repair, and use of any building or structure and grading, and require the following permits:

- Building Permit: A building permit is required to erect, construct, enlarge, alter, repair, move, improve, remove, convert or demolish any building or structure. A permit is also required for any sandblasting, liquid washing, compressed air cleaning or steam cleaning of exterior surfaces of any building or structure. The building permit usually does not cover any grading, plumbing, electrical, HVAC, fire sprinkler, pressure vessel, or elevator work that needs to be performed on the building or the site. A separate permit is typically obtained for each of those items.
- Grading Permit: A grading permit is required to import or export any earth materials to or from any grading site. A grading permit is also required to perform any grading within areas designated "hillside". Any grading project involving more than 100 cubic yards of excavation and involving an excavation in excess of 5 feet in vertical depth at its deepest point measured from the original ground surface and should be done by a State of California licensed contractor.
- Combination Building Permit: A combined building permit allows the permittee to obtain a single permit for all building, electrical, plumbing, heating, ventilating, and air conditioning work in lieu of obtaining separate permits. Combined building permits are only allowed when electrical, plumbing, heating, ventilating and/or air conditioning work is necessary and in conjunction with the building work being

performed, and will only be granted for work on single family dwellings and duplexes.

The provisions of this Code do not apply to "work located primarily in a public right of way; public utility towers and poles; certain governmental agencies, special districts and public utilities as determined by the building official; equipment not specifically regulated in this Code; hydraulic flood control structures; or minor work of negligible hazard to life specifically exempted by the building official". The reason for these exemptions is to not require cities to obtain permits for public works projects which are developed primarily by County/City engineering staff. However, as noted previously, the design and review process for public works projects is intended to ensure that projects are designed to meet the requirements of State and local codes.

Plumbing Code

The local Plumbing Code regulates the design, construction, quality of material, and installation of plumbing. The provisions of this Code apply to the construction, alteration, moving, removal, repair and use of any plumbing or drainage work, and the qualification and registration of certain persons performing such work. The following permit is required by the Plumbing Code:

- Plumbing Permit: A plumbing permit is required to add, alter, construct, install, move, relocate, reconstruct, repair, or replace any plumbing, rainwater piping, subsurface drainage piping, swimming pool piping, reclaimed water piping, or greywater piping. A plumbing permit is required for all the plumbing work in a relocated building; and no connection to a supply pipe or drainpipe shall be made until such permit has first been obtained from the County Public Works.

Again, as noted above, the provisions of this Code do not apply to work located primarily in a public way; work consisting of public utility service piping; certain governmental agencies, special districts and public utilities as determined by the Chief Plumbing Inspector; or work otherwise specifically exempted elsewhere in the Code or by the Chief Plumbing Inspector.

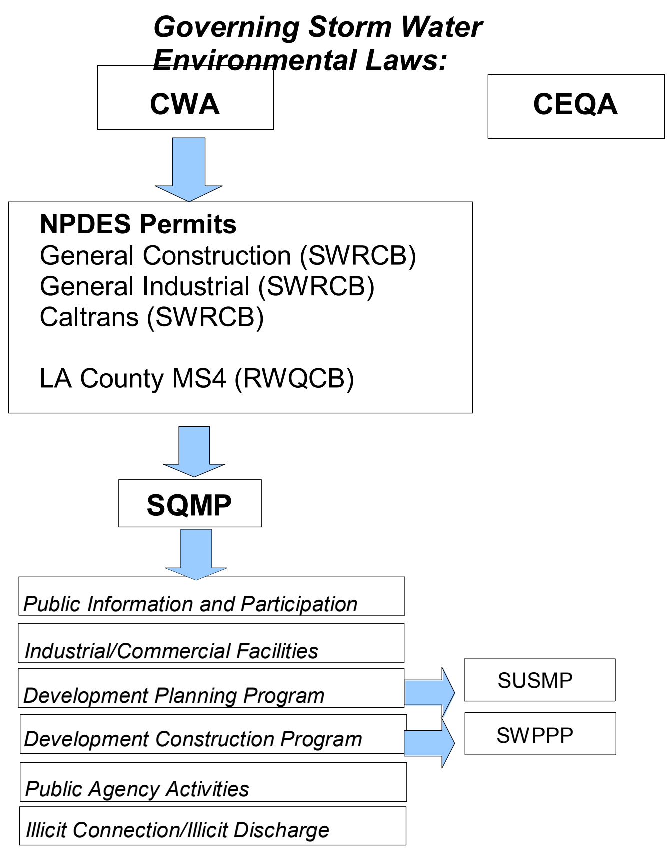
Fire Prevention

The Fire Prevention Office is responsible for enforcement of the Fire Code and fire and life safety provisions of the Municipal Code. In certain occupancy classes, subject to the State Fire Marshal's Regulations, the Fire Prevention Office is responsible for enforcement of nonstructural provisions of the California Building, Mechanical, and Electrical Codes. The Fire Prevention Office performs plan reviews; issues construction and installation permits; and conducts inspections of new construction, fire protection systems, and hazardous processes.

Stormwater Management

The Los Angeles County Stormwater Ordinance addresses provisions that apply to the discharge, deposit or disposal of any stormwater and/or runoff to the storm drain system and/or receiving waters within any unincorporated area covered by the NPDES municipal stormwater permit. Similarly, the many city stormwater ordinances contains provisions requiring construction, commercial, and industrial activities, as well as new development, and it is the implementation mechanism for the City's portion of the municipal (MS4) stormwater NPDES permit.

In 1987, the Federal Water Pollution Control Act (also referred to as the Clean Water Act [CWA]) was amended to provide that the discharge of pollutants to waters of the United States from stormwater is effectively prohibited, unless the discharge is in compliance with a National Pollution Discharge Elimination System (NPDES) Permit. The RWQCB adopted the NPDES Permit (Permit) for Municipal Separate Storm Sewer Systems (MS4) stormwater and urban runoff discharges within the County of Los Angeles on December 13, 2001. The Permit regulates 84 cities, the Los Angeles County Flood Control District, and portions of the unincorporated areas of Los Angeles County, which are referred to as the "Permittees" with the Flood Control District designated as "Principal Permitee." In compliance with the Permit, the Permittees have implemented a stormwater quality management program (SQMP) with the ultimate goal of accomplishing the requirements of the Permit and reducing the amount of pollutants in stormwater and urban runoff. The legal framework is summarized in the flow chart in Figure 1.



Abbreviation
CWA: Clean Water Act
CEQA: California Environmental Quality
MS4: Municipal Separate Storm Sewer
RWQCB: Regional Water Quality Control
SWRCB: State Water Resources Control
SQMP Stormwater Quality Management
SUSMP: Standard Stormwater Mitigation
SWPPP: Stormwater Pollution Prevention

Figure 1
Legal Framework for NPDES Permits

Other Local Regulations

The installation of on-site structural BMPs and the construction of regional runoff management options could involve work within the County/City road right-of-way. Permits would be required for private projects, or possibly in the case where one public agency intends to construct a project within the right-of-way of another agency or jurisdiction. Three types of permits are generally required for these types of projects, and an oak tree permit my be required:

- Construction Permit: A construction permit is required for the construction of driveways, curb drains, sidewalks, curbs and gutters and other types of surface construction.
- Excavation Permit: An excavation permit is required when any portion of the road right of way, which often includes the portion of land beyond the curb and all the way to the sidewalk, is cut for the purpose of laying down utility lines, installing electrical cabinets, installing poles or constructing manholes.
- Encroachment Permit: An encroachment permit is required when using any part of the road right of way for storing materials, detouring traffic or parking equipment in the street temporarily or long term.
- Oak Tree Permit: The Los Angeles County Department of Regional Planning requires Oak Tree Permits "For any activity that may result in an impact to the oak resource. Impacts include cutting, destroying, removing, relocating, inflicting damage or encroaching into the protected zone of any tree of the oak genus that is 25 inches or more in circumference or eight (8") in diameter as measured four and one-half feet above the mean natural grade, or in the case of multi trunks whose combined circumference of any two trunks is at least 12" in diameter." Permits are also required "for any activity that may impact any oak tree, regardless of size, which was provided as a replacement tree pursuant to the Los Angeles County Oak Tree Ordinance."
- In addition, since corralled animals may be a significant contributor to bacteria loadings in some stream reaches, it is worth noting these County regulations: Corralled Animals: Keeping corralled animals may also require a permit, depending on the number and type of animals kept. The Los Angeles County Department of Health Services issues a Public Health License and the regulations fall under Los Angeles County Codes Title 8 and Title 11. These licenses apply to anyone of who keeps, maintains, or raises 5 or more horses; 10 or more animals of the same or different classifications of the horse, cow, sheep, goat, or hog species; 50 or more rabbits or 500 or more fowl. The County routinely inspects permitted sites once or twice a year for pest management, sanitation, and distance requirements including from waterways, and the drainage water from areas where the horses are washed. Frequency of inspections is based not on the number of animals, but on the past history and gravity of existing or continuing violations. Los Angeles County Regional Planning under Title 22 Zoning Code also may or may not require a permit depending on the zoning the particular facility falls under, however, in most cases, no special permit is required if regulations are followed.

Table 1. Summary of County Regulations Potentially Relevant to Stormwater BMP Implementation				
Planning/ Zoning Code	Building Code	Plumbing Code	Environmental Protection	Other
Title 22 Planning and Zoning Code, Oak Tree Permit	Title 26 Building Code	Title 28 Plumbing Code	Title 12 Environmental Protection, Chapter 12.80 Stormwater and Runoff Pollution Control, Title 20 Utilities	Title 32 Fire Code, DHS permit for corralled animals

Issues Regarding Implementation of Options Consistent With Local Regulations

On-site Options

The installation of on-site solutions requires permitting from the County/City's Planning Division because the use of on-site structural BMPs is relatively new and uncommon, particularly at residential dwellings.

In general, the installation of on-site solutions requires only slight modification to a property. For instance, the installation of cisterns at a single-family residential property involves installing the cistern above-ground and modifying the roof gutter and downspout to direct the rain water to it. Also, the construction of porous pavement and bioretention involves minor earthwork and landscaping. Depending on the size of construction, the property owner would be required to obtain a building permit, a grading permit, a plumbing permit, and possibly a permit from the local environmental health department if there is a potential for vector or mosquito attraction. Projects within an ESHA or near wetlands or will require extensive documentation related to environmental impacts.

Table 2. On Site Solution Permitting Summary				
	Building Codes	Plumbing Codes	Planning and Zoning	Public Works[5]
Cisterns/On-site Storage and Reuse	Building Permit, Grading Permit	Plumbing Permit	Planning Approval	If using public right of way
Porous Pavement	Building Permit, Grading Permit	N/A	Planning Approval	If using public right of way
Bioretention	Building Permit, Grading Permit	N/A	Planning Approval	If using public right of way

[5] Vector Control mitigation plans are required on a jurisdiction-specific basis and while the review is often by a Vector Control Agency, it is often as a condition of plan approval by the local jurisdiction.

Regional Options

The aforementioned County/City Codes apply to the regional runoff management options as well. nd since regional options will often involve the use of the public right of way, a permit from the County/City Public Works agency would be necessary. For example, an encroachment permit must be obtained from the State of California, Department of Public Works, Division of Highways for permission to excavate, construct and/or otherwise encroach on a state highway. Similar permits are required for the options that involve diversion of treated runoff.

The regional runoff management options that involve treatment and storage require the construction of stormwater treatment and storage facilities. For these options, the building permit and grading permit are required.

Any of these projects, if constructed in an ESHA or near wetlands which will require extensive documentation related to environmental impacts.

2.2 State and Federal Regulations Governing Implementation

There are two major factors that impact whether state or federal regulations would govern the implementation options: 1) location of the facility and its potential construction footprint, as well as operational impacts of the option, and 2) management of the effluent.

Location of a Regional Facility

Location of a facility and how construction impacts particularly sensitive locations will determine in what ways a project is subject to a variety of state and federal resource protection requirements. For example, if the construction would impact a navigable water, a United States Army Corps of Engineers (CORPS) permit would be needed. If there were impacts to a wetland, a CORPS permit would be required, and the California Department of Fish and Game (CDFG) and the United States Fish and Wildlife Services (USFWS) would likely be involved, as would the RWQCB. Impacts related to location of a facility and construction would be analyzed during an environmental analysis under the California Environmental Quality Act (CEQA).

Location impacts are two-fold – impacts related to constructing a facility and impacts related to operating a facility. These impacts should be thoroughly analyzed in a CEQA document for the facility. In the course of defining these impacts, it should be understood that if there is an impact on fish, other aquatic life (either in a wetland or other habitat), or impacts to terrestrial or avian resources, contact should be made with the resource protection agencies so that they can participate and aid in the development of mitigation measures which would be adopted through the CEQA process.

With a completed CEQA document, including descriptions of impacts and mitigation for the impacts, negotiations for permitting and approval for construction and operations of a regional facility can be concluded.

The following sub-sections describe in more detail the regulations that may be invoked and agencies that may be involved for development of stormwater control options depending on location.

Input from Resource Protection Agencies

The three main resource protection agencies that may weigh in on an implementation solution (especially a regional approach) are the CDFG, USFWS, and the NOAA Fisheries in the Department of Commerce. These agencies are especially concerned about impacts of the regional facility and the effluent from the regional facility on the fish, and the marine life that fish depend on, and on wildlife that depend on marine and wetland habitats. Unless the on-site solutions are causing a wetland or other habitat to dry up, then it is unlikely that these agencies would be concerned with the on-site solutions.

If a regional solution involves crossing or otherwise impacting the bed and bank of any Waters of the State, Section 1600 of the California Fish and Game Code will be triggered. Section 1600 provides the authority for CDFG to require Streambed Alteration Agreements from public agencies for projects that propose to "divert, obstruct, or change the natural flow or bed, channel, or bank of any river, stream or lake" which provides fish or wildlife values. Section 1600 gives CDFG authority to impose restrictions on projects in order to protect associated fish and wildlife resources.

United States Army Corps of Engineers Permit Requirements

The primary charge of the CORPS is planning, designing, building and operating water resources and other civil works projects. The CORPS is also responsible for regulating any dredging and filling activities through issuance of Section 404 permits. Section 404 refers to the pertinent section of the Clean Water Act, and it regulates discharge of dredged or fill material into any "Waters of the U.S." which is defined in code and includes navigable waters, interstate waters, and all other waters where the use or degradation or destruction of the waters could affect interstate or foreign commerce. Tributaries of any of these waters, and wetlands that meet these criteria or that are adjacent to any of these waters or their tributaries are also included.

Determinations on Section 404 (b)(1) permits are made based on the balancing of public and private needs, evaluating the practicality of using reasonable alternative locations and methods, and considering the extent and permanence of beneficial and/or detrimental effects of the proposed project. CORPS will usually consult with the resource agencies (discussed above) for input on potential impacts to fisheries and wildlife prior to granting a 404 (b)(1) permit. A 404(b)(1) permit would be required for any project that involves construction in "Waters of the U.S."

In addition, any applicant for a Section 404 permit under the Federal Clean Water Act from the CORPS for an activity which may affect water quality also must apply to the RWQCB for Water Quality Certification under Section 401 of the Clean Water Act. Obtaining a RWQCB water quality certification is a condition of the CORPS' Section 404 permit.

If filling a wetland is contemplated, the policy of "no net loss" will be invoked and mitigation will be necessary. The RWQCB would require a public hearing on a wetland-related permit, as fill or discharge would need both NPDES and WDR permits as well as Section 404 permits.

Again, it is unlikely that the on-site BMPs will require any of the CORPS's permits or attentions, as long as wetlands are not impacted. For a regional facility, if the construction will impact the navigability of water or require dredging or filling of wetlands, the CORPS will be involved. As with the resource agencies, the Corps should be involved in discussion during the CEQA evaluation so that impacts can be clearly described and potential mitigation measures can be jointly developed. With the completion of the CEQA document, the CORPS will begin permit negotiation. CORPS permitting would be triggered, for instance, for any regional project that requires the diversion of instream flows.

It should be noted that wetlands constructed solely for use in treatment that are not located on a jurisdictional wetland site would be considered a treatment facility, not a wetland. Therefore these treatment wetlands would not require a 404 permit or 401 certification.

Management of the Effluent

The second major reason why a state or federal regulatory agency would govern the implementation options would be to ensure that the management of the effluent for discharge or for reuse would be consistent with other public health, environmental, and resource protection regulations. The effluent can be discharged either directly or indirectly to a surface water, percolated or injected into groundwater, or directly recycled for a variety of non-potable uses.

If the regional facility requires a new discharge, a new permit (WDR and/or NPDES) and an anti-degradation analysis may also be required. The resource protection agencies would comment on such an analysis with the worse case being a judgment that a threatened or endangered species would be harmed by a new discharge. In all instances other than a new surface or groundwater discharge, permits are already in place that allows stormwater discharges. The following section will discuss the permit requirements for the implementation solutions in further detail. Table 3 outlines the state and federal regulations and agencies that govern the implementation options under consideration.

Table 3. Summary of State/Federal Regulatory Requirements

	NPDES Permit	Dept. of Health Services	CA Fish and Game	Corps of Engineers	Fish and Wildlife
On Site BMPs					
Cisterns	Already approved in Phase I MS4 permit	NA	NA	NA	NA
Porous Pavement	Already approved in Phase I MS4 permit	NA	NA	NA	NA
Bioretention	Already approved in Phase I MS4 permit	NA	NA	NA	NA
Regional Solutions					
Treatment and Discharge Facility	Already approved in Phase I MS4 Permit—use of chemicals may require new permit; if new Ocean discharge, may need new permit and antideg analysis	NA	Depends on location of treatment and discharge; if new discharge would need approval	Depends on location of treatment and discharge	Depends on location of treatment and discharge; if new discharge would need approval
Treatment and Direct Reuse	New permit	Permit Required and likely must meet Title 22	Depends on location	Depends on location	Depends on location

Permit Requirements for Direct Discharge to Waters

Every discharge to Waters of the State must have Waste Discharge Requirements (WDR) – in effect, a discharge permit. Waters of the State includes groundwater (particularly for the case of injection). For waters of the United States (i.e., surface waters), a NPDES permit is also required. A NPDES permit is required under the Clean Water Act for discharges into any surface water. The Los Angeles Regional Water Quality Control Board is the state agency responsible for issuing and enforcing these permits under a delegation agreement between the state and EPA. The NPDES permit incorporates the water quality standards for a specific receiving water, includes water quality-based effluent limits for traditional point source discharges, or technology-based effluent limits such as BMPs for stormwater and nonpoint source discharges. The latter are intended to ensure compliance with water quality standards, and include implementation conditions for the discharge including programmatic schedules, monitoring and reporting requirements, and periodic evaluation of effectiveness. The NPDES permit is enforceable by the state, by the federal government, and by citizens.

On-Site Solutions

As mentioned previously, there is already an existing municipal NPDES permit for the stormwater discharges for the County of Los Angeles and the incorporated cities issued by the RWQCB that is a WDR and an NPDES permit. It requires BMPs that meet the Maximum Extent Practicable (MEP) standard to meet stormwater program requirements (under the Clean Water Act). This permit already requires and approves the BMPs for control of pollutants in stormwater (urban wet weather runoff). The development and implementation of various BMPs, including on-site solutions considered for control of the bacteria contamination in the Arroyo Seco Watershed, is already an integral element of compliance under the existing County MS4 permit.

Treatment and Discharge Solutions

If the MS4 permittees were to capture the entire stormwater flow, or any portion of the flow, treat it for bacteria and/or other pollutants, and then discharge it back into the same storm system, this could be considered consistent with the stormwater permit. This level of treatment could be considered a BMP, and MEP for stormwater, and thus the existing permit would be sufficient. If this is considered as an option, it would be prudent to discuss it with the co-permittees and with the RWQCB to ensure that they feel comfortable about the interpretation that this is a BMP and already allowed under the permit.

The Santa Monica Urban Runoff Reuse Facility (SMURRF) is a case-in-point that runoff – in this case dry weather runoff – that is captured, treated, and reused is permitted as a BMP. Regulatory compliance for the SMURRF was judged on the basis of the application of best available technology as a BMP covered under the Los Angeles County Municipal Stormwater NPDES Permit.

However, one factor to consider is that use of chemicals in the treatment process may make the case for a BMP permitting approach more difficult. A stormwater treatment system that uses peracetic acid (PAA) or other biocides may be treated like a POTW and would therefore require its own NPDES and WDR permits if discharged into a waterbody.

Treatment and Reuse Solutions

While reuse is not an option currently considered, potential permitting issues are discussed for informational purposes.

Beneficial reuse can take the form of irrigation as well as industrial use and other non-potable uses. To assure protection of public health where water reuse is involved, the California Department of Health Services (DHS) has been statutorily directed to establish statewide reclamation criteria for the various uses of reclaimed water (Water Code Section 13521). DHS has promulgated regulatory criteria which are currently set forth in the California Code of Regulations, Title 22, Division 4, Chapter 3, 60301 et seq. DHS's regulatory criteria include numerical limitations and requirements, treatment method requirements, and provisions and requirements related to sampling and analysis, engineering reports, design, operation, and maintenance.

DHS's regulations also permit the granting of exceptions to reclaimed water quality requirements and in some cases, call for a case-by-case review of groundwater recharge projects, and allow use of alternative methods of treatment as long as the alternative methods used are determined by the Department to assure equivalent treatment and reliability. Many of the regulatory requirements related to sampling, analysis, engineering reports, personnel, operation, and design are narrative in nature and leave room for discretionary decisions based on the individual project demands.

The RWQCB must also approve the application for beneficial reuse of wastewater. No person may either reclaim water or use reclaimed water until the RWQCB has either issued reclamation requirements or waived the necessity for such requirements (Water Code Section 13524). In the process of issuing reclamation requirements, the RWQCB must consult with and consider recommendations of DHS (Water Code Section 13523). Any reclamation requirements which are issued by the RWQCB, whether applicable to the reclaimer or to the user of reclaimed water, must include or be in conformance with any regulatory reclamation criteria adopted by DHS.

Title 22 officially only applies to recycled wastewater (of sewage origin). Formal application of Title 22 Regulations normally is triggered when a wastewater or water agency is proposing, often in conjunction with a water agency or with direct users, to deliver treated wastewater. That type of reuse must be permitted by the RWQCB through WDR's, which might be added to an existing NPDES/WDR permit or as a stand-alone Water Reclamation WDR. The RWQCB consults with DHS and together ensure that the permit requires adequate treatment and effluent requirements to meet Title 22 requirements for the intended use. Since most projects involve delivering water for unrestricted, potential public contact irrigation or other use, the "filtered disinfected" requirements that apply are intended to produce pathogen-free (<2.2 MPN) water.

However, if an agency is contemplating stormwater reuse, the permitting process is not as clear. RWQCBs have argued, in some cases, that stormwater that is recycled is really wastewater because it contains pollutants. If the stormwater project is just treatment and discharge back to the channel or storm drain, it is assumed that the RWQCB would view that as a BMP, not a new discharge. In the case of the SMURRF, a finding was made that the facility itself is a Best Management Practice and a discharge permit was not issued. The SMURRF was also considered in compliance with Title 22.

If the reuse project is going to look like a "traditional" reuse project, where the "producing" agency (e.g. the MS4 agency) is delivering water to others for unrestricted irrigation use, it is a safe assumption that it would need to be free of potential pathogens that might have been in the source water (runoff). It is possible that this quality might be achieved with a slightly less stringent treatment train than typical Title 22 treatment, if the influent bacteria density is a few logs lower than secondary effluent and equivalent effluent quality could be demonstrated. Further discussion with both DHS and the RWQCB should take place before design is contemplated on any stormwater reuse option.

Injection of Treated Stormwater into a Groundwater Basin

Injection of stormwater into a groundwater basin differs infiltration BMPs, but is discussed here in the event that infiltration BMPs are considered groundwater replenishment measures and require the associated permitting procedures. In many places in Southern California, stormwater is used to recharge aquifers; however, this is done through spreading basins. The spreading and filtration into the aquifer provides additional treatment as the water passes through the soils. This additional treatment is not provided when injection is employed.

Injection into the groundwater basin has been practiced by the County of Los Angeles and other Southern California agencies as a way to develop a salt water intrusion barrier along the coast. The injected freshwater creates pressure ridges along the coastline, thereby preventing salt water from entering and spoiling the aquifers. The three salt water intrusion projects in the County inject a blend of treated imported water and highly treated recycled water meeting Title 22 requirements; the quality of the aquifers is thereby maintained for drinking water purposes.

Recycled water, originating either from stormwater or from effluent, injected into a groundwater basin that is primarily used for a municipal supply, will likely be required to meet drinking water standards prior to injection. These standards include removal of metals, pathogens and other toxics. The West Basin Municipal Water District, the Water Replenishment District of Southern California, and the Orange County Water District all inject drinking water quality reclaimed water into the groundwater basin. The reclaimed water is intended as a sea water intrusion barrier, and the groundwater basin is a drinking water basin.

Another more recent concern about injection of reclaimed water, especially wastewater effluent but also stormwater, is the potential for contamination of a groundwater basin with endocrine disrupters which can be found in effluent and stormwater that receives inflow and infiltration from a wastewater collection system. As a result of this concern, the DHS subjects injection projects to close review, but projects are being approved.

Implementing BMPs Consistent With State and Federal Regulations

On-site BMPs are already permitted under state and federal regulations. Only in an extreme situation in which the on-site solution would have the potential to damage a natural resource protected by a state or federal resource agency (e.g. a wetland) would it be considered necessary to go beyond the existing permits.

However, for the regional solutions which involve treatment, discharge, or reuse, the state and federal regulations would be applicable if:

- The location of the regional facility impacts the natural aquatic, terrestrial or avian resources protected by the state and federal resource protection agencies.

- The location of the facility requires construction in a wetland or Waters of the U.S., or requires dredging and filling of a wetland or Waters of the U.S., both of which would involve the CORPS and the state and federal water quality and resource protection agencies.
- A new surface water discharge is developed for the product (effluent) of the regional facility requiring a new NPDES permit, and potentially an anti-degradation analysis.
- The product or effluent of the regional facility is reused as a non-potable water supply either directly or after storage in an aquifer where it is injected. This would require the RWQCB and DHS to permit the reuse and the groundwater replenishment.

3.0 Conclusion

Consideration of permitting issues is essential at the preliminary planning phase. There are regulations that would be applicable for all of the proposed runoff management options. Early communication and engagement with local, state, and federal regulatory agencies, as well as clear descriptions and full and thorough CEQA documentation, will help facilitate permits and approvals for Arroyo Seco Watershed implementation projects.

As previously mentioned, the purpose of this document is to provide an overview of the regulatory issues that need to be considered to determine the feasibility of treatment and management options currently being considered for the Arroyo Seco Watershed Restoration Plan . It does not constitute a legal opinion, and further detailed investigation is required for project implementation.