Public Draft

Riparian Restoration Action Plan

Prepared for:

City of San José

Prepared by:

Jones & Stokes

February 2000

Riparian Restoration Action Plan – Public Draft

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Cover photos:

Background: Guadalupe Creek, view to west from Almaden Expressway.
Top inset: San Tomas Aquinas Creek, view to north from Hamilton Avenue.
Center inset: Guadalupe River, view to west from Taylor Street.
Bottom inset: Ross Creek, view to west at Meridian Avenue.

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Overview

Within San José's Urban Service Area are 136 miles of streams that drain into San Francisco Bay. Many of these streams are a valuable natural resource supporting a diversity of habitats and a great variety of plant, aquatic and terrestrial species, but others have suffered considerable damage as a result of the urbanization of the valley floor.

Most of San José's geographic area was developed during the latter half of the 20th century, a time when evolving engineering technologies were seen as the solution to flood protection for urban communities. The biotic values of streams were often overlooked or unknown and riparian corridors were crowded by buildings and paving. Many streams were reconfigured as trapezoidal channels and/or straightened, in order to convey floodwaters.

We now know that these practices often left developed areas at continuing risk of damage from flooding and that many valuable habitats and the wildlife that would naturally thrive in them are lost. Concurrently, water quality is severely compromised as urban runoff is increased and the stream's natural ability to filter and remove runoff toxins and debris is impaired.

The City of San José is committed to the protection of its streams and riparian corridors. In 1994 the City Council approved the *Riparian Corridor Policy Study,* which contains a baseline inventory of riparian corridors and a series of development guidelines designed to limit or avoid future damage to riparian corridors resulting from new development in the City's urban area.

This *Riparian Restoration Action Plan* (RRAP) is a guide for correcting and reversing past damages to streams and corridors within San José's Urban Service Area. Successful restoration projects are expected to accrue significant benefits for the community, such as:

- improvement of water quality in the City's streams;
- improvement of drainage into the Bay;
- preservation and restoration of habitat and native riparian species; reestablishment of birds, fish and other wildlife in the City's urban areas;
- increase in quality of open space and parks within the Urban Service Area;

- reduction of further habitat damage;
- preservation and restoration of the natural, aesthetic resources of the City's creeks;
- increase in San José property values;
- improvement in the connection between community groups and the creeks, by encouraging projects that are environmentally sound and enjoyable for volunteers;
- increase in recreational and educational opportunities via the development of trails; and
- improvement in quality of living for San José residents.

The City of San José is fully committed to the concept of riparian restoration and will take all feasible steps to ensure that restoration occurs wherever it is warranted and practicable. The City itself, as well as many different individuals, organizations, and public and private agencies, can be expected to undertake specific restoration projects. The City will assist and encourage these efforts by:

- cooperating and coordinating with the efforts and programs of the Watershed Management Initiative;
- maintaining the RRAP as a guide to the City's restoration objectives and to methods for achieving them;
- assisting potential restorers and others in the use of the RRAP;
- implementing restoration projects on City-owned lands as appropriate;
- establishing dialogues with other public agencies and organizations in order to communicate the importance of restoration, to offer supportive information, and to elicit cooperation in the form of restoration projects;
- encouraging private property owners and developers to incorporate riparian restoration into their own projects as appropriate, and establishing onsite restoration as the preferred mitigation for specific impacts on streams and/or corridors
- encouraging private property owners to undertake restoration projects on their own lands, and providing assistance in the form of direction, process and technical information and incentives, as available;

- establishing incentives as is practical (examples may include City-sponsored project monitoring, assistance with permitting processes, sharing of technical information available to the City, coordination with nearby properties, etc.);

- sharing available technical information and process assistance with individuals as well as school and community groups who may wish to undertake a restoration project; and

- maintaining a record of restoration projects within the City of San José as a performance measure as well as a resource for those making future restoration project decisions.

Who Will Use the Riparian Restoration Action Plan?

The RRAP is intended to provide general guidance and some specific details about the circumstances and methods deemed to be most appropriate for the restoration of San José's streams. Its intended audience is the whole range of individuals and organizations who might wish to, or might be required to, become involved in restoring segments of streams and riparian corridors within San José. Some of these are:

- public agencies,
- environmental groups,
- private developers,
- owners of both small and large properties adjacent to creeks,
- neighborhood organizations, and
- school groups.

The City of San José encourages any qualified individual or group to participate in appropriate restoration activities and will work to support these efforts as they will ultimately provide a public benefit. Many types and levels of restoration projects can be effective and meaningful—modest or ambitious, short-term or long-term—and can provide opportunities for a wide range of participants. For example:

1. The City of San Jose will incorporate riparian restoration principles into its parks, roadways, and other projects that interface with streams and riparian corridors.

2. The Santa Clara Valley Water District has primary responsibility for flood protection and water flow along streams in Santa Clara County.

3. Environmental groups and other similar groups may choose to sponsor major projects such as restoring natural stream alignments, "daylighting" buried streams, or any of a myriad of other possible projects that will restore the natural resources once offered by streams that have been damaged.

4. Private developers may invest in the restoration of a creek to serve as an amenity for project occupants and/or as mitigation for project impacts.

5. Property owners can make informed decisions about how they manage their land adjacent to streams. Positive practices could include using native plant species as landscaping, removing invasive ornamental species, removing debris, etc.

6. Neighborhood organizations may conduct neighborhood "creek clean-ups", to remove invasive ornamental plants or debris from the stream corridor, to replant native species in the corridor, etc.

7. School groups and/or classes may decide to "adopt" a creek segment, and/or to engage in ongoing educational activities that raise awareness about stream preservation and restoration.

Chapter 1. Introduction

Purpose of the Riparian Restoration Action Plan

This Riparian Restoration Action Plan is intended to provide an overall policy framework outlining rationale, standards, and responsibilities for riparian restoration projects in the City of San José (the City). The primary purpose of the Riparian Restoration Action Plan (hereafter, RRAP) is to identify strategies for enhancing and restoring riparian and instream habitat values and improving water quality along the 35 streams—totaling136 miles of channel—contained in the City's Urban Service Area. Specifically, the RRAP aims to:

- provide an overview of existing stream corridor conditions in the Urban Service Area;
- summarize existing programs and policies that may affect implementation of riparian restoration efforts in the Urban Service Area;
- identify general goals and improvement strategies that should guide Urban Service Area restoration projects;
- identify opportunities for, and constraints on, riparian restoration activities in the Urban Service Area;
- summarize implementation strategies for riparian restoration activities;
- identify potential sources of funding for riparian restoration;
- outline applicable local, state and federal regulatory policies that may affect implementation of riparian restoration activities in the Urban Service Area;
- identify potential projects and programs for short-term and long-term implementation; and
- provide an overview of additional focused technical studies, data acquisition programs, and detailed construction plans that may be required to implement site-specific restoration projects.

Restoration activities range from the simple and straightforward to the scientifically and technically complex; they may require only the desire to make a positive change (e.g., removing urban trash from area streams), or they may demand scientific and technical expertise (e.g., channel reconstruction, bank recontouring). Riparian restoration thus provides a spectrum of opportunities for community involvement. Individuals or community organizations may choose to sponsor local restoration projects. Individuals and groups can also provide essential volunteer labor for many types of restoration activities. The RRAP is intended to provide background information and planning guidance to organizations and individuals who wish to sponsor riparian restoration projects in the Urban Service Area. It also discusses the types of detailed, site-specific assessment and planning that will be necessary, and the types of expert consultation that may be required, for individual restoration projects.

Background of the Riparian Restoration Action Plan

More than 136 miles of riparian corridor, representing 35 distinct streams and rivers and their tributaries, lies within the City of San José's Urban Service Area and adjacent Urban Reserves (City of San José 1994). These streams have historically supported several distinct types of riparian habitats, including:

- seasonal freshwater wetland,
- riparian forest,
- riparian woodland, and
- perennial freshwater wetland.

Over time, the needs of residential, commercial, industrial, and agricultural development have resulted in significant alteration of riparian habitat within the City's Urban Service Area. Creeks and rivers that historically supported wider, more continuous bands of riparian and wetland vegetation now support narrow disjunct strips of vegetation, or have been converted to earthen or concrete channels for flood protection or water supply purposes.

Recognizing the biological, recreational, aesthetic and economic importance of its remaining corridors, the City commissioned the Riparian Corridor Policy Study in 1992. This study, approved in 1994 and revised in 1999, provides an up-to-date inventory of the City's riparian resources, addresses the general effects of development on riparian corridors, and provides detailed standards and guidelines for maintaining and enhancing existing riparian habitats in areas where future development has been proposed. The Policy Study also identifies the need to develop a comprehensive riparian corridor restoration and enhancement program or "action plan" for the City's Urban Service Area.

Location and Geography of the Urban Service Area

The City's Urban Service Area and Urban Reserves are located south of San Francisco Bay along the eastern side of the Santa Clara Valley (Figure 1-1), and together contain approximately 89,000 acres of baylands, alluvial flatlands, and low rolling foothills. Elevations range from near sea level at the southern end of San Francisco Bay to as much as 1,000 feet above sea level along

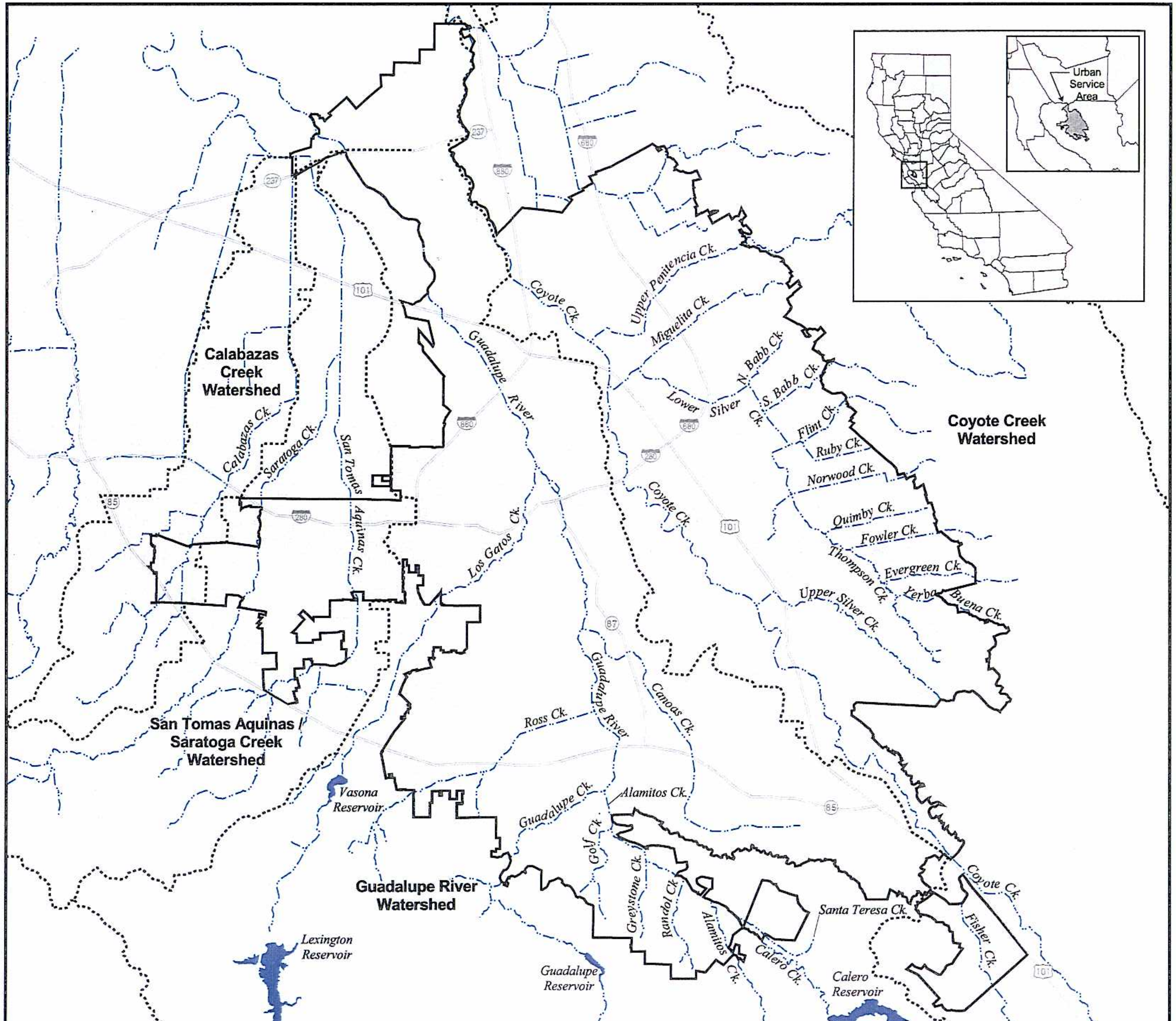


Figure 1-1

San José Riparian Restoration Action Plan

Study Area

Legend

- Urban Service Area boundary
- Freeways and highways
- Rivers and creeks
- Watershed boundaries
- Reservoirs

1 0 1 2 3 4 5

Scale in miles

Jones & Stokes

the eastern boundary of the Urban Service Area. Although most of the baylands and flatlands located within the Urban Service Area have been developed for residential, industrial, and commercial uses, a significant proportion of the hillsides surrounding the Urban Service Area is devoted to non-urban uses, such as open space, rangeland, and wildlife habitat. Note that in this document, the terms *the City* and *Urban Service Area* are used interchangeably; both are understood to include the City of San José along with its greater Urban Service Area and Urban Reserves.

The hills and mountains surrounding the Urban Service Area are the source of numerous perennial and intermittent streams (Figure 1-1). These streams are important environmental features of the area, and they provide water supply, fish and wildlife habitat, recreational opportunities, and aesthetic benefits for the City and the region. Major waterways located within the Urban Service Area boundary include:

- the Guadalupe River and a number of its tributaries, including Guadalupe Creek, Ross Creek, and Canoas Creek, which flows out of the Santa Teresa Hills to the south of the Urban Service Area, and Alamitos Creek and Los Gatos Creek, which flow out of the Santa Cruz Mountains to the west of the Urban Service Area;

- Coyote Creek and a number of its tributaries, including Upper Penitencia Creek, Lower Penitencia Creek, and Silver Creek, all flowing out of the Diablo Range to the east of the Urban Service area; and

- Saratoga Creek and San Tomas Aquinas Creek, flowing out of the foothills of the Santa Cruz Mountains.

Plan Development Process

The information and recommendations included in this RRAP reflect the participation of numerous groups, agencies, and individuals. Jones & Stokes facilitated the development of the RRAP under the direction of the City's Department of Planning, Building, and Code Enforcement. The planning process involved compiling and reviewing existing background information on creeks located within the San José Urban Service Area, identifying opportunities for restoring riparian habitat and constraints on riparian restoration, and developing strategies for implementation of restoration programs.

Stakeholder participation in the plan development process was considered vital to the success of this plan. The Department of Planning, Building, and Code Enforcement organized a Riparian Restoration Technical Advisory Committee (RRTAC) consisting of representatives from:

- various City departments, including the Environmental Services Division, which also provided financial support for Jones & Stokes in the RRAP development process;

- Santa Clara County;

- the Riparian Restoration Work Group of Santa Clara Valley Water District's Santa Clara Basin Watershed Management Initiative (WMI); and

- other local agencies and organizations.

A number of RRTAC workshops were convened over the course of the planning process. Public meetings were also held at key points in the planning process to garner input and comments from environmental organizations, neighborhood associations, and other interested individuals and organizations. In addition, the RRAP will be submitted to the Planning Commission of the City of San José and to the San José City Council for review and approval.

Key Steps in the Restoration Planning Process

A thorough and carefully constructed restoration plan is crucial to the success of any restoration effort. The restoration plan establishes a basic framework for identifying problems, recognizing and prioritizing restoration opportunities, and developing strategies for restoring riparian functions and values to degraded stream corridors. Additionally, the plan serves as a record for all activities associated with the project, and provides information that can be transferred to other groups interested in undertaking restoration efforts.

Although restoration efforts may differ greatly in scope and cost, all restoration efforts rely on versions of the same basic plan development or decision-making process, which comprises the following key steps:

- **Step 1. Identify project participants and establish an advisory committee.**
- **Step 2. Identify funding sources.**
- **Step 3. Identify a suitable restoration site.**
- **Step 4. Define restoration goals and objectives.**
- **Step 5. Collect baseline data on existing site conditions.**
- **Step 6. Identify suitable restoration strategies.**
- **Step 7. Select the project planning and design team.**
- **Step 8. Develop a restoration plan and cost estimate.**
- **Step 9. Prepare environmental compliance documents and acquire permits.**
- **Step 10. Develop post-restoration monitoring and maintenance plans.**
- **Step 11. Implement restoration project.**
- **Step 11. Implement maintenance plan.**
- **Step 12. Monitor and assess success of restoration effort.**
- **Step 13. Distill lessons of project for application to other similar efforts.**

Prospective restoration planners should not view this process as strictly sequential: many of these fundamental steps will be repeated, while some may occur simultaneously. Other steps—such as preparing environmental compliance documents or acquiring necessary permits—may not be required for straightforward projects that involve only debris removal or exotic species management. The RRAP is intended to provide the basic information needed to guide prospective restoration planners through the planning process.

How to Use the RRAP Document

This document provides a variety of kinds of information designed to assist potential sponsors of riparian restoration projects in the City's Urban Service Area in selecting restoration sites and carrying out initial project planning. This document includes:

- Background information and a summary of the RRAP's environmental, historical, and programmatic context (Chapters 1, 2, and 3).
  - **Chapter 1** summarizes the RRAP's purpose and background, and describes the geographic setting of the City and its Urban Service Area.
  - **Chapter 2** discusses relevant local and regional programs and policies, and identifies the RRAP's primary and secondary goals.
  - **Chapter 3** provides an overview of historical and existing conditions in the study area, and an evaluation of existing stream corridor conditions in the City's Urban Service Area. These historical and existing conditions are the foundation for Chapter 4's discussion of restoration opportunities and constraints in the Urban Service Area.
- An overview of restoration opportunities in the Urban Service Area (Chapter 4).
  - **Chapter 4** identifies opportunities for restoring riparian habitat, and constraints on riparian restoration efforts, within the Urban Service Area, based on the historical and existing conditions discussed in Chapter 3. Restoration opportunities and constraints in turn underpin the general restoration strategies described in Chapter 5, and the implementation guidelines presented in Chapter 6.
- Information on riparian restoration strategies (Chapters 5 and 6).
  - **Chapter 5** outlines technical, legal, and educational components of riparian habitat restoration strategy for the Urban Service Area.

- **Chapter 6** presents guidelines for identifying and prioritizing sites for riparian restoration, and for planning, designing, monitoring and maintaining site-specific riparian restoration projects. Chapter 6 synthesizes the restoration strategy components presented in Chapter 5.

- Reference tables and information on additional resources (Chapter 7, appendices).

    - **Chapter 7** presents a list of references that are cited in this document, or were used as background material in developing the RRAP.

    - **Appendix A** summarizes key programs, studies, and policies relating to the RRAP in table format.

    - **Appendix B** lists plant and wildlife species associated with the riparian corridors of the Urban Service Area.

    - **Appendix C** describes the various federal, state, and local regulations that apply to the implementation of strategies outlined in the RRAP.

    - **Appendix D** identifies additional sources of information relevant to riparian restoration activities.

    - **Appendix E** provides a glossary of technical terms used in this document.

Chapter 2. Action Plan Goals

A crucial part of the restoration planning process is the development of a series of realistic, achievable goals that provide the basic framework for restoration efforts within a planning area. As discussed in Chapter 1, restoration goals should be developed as part of a consensus-based planning process involving key decision makers along with advisory groups and other interested parties. This chapter contains an overview of the goals development process and a description of the primary and secondary goals developed for the RRAP. Because the RRAP exists in, and is affected by, a larger context of related programs and policies at various levels, descriptions of related programs and policies are given first.

Related Programs and Policies

The following section provides a brief overview of regional and local programs and policies relevant to development of the RRAP. These programs were reviewed prior to development of the RRAP to ensure that goals formulated in the RRAP planning process would be consistent with local land use planning policies and with the goals and objectives established by regional conservation and restoration planning programs. Table 2–1 provides an overview of the general goals of these programs and policies; more detailed descriptions are given in Appendix A.

Programs and Policies at the Regional Level

CALFED Bay-Delta Program Ecosystem Restoration Goals

The CALFED Bay-Delta Program (CALFED) was initiated in 1994 as a collaborative effort among state and federal agencies and agricultural, environmental, and urban stakeholders to address environmental and water management problems in San Francisco Bay, the Sacramento and San Joaquin rivers, and the watersheds that feed them. CALFED's mission is to develop a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses of the Bay-Delta system. To accomplish this, CALFED focuses on four key program areas: water quality, ecosystem quality, water supply reliability, and Bay-Delta system vulnerability. CALFED is now in the process of refining specific Ecosystem Restoration Goals designed to achieve ecosystem quality by fostering healthy, self-maintaining ecosystems with natural, aesthetic, and economic value.

San Francisco Bay Wetlands Ecosystem Goals Project

The San Francisco Bay Ecosystem Goals Project (Goals Project) was a 5-year volunteer collaborative effort completed in 1998. It involved more than 100 scientists from federal, state, and local agencies, from private consulting firms, and from universities. The results of the Goals Project address an area encompassing nine counties, and including the entire estuary downstream of the Sacramento-San Joaquin Delta (Goals Project 1999). This document provides guidance to public and private stakeholders interested in restoring and enhancing wetlands and related habitats of the San Francisco Bay estuary system. Strictly speaking, it is not a regulatory policy, but rather an informational document that recommends the types, areal extent, and distribution of habitats needed to sustain diverse and healthy ecosystems in the San Francisco Bay estuary.

San Francisco Estuary Project Comprehensive Conservation and Management Plan

Sponsored by the U. S. Environmental Protection Agency (EPA) and the State of California, the San Francisco Estuary Project was established in 1987 to promote more effective management of the San Francisco Bay-Delta estuary and to restore and maintain the estuary's water quality and natural resource values. In 1993, the San Francisco Estuary Project adopted a Comprehensive Conservation and Management Plan. This plan was the result of a collaboration among more than 100 representatives from the public and private sectors—including government, industry, business, and environmental interests—as well as elected officials from all 12 counties in the San Francisco Bay-Delta area. The Comprehensive Conservation and Management Plan recommends corrective action plans, management strategies, monitoring programs, legislation and regulations research, and continuing programs for public information and involvement.

Riparian Habitat Joint Venture

The mission of the Riparian Habitat Joint Venture is to promote conservation and restoration of riparian habitat sufficient to support the long-term viability and recovery of native bird populations and associated species. The Riparian Habitat Joint Venture was established by the California Partners In Flight program, which was initiated in 1993 to identify and address major avian conservation issues in California.

Stream Protection Policy

The San Francisco Bay Regional Water Quality Protection Board has recently received EPA funding to support the development of a regional stream protection policy for the greater San Francisco Bay area. The Bay Area Stream Protection Policy is intended to build on an area-wide understanding of stream function, and will provide guidelines for protection and restoration of riparian habitat as well as maintenance or improvement of flood retention, waters conveyance, and sediment transport capacity. The Policy will address recommended best management practices (BMP's), such as implementation of adequate setbacks and appropriate slope design, reservation of

Table 2–1. Related Programs Now in Effect, and Their Goals

Program	Protection/Restoration of Riparian Habitat and Wetlands	Flood Protection	Recreational Use of Waterways	Fish/Wildlife Protection	Pollution Reduction/ Water Quality
CALFED Bay-Delta Program	✔		✔	✔	✔
Riparian Corridor Policy Study	✔	✔			✔
Riparian Habitat Joint Venture	✔				
San Francisco Bay Wetlands Ecosystem Goals Project	✔			✔	
San Francisco Estuary Project Comprehensive Conservation and Management Plan	✔			✔	✔
San José 2020 General Plan	✔	✔	✔	✔	
Santa Clara Basin Watershed Management Initiative	✔	✔	✔	✔	✔
Santa Clara County Countywide Trails Master Plan			✔		
Santa Clara County General Plan	✔		✔		✔
Santa Clara Valley Urban Runoff Pollution Prevention Program					✔
Santa Clara Valley Water District					
Flood Damage Reduction Plan		✔		✔	✔
Adopt-A-Creek					✔
SCV Nonpoint Source Pollution Control Program	✔			✔	✔
Groundwater Protection Programs					✔
Environmental Programs	✔	✔			✔
Comprehensive Reservoir Watershed Management Program			✔		✔
Environmental Compliance Programs				✔	✔
Design Coordination Programs		✔		✔	✔
Water Supply Programs		✔			

	Protection/Restoration of Riparian Habitat and Wetlands	Flood Protection	Recreational Use of Waterways	Fish/Wildlife Protection	Pollution Reduction/ Water Quality
San Francisco Bay Regional Water Quality Control Board – Bay Area Stream Protection Policy	✔	✔			?
City of San José Water Policy	✔	✔	✔	✔	✔

adjacent floodplains for non-structural uses, and measures to promote water retention and minimize degradation of individual stream systems. A draft Stream Protection Policy document is slated for completion in December 2000.

Programs and Policies at the Local Level

Santa Clara County General Plan

The Santa Clara County General Plan was adopted in 1994. Its purpose is to provide the county with comprehensive countywide direction for growth and development from 1995 to 2010. The aims of the plan are expressed through a series of goals that can be classified under four basic themes:

- social and economic well-being;
- managed, balanced growth;
- livable communities; and
- responsible resource conservation.

Technically, the County General Plan is not legally binding for cities under County jurisdiction, many of which, including San José, have separate city-level general plans. However, the County General Plan encourages the voluntary support of Santa Clara County municipalities to achieve its countywide goals.

Santa Clara County Countywide Trails Master Plan Update

The Santa Clara County Countywide Trails Master Plan Update summarizes the County's trails planning history and presents a master plan for a countywide trail network. The plan was developed by the Santa Clara County Trails Master Plan Advisory Committee and was adopted by the Santa Clara County Board of Supervisors on November 14, 1995. The countywide trail network proposed in the Trails Master Plan Update comprises 535 miles of off-street trails (105 miles of existing trails and 430 miles of proposed trails) and an additional 120 miles of on-street bicycle-only routes (Santa Clara County 1995). The proposed trail system traverses both public and private lands. To guide implementation of the trail system plan, the Trails Master Plan Update suggests procedures for coordinating with private landowners, establishing trail segment priorities, mitigating environmental impacts, and specifying details of trail design, operations, and management. Construction of the proposed trail system is expected to take place over several decades.

City of San José General Plan 2020

The City of San José's General Plan 2020 was adopted in 1994 as a comprehensive 25-year plan for the City's Sphere of Influence. It represents the City's assessment of the amount, type, and phasing of development needed to achieve specific social, economic, and development objectives (City of San José 1994). Seven major strategies, each defined by specific goals and supported by specific policies, encompass the principal objectives of the General Plan. Of these, both the Greenline Major Strategy and the Sustainable City Major Strategy are vital to the preservation of natural habitat and a healthy living environment in the City's Urban Service Area.

Programs of the Santa Clara Valley Water District

The Santa Clara Valley Water District (the District) was formed in 1968 when the Santa Clara Valley Water Conservation District merged with the Flood Control District. The main purposes of this union were to prevent flooding and to maintain a high standard of water quality for Santa Clara County. The District now works with cities and with Santa Clara County to evaluate the potential impacts of development on streams and on floodflows.

The District has implemented various integrated water-resource management programs designed to improve water quality and flood protection in southern San Francisco Bay and the streams of Santa Clara County. These include:

- the Flood Damage Reduction Program,
- the Adopt-A-Creek Program,
- the Creek Connections Program,
- the Santa Clara Valley Nonpoint Source Pollution Control Program,
- a variety of groundwater protection programs and environmental programs,
- the Comprehensive Reservoir Watershed Management Program,
- programs for environmental compliance,
- design coordination programs, and
- water supply programs.

Santa Clara Basin Watershed Management Initiative

The Santa Clara Basin Water Management Initiative (WMI) was begun in1996, with a stated mission of "protecting and enhancing the watershed, [and] creating a sustainable future for the community and the environment." WMI was conceived by the EPA, the State Water Resources Control Board, the District, and the San Francisco Bay Regional Water Quality Control Board. The WMI addresses all sources of pollution threatening San Francisco Bay, in order to safeguard water quality throughout the Santa Clara Basin watershed. The central aim of WMI is to coordinate existing regulatory activities on a basinwide scale, rather than to establish separate regulatory actions for specific issues. Because of its regional scope, WMI involves the coordination of numerous stakeholders representing a cross section of the Santa Clara Basin business, agricultural, residential, environmental and regulatory communities. A major milestone of WMI will be the development and approval of a regional watershed management plan.

Santa Clara Valley Urban Runoff Pollution Prevention Program

Fifteen Santa Clara County entities participate in the Santa Clara Valley Urban Runoff Pollution Prevention Program, including the City of San José and 12 other local municipalities, the County of Santa Clara, and the District. These agencies are co-permittees under a National Pollutant Discharge Elimination System stormwater permit issued by the RWQCB. As a condition of the permit, the participant agencies created an Urban Runoff Management Plan, which identifies the activities various City departments are required to undertake in order to comply with the federal and state requirements of the stormwater permit.

Riparian Corridor Policy Study

The Riparian Corridor Policy Study (RCPS) was commissioned by the City of San José in 1992 in response to the City's recognition of the biological, recreational, aesthetic, and economic importance of its remaining riparian corridors. The intent of the study was to examine in detail issues related to, and methods for promoting, the preservation of riparian corridors. The RCPS focuses on riparian corridors within the Urban Service Area, on the assumption that corridors outside the Urban Service Area are more widely protected by the County's General Plan. Results of the study were approved in 1994, and underwent revisions in 1999 (City of San Jose 1994). Baseline inventories and policy guidelines from this study provide the City with information necessary to maintain and enhance existing riparian habitats in areas slated for future development. The RCPS includes provisions for a 100-foot setback from streams, as well as other measures designed to minimize the impact of new construction on remaining riparian corridors in the City's Urban Service Area.

Goals of the Riparian Restoration Action Plan

The following sections summarize the RRAP's riparian restoration goals. Draft goals for the RRAP were initially developed during a series of RRTAC meetings. A preliminary set of goals was then presented to the public at a meeting held on August 31, 1999. Based on public comments and input from RRTAC members, the goals were further refined, and a final set of goals was developed to guide the RRAP planning process. The RRAP's restoration goals are subdivided into primary and secondary goals.

Primary Restoration Goals

The RRAP's primary goals provide the basic framework for identifying and prioritizing restoration opportunities within the City's Urban Service Area and for identifying restoration strategies that could be implemented on a site-specific basis. These goals apply to the entire Urban Service Area, and include:

- *restoration of riparian habitat* by planting locally native species (plants grown from seeds or cuttings harvested from donor plants at approximately the same elevation along the same creek or from donor plants at approximately the same elevation on the closest creek in the same watershed), by encouraging natural regeneration of native species, and by controlling growth of non-native species;

- *enhancement of wildlife and fish habitat* by restoring the connection between existing patches of riparian vegetation, by restoring the connection between the baylands and the upper watershed, by providing diverse aquatic habitats, and by ensuring fish passage; and

- *protection and improvement of water quality* by controlling erosion and sediment deposition, and by filtering overland and street storm runoff.

Secondary Restoration Goals

The RRAP's secondary restoration goals provide additional parameters for identifying and prioritizing restoration opportunities within the Urban Service Area. These secondary goals should be carefully evaluated on a site-specific basis to ensure that they directly or indirectly support the primary goals for a specific creek segment or restoration project. Secondary goals of the RRAP include:

- *enhancement of recreational opportunities* by incorporating provisions for public use and access—such as trail corridors, parks, and open space preserves—into restoration planning;

- *enhancement of public education and outreach opportunities* by incorporating environmental education and interpretation into restoration planning, by involving local schools and community groups in restoration activities, and by interfacing with existing community programs such as Adopt-a-Creek and Adopt-a-Park; and

- *maintenance or increase of flood protection* by incorporating measures to maintain or improve channel capacity and reduce required channel maintenance into restoration planning.

Limitations of the Riparian Restoration Action Plan

The RRAP is a practical document. Although the goals of the RRAP are broad and far-reaching, the City recognizes that these goals must be accomplished within the limitations imposed by existing environmental conditions, by the needs of the public arena, and by financial constraints. Potential physical, social, and financial limitations on implementation of the RRAP's goals are discussed in greater detail in Chapters 3 and 4 of this document.

The City also recognizes that the RRAP is a regional planning document and not a blueprint for site-specific restoration projects. The RRAP is meant to aid planners in prioritizing, selecting, and developing preliminary designs for restoration projects within the City's Urban Service Area;

it is not intended to provide the guidance or technical assistance necessary to implement a site-specific restoration project. Before a restoration project of any size can be undertaken, site-specific surveys and analyses must be carried out, and detailed site-specific designs must be developed.

Chapter 3. Historic and Existing Conditions in the San José Urban Service Area

This chapter describes historic and existing conditions in the City's Urban Service Area as they relate to riparian corridors. The first section summarizes human activity in the area from prehistory through the present. The second section describes the current environmental setting of the Urban Service Area, and includes information on topography, soils, hydrology, land use, and vegetation and wildlife habitats. The third section integrates the physical features of riparian corridors with discussions of their habitat functions and values in the past (prior to European settlement, the *historic* or *reference condition*), at the present time (the current or *existing condition*), and in the future (the *desired condition*). The current and desired future conditions form the basis for the evaluation of restoration opportunities and constraints on restoration, the restoration strategies, and the guidelines for implementing restoration projects outlined in Chapters 4, 5, and 6. Unless otherwise noted, discussions in this chapter refer to the Urban Service Area of the City of San José.

Cultural Context

Ethnographic Context

The Santa Clara Valley and the surrounding vicinity, including what is now the San José Urban Service Area, are the traditional home of the Ohlone, a Native American group bound by a common linguistic heritage. The Ohlone were gatherers and hunters; like many California native groups, they relied on the acorn as a major food source. The Ohlone also used a wide range of other natural resources for food, shelter, and the production of material goods, including various seeds, berries, roots, land and sea mammals, waterfowl, reptiles and insects. In addition, the Ohlone practiced controlled burning to promote a consistent and abundant resource supply.

Archaeological and ethnographic evidence indicates that various Ohlone groups lived along major drainages such as the Guadalupe River for more than a millenium prior to European occupation. It is estimated that in the 1770's, when the first mission was established in the area, the Ohlone population was approximately 10,000. By 1832, the population had declined to less than 2,000, because of introduced disease, harsh living conditions, and a reduced birth rate. The Ohlone culture suffered as a result of these changes. However, descendants of the Ohlone have maintained many of their cultural traditions and continue to pass on their heritage to younger generations (Levy 1978).

Historic Context

The Guadalupe River has long been the focus around which development of the Santa Clara Valley and San José has prospered. When early Spanish explorers traversed the area in 1769 and 1775 in search of appropriate locations for the establishment of presidios, missions, and pueblos, the route they took followed the Guadalupe River through the Santa Clara Valley. This route eventually became established as a segment of *El Camino Real.*

Mission Santa Clara

In 1777 Mission Santa Clara was established on the banks of the *Rio Guadalupe*. The mission soon planted crops and built a bridge across the Guadalupe River. However, because of repeated flooding, as well as the earthquakes of 1812 and 1818, the mission site was moved several times. It was finally established in its present location in 1825. One of the most successful endeavors of the mission was its embarcadero, which was located at the head of Alviso Slough. This landing became important in the shipping of goods into and out of surrounding inland areas. Eventually, with the development of the New Almaden Mine after the California Gold Rush, the embarcadero became a major west coast shipping nexus (Hoover et al. 1970).

After Mexico won independence from Spain in 1821, plans were initiated to secularize the California mission properties. An unfortunate result of secularization was the neglect and deterioration of mission buildings, grounds, and facilities, including those of Mission Santa Clara (Hoover et al. 1970). Mission Santa Clara lay in a state of neglect until 1855, when the buildings were rehabilitated and substantially altered for use as a college, eventually becoming Santa Clara University.

The year 1797 saw the establishment of the *Misión del Gloriosísimo Patriarch San José*, sometimes also called Mission San José de Guadalupe. This second area mission was situated at some distance from Mission Santa Clara, in the foothills of the Diablo Range; the site is now within the modern city of Fremont. Mission San José currently operates as a museum.

El Pueblo San José de Guadalupe

In 1777, *El Pueblo San José de Guadalupe* was founded along the Guadalupe River about two miles from the mission. The pueblo was intended to serve as an agricultural settlement to provision Spain's religious (mission) and military (presidio) establishments in the northern part of Alta California. The city of San José, then, has the distinction of being California's oldest civil settlement. Like the mission, however, the original town was situated on the floodplain and was subject to flooding; many settlers moved their residences to higher ground over the years (Hoover et al. 1970).

Settlers within the pueblo were granted house lots and cultivation plots based on a very loose ownership arrangement. These lands continued to be property of the King of Spain and could not be sold by the grantees, but were passed on to succeeding generations of the family. Following Mexican independence from Spain in 1821, large tracts of land were transferred to individual ownership (City of San José 1994). When California became part of the United States after the United States – Mexican War of 1848, land ownership became a source of long and bitter legal disputes (Robinson 1948).

By the late 1840's the Euroamerican population in San Jose was increasing rapidly. Lots along the Guadalupe River and Coyote Creek were particularly desirable. Land uses at this time included agriculture and pasturage. Land also served as an investment. In addition, the mid-19th century saw the onset of industrial development along area waterways, in the form of grist mills, brick kilns, lumber yards, wineries, and canneries. By the end of the century, population growth had prompted the incorporation of peripheral areas into residential subdivisions of the City (Hoover et al. 1970).

Agriculture

Agriculture was the economic mainstay of the Santa Clara Valley throughout the 19th century. By mid-century, much of the Valley was under hay and grain cultivation. During the second half of the century, vast areas of the valley were converted into orchards of prunes and other fruits. Additional settlements were established in the Santa Clara Basin following the completion in 1864 of the railroad linking San José with San Francisco, and the completion in 1869 of the transcontinental railroad. Agricultural production intensified in San José with the advent of the refrigerated railroad car in the 1880's. By 1900, fruit orchards covered 100,000 acres in the basin (Soil Conservation Service 1968), and the region became a major provider of canned and dried fruit. Agriculture remained the dominant industry in the Santa Clara Basin until the mid-20th century.

During this period, increasingly intensive agricultural practices led to efforts to modify and control the flooding of the Guadalupe River (Laffey 1990). Valley watercourses were dammed, rechanneled, and diverted, to prevent flooding of cultivated and developed areas.

High-Tech Industries

Beginning in the 1950s, the economy of the Santa Clara Valley was quickly transformed from one based on agriculture to one dominated by the emerging high technology industry. As a result of this economic revolution, the Valley's vast orchards and remaining ranchlands were replaced by residential and commercial developments and major transportation corridors. Today, San José is part of the Silicon Valley, the largest and most concentrated center of computer-related industries in the world (City of San José 1994). As population in the San José area has grown, the need for flood protection and water supply has intensified, resulting in increasing impacts on area streams and rivers as well as local groundwater reserves, and necessitating increasingly proactive water management.

Environmental Setting

Location, Topography, and Soils

The City of San José is located in the northern Santa Clara Valley, southeast of San Francisco Bay (Figure 1–1). It is bounded on the northeast by the city of Milpitas, and on the west by the cities of Santa Clara, Cupertino, Campbell, and Saratoga. The City's Urban Service Area encompasses approximately 89,000 acres, of which the majority is flat terrain, although the eastern portion of the Urban Service Area includes the foothills of the spectacular Diablo Range. The Diablo Range defines the eastern flank of the Urban Service Area; its western and southwestern edges are defined by the Santa Teresa Hills and Santa Cruz Mountains. Elevations of creeks and rivers in the Urban Service Area range from near sea level at the mouths of Coyote Creek and the Guadalupe River to approximately 600 feet at the southeastern edge of the Urban Service Area. Approximate maximum elevations for the major creeks within the Urban Service Area are:

- Coyote Creek – 250 feet above sea level,
- Alamitos Creek – 320 feet above sea level,
- Upper Silver Creek – 480 feet above sea level,
- Thompson Creek – 500 feet above sea level, and
- Fowler Creek – 600 feet above sea level.

The soils of the Urban Service Area range from clay at lower elevations to loam and gravelly loam at mid-elevations (City of San José 1994). The Natural Resources Conservation Service (formerly the Soil Conservation Service) has recognized 20 soil associations within the greater Santa Clara Valley. Based on soil characteristics, including typical slope steepness, the soil associations of the Santa Clara Valley are organized into five groups, numbered I through V (Soil Conservation Service 1968).

Riparian areas in the Urban Service Area are underlain primarily by soils belonging to Groups I, II, and III. Group I soils are clay-rich and silty soils that occur along the edge of San Francisco Bay, and thus experience tidal inundation. Group III soils are distributed throughout the majority of the lower elevations of the valley. Group II soils generally occur in a transition zone between Group I soils and Group III soils, on fairly level topography, and are characteristically very deep and poorly drained. Soils occurring in riparian areas are described in greater detail in Table 3–1.

Land Use

Land use in the Urban Service Area affects the region's riparian corridors and is therefore important to consider in designing and implementing restoration projects. For example, if a watershed is largely dedicated to industrial uses, the potential for certain types of stormwater runoff may increase. Where residential development takes place adjacent to a riparian corridor, pet access must be minimized, in order to prevent disturbance and mortality of wildlife as a result of domestic cat and dog predation; "escaped" non-native ornamental plants must also be controlled. On the other

Table 3–1. Characteristics of Riparian Soil Associations within the San José Urban Service Area

Soil Group	Soil Association	Description	General Distribution in the Service Area	Typical Riparian Vegetation
I	Alviso	• very poorly drained under natural conditions • clays • developed in alluvium	tidal flats along the margins of San Francisco Bay	salt/brackish marsh
	Tidal Marsh	• very poorly drained • fine-grained soils • periodically experiences tidal inundation	tidal marshes	salt/brackish marsh
II	Clear Lake-Campbell	• somewhat poorly to poorly drained • clays and silty clay loams • developed in alluvium with sedimentary parent rock	low elevations on the alluvial plains, along Fisher Creek and Silver Creek	freshwater marsh and herbaceous riparian
	Sunnyvale-Castro-Clear Lake	• poorly drained • primarily clays and silty clays; locally includes small areas of clay loam • locally contains calcium carbonate • developed in alluvium, much of which has sedimentary parent rock	low elevations on the alluvial plains of the valley floor, from San José northwesterly to the tidal marsh areas of the Bay margin	freshwater marsh and herbaceous riparian
	Orestimba-Willows	• poorly drained • clays, clay loams and silty clay loams • developed in alluvium with sedimentary parent rock	low elevations on the alluvial plains of the San José Urban Service Area	freshwater marsh and herbaceous riparian
III	Yolo	• well drained • loams; locally includes silty clay loams • developed in alluvium with sedimentary parent rock	along the major drainages of the Urban Service Area.	herbaceous riparian and riparian woodland
	Zamora-Pleasanton	• well drained • medium- and fine-grained • developed in alluvium	on low-gradient alluvial fans along the eastern edge of the Urban Service Area; typical slopes are < 2% but near areas where streams are entrenched, slopes range up to 25%	herbaceous riparian and riparian woodland

Sources: Soil Conservation Service (1968), Replogle (pers. comm.)

hand, vacant lands adjacent to riparian corridors can be restored to support important upland habitat and expand the habitat corridor. The following sections provide a general description of existing land uses within the City's Urban Service Area, and descriptions of land uses along the Guadalupe River, Coyote Creek, and selected minor creeks. More detailed information on land uses within the Urban Service Area can be found in the San José General Plan 2020 (City of San José 1994).

Overview of Land Use in the City's Urban Service Area

The Urban Service Area encompasses approximately 89,000 acres. The City's predominant land use is residential: 59% of the City's land area is devoted to residential use. Commercial development currently occupies about 4% of the City's area, and industrial development another 9%; about 10% is preserved as public parks and open space. At the present time, some 17.5% of the City's land remains vacant or unused. The majority of this unused land is designated for some form of development in the future, with land uses allocated as follows:

- residential development - 42%,
- commercial use - 4%,
- industrial use - 29%, and
- non-urban uses, quasi-public lands (schools, libraries, fire stations, water treatment facilities, and airports), and other uses - 15% (City of San José 1994).

The northern portion of the City is primarily industrial but also has a large proportion of medium- to high-density residential development. Central San José is mainly occupied by medium-density residential development with a small amount of commercial and a moderate amount of industrial development. Central San José also contains the City's downtown area, Guadalupe River Park, and a small amount of private open space. In addition, both San José International Airport and San José State University are located in central San José. Southern San José consists chiefly of residential areas, with a small percentage of industrial and office development. A significant proportion of public open space is also located in this region.

The Urban Service Area is adjacent to both the South Almaden Valley Urban Reserve (SAVUR) and the Coyote Valley Urban Reserve (CVUR). SAVUR is currently in agricultural use but is slated for low-density residential development incorporating open space. At present, CVUR allows only agricultural and rural residential land uses; it is not required to accommodate growth, but will eventually be considered for residential, commercial, and mixed use development.

Guadalupe River

Land uses adjacent to the Guadalupe River change significantly from the river's mouth at Alviso Slough to its upstream limit in the Urban Service Area. Large tracts of public and private open-space land are situated along the shoreline of Alviso Slough. From the head of Alviso Slough south to Highway 237, the Guadalupe River is surrounded by a mixture of commercial, industrial and residential land uses in the old town of Alviso (see discussion under ***Mission Santa Clara*** above). From Highway 237 to Highway 101, land use around the river includes industrial and residential development along with a small amount of open space immediately adjacent to the river channel. (From the river's mouth to Highway 101, the west bank of the Guadalupe River is within Santa Clara city limits.) From Highway 101 upstream to Highway 880, land immediately west of the river is occupied by San José International Airport. This portion of the river's east bank is a mixture of industrial and commercial development and medium-density residential development. From Highway 880 upstream to Highway 280, the west bank of the river is dominated by a large area of open space in the airport approach zone. Additional public lands, including developed and planned future portions of the Guadalupe River Park, along with some industrial and commercial development, are also located in this area; the City's General Plan 2020 (City of San Jose 1994) designates a residential support zone for the core of this area, composed of high-density (>25 dwelling units per acre) residential use and/or mixed commercial and high-density residential development. The east bank of the river between Highway 880 and Highway 280 is dedicated to neighborhood/community commercial development along with a small amount of office and high-density residential use. This area also contains some quasi-public lands and a nearby transit-oriented development corridor that permits high-density residential and mixed uses. Between Highway 280 and Highway 85, the west bank of the river is almost entirely occupied by medium-density residential development, with a small amount of general commercial development. This segment of the east bank is similar, with a mix of medium-high to high-density residential development and commercial development. The southernmost portion of the river within the Urban Service Area, from Highway 85 upstream to SAVUR, is primarily low-density residential development, with a large amount of open space (most of which is occupied by Almaden Lake Park) adjacent to the river. A small amount of medium-density residential development is located in the immediate area. In addition, a large area of designated Non-Urban Hillside occurs near the river.

Coyote Creek

Land adjacent to the segment of Coyote Creek contained in the Urban Service area is zoned for a variety of uses, and includes a number of open space preserves of varying size. North of Highway 237, Coyote Creek traverses a large expanse of public and quasi-public lands. Between Highway 237 and Highway 101, Coyote Creek is surrounded by industrial land uses, with almost half of the area bordering the creek's west side supporting heavy industrial uses. East of the creek, a small amount of high-density residential development, a large area of open space, and some commercial use are also present. Both North Coyote Park and the immediately adjacent San José Municipal Golf Course are located along this segment of the creek. From Highway 101 to Highway 280, the creek is surrounded primarily by medium- to medium-high density residential development, with some general commercial development, and some land designated for open space use. Open space areas along this segment of the creek include Watson Park, William Street Park, and Roosevelt Park. This segment of the creek also intersects a transit-oriented development corridor that will allow high-density residential and mixed uses. From Highway 280 upstream to the edge of the City's Urban Service Area, the creek is enclosed by the Coyote Creek Park Chain. Much, but not all, of this planned park chain is in public ownership, and significant portions have been developed for park purposes.

Minor Creeks

Several tributaries to Coyote Creek create a network of small creeks throughout the eastern portion of the Urban Service Area (Figure 1-1). The northernmost tributary of Coyote Creek within the Urban Service Area is Upper Penitencia Creek; Penitencia Creek County Park is surrounded by a large area of open space. The next major tributary to the south is Lower Silver Creek, which flows from Lake Cunningham, adjacent to Reid Hillview Airport. The southernmost main tributary is Upper Silver Creek, which runs adjacent to the Silver Creek Planned Residential Community. Except for the open spaces already discussed, land use surrounding these creeks is principally medium-density residential. This area also supports a mixture of public and private open space, public and quasi-public lands, low-density residential development, designated Urban and Non-Urban Hillside, commercial development, and industrial parks.

The western portion of San José is dissected by tributaries flowing into the Guadalupe River (Figure 1–1). The Guadalupe River is created by the confluence of Guadalupe Creek and Alamitos Creek north of the Santa Teresa Hills. The tributaries of Alamitos Creek flow through a medium-low-density residential area, and Guadalupe Creek is adjacent to this residential area. The northernmost tributary of the Guadalupe River is Los Gatos Creek. Community land uses adjacent to the creek are primarily low- and medium-density residential, and include some commercial, mixed use, and industrial/commercial use, as well as public and quasi-public lands.

Hydrology

The hydrology of the Urban Service Area is strongly influenced by the region's Mediterranean climate, which is characterized by cool, wet winters and hot, dry summers. Almost all precipitation occurs in the winter and spring (November through April), and local rainfall varies significantly as a result of topography. Average annual precipitation ranges from to 13–14 inches in downtown San José to 40–60 inches in the nearby Santa Cruz Mountains (Santa Clara County 1994b).

Watersheds, or drainage basins, are basic geographic units of hydrologic analysis. A watershed is a basin encompassing the area that drains into a single major river or stream. Watersheds are important units of study for riparian restoration because activities anywhere within a watershed can affect the success or failure of a site-specific restoration project. For example, the flood frequency of a river is determined, in part, by watershed size, by characteristics of the watershed such as soil types and amount of impervious cover, and by rainfall patterns within the watershed. Other characteristics of a riparian corridor such as water quality are also strongly influenced by watershed factors.

The San José Urban Service Area is located within the Santa Clara hydrologic basin, which contains 13 watersheds (RRM Design Group and Habitat Restoration Group 1999). The Urban Service Area contains portions of four Santa Clara Basin watersheds: the Coyote Creek, Guadalupe River, San Tomas Aquinas/Saratoga Creek, and Calabazas Creek watersheds (Table 3–2) (Figure 1–1).

Table 3–2. Watersheds in the City of San José Urban Service Area

Watershed	Total Area of Watershed (acres)	Area of Watershed within San José Urban Service Area (acres)	Percentage of Watershed within Urban Service Area
Coyote Creek	206,080	43,846	21%
Guadalupe River	108,800	39,248	36%
San Tomas Aquinas/Saratoga Creek	24,960	1,849	7%
Calabazas Creek	14,080	899	6%

Sources: RRM Design Group and Habitat Restoration Group (1999); Santa Clara Valley Water District (1997); Jones & Stokes (1999).

Coyote Creek Watershed

The Coyote Creek watershed is the largest in the Santa Clara Basin, draining an area of approximately 322 square miles (RRM Design Group and Habitat Restoration Group 1999). Coyote Creek originates in the Diablo Range east of San José, where its headwaters are situated in rugged terrain at an elevation of approximately 3,000 feet above sea level. Coyote Creek flows north along the eastern side of the Basin, draining most of the western slope of the Diablo Range, and eventually emptying into Mud Slough and San Francisco Bay. Major tributaries to Coyote Creek in the Urban Service Area include Fisher, Upper Silver, Lower Silver, and Upper Penitencia Creeks.

Guadalupe River Watershed

The Guadalupe River watershed is the second largest in the Santa Clara Basin and drains an area of approximately 170 square miles (Santa Clara Valley Water District 1997). Tributaries of the Guadalupe River originate in the Santa Cruz Mountains west and south of San José. The river receives surface runoff from western and southern portions of Santa Clara County, and flows north into San Francisco Bay. Major tributaries of the Guadalupe River within the Urban Service Area include Guadalupe, Alamitos, Los Gatos, Ross, and Canoas Creeks.

San Tomas Aquinas/Saratoga Creek Watershed

The San Tomas Aquinas/Saratoga Creek watershed drains an area of approximately 39 square miles. This system carries surface runoff from the foothills of the Santa Cruz Mountains northward into Guadalupe Slough, which in turn empties into San Francisco Bay. The Urban Service Area contains 7 % of the San Tomas Aquinas/Saratoga Creek watershed and includes only 5 miles of San Tomas Aquinas Creek and 2 miles of Saratoga Creek.

Calabazas Watershed

The Calabazas Watershed covers an area of approximately 22 square miles, draining northward from the foothills of the Santa Cruz Mountains. Like the San Tomas Aquinas/Saratoga Creek system, Calabazas Creek discharges into Guadalupe Slough. The Urban Service Area includes 6 % of the Calabazas watershed and only 2 miles of Calabazas Creek.

Water Supply

The City and its Urban Service Area derive water for domestic, agricultural, and industrial use from a combination of surface and groundwater sources. The watersheds that supply the Urban Service Area contain several important lakes and reservoirs, which were constructed primarily for water conservation and storage, but also have flood protection benefits. Lake and reservoir outflow is managed seasonally, to prevent flood damage and to permit aquifer recharge. The Urban Service Area contains both on-stream groundwater recharge sites—located along stream reaches with naturally permeable substrates—and off-channel groundwater percolation ponds. Off-channel ponds receive diverted streamflow via pipelines or canals (RRM Design Group and Habitat Restoration Group 1999). Flow in streams of the Urban Service Area is thus subject to significant regulation, and restoration projects on area streams must take this into account.

The Coyote Creek watershed contains two major reservoirs: Anderson Reservoir on Coyote Creek, and Coyote Reservoir, located upstream from Anderson Reservoir (Figure 1-1); both are important sources of water for City residents, although they are outside the Urban Service Area boundary. Water released from Coyote Reservoir flows into Anderson Reservoir. Water released from Anderson Reservoir is diverted after a short distance into a series of percolation ponds along Coyote and Penitencia creeks, within the Urban Service Area. These ponds were constructed to promote recharge of the Santa Clara Groundwater Sub-Basin. During drier years, the reach of Coyote Creek immediately downstream from the percolation pond diversion often runs dry; farther downstream, the stream becomes effluent (fed by groundwater), and runs in all but the driest years (RRM Design Group and Habitat Restoration Group 1999).

The Guadalupe River watershed contains six major reservoirs: Calero Reservoir on Calero Creek (Arroyo Calero), Guadalupe Reservoir on Guadalupe Creek, Almaden Reservoir on Alamitos Creek, Vasona and Lexington reservoirs on Los Gatos Creek, and Lake Elsman on Los Gatos Creek (Figure 1-1). All are located outside the boundary of the Urban Service Area. In addition, both on-stream recharge sites and off-channel percolation ponds are located on Los Gatos Creek, Guadalupe Creek, and Alamitos Creek, serving to recharge the Santa Clara Groundwater Sub-Basin (RRM Design Group and Habitat Restoration Group and Habitat Restoration Group 1999).

Flooding and Flood Protection

Rivers, streams, and creeks within the Urban Service Area convey storm runoff from the Diablo Range and the Santa Cruz Mountains to San Francisco Bay. Storm runoff from the urbanized areas of the City enters local storm drain systems. These in turn discharge into creeks. Local creeks convey runoff to the north for discharge into the Bay.

In general, the existing stormwater drainage system adequately conveys normal storm runoff through the City. However, even during years when rainfall is normal, localized flooding can occur when catch basins or storm drains become clogged with debris, when high water levels in the creeks prevent storm drains from discharging, or during peak events when the drainage system does not have sufficient capacity to accommodate runoff. Waterways prone to flooding include portions of Berryessa Creek, Sierra Creek, Canoas Creek, Ross Creek, Coyote Creek, Upper Penitencia Creek, Lower Silver Creek, Fisher Creek, and the Guadalupe River. The Flood Insurance Rate Maps prepared by the Federal Emergency Management Agency for the San José area indicate that during a 100-year event (the magnitude of flood expected to occur an average of once every 100 years), sections of San José would be subject to flooding from creek overbanking or inundation from the Bay. Sections that are subject to shallow inundation (0–2 feet) during a 100-year event include central San José near the Guadalupe River, Upper Penitencia Creek, Lower Silver Creek, and the area near Williams Street Park along Coyote Creek.

Historically, the Guadalupe River has been particularly prone to flooding. The river flooded San José in the winters of 1982, 1983, 1986, and 1995 (Santa Clara Valley Water District 1997). During a storm on March 10, 1995, the Guadalupe River had a peak discharge downstream of its confluence with Los Gatos Creek of 10,500 cubic feet per second (cfs). The Santa Clara Valley Water District (the District) and the U. S. Army Corps of Engineers have recently proposed flood protection improvements along the Guadalupe River designed to accommodate a peak floodflow of as much as 17,000–20,000 cfs (the volume expected in the 100-year flood) where the river intersects Highway 101.

Water Quality

Water pollution reaches riparian corridors by two primary paths, from point sources and non-point sources. Point sources of pollution include stationary and defined sources such as fuel storage tanks, drains from industrial facilities (not storm drains), and discharges from sewage treatment plants. Non-point source pollution occurs primarily during winter storms, when stormwater enters riparian corridors as runoff from streets, highways, construction sites, exposed soil, roofs, and parking lots.

Non-point source pollution is a major threat to water quality in urban riparian corridors. Major pollutants found in stormwater runoff include:

- oil and grease;
- metals from automotive brake linings and other sources;
- pesticides, herbicides, and fertilizers from landscaped and agricultural areas;
- sediment from urban landscaping, hillsides, and construction areas;
- biological contaminants from plant litter and animal wastes; and
- smog and other air pollution deposited on the ground and then washed into streams.

Some of these compounds may enter the food chain, where they are hazardous to wildlife. Other compounds such as grease and oil may, in addition to posing a direct hazard to wildlife, alter the physical characteristics of the water itself (e.g., turbidity, temperature) and thus indirectly affect both aquatic and terrestrial wildlife.

Pollutants supplied to streams that drain into San Francisco Bay are ultimately delivered to the Bay. Because of its large capacity and its location in a dense urban area, the Guadalupe River contributes more pollutants to San Francisco Bay than any other stream in the Urban Service Area (Santa Clara Valley Water District 1991). Table 3–3 shows the average annual wet-weather loads of heavy metals for the four watersheds within the Urban Service Area. The contribution of the Urban Service Area to these values is unknown.

Table 3–3. Average Annual Wet-Weather Loads (lbs/year) of Heavy Metals Within the Four Watersheds in the Service Area

Watershed	Cd*	Cr*	Cu*	Pb*	Ni*	Zn*
Calabazas Creek	32	592	1,072	1,068	1,377	2,828
San Tomas Aquinas/ Saratoga Creek	79	1,292	1,864	2,074	2,799	8,132
Guadalupe River	155	2,583	3,999	4,375	5,683	15,913
Coyote Creek	76	1,252	1,767	1,974	2,701	7,914

*Cd = Cadmium; Cr = Chromium; Cu = Copper; Pb = Lead; Ni = Nickel; Zn = Zinc.

Source: Santa Clara Valley Water District (1991).

Trash is a common feature in the urban streams in the Urban Service Area, and represents a third source of water pollution. Large persistent trash includes shopping carts and automobile parts such as tires, filters, and mufflers (Figure 3–1). Smaller trash commonly includes plastic bags, bottles, aluminum cans, styrofoam, and clothing. All of this trash is unsightly; some of it degrades water quality. For example, automobile parts can leak oil and grease, while shopping carts and steel cans can rust. The extent to which trash contributes to the degradation of water quality in urban streams is unknown.

Vegetation and Wildlife

Four major habitat types have been identified within the riparian corridors of the City's Urban Service Area: riparian woodland and forest, riparian scrub, seasonal freshwater wetland, and perennial freshwater wetland. The major functions and values of these habitats, including characteristic vegetation and wildlife, are described below. Table 3–4 gives an overview of typical vegetation and wildlife of the Urban Service Area's riparian corridors. Appendix B provides a detailed list of common and scientific names for native and non-native species of plants, fish, and wildlife associated with riparian habitats in the Urban Service Area. Figure 3–2 is a conceptual diagram illustrating riparian vegetation in relation to an idealized creek channel.

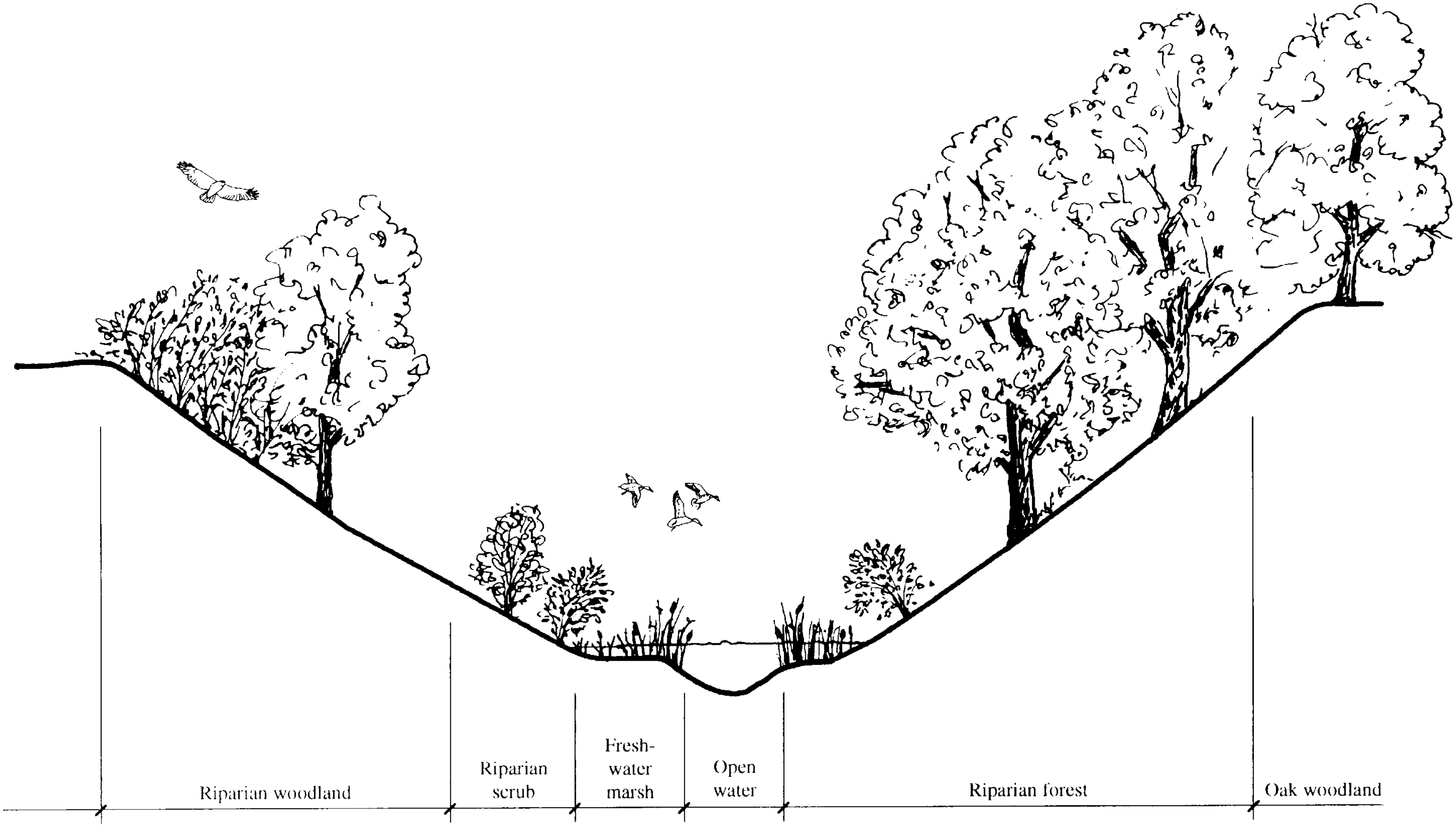
Riparian Woodland and Forest

Habitats where trees are common may be referred to as either woodland or forest. Where trees are dense and form a continuous or nearly continuous canopy, the habitat is referred to as a forest. Where trees are sparse and the canopy is broken by large gaps, the habitat is called a woodland. The density of the tree canopy may be related to environmental factors such as depth to the water table or frequency of flooding, or to other factors such as past clearing or disease. In most cases, tree density probably reflects a combination of several environmental and land use factors. Riparian woodland and forest habitats in the Urban Service Area are dominated by cottonwood, willow, oak, and California sycamore.

In wetter portions of the Urban Service Area, cottonwood and willow occur together, forming cottonwood-willow riparian woodland or forest. Cottonwood-willow riparian woodland and forest occur at low elevations along the valley floor, typically where the water table is high and/or there is year-round flow of surface water. Frequent winter floodflows produce areas of scour and fresh sedimentation within stream channels. This dynamic hydrologic regime contributes to the habitat's geomorphic diversity and to its high wildlife value. For example, cottonwoods depend on periodic flooding to create habitat for successful seedling establishment and growth.

In drier riparian areas, oak and California sycamore tend to occur together, to the exclusion of willow and cottonwood. The oak-sycamore riparian woodland or forest is generally associated with upland areas; it is found along Coyote Creek above Metcalf Road, and along upland creeks such as the tributaries of Coyote Creek and the Guadalupe River (e.g., City of San José 1992). Where hillside open space adjoins the riparian corridor, the oak-sycamore riparian woodland or forest often intergrades with adjacent coast live oak woodland, thus increasing its wildlife habitat value. Oak and sycamore are tolerant of some flooding, but floods are typically less frequent in oak-sycamore riparian woodland and forest than where cottonwood-willow riparian woodland or forest is found.

Figure 3-1
Trash in Los Gatos Creek



Note: Drawing is conceptual and is not intended for construction use.

No scale

Jones & Stokes

Figure 3-2
Example of Riparian Vegetation

Vegetation. Vegetation within the cottonwood-willow riparian forest is predominantly composed of deciduous species. Species associated with cottonwood-willow riparian forest include Fremont cottonwood, arroyo willow, yellow willow, red willow, box elder, California sycamore, blue elderberry, and coast live oak, as well as big leaf maple, white alder, and valley oak. Shrubs include California blackberry, snowberry, toyon, and California wild rose.

Oak-sycamore riparian woodland and forest is characterized by an overstory including both evergreen and deciduous tree species, including California sycamore, coast live oak, valley oak, and blue oak. Associated species include California buckeye, red willow, blue elderberry, and California bay. The understory varies from areas with dense concentrations of shrubs such as California blackberry, coyote brush, and California wild rose, to relatively open areas dominated by grasses and other herbaceous plants.

Non-native trees that have escaped from nearby cultivation or have been deliberately planted as part of past restoration projects occur along many of the Urban Service Area's riparian corridors. As part of its revegetation projects in the 1970s and early 1980s, the District planted non-riparian or non-native trees[1] such as knobcone pine, red horsechestnut, Bailey acacia, Sydney golden wattle, coast redwood, Aleppo pine, and holly oak (Goldner 1984). Similar designs were used for shrub species in the understory. Non-riparian or non-native shrubs used in revegetation included bearberry, English lavender, glossy privet, Italian buckthorn, and Japanese barberry. Many of these trees and shrubs persist in the riparian corridor, and some have likely spread beyond their original planting locations.

Wildlife. Cottonwood-willow riparian forest supports an unusually high diversity and abundance of bird species, because of a combination of factors including proximity to water, abundance of insects, presence of tall vegetation, high structural diversity of vegetation, and location along the Pacific flyway. Bird diversity is particularly high during spring and summer, when deciduous trees and shrubs are used by neotropical migrant birds for nesting and foraging. For example, the Santa Clara Valley Audubon Society recorded 143 different species of birds on Coyote Creek during a single day in 1996 (Breon pers. comm.). Mature large trees provide numerous cavities for cavity-dependent wildlife such as woodpeckers. Tall trees are used by nesting raptors, and streambanks provide nesting and foraging habitat for fishing birds like the belted kingfisher and osprey.

Riparian vegetation in areas of cottonwood-willow woodland and forest also contributes to the quality of instream habitats. Trees overhanging creeks drop leaves in the stream. This leaf litter is a critical food source for shredding aquatic insects; it also provides a substrate for algal growth, and cover for juvenile fish and insects. Vegetation rooted at the water's edge provides escape cover, shade, and food for fish. This is especially critical along intermittent streams where remnant summer pools provide refugia for fish. Coyote Creek, Los Gatos Creek, Upper Penitencia Creek, and the Guadalupe River all provide warmwater habitat for native fish such as hitch, California roach, and

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[1]Non-riparian species include species native to the San Francisco Bay Area or to California but not found naturally in riparian corridors. Non-native species are not native to California.

threespine stickleback. These stream systems are also potential habitat for chinook salmon and steelhead trout (Figure 3–3).

Oak-sycamore riparian forest also exhibits rich habitat values. Mature trees provide cavities and snags, which are important for cavity-nesting species. Oak trees also produce acorns, an important seasonal food for wildlife. As in cottonwood-willow woodland and forest, vegetation that overhangs the stream channel is an important feature for fish in areas of oak-sycamore woodland and forest. In particular, the presence of evergreen trees (oaks) provides some year-round escape cover and shade. Logs, tree roots, pools, and riffles provide habitat for fish, including steelhead trout populations in portions of Upper Penitencia, Guadalupe, Alamitos, and Calero Creeks.

Riparian Scrub

Riparian scrub is found in drier sites which do not support trees. Riparian scrub may also be a temporary community that exists until trees such as cottonwood or willow grow over them; as the trees mature, the shrubs are either "shaded out" or become part of the understory of the riparian forest or woodland. Throughout the Urban Service Area, riparian scrub communities occur intermixed with riparian woodland or forest and with herbaceous communities such as perennial freshwater wetland.

Vegetation. Riparian scrub is dominated by woody riparian species such as mule fat, coyote brush, red willow, arroyo willow, poison oak, California blackberry, and Himalayan blackberry.

Wildlife. Riparian scrub provides important habitat for burrowing mammals such as ground squirrels and rabbits as well as nesting and foraging habitat for birds such as ruby-crowned kinglets and Hutton's vireos.

Seasonal Freshwater Wetland

Seasonal freshwater wetland communities occur primarily along intermittent streams in the upper portions of the basin. In many places, the structure of vegetation communities reflects the long-term influence of land use practices such as livestock grazing, which have led to the reduction or elimination of woody plants.

Vegetation. Seasonal freshwater wetland communities typically consist of hydrophytic (water-loving) species that grow within the creek channel. The flora is composed of both native and non-native grasses and herbs, including rushes, watercress, water speedwell, and smartweeds.

Wildlife. Seasonal freshwater wetland vegetation provides cover for amphibians, and the formation of seasonal ponds provides breeding habitat for amphibian species. Ponded areas also provide important water sources for other wildlife and may provide foraging habitat for some waterbirds. Seasonal freshwater wetland areas generally do not provide fisheries habitat.

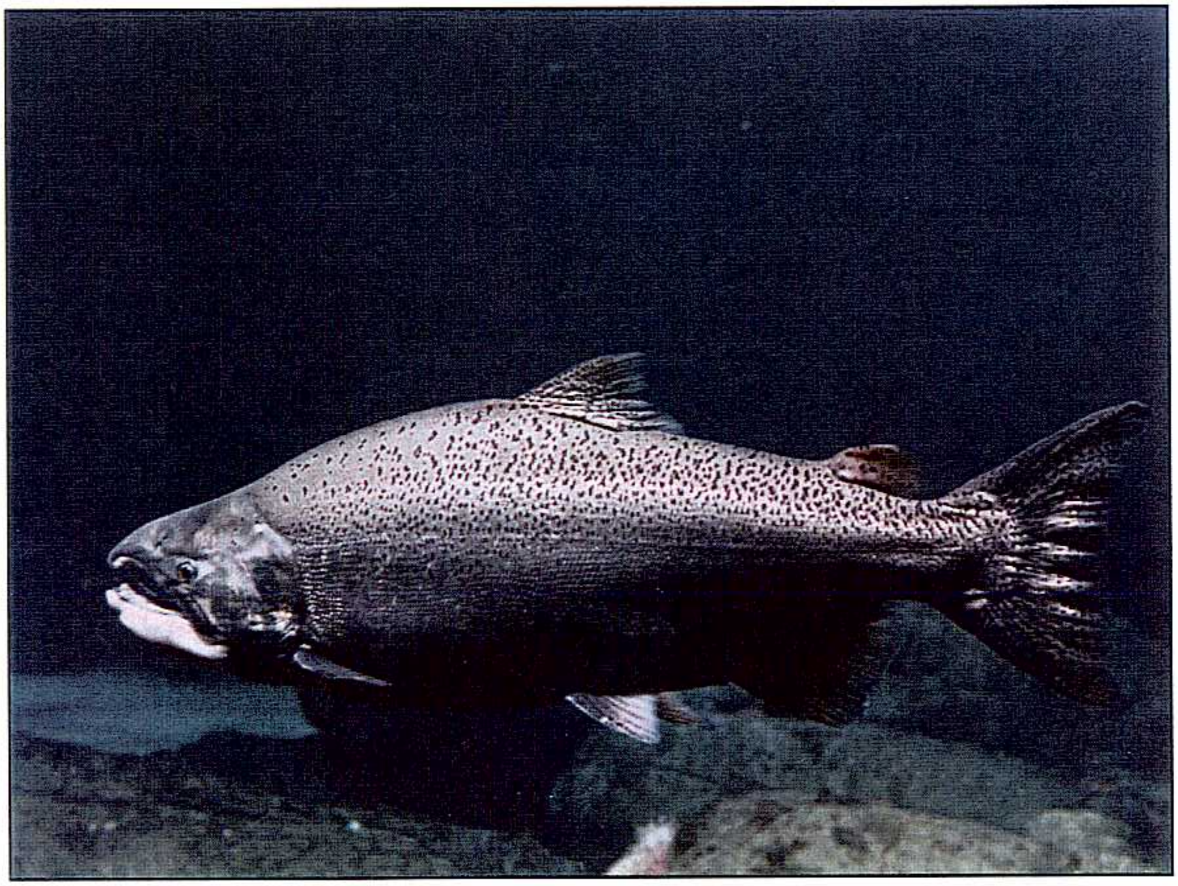


Figure 3-3
Chinook Salmon

San Tomas Aquinas Creek, view to north from Hamilton Avenue.

Ross Creek, view to west at Meridian Avenue.

Figure 3-6
Mixed Hardscape Channel

Perennial Freshwater Wetland

Perennial freshwater wetland occurs along creeks in the Urban Service Area, often as an understory in close association with riparian woodland vegetation. Perennial freshwater wetland is also common in the bottom of channels where natural hydrology has been modified by channel widening or artificial control. Perennial freshwater wetland is present in most of the creeks in the study area, although its extent fluctuates in relation to water availability and intensity of winter flooding.

Vegetation. Perennial freshwater wetland vegetation consists of emergent herbs and hydrophytic herbs and grasses. Typical dominant species include rabbitsfoot grass, nutsedge, willow weed, and watercress. Common associated species are yellow water-primrose and broadleaf cattail.

Wildlife. Perennial freshwater wetland provides foraging habitat for herons, ducks, grebes, and shorebirds. Waterbirds nest in large areas of perennial freshwater wetland vegetation. This dense vegetation also provides breeding sites and cover for pond turtles, frogs, and newts.

Perennial freshwater wetland vegetation provides some cover and shade for fish within the streamchannel. Areas with large expanses of perennial freshwater wetland, such as the lower Guadalupe River, support warmwater fisheries. However, the lack of woody overstory in marsh areas results in warm summer water temperatures that make these streams unsuitable for year-round trout habitat.

Table 3-4. Vegetation and Wildlife of the Urban Service Area's Riparian Corridors

Habitat Type	Vegetation	Wildlife
Riparian Woodland and Forest	Fremont cottonwood California sycamore arroyo willow red willow box elder coast live oak valley oak California buckeye	Wilson's warbler warbling vireo winter wren osprey raccoon Western gray squirrel Virginia opossum Townsend's big-eared bat California slender salamander Western skink
Riparian Scrub	mule fat coyote brush red willow arroyo willow	California ground squirrel brush rabbit ruby-crowned kinglet Hutton's vireo
Seasonal Freshwater Wetland	rushes watercress smartweeds	Western terrestrial garter snake Western aquatic garter snake Western pond turtle

Table 3-4, continued.

Perennial Freshwater Wetland	rabbitsfoot grass nutsedge willow weed watercress yellow water-primrose broadleaf cattail	Pacific tree frog California newt Western terrestrial garter snake Western aquatic garter snake Western pond turtle

Non-Native Plant Species

As a result of human activities, a variety of invasive non-native and ornamental plant species have become established in the Urban Service Area's riparian corridors. Invasive non-native plants compete successfully with native plant species for limited water, nutrients, light, and space. This tends to decrease the overall species diversity and, as a result, the habitat quality of affected riparian areas. Problematic invasive plant species commonly found in riparian habitats include giant reed, poison hemlock, white sweet clover, periwinkle, and Himalayan blackberry.

Ornamental plant species include plants that were intentionally planted or have naturalized within and/or immediately adjacent to the riparian corridor; these include both species native to parts of California outside the Urban Service Area, and non-native species. In general, ornamental species do not pose a substantial threat to native habitats because they do not survive without year-round watering and fertilization. However, some ornamental species such as tree-of-heaven and English ivy can spread and displace native vegetation. Ornamental plant species commonly found in riparian habitats include eucalyptus, redwood (native to the Sierra Nevada region and to parts of northern California including the Santa Cruz Mountains, but not to the Urban Service Area), *Myoporum*, elm, black locust, tree-of-heaven, English ivy, and California pepper. Remnant fruit and nut trees, such as almond and English walnut, are also commonly found in the Urban Service Area's riparian corridors.

Special-Status Plant and Wildlife Species

In addition to supporting vegetation and wildlife communities with a high degree of biological diversity, riparian corridors also contain particular special-status plant and animal species. The term *special-status species* is used to refer to species which are

- federally listed as endangered or threatened,
- state-listed as endangered or threatened, or
- state-listed as a "species of concern."

The presence of one or more such species in a local riparian environment offers a unique opportunity to maintain and enhance habitat for the species. If a species is absent from an environment where it should be found, there may be opportunities to restore its habitat to allow natural colonization or deliberate reintroduction from other populations nearby.

Six species of plants and 21 fish and wildlife species that either occur or may occur in the Urban Service Area have been afforded special status by federal, state, and local agencies and organizations. Tables 3–5 and 3–6 describe these species and some of the restoration strategies that could improve their habitats. Relatively few special-status plants are listed in Table 3–5 because riparian corridors in California typically do not harbor many rare plants (Skinner and Pavlik 1994). This is probably because substrates along riparian corridors throughout the state are similar, and because riparian corridors statewide experience a high frequency of disturbance. In addition, the long, linear shape of riparian corridors allows species within them to disperse across long distances, limiting the formation of isolated, unique species.

Riparian Corridor Conditions

Historic Conditions

In order to restore any habitat, a target condition must be established. The success of the restoration can be evaluated based on how well the target is achieved. In most restoration projects, the habitat condition prior to human disturbance provides the target condition. In remote areas, the the habitat condition prior to European settlement might provide an appropriate target condition. The undisturbed condition can be measured if there are examples of the target habitat near the restoration site where environmental conditions approximate those of the restoration site.

In areas with extensive development and a history of ongoing disturbance, determining the target condition for restoration can be difficult. In such situations, it is usually no longer possible to recreate the undisturbed habitat condition because disturbances of many kinds continue to operate. However, even in extensively disturbed areas, it is still important to understand the historic, undisturbed habitat condition in order to restore as many functions and values of the original habitat as possible.

Key Functions and Values of Undisturbed Riparian Corridors

Undisturbed riparian corridors provide numerous functions and values for plants, wildlife, the surrounding environment, and humans. Some of the primary functions and values are listed below:

Plant Habitat:

- habitat for native plants, and
- resistance to invasion by exotic plants.

Wildlife Habitat:

- habitat for a diverse assemblage of aquatic invertebrates;
- warmwater fish habitat;
- coldwater fish passage and spawning and rearing habitat;
- foraging, roosting, and nesting opportunities for waterbirds, neotropical migrant birds, raptors, and other resident terrestrial birds;
- burrowing sites for fossorial birds and mammals;
- wildlife foraging and cover habitat; and
- wildlife corridor for mammal dispersal.

Water Quality:

- reduced erosion and water turbidity, and
- pollutant filtering.

How do riparian corridors provide these functions and values in the Urban Service Area? Unfortunately, we do not know the exact composition and extent of riparian corridors in San José prior to land clearing in the Santa Clara Basin. However, the historic condition of riparian corridors can be inferred from a variety of sources, including:

- the physical features, vegetation composition, and wildlife communities in unmodified channels in the San José area;
- the physical features, vegetation composition, and wildlife communities in undisturbed riparian corridors upstream from San José;
- the physical features, vegetation composition, and wildlife communities in undisturbed riparian corridors in low-elevation floodplains elsewhere in coastal northern California;
- historic maps and old aerial photos showing the physical features of the Santa Clara Basin; and
- written accounts of the area by early explorers or naturalists.

A thorough discussion of possible historic conditions in the riparian corridors of the Santa Clara Valley would require a technical analysis of functioning corridors, which is beyond the scope of this plan. Below is a brief summary of the probable historic condition of selected characteristics of riparian corridors in the Santa Clara Basin for which information is readily available. The

Table 3-5. Special-Status Plant Species Known to Occur or With the Potential to Occur in the San José Urban Service Area

Species	Federal/State/ CNPS Status [a]	Distribution and Known Occurrences in RRAP Area (if any)	Habitat	Restoration Opportunities
Mt. Hamilton thistle *Cirsium fontinale* var. *campylon*	E/–/1B	Northern California (Alameda, Santa Clara, and Stanislaus counties). Has been observed along tributaries of Silver and Santa Teresa creeks and along the hillsides east of Coyote Creek, including a drainage in Hellyer Canyon. Also occurs in the Santa Teresa Hills, the Metcalf Canyon area, and in Anderson Lake and Burnett Avenue County Parks.	Seeps and springs occurring in serpentine-derived soils. Chaparral, cismontane woodlands, and valley foothills and grasslands.	Establishment of buffer zones is recommended. Exclusion of livestock and recreation from habitat would prevent trampling; control of non-native plants in upland habitat adjacent to riparian corridor may reduce competition and enhance populations of this species.
Western leatherwood *Dirca occidentalis*	–/–/1B	Northern California (Alameda, Contra Costa, Marin, Santa Clara, San Mateo, and Sonoma counties). Occurs in the foothills of the Santa Cruz Mountains.	Broadleaved upland forests, closed-cone conifer forests, chaparral, cismontane woodlands, riparian forests, and mesic riparian woodlands.	This shrub could be planted at higher elevations in the San José area; bank stabilization and control of exotic species would enhance habitat.
Mexican mosquito fern *Azolla mexicana*	–/–/4	Arizona, Nevada, Oregon, California, Baja California including Isla Guadalupe.	Ponds, slow-moving streams, wet ditches, marshes, and swamps.	Creation of ponds and slow-moving streams may enhance habitat.

[a] **Status explanations:**

Federal
SC = species of concern (term has no official status but refers to an entire realm of taxa whose conservation status may be of concern).
E = endangered species.
– = no status definition.

State
– = no status definition.

California Native Plant Society
1B = List 1B species: rare, threatened, or endangered in California and elsewhere.
2 = List 2 species: rare, threatened, or endangered in California but more common elsewhere.
3 = List 3 species: plants about which more information is needed ("review list").
4 = List 4 species: plants of limited distribution ("watch list").

Sources: Skinner and Pavlik (1994), California Natural Diversity Database (1999), RRM Design Group and Habitat Restoration Group (1999), Corelli and Chandik (1995).

Table 3–6. Special-Status Wildlife Species Known to Occur or with the Potential to Occur in the Riparian Corridors of the San José Urban Service Area

Species	Federal/ State Status[a]	Distribution and Potential for Occurrence in Service Area	Habitat	Restoration Opportunities
Ricksecker's water scavenger beetle *Hydrochara rickseckeri*	SC/–	Known from a few widely scattered localities in parts of the San Francisco Bay area, including Livermore Valley, the East Bay, and San Mateo County. Creeks in San José area may provide suitable habitat.	Quiet waters of stagnant ponds, littoral areas of lakes, and shallow margins of streams supporting an abundance of aquatic vegetation.	Additional freshwater marsh vegetation could provide suitable habitat and may attract species to site; adding instream features to create ponds (e.g., logs, weirs, boulders) could create suitable habitat.
Steelhead and rainbow trout (central CA coast) *Oncorhynchus mykiss*	T/–	Occurs along the Pacific coast from Alaska to Baja California, and in interior rivers in British Columbia, Alberta, and California. Originally found in most major streams in California; water diversion and impoundments have substantially reduced both the range and numbers of this species in California. The federal government has listed the species as threatened on the central coast of California, and in all coastal basins from the Russian River (Sonoma County) south to Soquel Creek (Santa Cruz County), including San Francisco and San Pablo bays. Despite widespread distribution, local populations do not mix with those to the north or south. Resident form (hatchery stock) is widely introduced as a game fish throughout the world. Found in Guadalupe River, Los Gatos Creek, and Coyote Creek; may be present in San Tomas Aquinas and Saratoga Creeks.	Rainbow trout are resident in freshwater streams with adequate flow, cool temperatures (< 61° F), well oxygenated water, and good water quality. Steelhead trout spend their adult lives in salt water and migrate to freshwater streams to breed. Steelhead require similar freshwater conditions to those for rainbow trout, and also require streams without barriers to prevent migration to and from the sea.	Many restoration strategies would improve habitat for rainbow and steelhead trout, including: • reducing water temperature (e.g., by planting overhead tree cover); • removing barriers to fish passage; • augmenting stream gravels; • augmenting streaflow; • planting emergent aquatic vegetation to provide cover; • creating pools (e.g., by using logs and weirs) to provide resting places for trout; and • removing damaging non-native species such smallmouth bass and sunfishes (which may compete with adults and eat juveniles).

Species	Federal/ State Status[a]	Distribution and Potential for Occurrence in Service Area	Habitat	Restoration Opportunities
Fall-run chinook salmon[1] *Oncorhynchus tshawytscha*	–/CSC	Found along Pacific coast from Alaska to the Ventura River (southern California) and along the coast in northeast Asia. Widely stocked as a game fish throughout the world A small population occurs in the Guadalupe River, Los Gatos Creek, and Coyote Creek.	Cold freshwater streams with suitable gravel beds for spawning	Many of the same factors that would improve habitat for rainbow and steelhead trout would also improve habitat for chinook salmon.
Pacific lamprey *Lampetra tridentata*	SC/–	Found in most of the coastal streams and creeks of California. Occurs in Guadalupe River, Guadalupe Creek, Alamitos Creek, and Los Gatos Creek, and in Coyote Creek and its tributaries.	Rivers and tributaries with fine gravel beds.	Gravel augmentation could increase suitable habitat for this species in creeks where it already occurs. Flow augmentation during low flow sumer period. Barrier removal.
California tiger salamander *Ambystoma californiense*	C/CSC	Central Valley, including the foothills of the Sierra Nevada up to approximately 1,000 feet; coastal regions from Butte County south to Santa Barbara County. Aquatic and upland habitat in the foothills of the San José area may support this species. Historically occurred in Guadalupe Creek, in Coyote Creek and its tributaries, and at Calero Reservoir.	Valley floor and foothill grasslands, open oak woodland. During breeding (November–January rainy season): quiet water of ponds, reservoirs, lakes, temporary rain pools, and, occasionally, streams, within a ½ -mile radius of burrow. During summer dormancy: rodent burrows, rock crevices, or fallen logs.	Restoration of species' riparian habitat will be possible only if suitable upland habitat is present adjacent to the site, and only if it is connected to large open space for juvenile dispersal.

[1]The chinook salmon in the Guadalupe River and Coyote Creek systems are of unknown origin. Chinook populations may have established themselves from hatchery migrants. Genetic analysis strongly suggests Central Valley hatchery origin..

Species	Federal/ State Status[a]	Distribution and Potential for Occurrence in Service Area	Habitat	Restoration Opportunities
California red-legged frog *Rana aurora draytonii*	T/CSC	West of the Sierra Nevada-Cascade Range crest, and in the Coast Ranges along the entire length of the state. Occurs in Silver Creek, Penitencia Creek, San Tomas Aquinas Creek, Guadalupe Creek, Los Gatos Creek, Calaveras Reservoir, and Calero Reservoir.	In quiet pools along streams, especially those with small drainage areas and low gradient; in marshes and ponds. Favors intermittent streams that include areas with water at least 2 feet deep, have emergent or shoreline vegetation, and lack introduced bullfrogs and predatory non-native fishes (such as the green sunfish). During reproductive season (January–March): eggs deposited on submerged vegetation at or near the surface	Creation of ponds and addition of freshwater marsh vegetation could provide suitable habitat; improving water quality would enhance habitat. Because tadpoles of non-native bullfrogs compete with red-legged frog tadpoles, and adult bullfrogs eat eggs and juvenile red-legged frogs, removal of bullfrogs would increase chance of successful breeding. <u>Note</u>: restoration for this species will be successful only in areas with adjacent upland habitat and open-space connections to other suitable breeding sites (for juvenile dispersal).
Foothill yellow-legged frog *Rana boylii*	SC/CSC	Coast Ranges from Oregon south to the Transverse Ranges; west of the Sierra Nevada-Cascade Range crest. Potential habitat exists in the San José area along forested riparian corridors with perennial water and cobble substrates.	Rocky streams in a variety of habitats, including valley foothill hardwood forest/woodland, valley foothill riparian forest/woodland, coastal scrub, mixed conifer forest, mixed chaparral, and wet meadows. Typically found in shallow water of partly shaded streams; prefers sites with riffles and at least cobble-sized substrates.	Increasing quality and number of stream riffles and roughness of creek bed may enhance habitat for this species. Other restoration issues are similar to those discussed for California red-legged frog.

Species	Federal/ State Status[a]	Distribution and Potential for Occurrence in Service Area	Habitat	Restoration Opportunities
Southwestern pond turtle *Clemmys marmorata pallida*	SC/CSC	West of the Sierra Nevada range and west of the San Joaquin Valley, from the San Francisco Bay area south as far as the middle of the Baja California peninsula. Known to occur in Coyote Creek; potential habitat is found along all riparian corridors of the San José area.	Permanent freshwater ponds, lakes, marshes, and rivers.	Additional riparian vegetation would improve movement and dispersal corridors, and would improve habitat for foraging, basking, and breeding. Large logs in streambed would provide basking sites and refuges from predators and collectors.
Northern harrier *Circus cyaneus* (nesting)	–/CSC	Throughout lowland California; has also been recorded in fall at high elevations. Resident of the Alviso Slough area; marsh habitats at mouths of Guadalupe River and Coyote Creek may provide suitable breeding habitat	Tall grasslands, meadows, marshes, and seasonal and agricultural wetlands that provide tall cover.	Creation of grassland, perennial freshwater wetland, or salt marsh habitat would increase foraging habitat; planting trees in these habitats reduces foraging opportunities for this species.
Sharp-shinned hawk *Accipiter striatus* (nesting)	–/CSC	Permanent resident at mid-elevations in the Sierra Nevada, Cascade, Klamath, and northern Coast Ranges and along the coast in Marin, San Francisco, San Mateo, Santa Cruz, and Monterey counties. Winters over the rest of the state except at very high elevations. Found in forested riparian corridors in San José during migration and winter (September–early May).	Dense canopy ponderosa pine or mixed-conifer forest and riparian habitats.	Increasing cover of tall riparian trees would enhance roosting and resting sites for species during winter migration.

Species	Federal/ State Status[a]	Distribution and Potential for Occurrence in Service Area	Habitat	Restoration Opportunities
Cooper's hawk *Accipiter cooperii* (nesting)	–/CSC	Permanent resident throughout California, except at high elevations in the Sierra Nevada. Winters in the Central Valley, southeastern desert regions, and plains east of the Cascade Range. In Santa Clara County, primary nesting habitat occurs in the forests of the Santa Cruz Mountains and the Diablo Range; pairs have nested occasionally in urban forests of San José, including the Willow Glen District and the area between Coyote Creek and the Guadalupe River. Cooper's hawk is an expected regular migrant and winter visitor along riparian corridors in the San José area	Nests primarily in riparian forests dominated by deciduous species; also nests in densely canopied forests from digger pine-oak woodland up to ponderosa pine; forages in open woodlands Migrant and wintering individuals use a variety of habitats, including oak woodland, conifer and mixed broadleaf forests, grassland, residential areas, riparian woodland, and marshes.	Increasing cover of tall riparian trees, increasing width of riparian corridors, and increasing connectivity of riparian habitat would all increase the availability of suitable nesting sites for this species.
Osprey *Pandion haliaetus* (nesting)	–/CSC	Throughout California, except at high altitudes in the Sierra Nevada. Present between February and October; some are resident year-round. Known to occur in larger creeks and rivers of the San José area, such as Guadalupe River and Coyote Creek.	Forages for fish in freshwater rivers and lakes; nests in tall trees within cruising range of foraging habitat.	Increasing cover and connectivity of riparian forest would increase nesting opportunities for osprey.
Merlin *Falco columbarius* (wintering)	–/CSC	Rare but widespread winter (September–April) visitor to the Central Valley and California coastal areas; does not nest in California. Regular winter visitor throughout San José area marshes, urban forests, and riparian corridors (as well as other areas of Santa Clara County with similar vegetation).	Forages along coastlines and in open grasslands, savannas, and woodlands; often forages near lakes and in other wetlands.	Increasing dense woody riparian vegetation would increase roosting and resting sites for this species; increasing grassland and oak woodland adjacent to riparian corridors would increase foraging opportunities.

Species	Federal/ State Status[a]	Distribution and Potential for Occurrence in Service Area	Habitat	Restoration Opportunities
American peregrine falcon *Falco peregrinus anatum*	–/CE	Permanent resident in the northern and southern Coast Ranges. Winters from the Central Valley south through the Transverse and Peninsular Ranges, and in the plains east of the Cascade Range. May summer in the Cascade and Klamath Ranges south through the Sierra Nevada to Madera County. Occurs in tidal marshes of Coyote Creek and the Guadalupe River during winter (October–May), and in other bayside marshes in Santa Clara County.	Nests and roosts on protected ledges of high cliffs, usually adjacent to lakes, rivers, or marshes that support large populations of other bird species.	Widening riparian corridors and increasing cover of open water to attract waterfowl would increase foraging opportunities for this species.
White-tailed kite *Elanus leucerus* (nesting)	–/FP	Resident in California from Sonoma County and Sacramento Valley south into Mexico. Found along major rivers and creeks such as Guadalupe River and Coyote Creek, and in adjacent grasslands and woodlands.	Nests in riparian woodlands and forests, and in isolated trees; forages in adjacent agricultural fields, grasslands, and wetlands.	Increasing cover of tall riparian trees would increase nesting sites for this species.
Western burrowing owl *Athene cunicularia hypugea* (burrows)	SC/CSC	Inhabits lowlands throughout California, including the Central Valley, northeastern plateau, southeastern deserts, and coastal areas; rare along south coast. Known to occur near disturbed stream corridors, such as the Guadalupe River downstream from Blossom Hill Road, Calabazas Creek, and Coyote Creek. Nesting burrowing owls concentrate along the south bay margin and in southeast and northern San José.	Occupies rodent burrows in sparse grassland, desert, and agricultural habitats with raised areas for perch sites.	Creation of sparse grassland along levee tops or in adjacent upland habitat could create habitat for burrowing rodents, thus providing habitat for burrowing owls.

Species	Federal/ State Status[a]	Distribution and Potential for Occurrence in Service Area	Habitat	Restoration Opportunities
Willow flycatcher *Empidonax traillii* (nesting)	S/CE	Historically inhabited lowland willow riparian habitats throughout California, including Santa Clara County. In summer, now inhabits a narrow belt along the eastern Sierra Nevada from Shasta County to Kern County, and a second belt along the western Sierra Nevada from El Dorado County to Madera County, along the Kern, Santa Margarita and San Luis Rey Rivers. Widespread during migration (spring and fall). Typically prefers riparian habitats. Occurs along San José area riparian corridors during spring and fall migration.	Riparian areas and large, wet meadows with abundant willows for breeding. Usually found in riparian habitats during migration.	Increasing extent of riparian forest near standing water would increase insect populations and insect diversity and would enhance foraging habitat for willow flycatcher during migration.
Loggerhead shrike *Lanius ludovicianus*	SC/CSC	Resident and winter visitor in lowlands and foothills throughout California. Nesting pair observed along Coyote Creek adjacent to a large ruderal field; expected to nest along San José riparian corridors adjacent to open habitat or where ruderal levee slopes are interspersed with trees and shrubs.	Prefers open habitats (grasslands, wetlands, and agricultural areas) with scattered shrubs, trees, posts, fences, utility lines, or other perches.	Increasing numbers of riparian tree saplings and riparian shrubs would increase nesting opportunities for shrikes. Once saplings mature, these nesting sites would be gone.
Yellow warbler *Dendroica petechia brewsteri* (nesting)	–/CSC	Summer resident throughout California except in the deserts and at high elevations in the Sierra Nevada. Nests along the Guadalupe River, Penitencia Creek, Los Gatos Greek, and Coyote Creek. Common in riparian corridors of San José area during breeding, and migration, periods; one of the few neo-tropical migrants still nesting in selected sites in San José riparian areas.	Nests in riparian areas dominated by willows, cottonwoods, sycamores, or alders.	Increasing cover or riparian woodland and forest will increase suitable nesting habitat for species; increasing connectivity of riparian corridor vegetation will enhance migration and dispersal habitat.

Species	Federal/ State Status[a]	Distribution and Potential for Occurrence in Service Area	Habitat	Restoration Opportunities
Yellow-breasted chat *Icteria virens* (nesting)	–/CSC	Uncommon migrant in California; nests in a few locations with appropriate habitat, including sites in El Dorado, Shasta, Sonoma, Mendocino, and Yolo Counties. Historically nested along riparian forests throughout California, including Santa Clara County. Observed at Coyote Creek during spring and fall migration; suitable migration habitat exists along San José area streams. Now an extremely rare breeder in Santa Clara County.	Nests in dense, wide riparian habitats dominated by willows, alders, Oregon ash, tall weeds, blackberry vines, and grapevines.	Increasing cover, width, and connectivity of riparian scrub and riparian woodland would increase nesting habitat for this species.
Saltmarsh yellowthroat *Geothlypis trichas sinuosa*	SC/CSC	Breeds in San Francisco Bay area and along the coast from Half Moon Bay to Pescadero. Known as far south as San Diego County during fall migration and winter. Nests along the mouths of the Guadalupe River and Coyote Creek.	Perennial freshwater wetland and brackish marsh during the breeding season (March–July); salt marshes during winter.	Increasing the extent of perennial freshwater wetland and brackish marsh near the mouths of the Guadalupe River and Coyote Creek could increase the breeding habitat available to this species and increase its population.
Pacific western big-eared bat *Corynorhinus townsendi townsendi*	–/CSC	Ranges throughout the state, including the Channel Islands.	Uses rocky outcrops, cliffs, caves, crevices, and buildings for roosting; requires access to open habitats for foraging.	Additional riparian vegetation and an increase in number and quality of snags with cavities could increase roosting potential; installation and maintenance of bat houses would also increase nesting and roosting opportunities.
Greater western mastiff-bat *Eumops perotis californicus*	–/CSC	Makes local seasonal movements but remains in California throughout the year.	Uses caves, crevices, and buildings for roosting; requires access to open arid areas with high cliffs.	Additional riparian vegetation and an increase in number and quality of snags with cavities could increase roosting potential; installation and maintenance of bat houses would also increase nesting and roosting opportunities.

Species	Federal/ State Status[a]	Distribution and Potential for Occurrence in Service Area	Habitat	Restoration Opportunities
Small-footed myotis bat *Myotis ciliolabrum*	–/CSC	Most of California except coastal redwood region.	Uses rocky outcrops, cliffs, caves, crevices, and buildings for roosting; requires access to open habitats for foraging.	Additional riparian vegetation and an increase in number and quality of snags with cavities could increase roosting potential; installation and maintenance of bat houses would also increase nesting and roosting opportunities.
Long-eared myotis bat *Myotis evotis*	–/CSC	Ranges over the entire state; common in montane forests.	Uses rocky outcrops, cliffs, caves, crevices, and buildings for roosting; requires access to open habitats for foraging.	Additional riparian vegetation and an increase in number and quality of snags with cavities could increase roosting potential; installation and maintenance of bat houses would also increase nesting and roosting opportunities.
Fringed myotis bat *Myotis thysanodes*	–/CSC	Occurs throughout California; most common in coastal and montane forests.	Uses rocky outcrops, cliffs, caves, crevices, and buildings for roosting; requires access to open habitats for foraging.	Additional riparian vegetation and an increase in number and quality of snags with cavities could increase roosting potential; installation and maintenance of bat houses would also increase nesting and roosting opportunities.
Long-legged myotis bat *Myotis volans*	–/CSC	Occurs throughout California, in both forested regions and brushy areas.	Uses buildings, trees, and crevices in cliffs for roosting; requires access to open habitats for foraging.	Additional riparian vegetation and an increase in number and quality of snags with cavities could increase roosting potential; installation and maintenance of bat houses would also increase nesting and roosting opportunities.

Species	Federal/ State Status[a]	Distribution and Potential for Occurrence in Service Area	Habitat	Restoration Opportunities
Yuma myotis bat *Myotis yumanensis*	–/CSC		Uses rocky outcrops, cliffs, caves, crevices, and buildings for roosting; requires access to open habitats for foraging.	Additional riparian vegetation and an increase in number and quality of snags with cavities could increase roosting potential; installation and maintenance of bat houses would also increase nesting and roosting opportunities.

[a]**Status explanations:**

Federal

E = listed as endangered under the federal Endangered Species Act.
T = listed as threatened under the federal Endangered Species Act.
C = candidate species (species for which sufficient information on their biological status and threats warrant proposal as endangered or threatened taxa).
ED = federally endangered species proposed for delisting.
SC = species of concern (term has no official status but refers to taxa whose conservation status may be of concern).
S = species identified as sensitive because of declining populations.
– = no status definition.

State

CE = listed as endangered under the California Endangered Species Act.
FP = fully protected species under the California Department of Fish and Game Code.
CSC = California Department of Fish and Game species of special concern (based on declining population levels, limited ranges, continuing threats); regulated by the California Environmental Quality Act.
– = no status.

Sources: McGinnis (1984), Grinnell and Miller (1986), RMI Design Group and Habitat Restoration Group (1999), California Department of Fish and Game (1999), Page and Burr (1991), Brown, Weston, and Buzzell (1986), United States Army Corps of Engineers (1999).

discussion is linked to the ways riparian corridors once provided the functions and values itemized above.

Historic Physical Features

Channel Morphology. Stream channels are dynamic. When unconstrained by barriers, channels shift position or migrate on the floodplain as water deposits sediment in one place and removes it in another. For example, based on U. S. Geological Survey topographic maps, the channel of Coyote Creek shifted its position dramatically between the years of 1899 and 1961; there is almost no overlap between its 1899 and 1961 positions.

The Guadalupe River, like many other rivers and creeks in the City's Urban Service Area, has been substantially modified from its pre-settlement condition. One of the first records of this modification of the river comes from 1777, when Spanish settlers built a small dam above the early pueblo in San José (Santa Clara Valley Water District 1997). Since that time, the course of the Guadalupe River has been substantially straightened and narrowed, and its location altered, to provide flood protection for area residents. Many of the Guadalupe River's tributaries have also been substantially altered. For instance, prior to historic modifications, the river's confluence with Canoas Creek was about three miles downstream from its present location (Santa Clara Valley Water District 1997).

Historically, the smaller streambanks in the Urban Service Area were probably unstable as a result of infrequent high-volume flows during winter storms. Intermittent streams such as the tributaries to Coyote Creek in the eastern portion of the Urban Service Area may have changed position frequently, forming multiple channels. Like many small creeks in California that emerge from steep arid or semi-arid mountains, some creeks in the Urban Service Area may historically have had braided channels, which bifurcate and rejoin multiple times (Mount 1995). Today, however, these creeks are confined to single channels.

We also know that creeks and rivers in the Urban Service Area were once at higher elevations than they now occupy. Subsidence of the land surface, caused primarily by groundwater withdrawal in the past half century, has caused the elevation of river beds on the valley floor to drop by as much as 8 feet in some areas (Santa Clara Valley Water District 1997). Because the elevation of river headwaters has not changed significantly over this time period, channels within the Urban Service Area now have steeper gradients than they did prior to the 20th century.

Streambed Characteristics. Streams that are unconstrained typically create a diversity of streambed conditions (Mount 1995). Bends in rivers tend to contain areas of deeper, slower-moving water, or pools. Areas between bends commonly contain areas where shallower water moves more rapidly; in streams with gravel beds, these shallower segments of channel are riffles. Because different insect communities inhabit pools and riffles, an abundance of each type of aquatic habitat would increase insect diversity. Pools and riffles also have different fish habitat characteristics.

Most of the creek beds in today's Urban Service Area are highly modified and constrained, largely as a result of flood protection activities. In the past, area creeks had a greater abundance of pool and riffle habitats. In addition, before they were stabilized with concrete or excavated and realigned, creekbeds historically contained more boulders, cobbles, and gravel than they now carry. This resulted in greater hydraulic roughness and resulting water turbulence (and hence, water oxygenation) than current conditions allow.

Water Characteristics. Water conditions in streams in the Urban Service Area were likely much different historically from those that prevail today, in part because of changes in streamchannel conditions and in patterns of vegetation on the streambank. As discussed earlier, the water quality of creeks in the Urban Service Area is often less than optimum. Water quality in the past was likely much better, due primarily to the absence of the point- and non-point sources of pollution found throughout the watersheds today.

In addition, we can infer from the current composition of the fish community that water temperatures in the past were lower than they are today in most of the Urban Service Area's streams. Cold streams contain more dissolved oxygen than warm streams. Some fish, such as steelhead trout, can tolerate only a narrow range of (fairly cold) water temperatures and dissolved oxygen levels. Others, such as the California roach and Sacramento sucker, can tolerate higher temperatures and lower dissolved oxygen concentrations. California roach and Sacramento sucker are still common in the Urban Service Area, while steelhead trout are not.

Historic Vegetation

Terrestrial Vegetation. The native trees still present in riparian corridors in the San José area provide a good guide to the species composition of the corridors before widespread disturbance. Common and scientific names for these species are given in Appendix B. Along perennial streams, the most common trees were probably Fremont cottonwood, black cottonwood, arroyo willow, shining willow, red willow, and box elder. In intermittent streams on small watersheds, or near stream headwaters, trees such as California sycamore, coast live oak, and California bay probably dominated. All of these species were likely more common historically than they are today. Exotic and ornamental plants now common in the Urban Service Area (see Appendix B) represent comparatively recent arrivals to area's riparian corridors.

One consequence of the former abundance of trees is that they created shade, which helped to keep water temperatures in streams lower year-round. This would have been beneficial to coldwater species such as steelhead trout. Also, more leaf litter fell into the streams, creating habitat and providing a food source for aquatic invertebrates such as stoneflies, beetles, caddisflies, and snails.

Aquatic Vegetation. The aquatic vegetation present today in riparian corridors of the Urban Service Area probably includes most if not all of the species that were historically present in the region's aquatic habitats (see Appendix B). Of course, exotic aquatic plants from Europe and Asia such as water speedwell and watercress, which are now common in riparian corridors, were previously absent. In addition, some creeks may have supported less abundant growth of aquatic algae in the past than they do today. Periods of rapid algal growth ("algal blooms") are common in aquatic systems in which there are seasonal peaks in the abundance of key nutrients. Phosphorus is often the limiting nutrient in aquatic systems. Phosphorus compounds are commonly found in detergents that wash into streams, so occasional pulses of phosphorus input from storm runoff can cause algal blooms in today's streams. Streams in the past were likely subject to less frequent and less widespread algal blooms than present-day streams.

Historic Wildlife

Terrestrial Wildlife. Mammal and bird populations in riparian corridors of the past were very different from those of today. Excavations of prehistoric Native American middens indicate that mule deer, pronghorn antelope, elk, California grizzly bears, and badgers were once common in the region. Accounts by early settlers and explorers in the region paint a consistent picture of extensive populations of waterfowl, large mammals, and birds of prey in the South Bay (RRM Design Group and Habitat Restoration Group 1999). All of these species would have used riparian corridors to some degree. For example, California grizzly bears are reported to have been common in dense stands of cottonwood and willow trees, where they would have foraged for trout and salmon during the annual upstream spawning runs. Bald eagles, once common along the California coast, may have nested in riparian corridors, close to the open waters in which they feed. However, because many obligate riparian species—such as willow flycatchers and yellow-billed cuckoos—were not used as food and were not documented scientifically, we know little about their historic abundance in the Urban Service Area.

Amphibian and reptile populations in the Urban Service Area's riparian corridors have probably also undergone significant changes from their undisturbed condition. California tiger salamander historically occurred in Guadalupe Creek and Coyote Creek. California red-legged frog, foothill yellow-legged frog, and the southwestern pond turtle were likely all more common in the past, when riparian corridors were unbroken and were surrounded by undisturbed upland habitat through which amphibians and reptiles could disperse. Furthermore, competitive non-native amphibians such as bullfrogs were absent from the riparian corridors of the past.

Aquatic Wildlife. The composition of fish populations in the Urban Service Area was much different in the past than it is today. Many native species now absent were once common in the creeks of the South Bay, while all of the 19 non-native fish species now found in the watersheds of the Urban Service Area (RRM Design Group and Habitat Restoration Group 1999) would of course have been absent in the past (see Appendix B). Table 3-7 describes the inferred historic composition of fish communities in the watersheds of the Urban Service Area. Because inferred historic data are based solely on collections, which are necessarily limited in scope, they may underrepresent the actual species diversity once present in the Urban Service Area.

Similarly, populations of aquatic insects and other aquatic invertebrates (e.g., bivalves, amphipods, nematodes, worms) were likely very different historically than they are today. Aquatic insects are a critical element of the food chain in a stream ecosystem; without them, few fish would have enough food to survive. Streams in the Urban Service Area likely had better water quality and higher habitat diversity historically than they do today. As discussed above, this would have supported larger and more diverse invertebrate populations than are present in area streams today. As another example, most streams in the Urban Service Area support populations of the exotic freshwater mollusk *Corbicula*, to the near-exclusion of native species.

Insect groups such as stoneflies, caddisflies, and mayflies are particularly sensitive to water quality. A recent survey of these groups in Coyote Creek showed that their diversity and abundance was very low, suggesting that poor water quality is affecting the aquatic insect community (Rogers 1999). In creeks with poor water quality and low habitat diversity, other insect groups such as midges which are more tolerant of a wide range of habitat characteristics may dominate the system (Merritt and Cummins 1996). Thus, creeks in the Urban Service Area probably had a greater diversity, and perhaps also a greater abundance, of some groups of environmentally sensitive insects —such as stoneflies, caddisflies, and mayflies—in the past than they do today.

Existing Conditions

As described in the previous section, streams, rivers, and creeks in the City's Urban Service Area once supported relatively wide and continuous corridors of native riparian vegetation. Over time, residential, commercial, industrial, and agricultural development, along with flood protection projects, have altered the natural landscape of the area, impacting the extent and condition of riparian and wetland habitats (Goldner 1984). Creeks and rivers that historically supported wide expanses of riparian vegetation along their banks now support narrow bands or remnant patches of vegetation, or have been completely cleared to reduce flood hazards on adjacent lands.

Stream Corridor Classifications

Based on existing stream channel and corridor conditions, we have developed the following eight classification categories to describe streams in the City's Urban Service Area:

- underground or covered
- concrete
- mixed hardscape
- excavated earthen
- unmodified – trees absent
- unmodified – trees sparse
- unmodified – trees abundant – narrow corridor
- unmodified – trees abundant – wide corridor

This classification system—which differs somewhat from that employed in previous area studies, including the Riparian Corridor Policy Study (City of San José 1992)—was intended to categorize stream corridors according to degree of modification. This in turn supports the prioritization of channel segments for riparian habitat restoration, as well as helping to identify

Table 3-7. Historic Composition of Native Fish Communities in the Major Watersheds of the San José Urban Service Area.

Common name	Scientific name	Major Watershed: Coyote Creek	Major Watershed: Guadalupe River	Major Watershed: San Tomas Aquinas Creek/ Saratoga Creek
Historically present (now extirpated)				
Pacific brook lamprey	*Lampetra pacifica*	X	X	
Thicktail chub	*Gila crassicauda*	X		
Sacramento splittail	*Pogonichthys grandis*	X		
Sacramento squawfish (Sacramento pikeminnow)	*Ptychocheilus grandis*	X	?	
Speckled dace	*Rhinichthys osculus*	X		
Tule perch	*Hysterocarpus traski*	?		
Present today				
Pacific lamprey	*Lampetra tridentata*	X		
Chinook salmon[1]	*Onchorhynchus tshawytshca*	X	X	
Rainbow and steelhead trout	*Onchorhynchus mykiss*	X	X	X
Hitch	*Lavinia exilicauda*	X	X	X
California roach	*Lavinia symmetricus*	X	X	X
Sacramento blackfish	*Orthodon microlepidotus*	X		
Sacramento sucker	*Catostomus occidentalis*	X	X	X
Threespine stickleback	*Gasterosteus aculeatus*	X	X	
Sacramento perch	*Archopites interruptus*	?		
Prickly sculpin	*Cottus asper*	X	X	
Riffle sculpin	*Cottus gulosus*	X	X	

Source: RRM Design Group and Habitat Restoration Group (1999).

[1]Although native to California, chinook salmon may not have been historically present in the creeks of the Urban Service Area. See text and Table 3-6 for further discussion of this special-status species.

constraints imposed on restoration activities by existing conditions along different channel segments. The physical and biological characteristics of each of these eight channel types, including substrate type and habitat values, are summarized in Table 3–8 and Table 3–9. Table 3–8 also summarizes the extent of each channel type for each stream within the Urban Service Area. Figure 3–4 illustrates the locations of channels of each type in the Urban Service Area. Note that the final four categories (unmodified channel – trees absent, unmodified channel – trees sparse, unmodified channel – trees abundant – narrow corridor, and unmodified channel – trees abundant – wide corridor) are not differentiated on Figure 3–4, because of limitations imposed by the map scale. These four categories are shown separately on the tables, and were considered separately in the GIS analysis carried out for the RRAP.

Table 3–9 summarizes the habitat values associated with each channel type. This table shows that habitat values are greater in less disturbed (less modified) channels. An alternative way of looking at this table is to consider the restoration opportunities associated with each channel type. Viewed in this manner, Table 3–9 implies that the more disturbance or modification a channel has undergone, the more restoration opportunities the channel presents. Also, note that in many cases, the various channel types exhibit a range values for the same habitat type. For example, although all channel types provide some warmwater fish habitat, unmodified channels with abundant tree cover provide far better warmwater fish habitat than do underground culverts or concrete channels. The same principle applies to most of the other habitat values shown on Table 3–9. Specific characteristics and habitat values of each channel type are described in the following sections.

Underground or Covered Channel. This category represents corrugated metal pipes (CMP), reinforced concrete pipes (RCP), or similar structures that have been placed underground to replace historic stream channels. This category also includes "covered" segments where creeks pass under bridges or other structures. Underground or covered channels are commonly found in highly constrained areas, where they allow a river or stream to pass under roadways, railroads, or areas of dense urban development. Although these modifications do facilitate surface water flow from upper watersheds to less-disturbed downstream riparian areas, they represent gaps in the linear connectivity of riparian habitat and may act as barriers to the movement of wildlife—including amphibians, reptiles, and some mammals—and fish.

Habitat Values: Because habitat associated with this classification is limited to pockets of aquatic vegetation—including watercress, sedges, and rushes—located at the inflow and outflow ends of the structures, wildlife and fisheries values for this channel type are limited (see Table 3-9). In areas where an underground culvert adjoins a surface channel, the inflow or outflow end of the structure may provide potential nesting habitat for birds such as swallows or black phoebes that construct mud nests under overhangs.

Underground culverts may act as physical barriers to the up- and downstream movement of both migratory fish species (chinook salmon and steelhead trout) and resident fish species. Fish passage may be impeded or delayed by insufficient water depth during periods of low flow, by behavioral responses to changes in light conditions, or by high water velocities within the culvert, especially during periods of high flow.

Examples: Examples of creek segments in the Urban Service Area that have been diverted into underground culverts include North Babb Creek at the intersection of White Road and Dale Drive, and San Tomas Aquinas Creek at the intersection of Stevens Creek Boulevard and Williams Road.

Concrete Channel. This category represents an engineered creek channel that has been hydraulically modified by widening the channel bottom and lining it with concrete (see Figure 3-5). In many cases the channel banks have also been lined with concrete to reduce bank erosion and channel incision, and to increase the ability of the channel to convey floodflows. Some concrete channels have also been realigned (usually straightened) to increase their capacity and to provide greater flood protection. Many of these channels receive regular maintenance from the District, including removal of sediment and woody vegetation, to ensure that hydraulic design requirements are met and that high-volume flows can be adequately conveyed. This type of channel alteration is typically used in areas where flood protection is a high priority and responsible agencies have limited land rights.

Habitat Values: Habitat values associated with this type of channel are limited. The lack of vegetation associated with this classification limits the use of these channels by riparian-dependent wildlife such as fish, aquatic invertebrates, and amphibians. The concrete slopes limit use of the channels by burrowing wildlife such as ground squirrels and western burrowing owls. Scattered riparian or ornamental trees may occur along the top of some channel banks and provide roosting and nesting habitat for hawks, owls and other bird species (Table 3-9).

In areas where sediment has accumulated on the channel bottom, concrete channels may support perennial freshwater wetland vegetation that provides cover and shade for both resident and migratory fish, and is also utilized by birds. The general lack of a woody overstory leads to warm summer water temperatures that limit the value of these areas for many native fish species, such as steelhead and salmon. Emergent vegetation is regularly removed or mowed in some channels to maintain maximum flood capacity. In these channels habitat values are reduced because of the severe disturbance associated with channel alteration.

Examples: Examples of creek segments in the Urban Service Area that have been modified into concrete channels include: Greystone Creek from Trinidad Drive to Almaden Road, Berryessa Creek from Morrill Avenue to Montague Expressway, and portions of San Tomas Aquinas Creek and Canoas Creek.

Mixed Hardscape Channel. This category represents historic creek channels that have been modified to provide increased capacity for flood protection, protecting adjacent properties and infrastructure. Channel banks, channel bottoms, or both have been lined with sack concrete, concrete blocks, gabions (wire baskets of rock), or riprap to reduce bank erosion and channel incision, and to increase the ability of the channel to convey floodflows (Figure 3-6). Like concrete channels, many mixed hardscape channels receive regular maintenance from the District, including removal

Table 3–8. Length and Proportion of Different Channel Types in Streams of the San José Urban Service Area

River/Creek	Underground or Covered Miles (% Length)	Concrete Miles (% Length)	Mixed Hardscape Miles (% Length)	Excavated Earthen Miles (% Length)	Unmodified – Trees Absent Miles (% Length)	Unmodified – Trees Sparse Miles (% Length)	Unmodified – Trees Abundant – Narrow Corridor	Unmodified – Trees Abundant – Wide Corridor	Total Miles (% Length)
Guadalupe River		0.215 (1%)	1.830 (12%)	10.190 (66%)	0.103 (1%)		2.87 (18%)	0.39 (3%)	15.53 (100%)
Los Gatos Creek	0.137 (4%)	0.609 (17%)	0.525 (15%)	0.479 (13%)			1.845 (51%)		3.595 (100%)
Ross Creek	1.110 (28%)	0.562 (14%)	0399 (10%)	1.925 (48%)					3.996 (100%)
Canoas Creek	0.466 (4%)	6.555 (63%)	3.400 (33%)						10.421 (100%)
Guadalupe Creek				10.190 (92%)	0.007 (0%)		0.825 (7%)		11.022 (100%)
Calabasas Creek	0.082 (4%)	0.060 (3%)	0.008 (0%)	0.327 (18%)			1.358 (74%)		1.835 (100%)
San Tomas Aquino	1.070 (21%)	1.590 (32%)	1.367 (27%)	0.957 (19%)		0.049 (1%)			5.033 (100%)
Saratoga Creek	0.029 (1%)	0.181 (9%)	0.356 (17%)	0.350 (17)%			1.129 (55%)		2.045 (100%)
Alamitos Creek	0.038 (1%)		0.641 (15%)	2.150 (49%)		1.19 (26%)	0.05 (1%)	0.39 (8%)	4.385 (100%)
Golf Creek	0.578 (26%)	0.078 (3%)	0.749 (34%)	0.829 (37%)					2.234 (100%)
Greystone Creek	0.084 (6%)	0.983 (65%)	0.067 (4%)	0.384 (25%)					1.518 (100%)
Randol Creek	0.140 (17%)	0.361 (44%)	0.306 (37%)	0.011 (1%)					0.818 (100%)
Santa Teresa Creek	0.012 (2%)						0.457 (97%)	0.02 (1%)	0.489 (100%)
Calero Creek	0.009 (1%)							0.879 (99%)	0.888 (100%)
Guadalupe River System	**4 (6%)**	**11 (18%)**	**10 (15%)**	**28 (44%)**	**0 (0%)**	**1.19 (2%)**	**8.534 (13%)**	**1.679 (3%)**	**64 (100%)**

River/Creek	Underground or Covered Miles (% Length)	Concrete Miles (% Length)	Mixed Hardscape Miles (% Length)	Excavated Earthen Miles (% Length)	Unmodified – Trees Absent Miles (% Length)	Unmodified – Trees Sparse Miles (% Length)	Unmodified – Trees Abundant – Narrow Corridor	Unmodified – Trees Abundant – Wide Corridor	Total Miles (% Length)
Coyote Creek	0.152 (1%)			7.746 (33%)		1.61 (79%)	2.11 (9%)	11.54 (50%)	23.16 (100%)
Fisher Creek	0.11 (2%)			2.32 (39%)	0.29 (5%)	3.19 (54%)			5.90 (100%)
Lower Silver Creek	1.336 (19%)	0.394 (5%)	0.040 (1%)	5.432 (75%)					7.20 (100%)
Miguelita Creek	2.743 (76%)					0.34 (9%)	0.1 (4%)	0.4 (11%)	3.61 (100%)
North Babb Creek	0.753 (61%)	0.350 (29%)	0.122 (10%)						1.23 (100%)
Thompson Creek	0.065 (1%)	0.035 (1%)	0.213 (4%)	0.154 (3%)	0.073 (1%)		4.617 (90%)		5.16 (100%)
South Babb Creek	0.051 (3%)	0.850 (56%)		0.057 (4%)				0.558 (37%)	1.52 (100%)
Flint Creek	0.998 (71%)		0.072 (5%)	0.256 (18%)				0.072 (5%)	1.40 (100%)
Ruby Creek	0.357 (62%)		0.216 (38%)						0.57 (100%)
Norwood Creek	1.809 (59%)	0.015 (0%)	0.027 (1%)	0.531 (17%)		0.691 (22%)			3.07 (100%)
Quimby Creek	0.233 (11%)			0.690 (33%)			1.141 (55%)		2.06 (100%)
Fowler Creek	0.392 (22%)							1.423 (78%)	1.82 (100%)
Evergreen Creek	0.042 (2%)	0.007 (0%)	1.830 (97%)						1.88 (100%)
Yerba Buena Creek								0.929 (100%)	0.93 (100%)
Cribari Creek	0.246 (100%)								0.25 (100%)
Upper Silver Creek	0.095 (2%)	1.161 (24%)			0.070 (1%)	0.38 (6%)	1.95 (40%)	1.35 (27%)	4.91 (100%)
Upper Penitencia Creek	0.126 (3%)			1.343 (33%)	0.055 (1%)	2.521 (62%)			4.04 (100%)
Berryessa Creek	0.113 (4%)	0.197 (8%)	0.284 (11%)	0.486 (19%)	0.189 (7%)	0.4 (15%)	0.93 (36%)		2.60 (100%)
Sierra Creek	0.764 (33%)	0.307 (13%)	0.008 (0%)	1.023 (44%)		0.244 (10%)			2.35 (100%)
Crosley Creek					0.014 (1%)	1.245 (99%)			1.26 (100%)
Coyote Creek System	**10.39 (14%)**	**3.32 (4%)**	**2.60 (3%)**	**20.25 (27%)**	**0.69 (1%)**	**11.28 (15%)**	**10.84 (14%)**	**16.27 (21%)**	**74.90 (100%)**
Total in Urban Service Area	**13.99 (11%)**	**14.15 (11%)**	**11.94 (9%)**	**37.84 (30%)**	**0.79 (1%)**	**12.47(9%)**	**19.37 (15%)**	**17.94 (14%)**	**125.98 (100%)**

Table 3–9. Habitat Functions and Values Associated with Channel Types

General Function or Value	Underground or Covered	Concrete	Mixed Hardscape	Excavated Earthen	Unmodified – Trees Absent	Unmodified – Trees Sparse	Unmodified – Trees Abundant – Narrow Corridor	Unmodified – Trees Abundant – Wide Corridor
Wildlife Habitat:								
Warmwater fish habitat	✓	✓	✓	✓	✓	✓	✓	✓
Coldwater fish passage				✓	✓	✓	✓	✓
Coldwater fish spawning							✓	✓
Foraging and roosting by waterbirds		✓	✓	✓	✓	✓	✓	✓
Foraging and roosting by neotropical migrant birds							✓	✓
Foraging and roosting by resident terrestrial birds						✓	✓	✓
Foraging by raptors		✓ (fish only)	✓ (fish only)	✓	✓	✓	✓	✓
Nesting by waterbirds			✓	✓	✓	✓	✓	✓
Nesting by resident terrestrial birds						✓	✓	✓
Nesting by neotropical migrant birds								✓
Burrowing sites for fossorial birds or mammals				✓	✓	✓	✓	✓
Wildlife corridor for dispersing mammals							✓	✓
Habitat for aquatic invertebrates				✓	✓	✓	✓	✓

Table 3–9. Habitat Functions and Values Associated with Channel Types

General Function or Value	Underground or Covered	Concrete	Mixed Hardscape	Excavated Earthen	Unmodified – Trees Absent	Unmodified – Trees Sparse	Unmodified – Trees Abundant – Narrow Corridor	Unmodified – Trees Abundant – Wide Corridor
Riparian Habitat:								
Herbaceous vegetation			✓	✓	✓	✓	✓	✓
Woody vegetation				✓	✓	✓	✓	✓
Resistance to invasion by exotic plants								✓
Water Quality:								
Reduce erosion/sediment load	✓	✓	✓	✓	✓	✓	✓	✓
Filter pollutants				✓	✓	✓	✓	✓
Recreation, Education, and Flood Protection:								
Provide shaded recreational trails							✓	✓
Provide opportunities for water resources education		✓	✓	✓	✓	✓	✓	✓
Provide educational opportunities for nature interpretation				✓	✓	✓	✓	✓
Dissipate flood energy					✓	✓	✓	✓

Fig 3-4

San Tomas Aquinas Creek, view to north from Hamilton Avenue.

Ross Creek, view to west at Meridian Avenue.

Figure 3-6
Mixed Hardscape Channel

of sediment and woody vegetation, to ensure that hydraulic design requirements are met and that high-volume flows can be adequately conveyed.

Habitat Values: Habitat values associated with this type of channel may be limited. The lack of vegetation associated with mixed hardscape channels where both channel bed and banks are armored limits the use of these channels by riparian-dependent wildlife such as fish, aquatic invertebrates, and amphibians (Table 3-9). However, in some mixed hardscape channels only the channel bed and lower slopes have been altered, leaving an expanse of riparian vegetation along the upper banks. These remaining habitat patches, along with riparian trees scattered along the top of the channel banks or at the water's edge provide movement corridors and cover for small mammals, as well as roosting and nesting habitat for a variety of bird species. Riprap may also provide cover and den sites for reptiles and small mammals such as rabbits and ground squirrels. Freshwater vegetation and woody riparian vegetation located along the water's edge or on channel banks provide cover and shade for both resident and migratory fish. If there is no woody overstory, summer water temperatures are very warm, which limits the value of these areas for native resident and migratory fish species.

Examples: Examples of creek segments located in Urban Service Area that have been modified into mixed hardscape channels include: Golf Creek at Redmond Avenue, Ross Creek at Meridian Avenue, and portions of Canoas Creek, Evergreen Creek, and the Guadalupe River.

Excavated Earthen Channel. This category is similar to concrete channels in that the creek channel has been engineered to provide increased flood capacity. Typically the channel bed has been widened, the banks modified, and the channel realigned (usually straightened) (Figure 3-7). The difference between this type of channel and the concrete channel is that the banks and bed of an excavated earthen channel remain exposed, although they are commonly compacted to increase their stability. In many cases, earthen channels receive regular maintenance from the District, including removal of sediment and woody vegetation.

Habitat Values: The compacted slopes, and the resultant lack of vegetation, associated with this category of channel limit the use of these channels by riparian-dependent wildlife and aquatic species such as fish, aquatic invertebrates, and amphibians (Table 3-9). However, in some stream segments only the channel bed and lower slopes have been altered, leaving an expanse of riparian vegetation along the upper banks. These remaining habitat patches, along with riparian trees scattered along the top of the channel banks or at the water's edge, provide movement corridors and cover for small mammals, as well as roosting and nesting habitat for a variety of bird species. The compacted slopes limit use of the channels by burrowing wildlife; however, channel segments with uncompacted soils may support ground squirrels or western burrowing owls.

Earthen channels typically support perennial freshwater wetland and riparian scrub species including cattail, smartweed, sweet clover, and willow. Invasive non-native species—such as giant reed, pampas grass, acacia, black locust, and tree-of-heaven—can also commonly be found along the channel slopes and banks. These invasive species adversely affect native riparian vegetation and reduce the value of the channels for riparian-dependent wildlife.

Along channel segments where riparian scrub or perennial freshwater wetland vegetation is present, excavated earthen channels may provide cover and shade for resident and migratory fish. The presence of instream woody material—for example, submerged logs and tree limbs—also contributes to fish habitat values. In addition, channel segments that contain natural channel features such as pools and riffles may provide habitat for warmwater fish.

Examples: Examples of creek segments located in the Urban Service Area that have been modified into excavated earthen channels include Fisher Creek from Santa Teresa Boulevard to Bailey Road and Ross Creek from Almaden Expressway to Los Gatos Road.

Unmodified Channel - Trees Absent. This category represents creek channels where the area between bank tops is unmodified but where native riparian vegetation has been disturbed as a long-term result of land use practices such as livestock grazing. The historic alignment and geometry of channels belonging to this category have not been substantially altered for flood protection or erosion control purposes. In general, channels of this type have unmodified earthen slopes and bottoms supporting limited herbaceous vegetation but no trees (Figure 3–8).

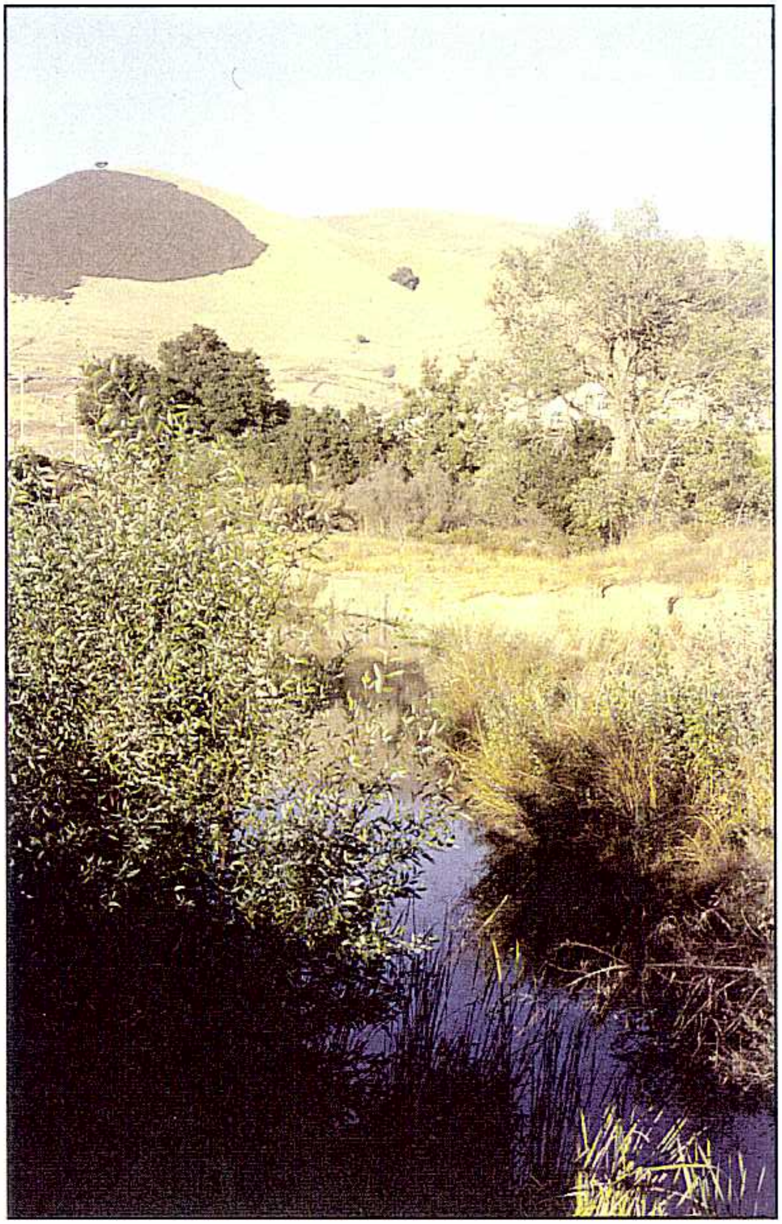
Habitat Values: Vegetation associated with this classification is limited to aquatic herbaceous species located within the creek channel (Table 3–9). Woody vegetation is either sparse or absent due to frequent disturbances such as mowing, use of off-road vehicles, or grazing by livestock. Typical herbaceous vegetation consists of the species described above as characteristic of seasonal or perennial freshwater wetland plant communities.

Herbaceous vegetation associated with this type of channel provides cover and foraging habitat for amphibians and reptiles. Seasonally ponded areas may provide breeding habitat for amphibians, as well as resting and foraging habitat for resident and migratory waterbirds. Ponded areas may also provide an important water source for other wildlife species.

Ruderal forbs and seed-producing plants associated with adjacent upland areas may provide foraging habitat for seed-eating birds and rodents, such as white-crowned sparrow, lesser goldfinch, mourning dove, pocket gopher, western harvest mouse, and house mouse. Upland vegetation may also provide cover and foraging habitat for reptiles such as western fence lizard, alligator lizard, and western terrestrial garter snake.

The lack of woody overstory and perennial freshwater wetland vegetation limits the value of these areas for native fish species.

Guadalupe Creek, view to northeast, west of Almaden Expressway.



Coyote Creek, view to south near Silicon Valley Road.

Examples: This category is primarily associated with the intermittent streams found in the upper watersheds of the Urban Service Area. Examples include Silver Creek from Evergreen Canal to Yerba Buena Road, and an unnamed tributary located upstream of Evergreen Canal.

Unmodified Channel - Trees Sparse. This classification includes creek channel segments that have been not been excavated, realigned, or otherwise modified for flood protection or erosion control purposes. These segments represent gaps in the riparian woodland typically found along unmodified channels in the Urban Service Area (Figure 3-9).

Habitat Values: The limited riparian vegetation and the resultant lack of connectivity associated with this channel category limits the use of these channel segments by riparian-dependent and aquatic species, including aquatic invertebrates, fish, and amphibians (Table 3-9). However, riparian trees scattered along the top of the channel banks or at the water's edge provide roosting and nesting habitat for owls, hawks, and other bird species. Similarly, herbaceous vegetation along the channel slopes and banks may provide foraging habitat for seed-eating birds and rodents such as white-crowned sparrow, lesser goldfinch, mourning dove, pocket gopher, western harvest mouse, and house mouse, and may also provide cover and foraging habitat for reptiles such as western fence lizard, alligator lizard, and western terrestrial garter snake. Invasive non-native species—for example, giant reed, pampas grass, acacia, black locust, and tree-of-heaven—are also typically found along the channel slopes and banks. These invasive species adversely effect the establishment and growth of native riparian vegetation and reduce the value of the channels for riparian-dependent wildlife.

In segments where perennial freshwater wetland species or riparian scrub species are present, channels may provide cover and shade for resident and migratory fish. However, in most cases the general lack of woody overstory, and the resultant warm summer water temperatures, limit the value of these areas for many native fish species, notably steelhead and salmon. The presence of instream woody material—for instance, submerged logs and tree limbs—locally contributes to fish habitat values; in addition, channel segments that contain natural channel features such as pools and riffles may provide habitat for warmwater fish, including California roach, Sacramento sucker, and prickly sculpin.

Examples: Examples of unmodified channels located in the Urban Service Area that support sparse riparian woodland include the segment of Saratoga Creek that parallels English Drive north of Prospect Road, and Coyote Creek near Metcalf Road.

Unmodified Channel - Trees Abundant. Unmodified channels with a continuous or near-continuous canopy of riparian trees represent the category of riparian corridors with the most intact functions and the greatest habitat values (Table 3-9). This type of channel is also important as a source of instream woody material, which may be transported for significant distances downstream, and provides critical fish habitat wherever it is present. However, despite their relative abundance of functions and values, in many cases corridors with unmodified channels still present numerous opportunities for restoration. An important distinction among riparian corridors of this type is the width of the corridor. Wider corridors provide greater habitat values and functions than narrow corridors, and they also provide greater opportunities for restoration. For these reasons, the category "unmodified channel - trees abundant" is split into two types, distinguishing between channels with relatively narrow and relatively wide corridors of vegetation. Each type is described in a separate section below.

Unmodified Channel - Trees Abundant - Narrow Corridor. This category represents creek channel segments that have been not been excavated, realigned, or otherwise modified for flood protection or erosion control purposes, and which retain continuous or near-continuous cover of riparian trees. These channels are characterized by narrow bands (< 50 feet wide) of riparian woodland located along the channel banks and at the water's edge (Figure 3-10).

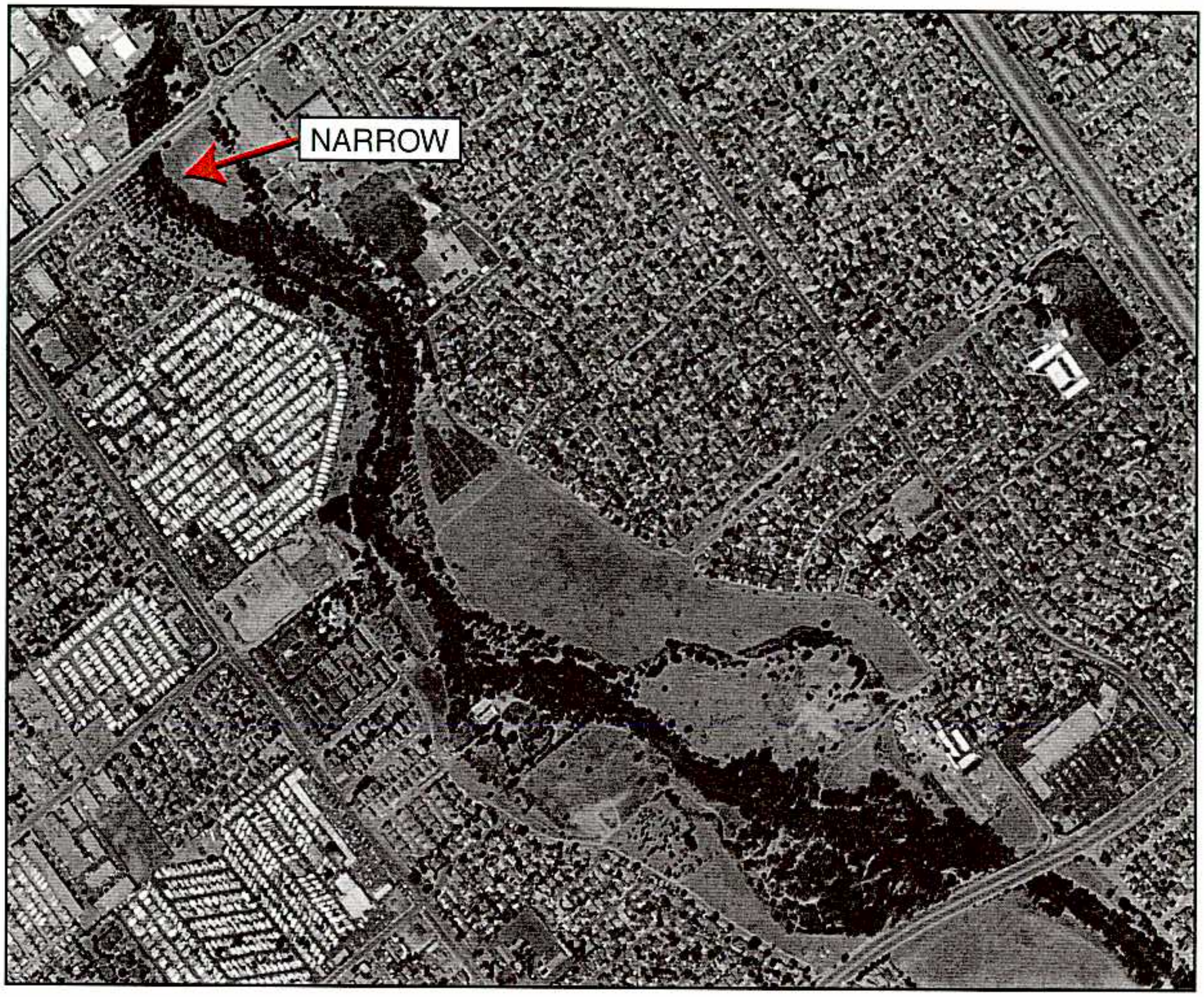
Habitat Values: The combination of tall riparian forest overstory vegetation and dense shrub understory vegetation associated with this type of channel provides greater habitat values for riparian-dependent wildlife and aquatic species than can be provided by highly modified channels or by unmodified channels that support less vegetation. However, because the riparian corridor associated with this channel classification is relatively narrow, these areas are likely to be subject to more disturbance than wider corridors because adjacent land uses are closer to the creek centerline. Non-native plants typically invade a riparian corridor along its edges, from neighboring back yards, roads or footpaths, and spread inward towards the creek. A narrower corridor is more susceptible to this type of invasion. In addition, where houses are found adjacent to riparian corridors, domestic pets can be an important factor in wildlife disturbance. If the corridor is narrow, pets are more likely to penetrate the entire corridor and harass or kill wildlife.

Ecologists commonly describe the susceptibility of native habitat to invasion or other disturbances based on a value called the "edge-to-area ratio." This is simply the length of the habitat's perimeter divided by the habitat's area. For the same length of stream, a narrow riparian corridor will have a higher edge-to-area ratio than a wider riparian corridor. Habitats with high edge-to-area ratios, such as narrow riparian corridors, tend to be less resistant to external disturbances and, in general, to support a lower native biological diversity.

Riparian forest and woodland areas along unmodified channel segments provide important habitat and resource for bird populations. Deciduous trees and shrubs found along streambanks are used by migrant birds (e.g., yellow-rumped warblers, cedar waxwings, and yellow warblers) for foraging during migration. Mature oaks and sycamores provide numerous cavities and snags for cavity-dependent birds such as woodpeckers. Oak trees also produce acorns, an important seasonal food for wildlife. Tall cottonwoods and sycamores provide roosting and nesting habitat for raptors, and streambanks provide nesting substrate for belted kingfishers.

Woody and perennial freshwater wetland vegetation that overhangs the channel or is rooted at the water's edge, along with instream habitat features including logs, undercut tree roots, pools, and riffles, all provide important escape cover, shade, and food for resident

Coyote Creek, view to south at Metcalf Road.



Aerial photo, Coyote Creek near intersection of Balfour Drive and Lone Bluff Way.

Figure 3-10a
Unmodified Channel
Trees Abundant - Narrow Corridor

Coyote Creek, view to northeast at intersection of
Balfour Drive and Lone Bluff Way.

Figure 3-10b
Unmodified Channel - Trees Abundant - Narrow Corridor

fish species like trout, and migratory fish species such as steelhead and salmon. In some channel segments remnant summer pools provide refugia for native warmwater fish, among them California roach, Sacramento sucker, and prickly sculpin.

Examples: Examples of creek segments located in the Urban Service Area that have not been modified and that support narrow bands of riparian woodland include: Los Gatos Creek from West Santa Clara Street to Meridian Avenue, and Coyote Creek from William Street to Wool Creek Drive.

Unmodified Channel - Trees Abundant - Wide Corridor. This category represents creek channel segments that have been not been excavated, realigned, or otherwise modified for flood protection or erosion control purposes. In general, these channels are characterized by relatively wide bands (>50 feet wide) of riparian forest along the channel banks and at the water's edge (Figure 3-11).

Habitat Values: Wide bands of riparian forest associated with this classification provide significantly higher habitat values for riparian-dependent wildlife and aquatic species than either highly modified channels or unmodified channels that support less vegetation. The wide band of riparian vegetation protects the physical and ecological integrity of the streamchannel by acting as a buffer against invasion by non-native and ornamental plants, disturbance by feral animals and domestic pets, and pollution by urban stormwater runoff. Because wide corridors have lower edge-to-area ratios than narrow corridors, they tend to be more resistant to external disturbances and are able to maintain a greater native biological diversity.

Deciduous trees and shrubs found along the channel banks are used by migrant birds (e.g., yellow-rumped warblers, cedar waxwings, yellow warblers) for foraging during migration. Tall cottonwoods and sycamores provide roosting and nesting habitat for raptors, and streambanks provide nesting substrate for belted kingfishers. Mature oaks and sycamores provide numerous cavities and snags for cavity-dependent birds such as woodpeckers. Oak trees also produce acorns, an important seasonal food for wildlife.

Woody and perennial freshwater wetland vegetation that overhangs the channel or is rooted at the water's edge, along with instream habitat features including logs, undercut tree roots, pools, and riffles, all provide important escape cover, shade, and food for resident fish species like trout, and migratory fish species such as steelhead and salmon. In some channel segments remnant summer pools provide refugia for native warmwater fish, among them California roach, Sacramento sucker, and prickly sculpin.

Examples: Examples of creek segments located in the Urban Service Area that have not been modified and that support wide bands of riparian forest include: Guadalupe Creek upstream of Masson Dam, and Coyote Creek from Capitol Expressway to Tully Road.

Aerial photo, Coyote Creek near intersection of Lone Bluff Way and Dakota Drive.

Figure 3-11a
Unmodified Channel
Trees Abundant - Wide Corridor

Coyote Creek, view to east at intersection of Lone Bluff Way and Dakota Drive.

4. Key Restoration Opportunities and Constraints

The following section provides an overview of factors in the City's Urban Service Area and Urban Reserves that provide opportunities for restoration, or that will impose constraints on restoration activities. These factors can be divided into two general categories: technical and non-technical. Technical opportunities and constraints include physical and/or biological considerations that may influence the selection of sites for restoration or the details of proposed site-specific restoration strategies. Non-technical opportunities and constraints comprise financial, political, institutional, social, and legal and regulatory issues and needs that may influence site selection or hinder the implementation of site-specific restoration projects. The opportunities and constraints summarized in this chapter provide the basis for the site prioritization and selection process discussed in Chapter 6.

Technical Opportunities and Constraints

Adjacent Land Use

Land uses adjacent to Urban Service Area rivers and creeks serve both to provide opportunities for riparian restoration and to impose constraints on restoration efforts. For example, where schools are located near area streams, it may be possible to involve teachers and students in restoration activities such as planting, weed control and monitoring. Restoration efforts can be incorporated into existing science curricula, or new programs can be developed in cooperation with interested school districts.

Publicly owned lands adjacent to creeks (e.g., schools, parks, and open space areas) offer important opportunities for realigning or modifying creek channels, and for establishing or widening riparian corridors. Potential restoration sites located near areas of public open space represent a special restoration opportunity. Restoration of sites located between two areas of existing open space may link open spaces and help to restore habitat connectivity along an urban riparian corridor (for additional information on this topic see the discussion of habitat connectivity under **Vegetation and Wildlife Habitat** below).

Different opportunities and constraints pertain where lands adjacent to area riparian corridors are privately owned. Privately owned properties abut directly onto a number of creeks throughout the Urban Service Area. Where property lines coincide with the creek channel, restoration efforts may be constrained by a lack of available land. However, where land is available, opportunities exist to conduct restoration in partnership with interested private landowners. In some cases, concerns with regard to liability issues associated with public access may represent a constraint on restoration efforts; the need for ongoing maintenance activities may pose a similar challenge. Finally, opportunities and constraints associated with private land ownership may change as ownership changes, complicating the long-term restoration planning effort.

Flood Protection

Because the San José area is highly urbanized, many of the City's creeks have been significantly modified—realigned, channelized, leveed, excavated, or regulated by dams and flow control structures—to protect adjacent properties from flood damage and to ensure a supply of high quality water for the City's residents. These modifications provide a spectrum of opportunities for riparian restoration. However, any planned restoration must be balanced by the constraint imposed by the need to maintain both flood protection and water supply for area citizens. For example, installing instream features such as boulders or logs to enhance fisheries habitat may decrease the capacity of the creek channel and increase the potential for flooding on adjacent and downstream properties. Conversely, restoration efforts that involve bank recontouring and/or the re-establishment of low floodplain terraces may increase channel capacity and reduce the potential for flooding, although of course restoration planners should consider any potential adverse effects on downstream properties that may result from local increases in channel capacity. Along a related line, restoration planners will also need to consider the potential impact of ongoing flood-protection maintenance programs on restoration sites.

The capacity of creek channels to convey floodflows varies considerably throughout the Urban Service Area (Figure 4–1). In general, creeks with limited capacity (those that can adequately convey flows ranging up to those expected from the 10-year flood) provide few opportunities for restoration of instream features or creekbank vegetation. However, these creeks do provide opportunities for other restoration activities, such as:

- removal of debris,
- control of invasive exotic species, and
- restoration of riparian vegetation on bank tops.

Creeks with the capacity to convey larger storm events (the 50- to 100-year flood events) provide a greater variety of restoration opportunities because in most cases restoration activities will not substantially reduce channel capacity or increase potential for flooding on adjacent or downstream properties.

Erosion and Sedimentation

Channel and flow modifications associated with the urbanization of the City of San José's streams have altered the way erosion and deposition of sediment occur in area creeks and rivers. For

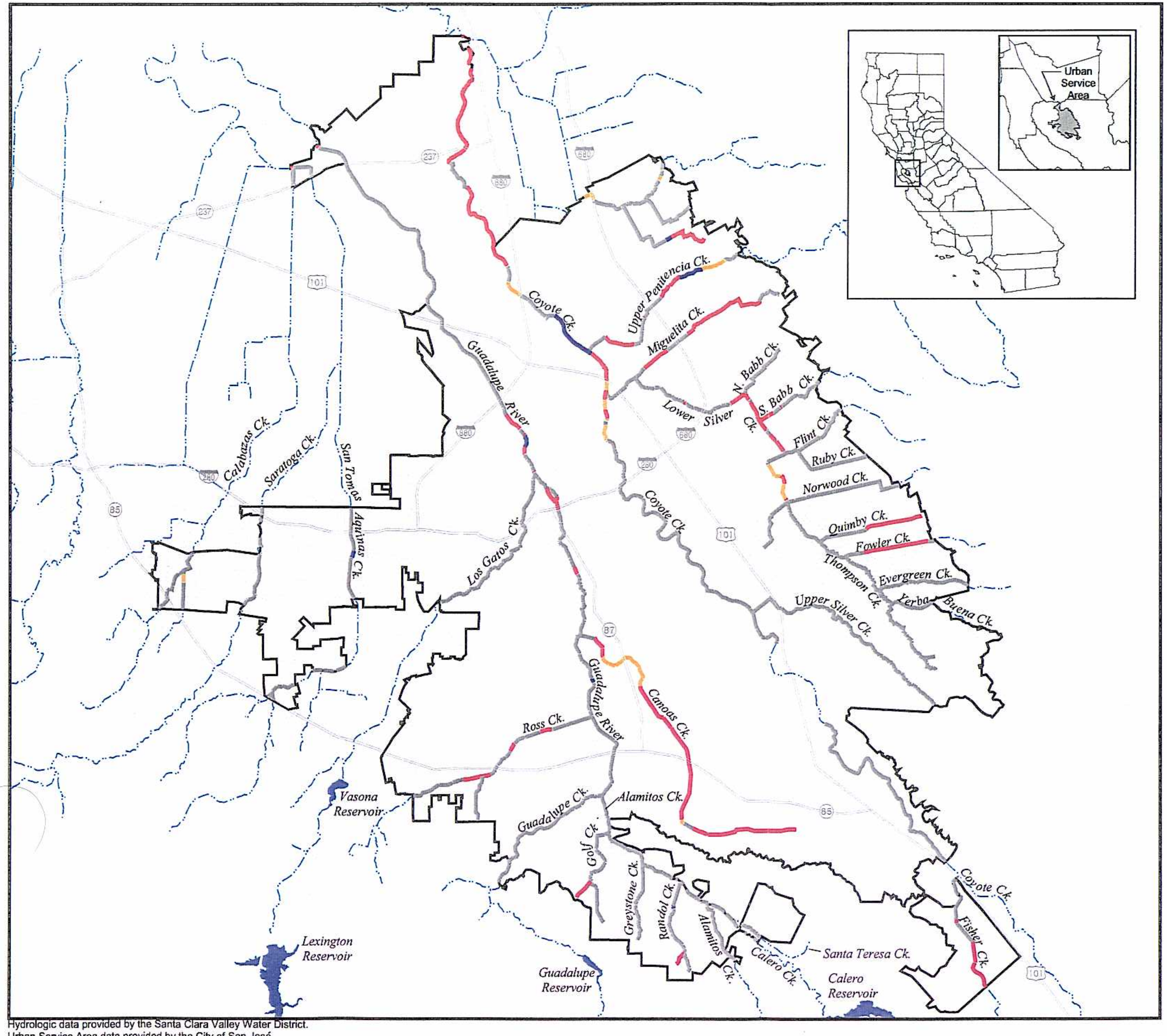


Figure 4-1

San José Riparian Restoration Action Plan

Frequency of Flooding on Rivers and Creeks in the San José Urban Service Area

Based on data provided by the Santa Clara Valley Water District

Legend

Flood frequency
- 0 - 10 years
- 11 - 25 years
- 26 - 50 years
- 51 - 100 years

- Urban Service Area boundary
- Freeways and highways
- Rivers and creeks
- Reservoirs

1 0 1 2 3 4 5
Scale in miles

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instance, dams and other flow control structures impound sediment on their upstream sides; as a result, water below the structure contains less sediment than it can carry, so it has excess energy. This "hungry water" will tend to erode an unprotected substrate. As another example, the steep, sparsely vegetated banks of many of the Urban Service Area's creeks are vulnerable to undercutting and slope failure during periods of high streamflow. High-velocity flows undermine the toe of the bank, resulting in slumping or sloughing of bank material. In other areas, where creekbeds have been cut into resistant bedrock, excess stream energy is directed toward the banks, causing the channel to widen significantly. Along some channel segments, receding bank slopes may jeopardize existing infrastructure such as roads, bridges, or underground utilities. In downstream areas where creek channels widen and/or channel slopes are reduced, flow velocities decrease rapidly, causing a significant decrease in the creek's sediment-carrying capacity and an increase in sediment deposition. While this is analogous to processes that occur in natural streams, accumulated sediment can reduce channel capacity, impair the creek's ability to convey high-volume flows, and result in flooding of adjacent and downstream properties during storm events.

Opportunities to reduce bank erosion and excess sediment remobilization can be found in creeks throughout the City's Urban Service Area. In some creek segments, modified channel cross sections can be altered to recreate floodplain terraces and to better define the low-flow channel. Floodplain terraces reduce bank erosion, increase channel capacity, and also provide opportunities for revegetation. A well-defined low-flow channel increases velocities under low flow conditions, improving the creek's sediment transport capacity. Areas with existing erosion problems may also provide opportunities for implementing biotechnical techniques that would stabilize stream banks and provide valuable wildlife and fisheries habitat. The Santa Clara Valley Water District's (District's) erosion-control focus areas, which represent creek segments that the District has targeted, based on a history of erosion, for future stabilization and erosion control activities, provide the basic framework for identifying these opportunities (Figure 4–2).

Vegetation and Wildlife Habitat

Because many of the creeks in the City's Urban Service Area have been extensively modified by past and present land use activities, the City's riparian corridors provide numerous opportunities for enhancing and restoring native riparian vegetation and improving the quality and diversity of wildlife habitat. Wildlife habitat values associated with a riparian corridor are strongly influenced by corridor width and habitat connectivity. Greater connectivity and increased width generally increase habitat values for riparian-associated wildlife species. In general, a wide, continuous band of native riparian vegetation provides habitat for a greater number and diversity of wildlife species than a narrow or highly fragmented corridor; a too-narrow corridor may create as significant a barrier to the movement of some species as would a complete gap in the corridor. Riparian vegetation restoration has the potential to increase the width of corridors, the size of habitat patches, and the overall continuity of riparian vegetation along the creeks of the Urban Service Area. Properly designed and managed restoration activities will benefit the Urban Service Area's populations of special-status species by expanding and linking potential habitat areas for these species. However, restoration planners should contact appropriate state and federal resource agencies early in the planning process to ensure that projected restoration activities will not adversely impact any special-status wildlife species while benefiting others.

Exotic Species

As a result of human activities, many invasive non-native species of plants and animals have been introduced into the Urban Service Area's riparian corridors. Non-native plant species displace native plant species by competing with them for limited water, nutrients, light and space, resulting in an overall decrease in species diversity and habitat quality. In addition, some non-native plant species grow so vigorously that they may reduce channel capacity; examples include water speedwell and giant reed (Figure 4–3). Introduced animal species, such as feral cats, may have an adverse effect on riparian ecology through predation on native species, or by competing with native species for food.

The widespread occurrence of exotic species in creeks of the Urban Service Area provides both opportunities for, and constraints on, potential restoration activities. For example, restoration efforts could focus on developing plans for removing existing populations of exotic species. Eradicating small existing populations would be a cost-effective strategy. However, because exotic species are widespread and are likely to reinvade riparian areas, ongoing monitoring and removal activities would probably be required. Efforts to control exotic species could be integrated with public education and outreach activities; this would help to reduce ongoing costs by educating the local community about the adverse affects of exotic species and involving them in efforts to control exotic species. Exotic-species control programs should also be integrated with restoration efforts that focus on establishing and managing native riparian vegetation and providing improved habitat for native fish and wildlife species. Prior to the establishment of new native plantings, exotics should be eradicated and an ongoing monitoring and control program implemented to prevent reinvasion of restoration sites. Once native trees become established on a restoration site, those with large canopies such as Fremont cottonwood and California sycamore may help to "shade out" and suppress some exotic species.

Non-Technical Opportunities and Constraints

Recreation

Many of the riparian corridors within the Urban Service Area are designated on the General Plan Scenic Routes and Trails Diagram as multi-use trail corridors (City of San José 1994). In addition, the County of Santa Clara has recently developed a Countywide Trails Master Plan (Santa Clara County 1995) for the greater Santa Clara Valley area, and the City, the County, and the District have collaborated to create a master plan for the development of Guadalupe River Park; documents related to these projects are available for public information through the County of Santa Clara.

Figure 4-2

San José Riparian Restoration Action Plan

Erosion Control Focus Areas

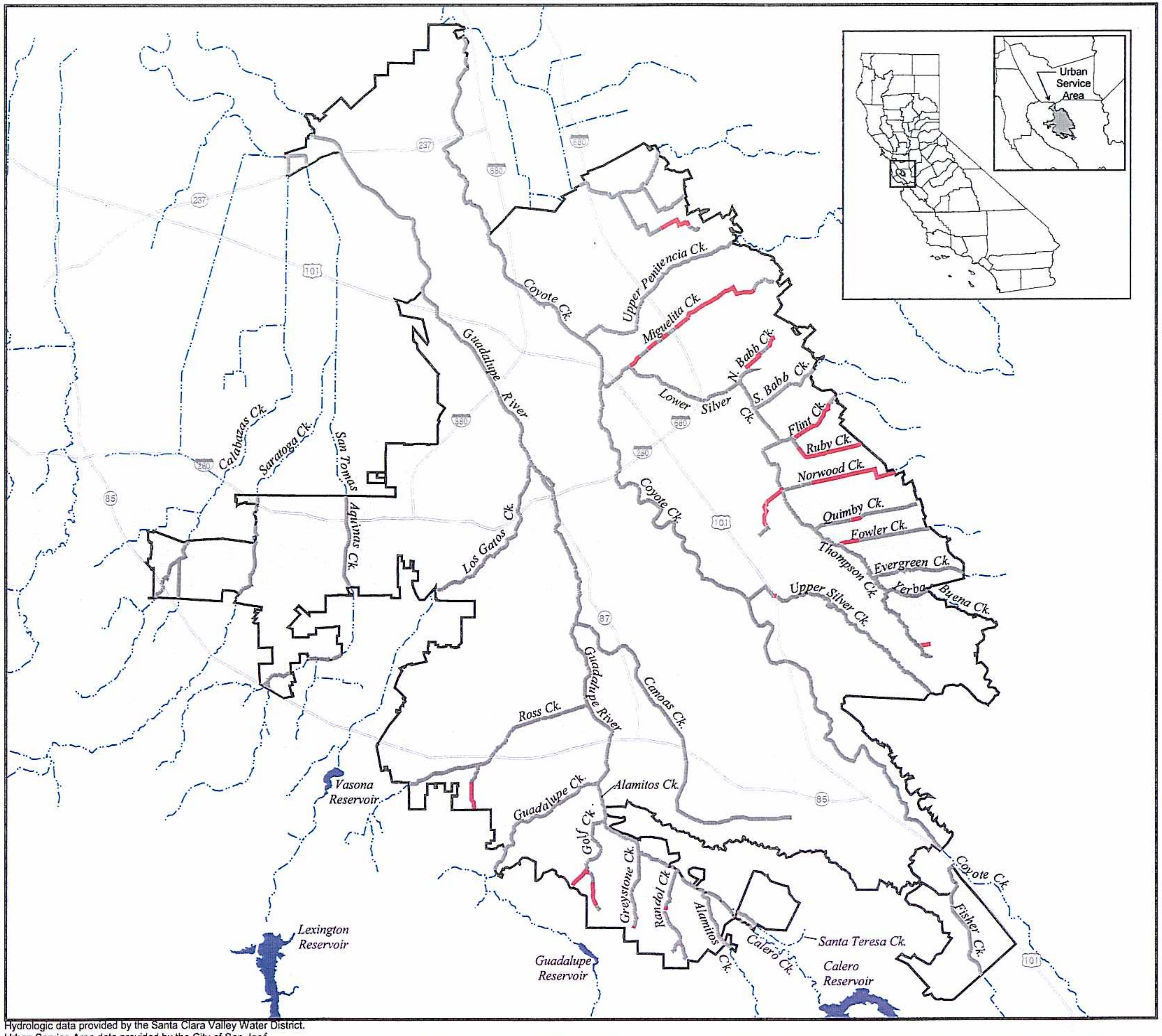

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Figure 4-3
Giant Reed *(Arundo donax)* in Los Gatos Creek

Finally, municipalities adjacent to the Urban Service Area have separate municipal trails plans.

The City's trail corridors are intended to accommodate pedestrians, bicyclists, and in some areas, equestrians as well. Portions of many of the trail corridors are already developed. Among their many public benefits, the City's trails existing and planned trails provide:

- passive recreation facilities to help promote exercise and healthier lifestyles;
- environmental education opportunities that can result in increased public awareness and appreciation of the natural environment, and a desire to protect it close to home;
- an alternative transportation mode that can reduce vehicular congestion and improve air quality; and
- a sense of civic identity and pride.

From a riparian restoration standpoint, public access and use of trails adjacent to riparian corridors can help build local support for restoration efforts, and can increase public awareness of the need to preserve and restore riparian habitat. Including public access and education as objectives of restoration projects can also increase opportunities to secure outside funding for project development and implementation. Restoration efforts often occur in conjunction with the construction of individual trail segments and can include active community participation. For example, the recent development of the Los Gatos Creek Trail between Blackford Elementary School and Meridian Avenue was planned in conjunction with a major community-based riparian restoration project of the Willow Glen Neighborhood Association (Slavit pers. comm.).

Both the San José General Plan 2020 (City of San José 1994) and individual trail master plan policies stress that the design, construction and management of trail corridors should be carefully executed in order to minimize environmental disturbance; preservation and enhancement of the natural environment is a dominant theme of the City's trail master plans. A major challenge presented by implementing a trails development program in an urban area is the need to achieve a balance between preserving the integrity of the creek environment and providing opportunities for public access and recreation. The selection of appropriate creek segments for integrating riparian restoration with public access and recreation should be based on site-specific considerations.

Both concentrated and dispersed recreational use of stream corridors may cause disturbance and ecological change. Foot and bicycle traffic can damage riparian vegetation, disturb riparian-dependent wildlife, and adversely affect water quality. Low streambanks or streamchannel pools can attract trail users, leading to the development of shortcuts and "informal" or "volunteer" trails, which increase bank erosion and sediment loading and have negative impacts on water quality and aquatic life. However, a number of measures can be implemented to minimize negative impacts, including:

- implementation of appropriate trail design and construction, including setback distance;
- use of barriers (barrier plantings of appropriate native species, or low fences);
- use of interpretive signage;
- active management and oversight of the City's trail system;
- regulation of the types and intensity of recreational use that occur; and
- implementation of a proactive maintenance program.

The City's Riparian Corridor Policy Study (City of San José 1994) contains specific guidelines limiting the intensity of recreational uses along riparian corridors. It also recommends methods for choosing appropriate trail locations and setbacks, and for designing and constructing trails and related amenities. The Uniform Interjurisdictional Trail Design, Use and Management Guidelines (Santa Clara County 1995) also contain specific guidelines designed to protect riparian lands.

Regulatory and Environmental Compliance

Each restoration effort has its own set of regulatory requirements, ranging from few or no requirements to a full spectrum of local, state, and federal regulatory permits and environmental compliance documentation. Restoration projects should be designed to meet or exceed all relevant local, state, and federal institutional and legal requirements. Local governments typically require contractors to obtain permits for:

- grading,
- excavation, and/or
- tree removal.

Depending on the project, restoration planners may also be required to comply with state and federal laws and regulations, including:

- the California Environmental Quality Act (CEQA),
- the California Endangered Species Act,
- the California Department of Fish and Game Streambed Alteration Agreement, and
- the federal Endangered Species Act.

Permits may also be required from the state Regional Water Quality Control Board, and from the U.S. Army Corps of Engineers, under Sections 401 and 404 of the federal Clean Water Act and Section 10 of the federal Rivers and Harbors Act of 1899. Chapter 6 of this document provides a summary of project features that would trigger the need for environmental or regulatory compliance; these requirements are discussed in greater detail in Appendix C. Restoration planners should contact the appropriate local, state, and federal agencies and involve them early in the planning process in order to ensure that all institutional and legal requirements are met.

Financial Issues

Not all restoration efforts are technically complex or require substantial financial investments. Some activities, such as removal of debris and control of exotic species, may depend heavily on volunteer labor and thus may involve only minor costs. Other activities, however, may require a substantial financial commitment because they are technically complex, or because they will require regulatory permits or environmental compliance documents.

The early phases of project planning must identify the level of funding necessary to complete the project successfully. If these early assessments determine that existing funds may be insufficient to accomplish the project, then the project sponsor has ample opportunity to identify alternatives for funding project completion. Alternatives may include:

- identifying alternative or additional sources of funding,
- identifying cost-sharing partners,
- identifying volunteer groups who could help to reduce labor costs,
- identifying sponsors who could provide support in the form of labor or materials,
- implementing the project in phases to reduce initial costs, or
- reducing the scale or complexity of the project.

Risk Assessment

Every riparian corridor restoration project involves a certain risk of failure, regardless of available funding, site and strategy selection, and the technical abilities of the project sponsor; risk assessment is particularly important for projects that require a significant investment of financial resources or that are controversial or highly visible within the local community. The primary source of risk is the variability associated with any natural system. For example, if native vegetation is planted along a channel with the capacity to convey flows associated with the 50-year flood event, and the vegetation requires 3 to 5 years to become established, there is a certain risk (which can be calculated) that a flood equal to or greater than the 50-year event will occur during the establishment period and that the restoration plantings will be destroyed. Additional risks are associated with the highly urbanized nature of the Urban Service Area. Restoration projects may be adversely affected by public access and recreational use, or by factors associated with adjacent land uses, such as illegal dumping, effects of urban stormwater runoff, impacts associated with domestic pets and feral animals, etc.

Public Involvement and Education

Throughout the urban service area, many opportunities exist for increasing public awareness of creek processes, water quality issues, and the importance of riparian habitat as a community resource, and for enhancing the participation of community groups in riparian restoration activities. The District currently operates an Adopt-a-Creek program that involves local schools, community organizations, and private companies in creek clean-up projects throughout Santa Clara County. The District also operates the Creek Connections Program, an action-oriented partnership of local government, nonprofit and environmental organizations whose shared goal is to engage volunteers in preserving and protecting the waterways of Santa Clara County. Both of these programs offer opportunities to build upon existing volunteer programs and combine resources in order to sponsor and implement community-based restoration activities. These programs also provide opportunities for involving the local community in post-restoration monitoring activities and for incorporating restoration into public school curricula. Ideally, all riparian habitat restoration projects should be viewed as opportunities for public education and involvement.

Riparian Restoration in a Larger Context: Mitigation Credits and Community Participation

The creeks of the City's Urban Service Area offer a range of opportunities for establishing riparian habitat that could be used to provide "mitigation credits" offsetting the environmental impacts associated with future flood protection or channel maintenance activities carried out by local agencies such as the District. District-sponsored habitat restoration projects would also provide excellent opportunities for collaboration between the District and interested neighborhood groups or organizations, in addition to those discussed in the preceding section. The District would provide the technical expertise and the financial resources necessary to plan and implement restoration projects; in exchange, neighborhood groups would provide the necessary labor. This approach has several advantages, including

- restoring habitat functions and values in advance of project-related impacts elsewhere in the Urban Service Area (rather than playing "restoration catch-up" after impacts have taken place),
- establishing habitat to provide mitigation credits for future projects, and
- providing additional opportunities for neighborhood groups to participate in valuable restoration activities.

Additionally, there opportunities may exist for the District, the City and other local agencies to establish a broader program that would a create a "bank" of riparian mitigation credits that could be withdrawn to offset impacts incurred as a result of flood protection, channel maintenance, or development activities. The establishment of a mitigation banking program would require close coordination between local agencies and the relevant state and federal resource and regulatory agencies to be effective.

Although the specific details of establishing these types of mitigation programs are beyond the scope of the RRAP, the programmatic and site-specific strategies for identifying and prioritizing restoration opportunities presented in Chapter 6 provide a basic framework that local agencies and neighborhood groups can use to identify and set priorities for establishing riparian mitigation credits within the Urban Service Area.

Desired Future Conditions

The desired future condition for a riparian restoration site is typically determined on the basis of:

- reconstructions of pre-development conditions based on historical photos and descriptive accounts, or
- studies of the structure and function of nearby riparian corridors that have been minimally disturbed by natural or human factors, or
- some combination of the above.

The ideal desired future condition for a site may be pragmatically unattainable because of physical, ecological, political, or economic constraints. This is especially true for riparian restoration projects planned for creeks within the Urban Service Area, where urban development and the need to maintain existing levels of flood protection place severe constraints on attaining pre-development or "natural" conditions. In most cases, the ability to attain these desired future conditions will be severely limited by existing stream corridor conditions (as described in Chapter 3), technical considerations, and funding levels.

Chapter 5. Restoration Strategies

Introduction

This chapter presents a broad range of restoration strategies and techniques that could be incorporated into site-specific restoration designs in order to achieve the City-wide goals of the Riparian Restoration Action Plan. The chapter begins with overviews of commonly used strategies, including the settings in which they are most effective, and any caveats which should be observed, and then briefly discusses the evaluation of cost and cost-effectiveness. The strategies are organized into three broad categories:

- technical strategies,
- education and outreach strategies, and
- legal strategies.

This chapter is not intended to furnish an exhaustive catalog of restoration techniques, nor is it intended to provide the level of detailed guidance necessary for actual implementation of the strategies described. Design plans, construction specifications, and implementation guidelines should be developed for individual projects on a site-specific basis, taking into account specific restoration goals for the individual site, site conditions, the project budget, and available resources. Depending on the complexity of any given project, an appropriate multi-disciplinary team of experts should be assembled to assess site-specific challenges and to design and implement feasible solutions. Among others, these teams might include physical and biological scientists, engineers, planners, and legal experts.

In order to be most effective, restoration strategies should be chosen and implemented as part of a river- or creekwide plan for restoration of specific functions and values to a riparian corridor. Some strategies may have substantial effects upstream and downstream from a restoration site; these effects must be considered when planning restoration. Implementing a strategy at a single site without considering its broader systemwide implications may result in a short-lived, ineffective fix, or may exacerbate problems up- or downstream. Therefore, strategies should be selected from the broadest perspective possible.

Overview of Selected Restoration Strategies

Technical Strategies

Technical strategies are those that physically change the riparian corridor. Technical strategies commonly depend on the application of specialized knowledge in a scientific discipline (e.g., ecology, hydrology, engineering, botany, horticulture), and in many cases, they require technical designs or planning. They may or may not require special skills to implement. For example, implementing some of the simple 'technical' strategies such as debris removal, fence installation, and construction of wildlife nesting boxes requires little specialized skill.

Technical strategies are divided into four categories, based on the location in the corridor cross section where the strategy is implemented and on the scale at which the strategy is most effective. A distinction can be made between strategies that are implemented instream and those which are implemented on the streambank or streambanks. Similarly, it is important to differentiate between strategies that must be implemented along an entire reach or segment of a stream in order to be effective ("reach-scale" strategies) and those that can be successfully implemented on a very localized basis ("site-specific" strategies). The four categories of possible strategies are:

- instream reach-scale strategies,
- streambank reach-scale strategies,
- instream site-specific strategies, and
- streambank site-specific strategies.

The following sections discuss each category of strategy in more detail. Within each category, strategies are discussed in the sequence in which they would typically be implemented. Note that, although some strategies may fit into two or more categories, each is described only once. Schematic diagrams are provided to illustrate many of the techniques throughout the chapter; they are referenced by figure number in the appropriate text section.

Instream Reach-scale Strategies

Reconstruct the Channel. Channel reconstruction is a broad term for any technique meant to alter the cross section or course of a stream. Modified creek channels commonly have uniform beds and provide little, if any, habitat for fish and aquatic macroinvertebrates. By contrast, creeks whose channels more closely approach natural streamchannel configurations (with bends, bifurcations, etc.) provide better aquatic habitat in the form of a more varied channel bottom, deeper pools, a greater range of flow velocities, and a higher quality of riffle environments. The water in these creeks also carries less suspended sediment, improving habitat for fish and invertebrates. Modifying the channel to include greater channel variability can thus improve both habitat quality and water quality. Channel reconstruction can be accomplished in several ways. Three common examples are provided below.

Recreate Meanders: Recreating meanders, or bends, in the streamchannel involves excavating a new channel for a previously modified stream. This usually requires heavy equipment and consultation with geomorphologists, stream hydrologists, and an experienced grading contractor. However, transforming a straightened stream into a meandering one reintroduces natural dynamics, and improves habitat quality, aesthetics, and other stream corridor functions and values.

"Daylight" Covered Channels: Daylighting is the restoration of a surface stream channel or wetland by unearthing a stream that runs in a pipe or culvert. Erosional damage is common at both the upstream and downstream ends of culverted streamchannel segments. Daylighting not only helps to restore the natural hydraulic functions of a streamchannel, but can also improve a site's aesthetic and habitat values.

Create or Enhance a Low-Flow Channel: A low-flow channel is a narrow channel in the streambed that confines streamflow during periods of low water volume. A constructed low-flow channel is analogous to the thalweg, or deepest portion, of a natural streamchannel. A low-flow channel can be created or enhanced by excavating small channels within the larger streambed. The low-flow channel will reduce water ponding and stagnation at low flow, which in turn will decrease channel siltation and thus improve both water quality and habitat values. Techniques for creating low-flow channels are described below under ***Reconstruct the Channel***.

Manage Streamflow and Sediment Budget. Many restoration options involve managing streamflow velocity and variability, and/or the budget of sediment supplied to and carried by a stream. The following sections discuss these issues in more detail.

Modify Streamflow: Many urban streams are impaired as the result of alterations in the amount or variability of streamflow. If the amount of impervious cover in a watershed increases, storm runoff may increase greatly. On the other hand, diversion or impoundment of water upstream may significantly reduce the amount of water in a channel. Upstream impoundment can also greatly affect the variability of streamflow; dams in particular may either increase or decrease flow volume and variability, depending on the management of dam releases. This in turn may have implications for water temperature. For example, dam releases that create more constant flows in a stream may contribute to constant stream temperatures. Some native organisms in the stream may be dependent on temperature variation through their life cycle; for instance, larvae may prefer warm temperatures while adults prefer cold temperatures. Such organisms would decline if stream temperature remained constant.

Thus, many stream functions can be enhanced by altering streamflow to more closely mimic natural flow volume and variability. Altering streamflow can be accomplished in a number of ways that range from the simple (e.g., altering upstream reservoir management) to the complex (e.g., manipulating watershed features such as land use, amount of impervious cover, or systemwide impoundment practices). Further, if planned streamflow modifications involve stream augmentation, they will only be possible to the extent that stream capacity can accommodate the increased flow.

Create Sediment Basins: In a natural stream system, the streambed is composed of sediment—boulders, cobbles, gravel, sand and mud—except where the stream cuts into bedrock; even segments of a natural stream with a bedrock "floor" may have veneer of loose sediment in places. A significant percentage of a natural stream's energy is expended in transporting the sediment supplied to it by its tributaries and by overland runoff. Coarser sediment particles are rolled, slid or bounced along the streambed (bedload). Finer particles may be suspended in the water column (suspended load). As a general rule, a faster-moving stream can carry larger particles. Similarly, the total amount of sediment a stream can carry is related both to the velocity of streamflow and to the volume of water in the stream. As flow velocity and available energy fluctuate, sediment may be temporarily deposited on the streambed, or eroded from it; flood events will also deposit and/or erode sediment in floodplain areas.

Sediment is a critical component of a healthy stream ecosystem. In both undisturbed and modified streams, sediment provides a substrate and nutrients for the growth of aquatic plants, and is thus important in supporting the aquatic food chain. However, excessive sediment can impede the functions and habitat values of a stream system. Large amounts of suspended sediment can cloud the water, reducing light penetration, and can clog fish gills, reducing habitat quality. Excessive sediment deposited in the streambed can severely reduce the channel's capacity to convey streamflow, increasing the risk of flooding; this is a common occurrence in modified streams which receive more sediment than they can transport.

A sediment basin is constructed to trap sediment transported by the creek before it damages aquatic habitat or is deposited in an undesirable location. Sediment basins are usually created by increasing the channel cross section, reducing the channel slope, or both. These alternatives have the same effect: reducing the velocity of flowing water so that sediment will be deposited in a controlled location. Coarse materials (boulders, cobbles, and gravel) are typically deposited first, as the flow decelerates; fine suspended load settles out as the water becomes stagnant.

Streambank Reach-scale Strategies.

Control Populations of Invasive Non-Native Species. Invasive non-native species can substantially degrade existing riparian habitat. Non-native species pose a serious threat to the successful establishment and survival of native vegetation planted as part of a restoration project, by competing with the natives for limited water, nutrients, light, and space. Invasive non-native species should thus be removed to enhance existing habitat, or to prepare a site for restoration planting. Removal should begin in the headwaters, and proceed downstream.

Depending on the species, plants can be eradicated by removal, by the use of herbicides, or through a combination of removal and herbicide applications (see Table 6-3). Because many invasive species are common in the City's Urban Service Area, and will likely re-colonize a site, they will require periodic removal throughout the life of the restoration project. The frequency of removal necessary depends on which species are present, on the severity of infestation, and on various other site conditions.

Fill Gaps in Existing Riparian Corridors. The width, length, and connectivity of areas of riparian vegetation are critical to habitat functions within the corridor and in adjacent ecosystems. Increasing the width, length and connectivity of habitat areas is an important landscape goal that should be applied to entire creeks, rivers, or watersheds. Increasing the linear extent of riparian vegetation along a creek will increase the numbers and diversity of fish and wildlife in and near the creek. For example, filling gaps in riparian tree cover will increase the amount of shaded riverine aquatic (SRA) cover. Greater SRA cover reduces stream temperatures and improves the aquatic habitat for many fish. Increasing the width of riparian habitat also increases the amount of habitat available to wildlife. Some species of wildlife require riparian areas of a certain width in order to breed and reproduce successfully. The width of habitat required varies with species and with factors related adjacent land use—e.g., amount and type of adjacent upland habitat, amount of noise or other disturbance nearby—but in general wildlife species diversity increases with riparian corridor width.

Habitat extent and connectivity are also important for regional wildlife diversity and for regional dispersal of wildlife. Many species of wildlife that are not specifically dependent on riparian vegetation use riparian corridors to disperse between upland sites. Connecting patches of riparian vegetation increases the overall connectivity of the habitat system and thus increases the value of riparian areas as regional wildlife corridors.

Instream Site-Specific Strategies

Reduce Channel Erosion, Construct Grade-Control Structures. Channel erosion can be a serious problem for flood protection, for the quality of instream aquatic habitat, and for the stability of streambank terrestrial habitat; in highly constrained channels with narrow banks, reducing channel erosion is also critical to maintaining substrate and nutrients for riparian vegetation. Instream grade-control structures such as keyed rock drop structures (Figure 5-1) are used to stop headcutting, to improve bank stability, and to build up bed elevations in unstable or incised channels. These structures are typically composed of rock, wood, or other materials that are placed across a channel and anchored in the streambanks. They provide a hard substrate that resists scour and prevents upstream bed erosion. These structures are sometimes constructed with artificial "scour holes" on their downstream sides; along with the upstream pool areas created by the structures, these can provide improved habitat for aquatic species.

If grade-control structures are designed or constructed improperly, they have the potential to become barriers to fish passage at low flow. Improper design of such structures may also result in further channel destabilization, causing the stream to widen so that it attacks and substantially erodes its banks. Therefore, grade-control structures must be used with a thorough understanding of possible consequences, and should be designed in consultation with engineers and stream hydrologists. Additional techniques for controlling erosion are listed in this section under ***Create or Enhance Instream Cover***, and in the next section, under ***Construct Biotechnical Bank Stabilization***.

Remove Debris from the Streamchannel. Debris such as trash, garbage and dumped waste can deflect streamflow and cause significant bank erosion, impede streamflow, increase the chance of localized flooding, restrict or delay the passage of migrating anadromous fish during periods of low flow, and reduce water quality. Removing debris from creek channels can help to:

- restore the ecological and aesthetic values of urban waterways,
- reduce water-quality impacts on aquatic resources, and
- maintain existing levels of flood protection.

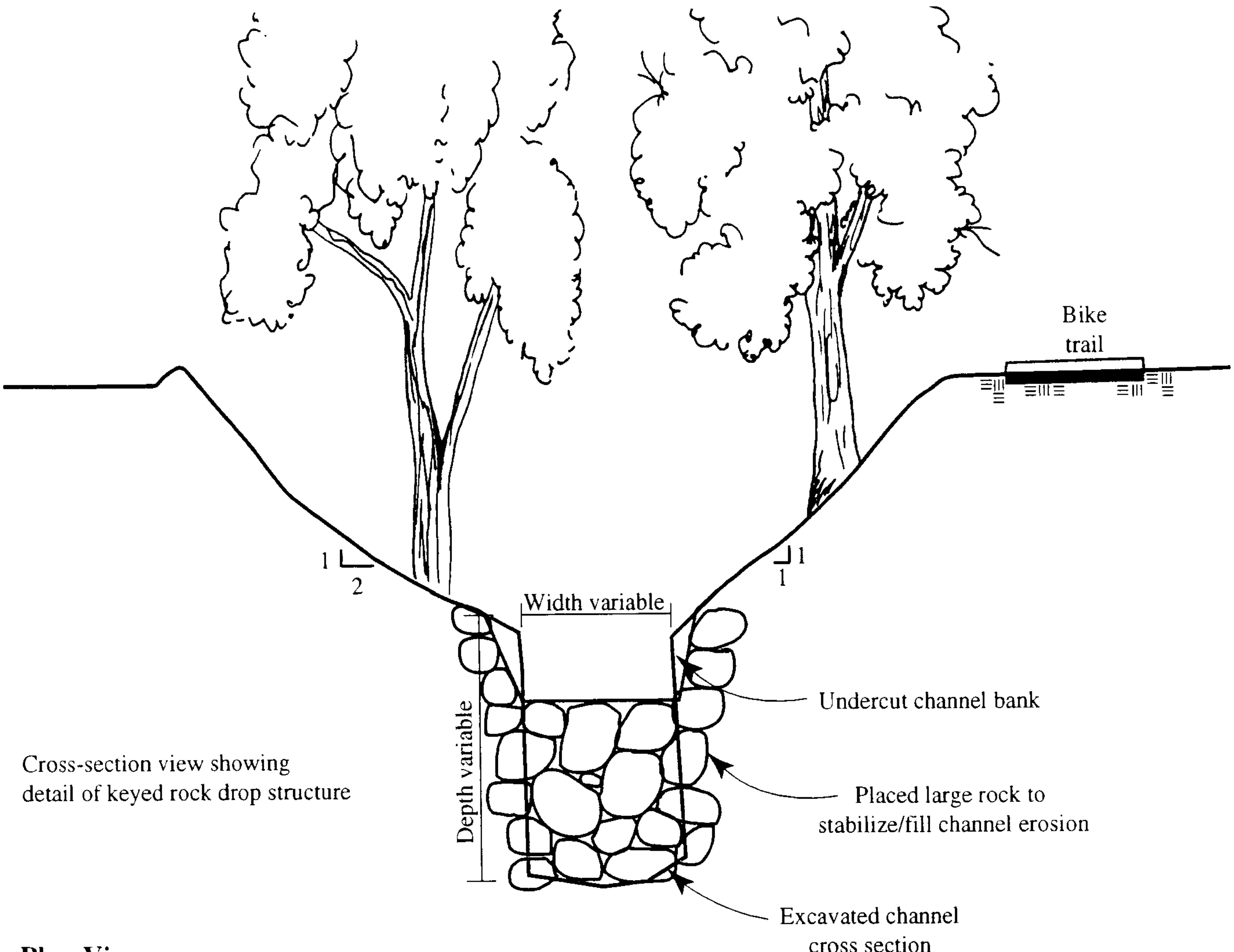
Improve Fish Passage. Instream features such as logs, debris, diversion structures, sills, low-flow vehicle crossings, drop structures, and culverts can be obstacles to up- and downstream passage of fish. If necessary, these barriers can be removed or modified to improve fish passage. For example, construction of

- fish ladders,
- weirs and fishways,
- fish bypasses,
- culverts,
- baffles,
- risers, and
- escape channels

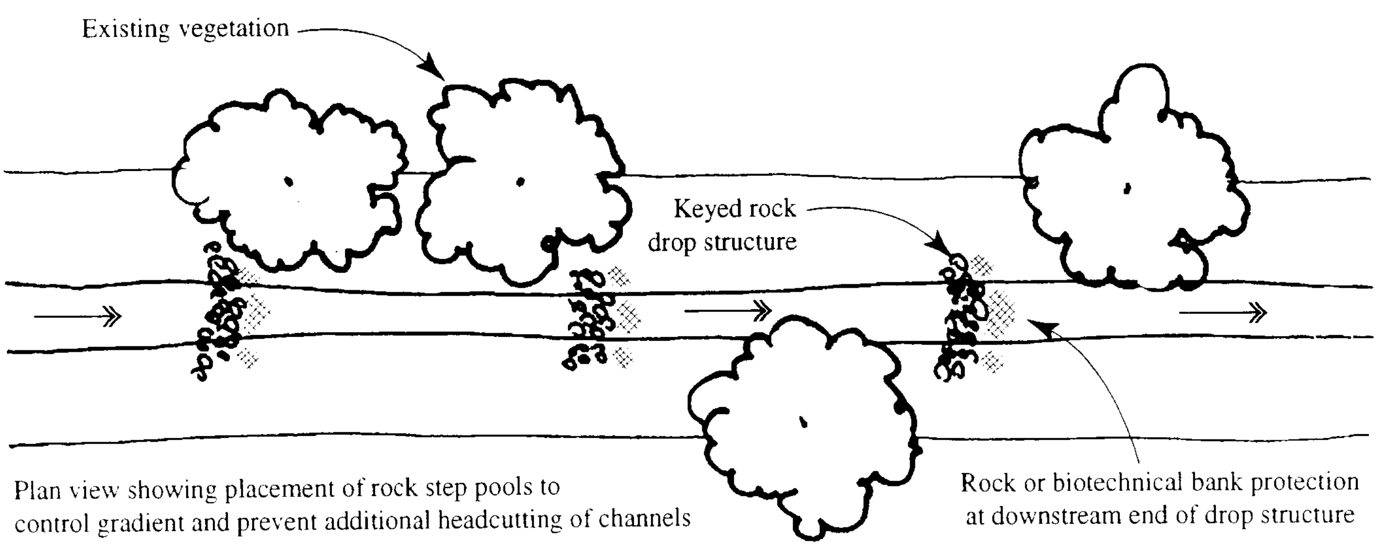
can facilitate upstream migration of adult salmonids and downstream migration of smolts. In addition, even where existing structures were designed to allow or facilitate fish passage, they may require structural improvements to function effectively over a wide range of flows. To ensure optimum performance, all structures require periodic inspection and cleaning to remove silt and debris.

It is important to consider that structures may have beneficial effects on some wildlife species and detrimental effects on others, or they may have detrimental effects on some species, but an overall beneficial effect on the environment. For instance, in some streams barriers which obstruct passage of native fish also impede movement of undesirable exotic species, and are useful in promoting bed scouring and sediment sorting. These obstructions can also create important backwater habitat, increase input of organic material, serve as a refuge for assorted species, help regulate water temperature, and oxygenate water. Thus, because the action may be irreversible, complete removal of obstructions should be carefully evaluated based on the larger restoration goals for the site and the Urban Service Area as a whole. To minimize undesirable effects, obstructions with beneficial effects should be removed in conjunction with the implementation of additional restoration strategies.

Cross-Section View



Plan View



Note: Drawing is conceptual and is not intended for construction use.

No scale

Jones & Stokes

Figure 5-1
Channel Stabilization

Prevent Fish Stranding. Fish may become stranded if they stray into side channels, ponds with narrow openings, or diversions. To prevent stranding, fish screens or other barriers can be installed to block such offstream areas. Screens or other barriers should be designed to minimize debris or sediment build-up and should be maintained regularly to ensure their effectiveness.

Augment Fish Spawning Gravels. Many anadromous fish require a coarse gravel substrate to spawn. However, factors in many modified streams reduce the quality and extent of spawning gravels. Below reservoirs, gravel is commonly depleted by channel scour, channel armoring, and blockage of sediment by the dam. Bank erosion and sediment deposition can also deplete spawning habitat.

Gravel augmentation can be an effective strategy to improve habitat for fish spawning. A variety of techniques are available, including:

- loosening armored substrate,
- maintaining and enhancing gravel recruitment in major spawning areas,
- artificially introducing spawning-sized gravel on a continuous basis, and
- creating riffles engineered and constructed with graded gravel.

To ensure success, gravel substrates should be monitored. Gravel markers such as colored granite can be used to track gravel persistence and movement in the system.

Create or Enhance Instream Cover. A variety of techniques can be used to increase instream cover and narrow stream channels to ensure that water depths necessary for fish passage are maintained. Selected techniques that might be appropriate for use in streams of the City's Urban Service Area are described below. Because all of these techniques have the potential for adverse impacts if incorrectly implemented, all should be designed and constructed in consultation with stream hydrologists, hydraulic and civil engineers, and fisheries biologists.

Biotechnical Bank Stabilization: This technique is described in detail in the section titled ***Streambank Site-Specific Strategies*** below. Boulders, root wads, and logs used for bank stabilization can improve fish habitat (Figure 5-2). When water levels are high, these structures provide instream (submerged) cover for fish and their prey. Deep scour pools may form around these structures, further enhancing habitat diversity.

Weirs: Weirs use strategic placement of boulders or other material to concentrate flow toward the center of the channel. Flow concentration causes flow velocity to increase, increasing both sediment transport and erosion. Scour holes are created immediately downstream from a weir; this provides a place for fish to rest. Commonly used types of weirs include vortex rock weirs (Figure 5-3), W-weirs (Figure 5-4), and log weirs.

Deflector Logs: Deflector logs are placed on opposite sides of the channel, either directly across from one another or in an alternating pattern, with the upstream ends of the logs keyed into the channel bottom and their downstream ends keyed into the bank above the bankfull water level (Figure 5–5). Deflector logs serve to focus flow into the center of the channel in order to create a low-flow channel and reduce stress at the bank toe and the water's edge. This reduces bank erosion, and by concentrating flow, helps to regulate water temperature. Deflector logs also provide resting areas for fish in small pockets of backwater created behind the logs.

Rock Vanes: Rock vanes are constructed of boulders placed in a line at an angle to the bank (Figure 5–6). Individual vanes are located on opposite sides of the channel in an alternating pattern. They direct flow toward the middle of the channel, narrowing the effective channel width and promoting the development of a low-flow channel and channel meanders. Rock vanes also help to prevent bank undercutting.

Boulder Wing-Deflectors: Boulder deflectors are triangular in plan view and are keyed into the streambank; they can be used either in pairs (placed on opposite banks directly across from one another) or alone. Boulder deflectors protect the bank by directing flow to the center of the channel, and enhance aquatic habitat by creating scour pools in the center of the channel and areas where fish can rest in quiet water downstream.

Streambank Site-Specific Strategies

Streambank protection measures should be designed to preserve existing riparian habitat, to support riparian habitat restoration, and to protect the visual quality of the riparian corridor. These measures include techniques that can be implemented in areas of significant bank erosion. Streambank protection techniques that might be appropriate for specific sites in the City's Urban Service Area are described below.

Remove Hardscape. Concrete and riprap are intended to armor streambanks and prevent natural erosional processes from operating. However, hardscape (including both concrete and riprap) typically provides a very localized fix, and may exacerbate erosion and channel stability problems in the adjacent downstream reach. Moreover, hardscape reduces aesthetic values while providing little or no habitat for riparian-dependent wildlife. An alternate strategy for erosion control is to replace concrete and riprap with aggressive biotechnical structures such as boulders, root wads, and logs, creating biotechnical bank stabilization (see below). These semi-natural structures effectively reduce streambank erosion and have the added benefit of providing terrestrial wildlife habitat, improving instream habitat, and greatly enhancing aesthetic values.

Construct Areas of Biotechnical Bank Stabilization. Biotechnical bank stabilization is a term used to describe a family of techniques designed to stabilize streambanks using natural and semi-natural materials such as rocks, wood, and live plants. Biotechnical bank stabilization was developed based on the principle that engineering goals and revegetation goals could be met simultaneously. As a result, biotechnical techniques combine basic engineering principles and practices with revegetation science applications. They are typically used where bank stability and maximum flood protection are critical.

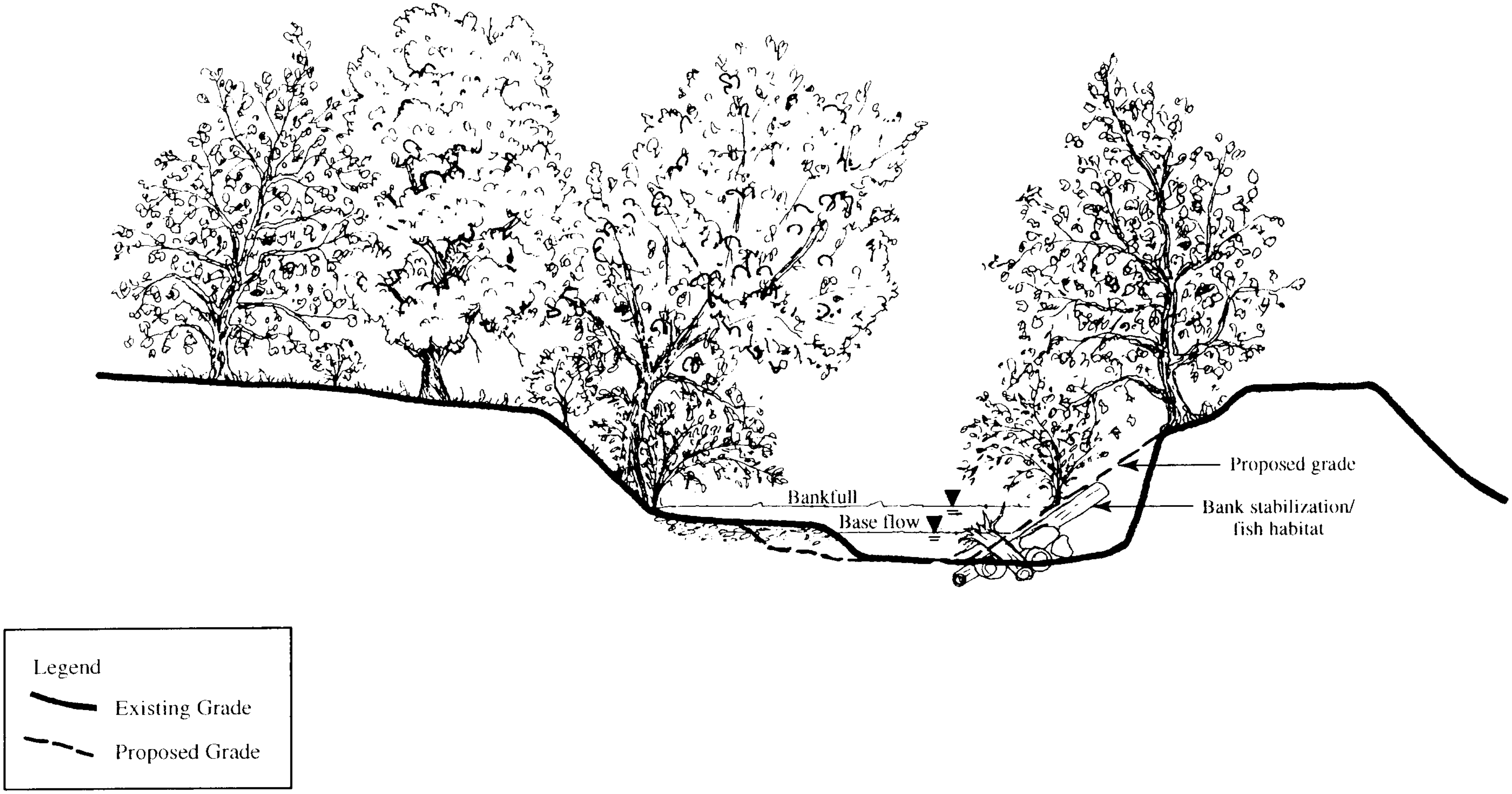


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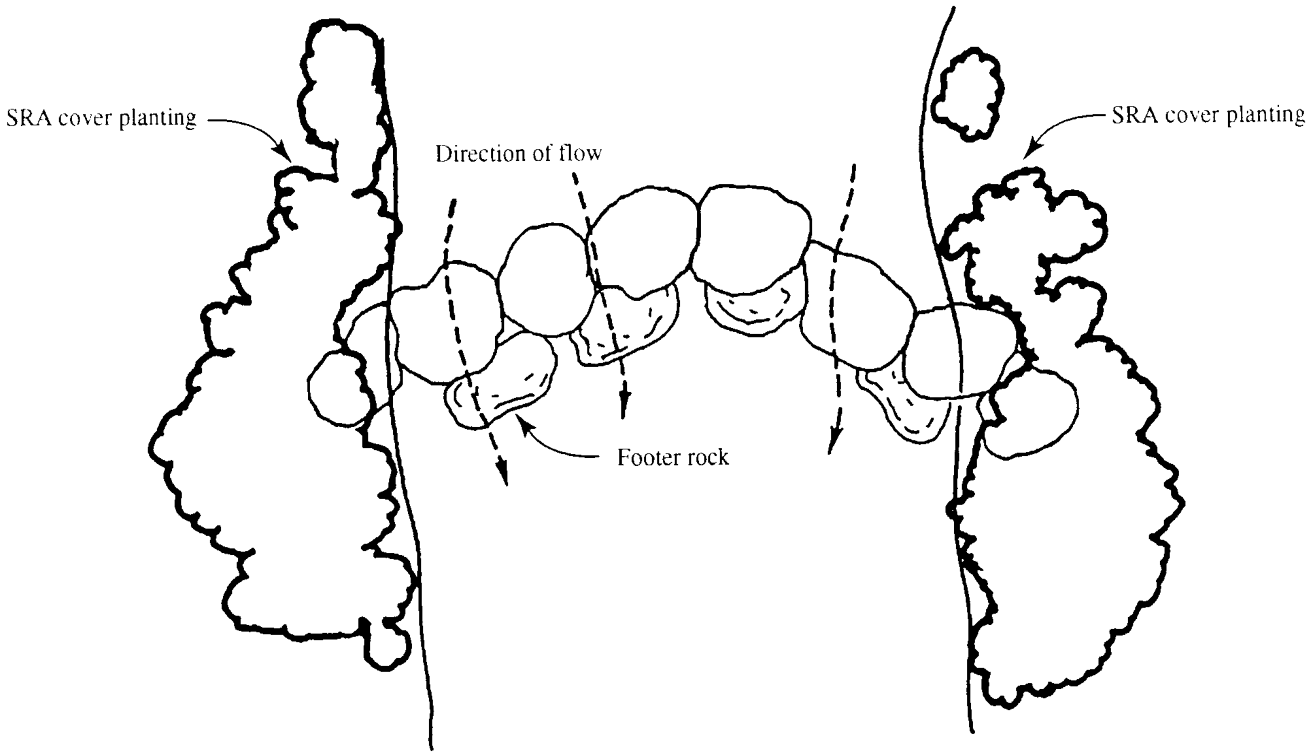
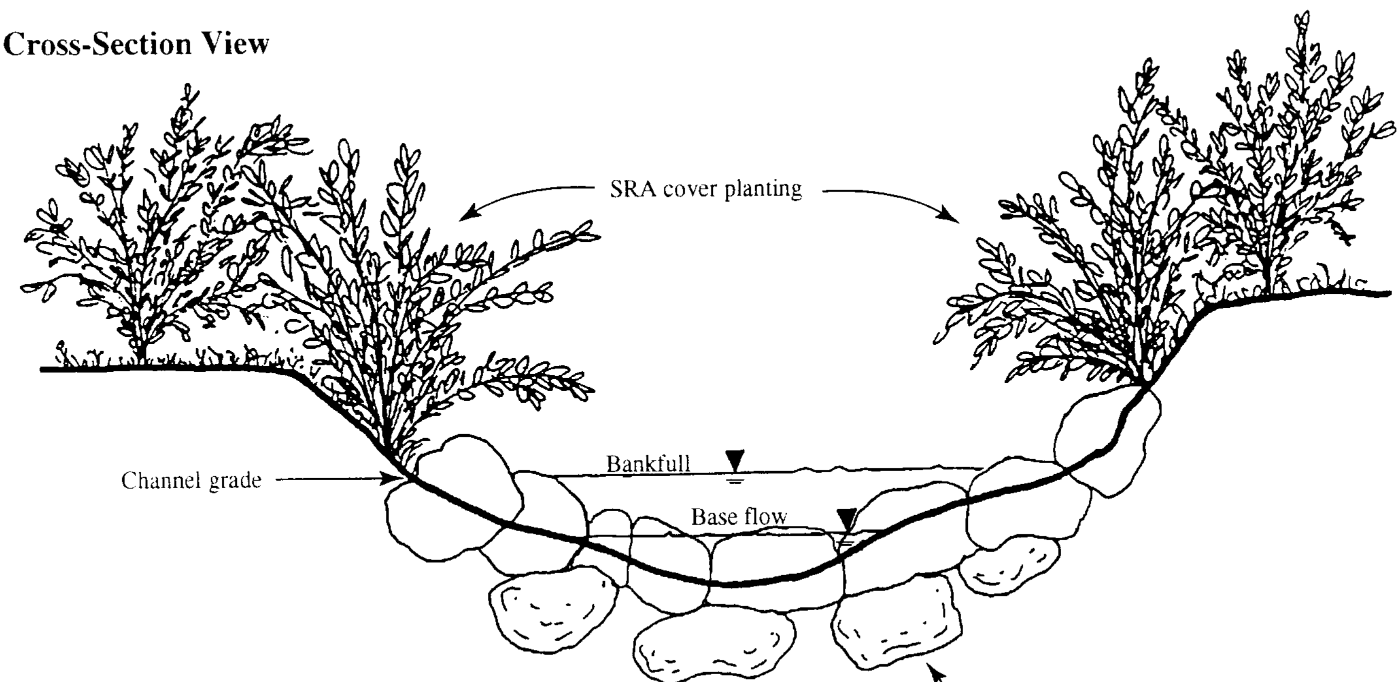
Figure 5-2
Biotechnical Bank Stabilization

Plan View



Cross-Section View



SRA = shaded riverine aquatic

Note: Drawing is conceptual and is not intended for construction use.

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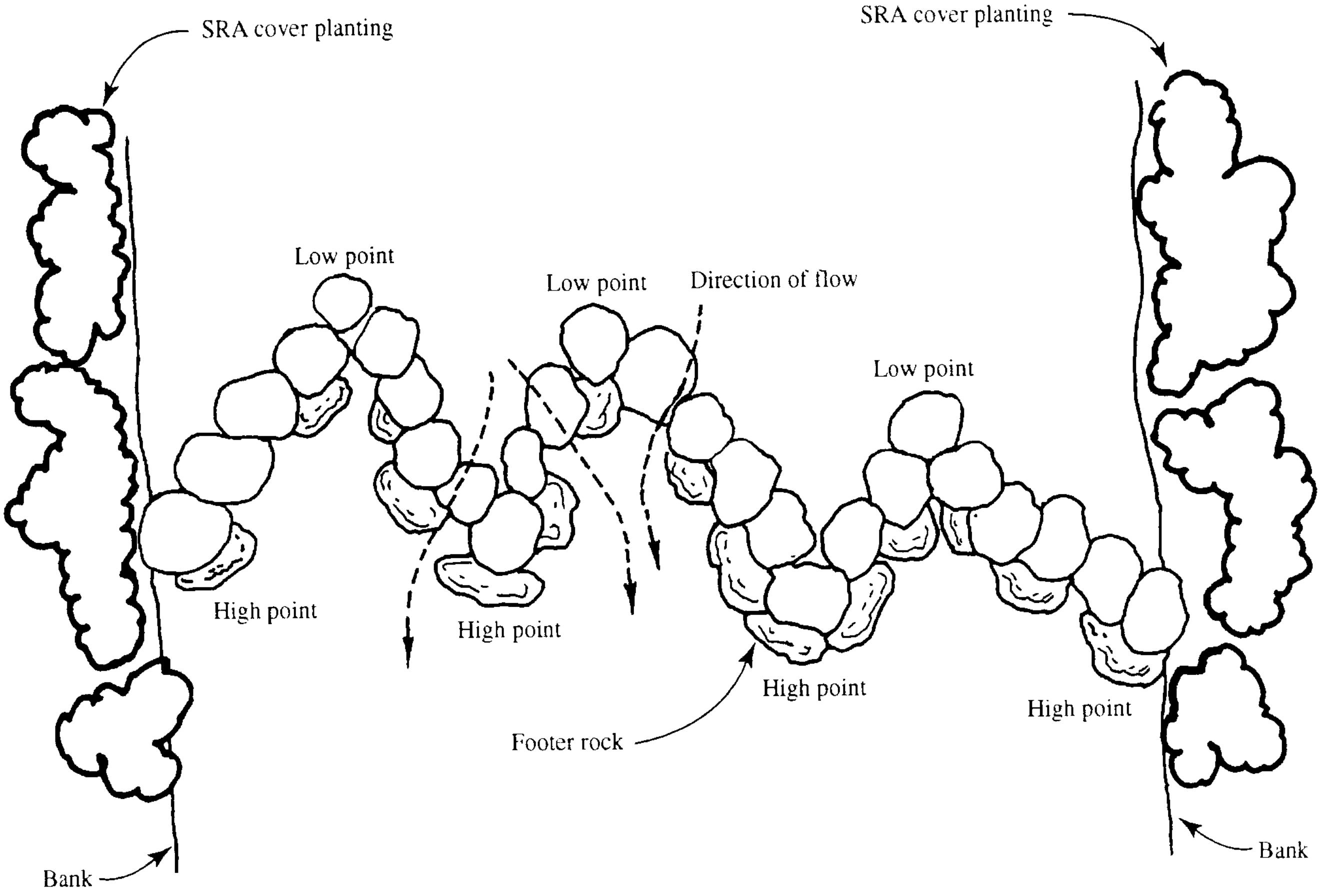
Jones & Stokes

Figure 5-3
Vortex Rock Weir
Plan View and Cross Section



SRA = shaded riverine aquatic

Note: Drawing is conceptual and is not intended for construction use.

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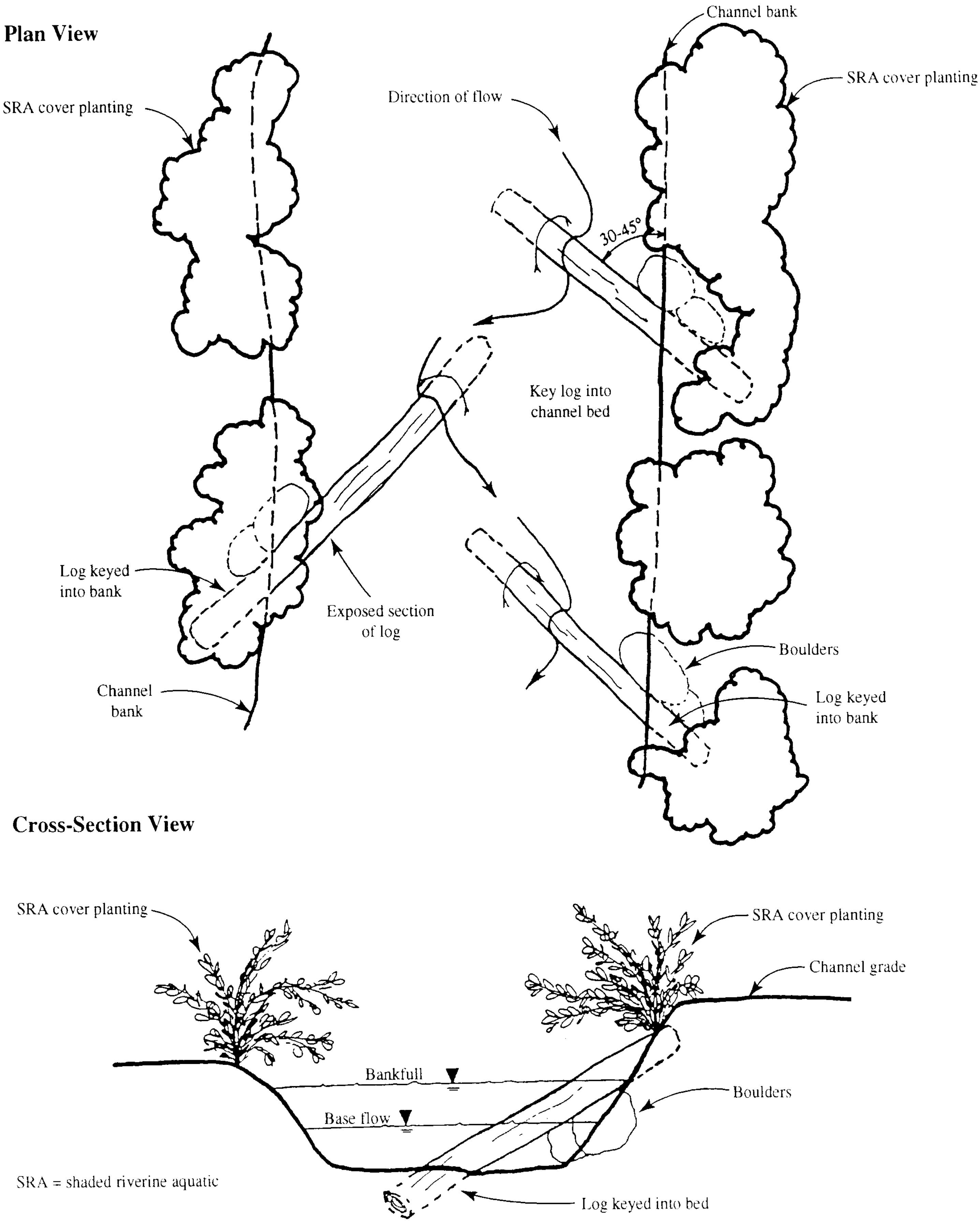
Figure 5-4
W-Weir Plan View



SRA = shaded riverine aquatic

Note: Drawing is conceptual and is not intended for construction use.

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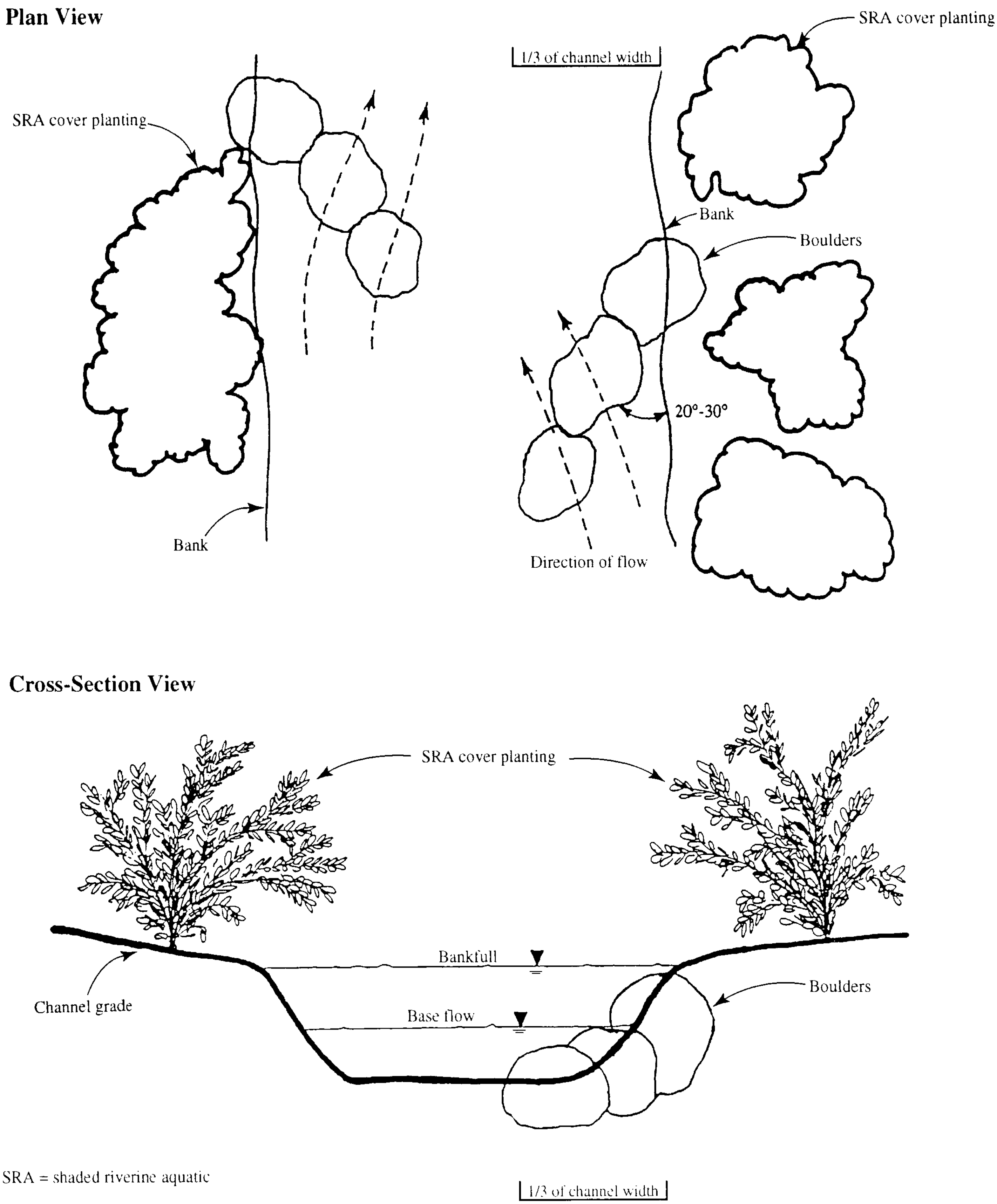
Jones & Stokes

Figure 5-5
Deflector Log Plan and Cross-Section Views



SRA = shaded riverine aquatic

Note: Drawing is conceptual and is not intended for construction use.

No scale

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Figure 5-6
Rock Vane Plan and Cross-Section Views

Biotechnical bank stabilization techniques have many advantages over traditional, purely engineering solutions:

- Biotechnical techniques are more environmentally compatible.
- Biotechnical techniques have greater aesthetic value.
- Biotechnical techniques commonly increase fish and wildlife habitat values.
- Many biotechnical techniques are self-repairing if damaged.
- Biotechnical techniques are often less expensive to install than conventional techniques.
- Because the construction of biotechnical bank stabilization does not always require heavy equipment, construction impacts associated with bank stabilization may be less when biotechnical techniques are used than when conventional techniques are used.

The following paragraphs describe examples of common biotechnical bank stabilization techniques that may be useful in restoration efforts designed for streams in the City's Urban Service Area.

Joint Plantings: Joint planting is a method of streambank stabilization used along banks where riprap either exists or is required. Live trees or shrubs are fashioned into "stakes" and installed in the joints between existing rocks, or while rock riprap is being placed on the slope face. As they become established, the root systems of the plantings provide a mat upon which the riprap rests and improve drainage in the soil below the riprap, helping to prevent erosion of the streambank.

Tree Revetments: Tree revetments are constructed of dead trees, placed end to end along the toe of a streambank so that they overlap slightly, and anchored to the bank toe, usually with wire. Tree revetments reduce flow velocities, slow erosion, trap sediment, and provide a substrate for the installation of restoration plantings. Although they have a limited lifespan, tree revetments are a relatively inexpensive method of slowing erosion. However, because the trees may eventually break loose from their moorings, tree revetments should not be used upstream from bridges or in other areas where debris jams could pose hazards.

Live Fascines: Fascines or wattle bundles are long cylindrical bundles of live cuttings taken from woody shrubs or trees (typically fast-growing species such as cottonwoods or willows) that are bound together with flexible cuttings, string, or other organic material. The bundles are placed in shallow trenches dug in rows perpendicular to the slope and then anchored to the soil either with wooden stakes or with stakes made of live cuttings. The bundles quickly take root in the bank and stabilize the soil. Natural growth fills in the gaps between the trenches. Planting live fascines is an effective way to stabilize and revegetate a streambank with a shallow to moderate slope. However, this technique is typically not effective in places that are regularly inundated; use of live fascines should be confined to upslope areas.

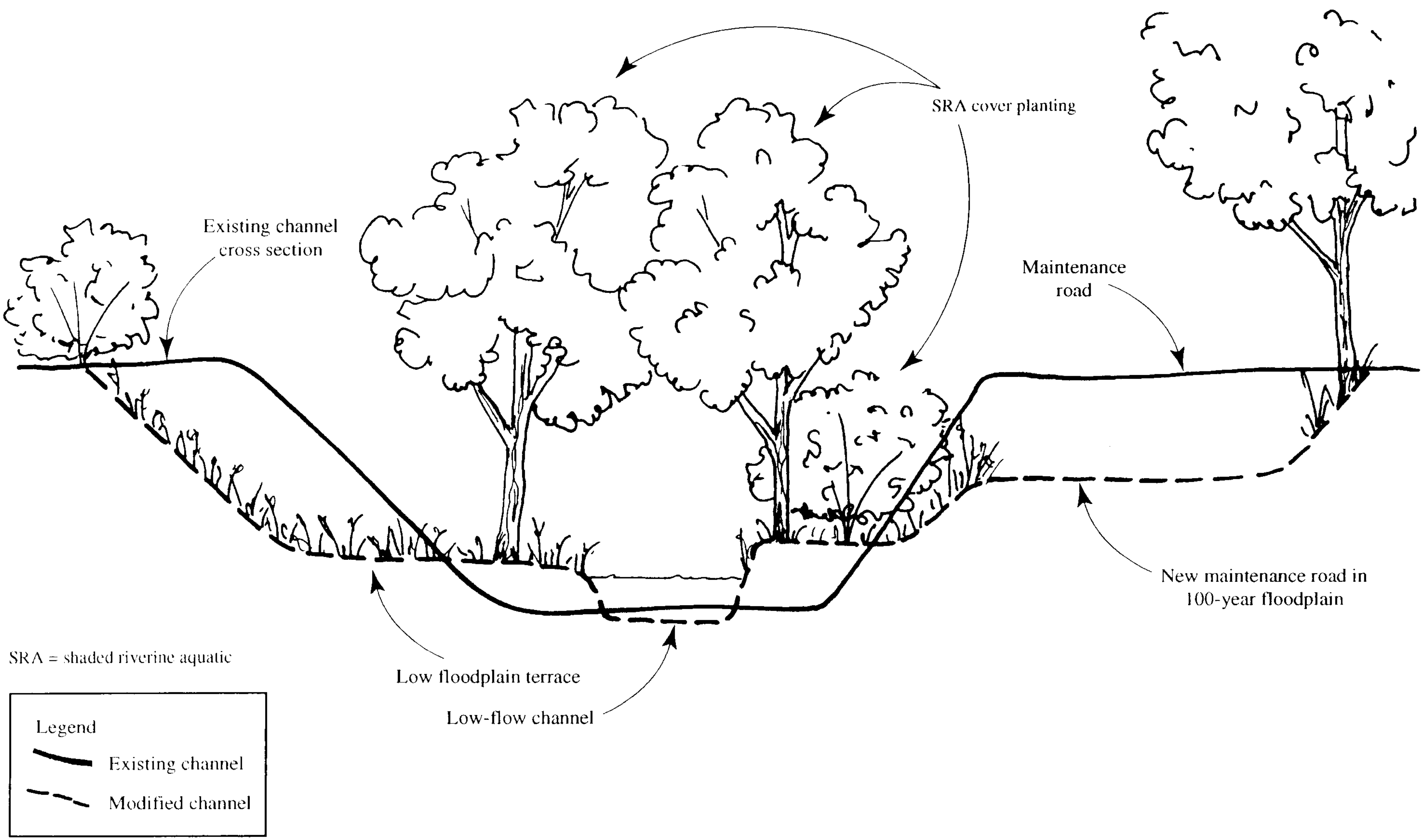
Bank Shaping and Planting: Steep, modified streambanks can be reshaped to more closely approximate a natural stream cross section (Figure 5-7). Typically, banks are recontoured to create slopes of 2:1 or less. One or more low terraces can also be created to facilitate revegetation and reduce erosion. The reshaped bank is then planted with vegetation suitable for the local area and slope characteristics. When feasible, this method is greatly preferable to maintaining steep streambanks.

Cribwalls: Live cribwalls consist of a series of hollow, interconnecting, box-like structures made of untreated logs or timber; each box is filled with soil and live cuttings of native woody plants (Figure 5-8). Over time, the cuttings take root and gradually replace the structural function of the logs or timber. Live cribwalls are used to replace concrete walls in protecting streambanks where vertical or near-vertical walls cannot be redesigned to reduce slopes. They are typically constructed of durable lumber such as redwood. Although they are expensive and complex to construct, properly designed and installed live cribwalls provide long-term stabilization that requires little maintenance. Construction of live cribwalls usually requires consultation and review by engineers.

Vegetated Gabions: Vegetated gabions, also known as gabion baskets, are rectangular baskets made of wire mesh and filled with soil and small- to medium-sized rocks. The baskets are stacked along steep slopes and live cuttings of native woody plants are planted between the baskets (Figure 5-9). With time, the cuttings take root, stabilizing the baskets and binding them to the slope. Vegetated gabions are particularly useful for protecting steep slopes where the bank is heavily loaded or where scouring or undercutting is taking place. Vegetated gabions represent a more environmentally friendly variation of traditional gabions, which are filled only with rocks. Vegetated gabions can be considered as an alternative to traditional gabions when engineering needs suggest that the use of gabions is an appropriate strategy.

Vegetated gabions are not recommended for use in areas subject to inundation because of the dangers they pose to fish. The wire in the baskets may degrade over time, creating sharp exposed wire points that pose a threat to fish. In addition, rocks and soil may migrate out of a damaged basket, leaving the empty portion of the basket acting as an effective gill net for fish.

Brush Layers: Brush layers are used in restoring slopes to improve the cross section of a stream. They are constructed by placing long branches on cut terraces with their cut ends anchored into the slope and their tops protruding from the surface of the finished slope. A single brush layer usually consists of three layers of branches with approximately 3 inches of soil between branch layers. A lift of 3 to 5 feet of soil is then placed on the brush layer to construct the next terrace.

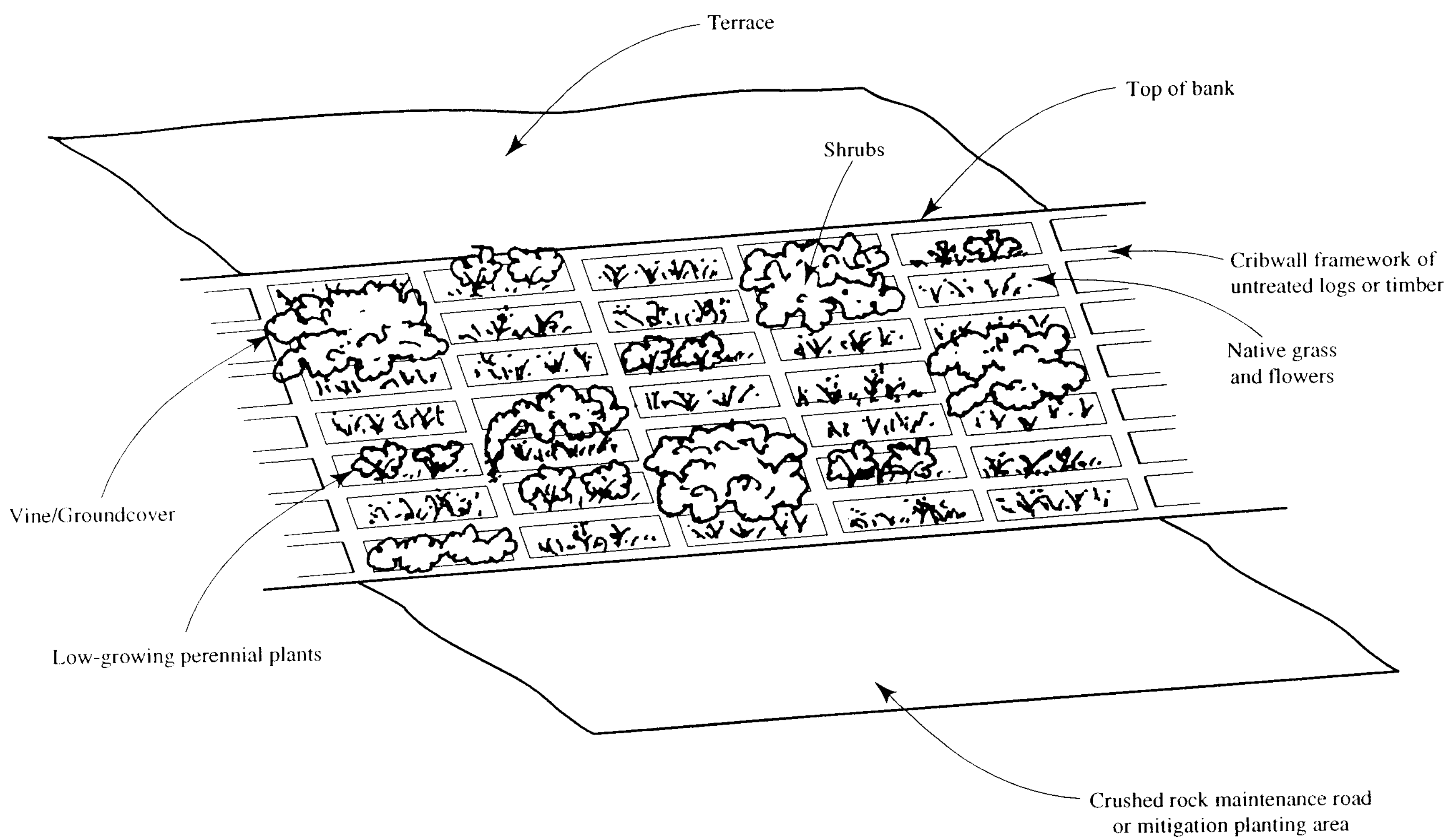


Note: Drawing is conceptual and is not intended for construction use.

No scale

Jones & Stokes

Figure 5-7
Typical Modified Channel Cross Section with Low-Flow Channel and Floodplain Terrace

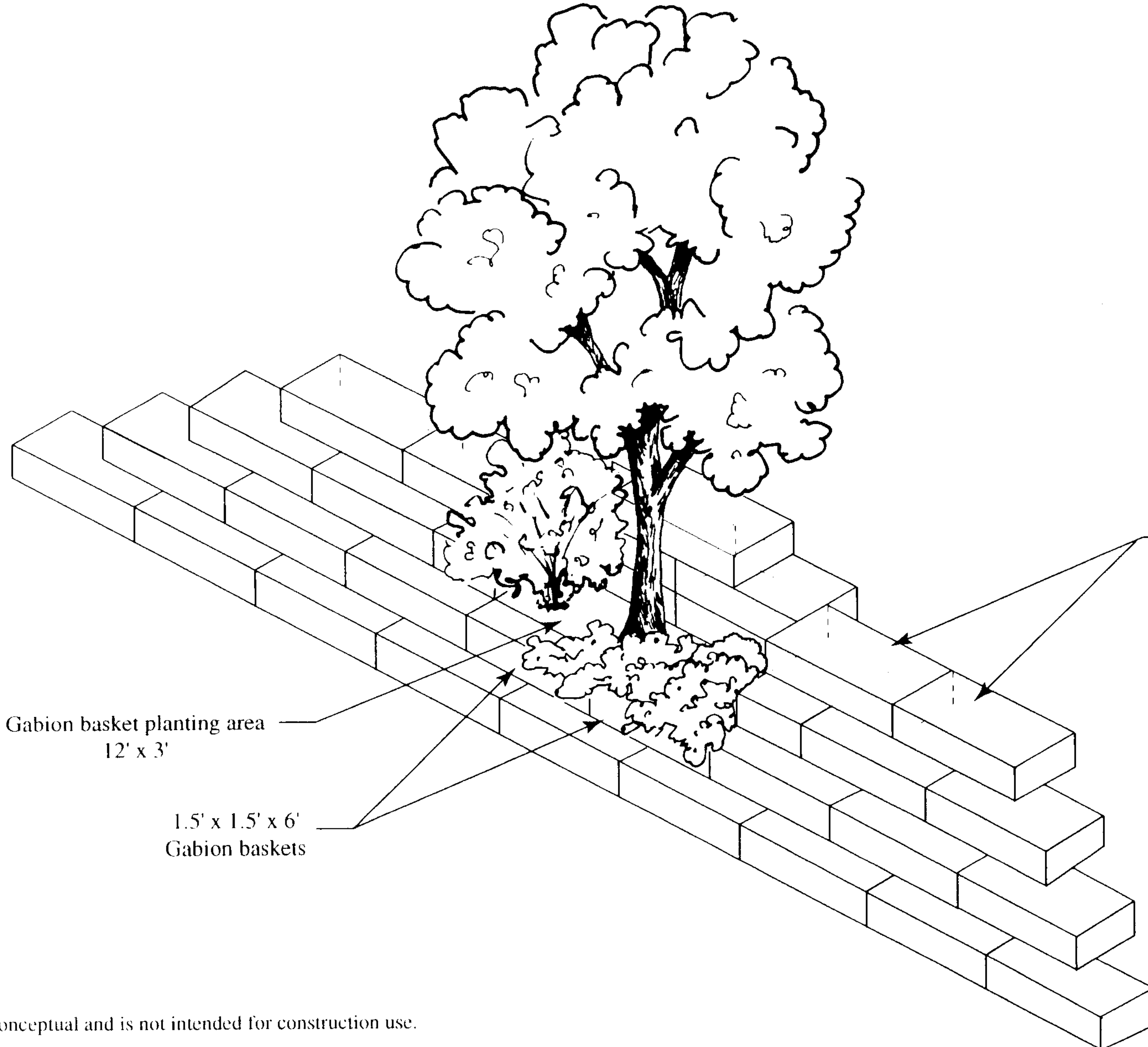


Note: Drawing is conceptual and is not intended for construction use.

No scale

Jones & Stokes

Figure 5-8
Typical Cribwall Planting Area



Notes: Drawing is conceptual and is not intended for construction use.

Refer to Draft Map and General Plan for Guadalupe River for details of gabion basket construction. (Santa Clara Valley Water District 1996)

No scale

Jones & Stokes

Figure 5-9
Typical Planting Pocket on Gabion Basket Retaining Wall

Erosion Control Blankets: Erosion control blankets are sheets of natural or synthetic materials that can be anchored on a bank surface to provide immediate protection of the soil surface against the forces exerted by flowing water. Firmly anchored blankets of sufficient strength and thickness can also provide a measure of protection against bank slumping. Erosion control blankets are generally used in combination with vegetative restoration approaches; plantings can be installed through openings cut into the blanket.

Brush Mattresses: As their name implies, brush mattresses are constructed by layering a pad or mattress of hardwood brush on a slope and securing it with a grid of stakes and wire or rope. The toe of the mattress is anchored below the waterline by strategically placed rock. A brush mattress acts as an organic erosion-control blanket, and provides mulch for seedlings and plantings established on the bank.

Plant New or Additional Riparian Vegetation. The goal of a restoration planting plan should be to maximize both species diversity and structural diversity. A high degree of species diversity is visually appealing, and also offers a broad range of habitat opportunities and resources to fish and wildlife. Vegetation assemblages that are structurally complex increase the kinds and numbers of wildlife that can use a riparian environment. Dense vegetation provides a buffer to screen the corridor from impacts associated with adjacent land uses.

A high degree of structural diversity can be achieved by establishing a multi-layered vegetative canopy that includes ground-covering plants, understory shrubs, and medium and large trees. Structural diversity can be further increased by varying vegetation densities along a restored corridor. Along channel segments with earthen berms, riparian or upland vegetation can be established on top of the bank to increase the width of the vegetated zone. Existing riparian corridors can also be enhanced by planting trees or understory shrubs to improve habitat structure and diversity.

Increase Shade Over Stream. Establishing vegetation over streams (SRA cover) can provide substantial shading for the channel and reduce water temperatures to improve fish habitat quality. Establishment of overhead SRA cover may include planting streamside riparian vegetation on channel banks and planting mid- and understory riparian vegetation beneath mature trees already providing SRA cover. As plants become established, their roots combat bank erosion. Increased vegetation cover and shading can also reduce evaporation, increase infiltration and subsurface flow, and help to maintain base flow.

Construct Wildlife Nesting and Roosting Structures. Nesting and roosting sites for waterfowl and other birds, as well as bats, can be increased by constructing nesting and roosting structures along the perimeter of the riparian habitat. Some bird populations are limited by the availability of snags or dead tree limbs in which to make nest cavities; however, many of these birds will nest in specially designed artificial structures such as nest boxes if natural structures are unavailable. In addition to nesting boxes, other types of structures useful in restoration efforts include nest platforms for waterfowl and raptors, and nest baskets for owls and waterfowl. Nesting or roosting structures should be carefully designed for the target species and should be durable, predator-proof, and economical to build and maintain. Appropriate nest structures, especially nesting boxes, can be purchased from commercial sources or from conservation groups such as the California Waterfowl Association and Bat Conservation International. Construction of nesting and roosting structures often provides excellent opportunities for community involvement because the required skills can be learned quickly. Local community groups in the Urban Service Area, such as scouting organizations or Audubon Society chapters, could build, install, maintain, and monitor the boxes.

Enhance Adjacent Upland Habitat. Upland habitat refers to non-wetland habitat outside the banks of a stream. The value of riparian habitat is greatly enhanced when it is adjacent to high-quality upland habitat because upland habitat provides foraging opportunities and can serve as a refuge for some species when streamflow is high. In general, the wider an area of upland habitat is, the more support it can offer to adjacent areas of riparian habitat. Expanding and enhancing upland habitat adjacent to riparian corridors can also greatly increase the public's opportunities for wildlife viewing, recreation, and environmental education.

Construct Protective Fencing. In many cases, riparian habitat is removed or degraded by impacts associated with land uses adjacent to the corridor. For example, livestock prefer grazing and resting in riparian corridors; livestock can substantially reduce riparian cover, impede seedling growth, and impair water quality. Some recreational activities that occur next to riparian habitat may also be incompatible with the preservation and restoration of riparian habitat; both mountain biking and off-road vehicle use can damage riparian vegetation.

Fencing can be used to exclude incompatible land uses from the riparian corridor. This exclusion may help to stimulate natural recovery of riparian vegetation. This is often the case if grazing is excluded. Fencing can also be used to protect plantings installed as part of a restoration project, or to restrict public access to areas that harbor sensitive wildlife resources, such as nesting habitat for endangered birds.

Education and Outreach Strategies

Public Education

Public education and outreach programs are integral to the success of restoration efforts along densely populated riparian corridors like those of the Urban Service Area: a community that appreciates a riparian corridor will be more likely to preserve and maintain that corridor over the long term. Outreach programs should be designed to target the segments of the public who will be involved with or affected by the restoration project, in order to educate stakeholders and elicit their support. Programs should provide technical information and background on restoration activities. Experience has shown that restoration programs may be most effective when local community groups and organizations are involved in their implementation.

Assistance to Landowners

Local agencies and organizations can facilitate the restoration of riparian corridors by providing assistance to private landowners who are interested in achieving the goals of the RRAP. Assistance could take a variety of forms, and should be tailored to the needs of each willing landowner. For example, agencies could provide technical assistance to landowners by:

- sponsoring seminars or workshops,
- providing one-on-one consultation,
- supplying planting materials (this would have the additional benefit of ensuring that the proper species and genetic stock are used),
- supplying bank stabilization materials,
- providing heavy equipment,
- providing labor,
- assisting with disposal of exotic vegetation and other debris removed from the restoration site,
- offering coordination services, or
- some combination of the above.

If there is a strong response from landowners asking for assistance, the City should consider dedicating a staff person to coordinate support services available from the City with those offered by other agencies or by local organizations. Local organizations may be particularly well-suited to provide volunteer labor to help landowners implement their restoration plans.

Legal Strategies

Land Acquisition

Some land uses in and around riparian areas have potential deleterious effects on aquatic habitat and populations. Examples include the effects of livestock grazing (mentioned above) and of discharge of waste or polluted stormwater into the corridor. Local government agencies and nonprofit organizations can work to reduce or eliminate potentially detrimental land uses and to facilitate future restoration activities by purchasing adjacent properties and altering their use. Opportunities for land acquisition may arise as part of a routine process such as parkland or park acquisition or development, development of flood protection projects, and acquisition or development of school sites. When land is acquired in appropriate locations and amounts, these areas can serve the dual purpose of providing recreation for the general public and protecting sensitive riparian resources. Although the costs associated with land acquisition are high, the results can be excellent.

Conservation/Public Open Space Easements

Conservation/public open space easements are effective tools for the management of stream corridors on private property. Through a conservation/public open space easement, a landowner receives financial compensation for giving up or restricting some of his or her development rights; landowners may also choose to donate conservation/public open space easements. In return, the holder of the easement, usually a local government agency, acquires the right to enforce those restrictions. Conservation/public open space easements are especially useful where stream segments would benefit from active restoration in conjunction with a change in adjacent land use practices. Ongoing maintenance of restoration sites within the easement may be the responsibility of the landowner, of a local, state, or federal agency, or of a non-profit organization such as a land trust. Details of conservation/public open space easements are developed on a case-by-case basis. Conservation/public open space easements may be very effective in restricting land use and development activities that are incompatible with the objectives of the RRAP.

Other Legal Strategies

In addition to acquiring land and creating conservation easements, local governmental agencies can adopt and enforce a variety of regulations designed to curb or minimize adverse impacts associated with land use adjacent to riparian corridors. For instance, the City's Riparian Corridor Policy Study (City of San José 1994) contains guidelines for development adjacent to riparian corridors. Additionally, the City could choose to require that mitigation measures be included in all proposed projects that have the potential to impact riparian corridors. Such a requirement could be enforced through the existing environmental review process.

Available and Appropriate Strategies

Not all of the restoration strategies described above are available or appropriate for use on all types of restoration corridors. Table 5-1 summarizes the strategies that are generally appropriate for a given stream corridor condition. However, project designers should consider that a number of factors in addition to stream corridor condition also affect decisions regarding which strategies are most appropriate for implementation at a particular site. These other factors include:

- cost (and available financial resources),
- availability of labor and equipment,
- compatibility with other strategies under consideration for the site,
- technical feasibility, and possibly
- additional site-specific factors.

Table 5–1. Restoration Strategies Available by Stream Corridor Condition

Restoration Strategies	Underground Culvert	Concrete Channel	Mixed Hardscape	Earthen Channel	Unmodified Channel – Trees Absent	Unmodified Channel – Trees Sparse	Unmodified Channel – Trees Abundant – Narrow Corridor	Unmodified Channel – Trees Abundant – Wide Corridor
Instream Reach-Scale Strategies:								
Recreate Meanders				✓				
"Daylight" Channels	✓							
Create or Enhance Low-Flow Channel			✓	✓	✓	✓	✓	✓
Water Management Strategies:								
Modify Streamflow	✓	✓	✓	✓	✓	✓	✓	✓
Create Sediment Basins			✓	✓	✓	✓	✓	✓
Streambank Reach-Scale Strategies:								
Control Invasive Non-Native Species		✓	✓	✓	✓	✓	✓	✓
Fill Gaps in Existing Riparian Corridors		✓	✓	✓	✓	✓	✓	✓
Instream Site-Specific Strategies:								
Reduce Channel Erosion			✓	✓	✓	✓	✓	✓
Construct Grade-Control Structures			✓	✓	✓	✓	✓	✓
Remove Debris	✓	✓	✓	✓	✓	✓	✓	✓
Improve Fish Passage	✓	✓	✓	✓	✓	✓	✓	✓
Prevent Fish Stranding	✓	✓	✓	✓	✓	✓	✓	✓
Augment Fish Spawning Gravels			✓	✓	✓	✓	✓	✓
Construct Vortex or W-Weirs			✓	✓	✓	✓	✓	✓

Restoration Strategies	Underground Culvert	Concrete Channel	Mixed Hardscape	Earthen Channel	Unmodified Channel – Trees Absent	Unmodified Channel – Trees Sparse	Unmodified Channel – Trees Abundant – Narrow Corridor	Unmodified Channel – Trees Abundant – Wide Corridor
Install Deflector Logs			✓	✓	✓	✓	✓	✓
Construct Rock Vanes			✓	✓	✓	✓	✓	✓
Construct Boulder Wing-Deflectors			✓	✓	✓	✓	✓	✓
Streambank Site-Specific Strategies:								
Hardscape Removal		✓	✓					
Joint Plantings			✓					
Tree Revetments				✓	✓	✓	✓	✓
Live Fascines				✓	✓	✓	✓	✓
Bank Shaping and Planting				✓	✓	✓	✓	✓
Cribwalls			✓	✓	✓	✓	✓	
Vegetated Gabions			✓	✓				
Plant Riparian Vegetation		✓	✓	✓	✓	✓	✓	✓
Brush Layers			✓	✓	✓	✓	✓	✓
Brush Mattresses			✓	✓	✓	✓	✓	✓
Erosion Control Blankets			✓	✓	✓	✓	✓	✓
Increased Shade over Stream		✓	✓	✓	✓	✓	✓	✓
Wildlife Nesting and Roosting Structures		✓	✓	✓	✓	✓	✓	✓
Enhancement of Adjacent Upland Habitat		✓	✓	✓	✓	✓	✓	✓

Restoration Strategies	Underground Culvert	Concrete Channel	Mixed Hardscape	Earthen Channel	Unmodified Channel – Trees Absent	Unmodified Channel – Trees Sparse	Unmodified Channel – Trees Abundant – Narrow Corridor	Unmodified Channel – Trees Abundant – Wide Corridor
Install Fencing		✓	✓	✓	✓	✓	✓	✓
Education and Outreach Strategies:								
Public Education	✓	✓	✓	✓	✓	✓	✓	✓
Assistance to Landowners		✓	✓	✓	✓	✓	✓	✓
Legal Strategies:								
Land Acquisition					✓	✓	✓	✓
Conservation/Public Open Space Easements			✓	✓	✓	✓	✓	✓

All relevant factors should be given thorough consideration in the design of a site-specific restoration plan. Chapter 6 provides additional information on site-specific factors that influence the selection of appropriate restoration strategies, and outlines a process for prioritizing and selecting potential restoration sites.

Cost Components

Before implementing a site-specific restoration plan, the City must carefully consider the costs implications of the project design. Major costs involved in implementing restoration strategies include:

- land transactions (e.g., purchase of fee titles or conservation easements);
- site preparation (grading, removal of exotic vegetation, etc.);
- planting;
- removal of instream fish barriers;
- construction of instream features (grade-control structures, flow modification structures, or fish passage structures); and
- installation of protective measures (fencing and signage).

Table 5-2 provides order-of-magnitude estimates of costs associated with the various restoration strategies outlined in this document. These order-of-magnitude estimates are intended for general planning and cost comparison purposes only. Actual construction costs may vary because of competitive bidding, negotiations between the project sponsor and potential contractors, fluctuations in market prices, or the use of volunteer labor.

Cost Effectiveness

Once the restoration strategies and associated costs have been identified for a particular restoration site, the next step is to evaluate whether the projected and perceived benefits of a strategy are "worth" their cost. Over the years, a variety of approaches and methods have been used by governmental agencies, and scientific and environmental organizations, to weigh the costs and benefits associated with restoration activities. The following section provides a brief overview of the two primary methods currently in use: cost-effectiveness analysis and incremental cost analysis.

Neither cost-effectiveness analysis nor incremental cost analysis provides the user with an optimal solution, such as that provided by a cost-benefit analysis. However, both techniques are

Table 5–2. Cost Estimates for Restoration Strategies Discussed in Text.

Restoration Strategy	Unit of Measurement	Cost Per Unit of Measurement ($)
Instream Creekwide Strategies		
Channel Reconstruction		
Recreation of Meanders	Linear foot	210-500
"Daylighting" Channels	Linear foot	210-500
Creation or Enhancement of Low-Flow Channel	**Linear foot**	**40**
Water Management Strategies		
Streamflow Modification		
Creation of Sediment Basins	Acre-foot	15,000
Streambank Creekwide Strategies		
Control of Invasive Non-Native Species	**Acre**	**200**
Filling Gaps in Existing Riparian Corridors	**Acre**	**17,000**
Instream Site-Specific Strategies		
Instream Erosion Control	**Linear foot**	**55**
Construction of Grade-Control Structures	**Item**	**15,000**
Debris Removal	**Cubic yard**	**5**
Improving Fish Passage	**Item**	**300,000**
Preventing Fish Stranding	**Item**	**250,000**
Augmenting Fish Spawning Gravels	**Cubic yard**	**15**
Creation or Enhancement of Instream Cover		
Weirs	Item	15,000
Deflector Logs	Item	10,000
Rock Vanes	Item	5,000
Boulder Wing-Deflectors	Item	15,000

Table 5–2—continued

Restoration Strategy	Unit of Measurement	Cost Per Unit of Measurement ($)
Streambank Site-Specific Strategies		
Hardscape Removal	**Linear foot**	**150**
Biotechnical Bank Stabilization		
Joint Plantings	Item	20
Tree Revetments	Item	2,000
Live Fascines	Linear foot	2
Bank Shaping and Planting	Square foot	0.30
Live Cribwalls.		
Vegetated Gabions.	Linear foot	
Brush Layering	Linear foot	25
Brush Mattresses	Linear foot	20
Erosion Control Blankets	Linear foot	2
Planting Riparian Vegetation**	**Acre**	**15,000**
Increasing Shade Over Stream	**Linear foot**	**0.50**
Construction of Wildlife Structures	**Item**	**30**
Enhancement of Adjacent Upland Habitat	**Acre**	**10,000**
Construction of Fencing	**Linear foot**	**10**
Legal Strategies		
Land Acquisition		**variable**
Conservation/Public Open Space Easements		**variable**

***Cost estimate includes collection, propagation, planting, and installation of tree shelters.*

valuable tools in aiding decision-makers to select the most feasible restoration solution. This selection may also be aided by decision guidelines, which could include consideration of:

- output targets (such as legislative requirements or regulatory standards),
- minimum and maximum output thresholds,
- maximum cost thresholds,
- sharp breakpoints in the cost-effectiveness or incremental cost curve, and/or
- the degree of uncertainty in the data used for cost analysis.

Cost-Effectiveness Analysis

Cost-effectiveness analysis evaluates the effectiveness of outlay costs in achieving desired results, or "output." In performing a cost-effectiveness analysis, the first step is to identify potential solutions that are unreasonable from a production or implementation perspective, and exclude them from consideration in subsequent analysis. If costs are easily determined, cost analysis is fairly straightforward. However, restoration planners should be mindful that the results of a restoration project (the "output") may be difficult to quantify. This is true in part because the output of a restoration effort includes intangibles like aesthetic value, and in part because evaluating the "worth" of a project's measurable results (such as the success of restoration plantings) raises complex values-related issues.

Ultimately, the goal of cost-effectiveness analysis to objectively weigh all the costs and outcomes associated with a restoration action. This is achieved by following the common-sense rule that a restoration solution is not cost-effective if either

(1) the same level of output could be achieved at a lower cost by a different action, or

(2) a greater level of output could be achieved by a different action at the same or lower cost.

Table 5-3 on the following page demonstrates the application of cost-effectiveness analysis to riparian restoration projects. In this example, four alternative plans for restoring riparian habitat (plans A, B, C, and D on Table 5-3) were identified by a project sponsor. The output for each plan is the amount of riparian habitat that would be restored under that alternative; the plans are listed in order of increasing output. For example, Plan A and Plan B each result in the restoration of 10 acres of riparian habitat; however, Plan B is more cost-effective because it restores the same amount of habitat for a lower cost. Similarly, while Plan C and Plan D each cost $225,000, Plan D is more cost-effective because it restores more habitat for the same cost.

Table 5-3. Examples of Cost-Effectiveness Analysis

Plan	Total Cost	Total Output
Plan A	$175,000	10 acres
Plan B	$150,000	10 acres
Plan C	$225,000	15 acres
Plan D	$225,000	25 acres

Incremental Cost Analysis

The intent of incremental cost analysis is to provide supplementary information facilitating a decision regarding the desired level of investment in a project. Incremental cost analysis examines the increase in cost of extra units of output increase as the output level increases. This requires information that demonstrates the difference in cost (incremental cost) and the difference in output (incremental output) between each action and the next-larger action.

Expanding on the cost-effectiveness analysis presented in Table 5-3 shows how incremental cost analysis would be used to determine the difference in cost that would result from selecting Plan D instead of Plan B. As shown on Table 5-4, the decision to implement Plan D instead of Plan B would result in the restoration of an additional 15 acres of riparian habitat, for an additional cost of $75,000. This information could be used by restoration planners to weigh whether the restoration of additional habitat is worth the added cost.

Table 5-4. An Example of Incremental Cost Analysis

Plan	Cost	Output	Incremental Cost	Incremental Output
B	$150,000	10 acres	not applicable	not applicable
D	$225,000	25 acres	$75,000	15 acres

Chapter 6. Guidelines for Implementing Restoration Strategies

This chapter presents guidelines for implementing the restoration strategies described in Chapter 5. The chapter begins by discussing approaches to the critical issue of identifying and prioritizing opportunities for restoration in the City's Urban Service Area. Next, it provides an overview of sources of funding and other types of support for restoration activities. It also presents information intended to guide the various phases of a restoration project, including:

- choice of the project planning and design team,
- site preparation,
- plant selection,
- irrigation,
- environmental compliance,
- monitoring, and
- ongoing site maintenance.

Identifying and Prioritizing Restoration Opportunities

The first step in implementing the RRAP is to identify and prioritize creek segments in the Urban Service Area that may provide opportunities for restoration. Restoration opportunities should be prioritized based on a number of criteria; first among these criteria is the ability of the restoration project to help achieve the primary and secondary goals of the RRAP, as described in Chapter 2. At the broadest level, creek segments where implementation of one or more restoration strategies would achieve multiple primary and secondary goals should be given a higher priority than segments where restoration would achieve fewer goals. Moreover, projects that address more than one goal provide greater opportunities for involving multiple stakeholders from local, state, and federal agencies as well as private entities, for leveraging limited financial resources, and for attracting outside funding in the form of state and federal grants. Once potential restoration sites have been identified and prioritized, the City or other restoration sponsor can focus its efforts on high-priority sites to build local support and develop the financial resources necessary to develop and implement a site-specific plan.

Two types of approaches may be applied to identifying and prioritizing restoration opportunities in the City's Urban Service Area: the programmatic or systemwide approach and the site-specific approach. These are discussed in greater detail in the following sections.

Programmatic Approach (GIS Analysis)

Whenever possible, the project sponsor should identify and prioritize restoration sites on the basis of existing stream corridor conditions and the maximum benefit that restoration would provide based on these conditions. These factors, in combination with additional technical and legal factors influencing restoration activities (see discussion of opportunities and constraints in Chapter 4) provide the basic framework for identifying and prioritizing opportunities on a programmatic or systemwide basis. Analysis is greatly facilitated by the use of geographic information systems (GIS) technology.

During the preparation of the RRAP, a series of ArcInfo (version 7.2.1) coverages representing existing stream corridor conditions and relevant technical and legal factors was used to identify and prioritize creek segments for future restoration efforts. GIS analysis addressed the primary and secondary goals of the RRAP, potential opportunities for restoration, and potential constraints on restoration activities. An initial ArcInfo analysis was completed to screen out creek segments already targeted by the Santa Clara Valley Water District (the District) for the implementation of future capital projects, including flood damage reduction and/or mitigation, in order to avoid conflict between restoration efforts and construction activities. Relative numerical weights or values were then assigned to the various factors depicted on the remaining map layers, based on their relationship to the expressed goals of the RRAP, and on their ability to affect the successful implementation of restoration strategies. Final presentation maps (Figure 1–1, Figure 3–4, Figure 4–1, Figure 4–2, and Figure 6–1) were created in ArcView (version 3.2).

The following factors were included in the GIS analysis carried out for the RRAP:

- **Sediment Removal Areas:** areas of historic sediment accumulation subject to ongoing maintenance activities by the Santa Clara Valley Water District (District). These areas present constraints on potential future restoration activities, because ongoing maintenance activities may have adverse effects on restoration plantings or other restoration features. Sediment removal areas were therefore assigned a value of -1.

- **Erosion Control Focus Areas:** areas of historic creekbank erosion targeted by the District for implementation of future erosion control activities. Creek segments identified for erosion control activities were assigned a value of +2, because implementing restoration strategies designed to control erosion and downstream sediment deposition would help to achieve the primary RRAP goal of improving water quality.

- **Stream Corridor Condition:** existing streamchannel conditions, as described in Chapter 3. Because restoring riparian habitat is a primary goal of the RRAP, creek segments were assigned numerical values representing their potential, based on existing conditions, to support riparian vegetation. The values are as follows:

    - underground or covered channel = -2,
    - concrete channel = -1,

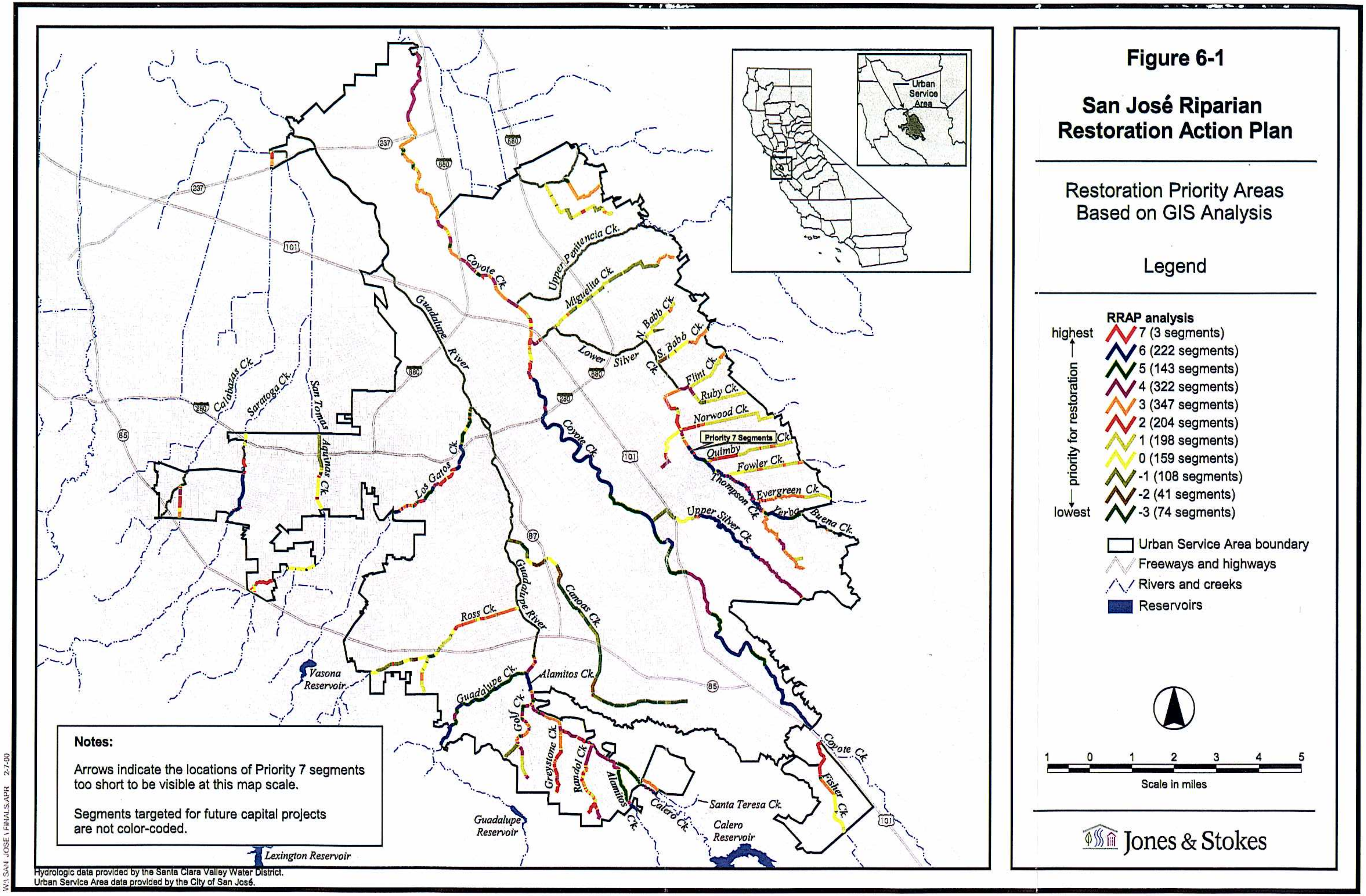


Figure 6-1
San José Riparian
Restoration Action Plan
Restoration Priority Areas
Based on GIS Analysis
Legend
RRAP analysis
highest
priority for restoration
lowest
7 (3 segments)
6 (222 segments)
5 (143 segments)
4 (322 segments)
3 (347 segments)
2 (204 segments)
1 (198 segments)
0 (159 segments)
-1 (108 segments)
-2 (41 segments)
-3 (74 segments)
Urban Service Area boundary
Freeways and highways
Rivers and creeks
Reservoirs
1 0 1 2 3 4 5
Scale in miles
Jones & Stokes
Urban Service Area
Coyote Ck.
Upper Penitencia Ck.
Miguelita Ck.
N. Babb Ck.
S. Babb Ck.
Lower Silver Ck.
Flint Ck.
Ruby Ck.
Norwood Ck.
Priority 7 Segments
Quimby Ck.
Fowler Ck.
Thompson Ck.
Evergreen Ck.
Yerba Buena Ck.
Upper Silver Ck.
Guadalupe River
Los Gatos Ck.
Calabazas Ck.
Saratoga Ck.
San Tomas Aquinas Ck.
Canoas Ck.
Ross Ck.
Alamitos Ck.
Guadalupe Ck.
Golf Ck.
Greystone Ck.
Randol Ck.
Calero Ck.
Santa Teresa Ck.
Fisher Ck.
Vasona Reservoir
Guadalupe Reservoir
Calero Reservoir
Lexington Reservoir
237
880
680
101
280
87
85
Notes:
Arrows indicate the locations of Priority 7 segments too short to be visible at this map scale.
Segments targeted for future capital projects are not color-coded.
Hydrologic data provided by the Santa Clara Valley Water District.
Urban Service Area data provided by the City of San José.
W:\SAN JOSE\FINALS.APR 2-7-00

- mixed hardscape channel = no value,
- excavated earthen channel = +1,
- unmodified channel = +2.

- **Vegetation:** the presence or absence of riparian trees. Creek segments without riparian trees provide opportunities to fill gaps in the existing riparian corridor. Restoring riparian habitat and enhancing wildlife habitat by restoring connectivity are primary goals of the RRAP, thus creek segments without riparian trees were assigned a value of +1.

- **Flood Frequency:** frequency of flooding associated with the creek segments. Creek segments with the capacity to convey flows associated with larger (50- to 100-year) flood events were assigned higher values (+1) than creeks with average capacity (10- to 50-year floodflows) (no value), or limited capacity (1- to 10-year floodflows) (-1), because high-capacity segments provide opportunities for restoration activities that would meet the secondary RRAP goal of maintaining existing levels of flood protection.

- **Land Ownership:** ownership of lands adjacent to a specific creek segment. Public and quasi-public lands adjacent to creeks provide opportunities for restoration activities, for public access, and for education, thus meeting a secondary goal of the RRAP without requiring land transactions. Creek segments adjacent to public or quasi-public lands were assigned a value of +1.

- **Recreation:** existing and proposed trails. Creek segments with existing or proposed trails provide opportunities for public access and education, meeting a secondary goal of the RRAP. Privately owned lands with trail easements were assigned a value of +1 (public and quasi-public lands were addressed under **Land Ownership**).

As a result of this analysis, three creek segments in the City's Urban Service Area were identified where implementation of restoration activities would achieve multiple RRAP goals (segments with a final numerical rating of 7). They are located along Thompson Creek between its confluences with Norwood Creek and Quimby Creek, and are indicated on Figure 6–1. Additional creek segments rated between -3 and +6 based on the factors above. They are also shown on Figure 6–1.

This programmatic approach provides a basic framework that the City can use to identify creek segments where riparian restoration activities would help to achieve the goals established in the RRAP. This approach will also permit the City to evaluate previously identified restoration sites relative to the RRAP's goals and to the opportunities and constraints described in Chapter 4.

Additional Criteria for Identifying and Prioritizing Restoration Sites

Although the GIS analysis described in the previous section is a valuable tool for focusing restoration efforts, many factors that should be considered in prioritizing potential restoration sites are not appropriate for GIS analysis. Appendix F contains an evaluation questionnaire form designed to guide the consideration of site-specific factors that are critical in assessing the suitability of a site for restoration, but cannot be adequately addressed via GIS analysis. This form should be completed for each site under consideration. The form will be helpful in identifying factors that may constrain project feasibility or success at a particular site and that will need to be compensated for in project design. Note that it is structured in such a way that a predominance of "true" and "somewhat true" responses indicates a site that is highly suitable for riparian restoration. However, this form was specifically designed to reflect the spectrum of conditions existing in the real world. Many sites will receive a mixture of "true" and "not true" responses; others may receive a high percentage of intermediate ratings. The sponsors of any proposed restoration project must establish the threshold of acceptability for various criteria vis-à-vis a specific project. Project sponsors may also wish to decide whether any specific criteria will represent such severe constraints on project feasibility or success that they should result in automatic rejection of the site.

Funding and Other Types of Support for Restoration Activities

Financial and material support represents an important constraint on riparian restoration planning. The following sections summarize key issues related to funding and other support constraints.

Funding

Identifying sources of funding for a restoration project should be among the first priorities of a project planner. Standard sources of funding include state and federal agencies as well as counties and other local governmental entities that have taxing authority, and hence revenues. Additional monies may be available from philanthropic organizations, non-governmental organizations, and landowners' associations. Table 6–1 provides an overview of potential funding sources for restoration activities. It is imperative to remember that financing may be derived from multiple sources; during the planning process, all potential contributors to project funding should be identified and appropriate cost-sharing arrangements developed. Restoration planners should keep in mind that many funding agencies will want to be involved in at least some aspect of the restoration decision-making process or to maintain some authority over the planning process.

An important element in the process of securing funding is linking available resources to specific project activities. Ultimately, the restoration planners are responsible for identifying and categorizing the various activities that will be necessary to achieve the desired restoration goals. In addition, they must determine the cost of implementing each activity, and ascertain how much funding is available for each activity. While performing this analysis, it is crucial to remember that funding and support for a project can take forms other than money. As an example, in many cases, the staff of participating agencies or other organizations can assist in the completion of project tasks.

Ideally, all necessary funding should be secured before a planned restoration project reaches the implementation stage; however, in practice, insufficient funds may be available to complete all activities outlined in the restoration plan. This is a frequent occurrence and should not prevent initiation of the project. Rather, insufficient funding serves as a wake-up call to prioritize activities

Table 6-1. Project Implementation Assistance

Agency	Program	Type of Assistance	Types of Actions Supported	Eligible Recipients
CALFED Bay-Delta Program	Category III and Proposition 204 programs	Funding	Support for non-flow-related ecosystem restoration actions to improve the health of the Bay-Delta ecosystem.	State and federal agencies, local governments, special districts, and nonprofit organizations.
Natural Resources Conservation Service (NRCS)	U.S. Department of Agriculture Farm Service Agency, Conservation Program, Wetland Resume Program and others	Funding, technical assistance	Under the 1996 farm bill, programs provide payment to participating landowners for restoring and protecting wetlands on their properties through conservation easements.	Landowners and local governments through the Resource Conservation Districts.
U.S. Environmental Protection Agency (EPA)	Public and private partnerships	Funding	Support for demonstration projects that encourage communities to explore public and private partnerships using alternative financing techniques.	Incorporated nonprofit organizations.
U.S. Fish and Wildlife Service	Wetland Easement Program	Funding	Acquisition of easements to preclude use inconsistent with waterfowl management and to ensure continued wetland habitat management.	Identified waterfowl habitat lands.
Natural Resources Conservation Service (NRCS)	Wetlands Reserve Program	Funding	Support for projects related to restoring and protecting wetlands on private property that provide landowner financial incentives to enhance wetlands in exchange for retiring marginal agricultural land; landowners sell a conservation easement or enter into a cost-share restoration agreement with the U.S. Department of Agriculture to restore and protect wetlands; the landowner voluntarily limits further use of the land but retains private ownership; the landowner and the Natural Resources Conservation Service develop a plan for restoring and maintaining the wetland.	Landowners who have owned their land for at least 1 year.

Agency	Program	Type of Assistance	Types of Actions Supported	Eligible Recipients
U.S. Fish and Wildlife Service	Partners for Wildlife	Funding, technical assistance	Support for projects related to restoring wildlife habitat on private property, including habitat on degraded or converted wetlands and riparian areas.	Cost-sharing with private landowners.
National Parks Service	Rivers, Trails and Conservation Assistance Program	Information, technical assistance	Support for community-based projects related to creating trails or greenways, conserving rivers, or protecting open spaces.	Public and private organizations.
California Environmental Trust	Successful Communities Program	Funding	Support for programs using innovative methods to address environmental problems.	
California Department of Transportation	Transportation Efficiency Act of 1998	Funding	Support for conservation-related projects, including land and scenic easement acquisition, pedestrian and bike trail construction and enhancement, and historic preservation and restoration.	Projects must be related to, or in the area served by, any active or completed transportation funds.
State Water Resources Control Board	Delta Tributary Watershed Program, Proposition 204	Funding	Support for watershed rehabilitation projects in waters tributary to the Delta, and their associated watersheds.	Counties that are joint powers authorities.
California Department of Education	Environmental Education Program	Funding	Support for projects that establish and implement environmental education programs and develop program facilities.	
California Department of Education	Environmental education state priority grants	Funding	Support for projects that benefit students in kindergarten through grade 12 in the study of environmental education.	
California Department of Forestry and Fire Protection	California Forest Improvement Program	Funding	Support for projects related to reforestation, site preparation, erosion control, revegetation, and fish and wildlife habitat improvement.	Private individuals, groups, associations, or corporations.

Agency	Program	Type of Assistance	Types of Actions Supported	Eligible Recipients
State Office of Emergency Services	Public Assistance Hazard Mitigation Program	Funding	Provides funding for implementation of watershed management practices, flood protection measures in floodplains, and soil bank stabilization.	Special districts, non-profit organizations; need to have suffered damage to be eligible.
California Department of Forestry and Fire Protection	Urban Forestry Program	Funding	Tree planting programs that will enhance the livability of urban areas.	Cities, counties, community groups, and other nonprofit organizations; program provides grants that cover up to 90% of program costs.
California Department of Parks and Recreation	Habitat Conservation Fund	Funding	Support for acquisition, restoration, and enhancement of wildlife habitat and significant natural areas.	Cities, counties, and special management districts.
	State Parks – Recreational Trails Program	Funding (matching funds up to 80% of project costs)	Support for construction of motorized and non-motorized trails projects.	Cities, counties, districts, state agencies, and non-profit organizations with management responsibilities over public lands.
California Department of Water Resources	Urban streams restoration grants	Funding	Support for projects that reduce damage from streambank erosion, watershed instability, and floods while restoring the environmental and aesthetic values of streams; priority given to proposals that encourage stewardship and emphasize community involvement.	Government agencies.
California Department of Water Resources	American Heritage Rivers Initiative	Funding	Support for projects related to revitalized community waterfronts	opportunities.
	Environmental Enhancement and Mitigation Program	Funding	Support for projects related to: highway landscaping; urban forestry; acquisition, restoration or enhancement of resource lands; and acquisition and/or development of roadside recreation	

Agency	Program	Type of Assistance	Types of Actions Supported	Eligible Recipients
California Resources Agency	Environmental license plate fund grants	Funding	Support for projects related to acquiring lands or easements for environmental protection; protecting, enhancing, and restoring natural areas, fish and wildlife habitat, and related water quality; and protecting nongame species and threatened and endangered animals and plants.	Public agencies.
Wildlife Conservation Board/California Department of Fish and Game	Riparian Habitat Conservation Program/Riparian Habitat Joint Venture	Funding	Support for projects related to restoration of riparian habitat throughout California; includes funding for land acquisition, leases, and conservation easements.	Nonprofit organizations, state and local governments, Resource Conservation Districts.
California Department of Fish and Game	Duck Stamp Program	Funding	Wetland habitat creation and enhancement, especially for waterfowl use.	Federal, state, local agencies, and private entities.
California Waterfowl Association	California Wood Duck Program	Funding, technical assistance	Support for regional wetland enhancement projects; California Waterfowl Association staff communicates habitat improvement methods to landowners and managers, evaluates habitat projects, and administers incentive programs.	

and continue with a reduced scale of work. If the project produces demonstrable positive results, additional funding can usually be acquired once the project is underway.

Incentives

Although limited resources often make it difficult for local agencies to provide financial assistance to potential restoration project sponsors, a range of non-financial incentives could be developed to encourage restoration activities in the City's Urban Service Area. Incentives can be an effective tool for encouraging and facilitating participation of private landowners and neighborhood associations in restoration activities. Incentive programs involving cost shares, tax advantages, or technical assistance encourage private landowners to implement restoration strategies on their own property, even if the results of these activities are not directly beneficial to the owner.

The following are examples of types of incentive programs that could be implemented to encourage riparian restoration activities in the Urban Service Area:

- The City of San José, the District, and/or other agencies could agree to accept responsibility for the long-term maintenance of a restoration project after its establishment by a private project sponsor.

- The City of San José, the District, and/or other agencies could initiate and complete the permitting process for a privately sponsored restoration project.

- The City of San José, the District, and/or other agencies could provide technical consultation or a variety of other assistance such as heavy equipment services, removal of debris, etc., to private sponsors of restoration projects, or could help coordinate with private providers of these services.

- The City of San José, the District, and/or other agencies could provide planting materials or provide a rebate toward the purchase of planting materials for privately sponsored restoration projects.

- The County of Santa Clara could be encouraged to provide landowners with a property tax credit for implementing restoration activities.

Local Agency Participation

The creeks of the Urban Service Area provide a number of opportunities for local agencies to participate directly or indirectly in restoration activities. For example, local agencies could work together to restore riparian habitat in a collaborative effort that would provide mitigation credits (as described in Chapter 4) to offset impacts associated with urban development, flood protection, or channel maintenance. The City of San José supports and encourages the development of collaborative agreements that would provide mitigation credits; however, development of these strategies would require close coordination between the City, the District, and state and federal resource and regulatory agencies, and is beyond the scope of the RRAP.

The City of San José or another local agency may also wish to coordinate and monitor future restoration activities within the Urban Service Area. A City staff person or review committee could be designated to oversee applications for proposed restoration activities submitted by project sponsors, and to monitor completed projects to ensure that implementation was effective. This individual or committee could also act as a clearinghouse for information on past, present, and pending mitigation and restoration projects in the Urban Service Area. A database could be established to track the relative success of these projects and to aid in the identification of strategies and methods that should be added to or deleted from the RRAP.

Site Planning and Design

Planning and Design Team

In order to ensure that project goals are met and detrimental results are avoided, planning, design, and implementation of site-specific restoration strategies must be carried out under the guidance of a multi-disciplinary team of technical experts. This team should include fluvial geomorphologists, stream and groundwater hydrologists, civil and hydraulic engineers, botanists, revegetation biologists, fisheries biologists, wildlife biologists, and possibly others, depending on specific project needs. Communication between all members of the project team must be well coordinated to ensure that project goals are efficiently and creatively met. Table 6–2 outlines the specialists recommended for the various restoration strategies described in Chapter 5.

Volunteers, including members of local communities, may constitute another important component of the project planning and design team. Local property owners and other interested members of the community should be contacted early in the planning process to solicit public involvement in project planning and implementation, and to identify public issues or concerns with regard to a planned restoration project. Community members will be able to perform a variety of activities associated with implementation. For example, efforts to control invasive exotic plant species are typically very labor intensive, but, with the exception of the team leader, they generally do not require specialized scientific expertise, and training can commonly occur on the job.

Instream Restoration

Successful planning, design, and implementation of instream restoration strategies requires consideration and understanding of conditions and processes at both the watershed scale and the reach scale. Any restoration project should be designed to maximize the potential of achieving the desired outcome and to minimize the likelihood of unintended results that may further degrade the system. A reach-scale project that achieves its goals but destabilizes other sites upstream and downstream from the project area is not a successful project.

Table 6-2. Planning and Design Team Required for Implementation of Restoration Strategies

Restoration Strategy	Geomorphologist	Stream Hydrologist	Groundwater Hydrologist	Engineer	Soil Scientist	Fisheries Biologist	Wildlife Biologist	Botanist/ Revegetation Biologist	Erosion Control Specialist
Instream Reach-Scale Strategies									
Recreate Meanders	✓	✓	✓	✓	✓	✓	✓	✓	✓
"Daylight" Channels	✓	✓	✓	✓	✓	✓	✓	✓	✓
Create/Enhance Low-Flow Channel	✓	✓	✓	✓	✓	✓	✓	✓	
Water Management Strategies									
Modify Streamflow		✓	✓			✓			
Create Sediment Basins	✓			✓	✓	✓			
Streambank Reach-Scale Strategies									
Control Invasive Non-Native Species							✓	✓	
Fill Gaps in Existing Riparian Corridors							✓	✓	
Instream Site-Specific Strategies									
Reduce Channel Erosion	✓	✓		✓		✓		✓	✓
Construct Grade-Control Structures	✓	✓		✓		✓			
Remove Debris									
Improve Fish Passage		✓		✓		✓			
Prevent Fish Stranding		✓		✓		✓			
Augment Fish Spawning Gravels	✓	✓				✓			
Construct Vortex or W-Weirs	✓	✓		✓		✓			
Install Deflector Logs	✓	✓		✓		✓			
Construct Rock Vanes	✓	✓		✓		✓			
Construct Boulder Wing Deflectors	✓	✓		✓		✓			

Restoration Strategy	Geomorphologist	Stream Hydrologist	Groundwater Hydrologist	Engineer	Soil Scientist	Fisheries Biologist	Wildlife Biologist	Botanist/ Revegetation Biologist	Erosion Control Specialist
Streambank Site-Specific Strategies									
Hardscape Removal	✓	✓		✓		✓			
Joint Plantings			✓					✓	✓
Tree Revetments								✓	✓
Live Fascines								✓	✓
Bank Shaping and Planting	✓	✓	✓	✓		✓	✓	✓	
Cribwalls	✓	✓		✓		✓		✓	
Vegetated Gabions				✓		✓		✓	
Plant Riparian Vegetation			✓		✓			✓	✓
Brush Layers									✓
Brush Mattresses									✓
Erosion Control Blankets									✓
Increased Shade over Stream			✓	✓	✓	✓		✓	
Wildlife Nesting/Roosting Structures							✓		
Enhancement of Upland Habitat					✓		✓	✓	
Fencing							✓	✓	
Education and Outreach Strategies									
Public Education		✓				✓	✓	✓	✓
Assistance to Landowners									
Legal Strategies									
Land Acquisition									
Conservation Easements									

Analysis at the Watershed Scale and the Reach Scale

An understanding of basic watershed conditions and functions is crucial to the success of any riparian restoration project. Factors which must be considered at the watershed scale include:

- watershed geology;
- watershed hydrology (including the timing, duration and magnitude of streamflows on the watershed);
- past, current, and projected land use in the watershed area;
- channel geomorphology and processes in the target stream;
- sediment supply and transport patterns in the target stream; and
- other instream and streambank projects in the watershed.

These factors must be considered over a historical time frame in order to identify possible changes through time, be they natural or human-induced. Factors that must be considered at the reach scale include all of the above, as well as

- detailed hydraulic and sediment-transport analysis of the project reach, and
- data on channel stability in the project reach.

Instream Restoration Strategies

This section presents general guidelines for implementing the instream restoration strategies introduced in Chapter 5. Detailed guidelines and site-specific designs should be delineated on a project by project basis, in consultation with appropriate experts.

Recreate Meanders. The design of recreated channel meanders must be based on natural watershed processes, with an understanding that a stream is an inherently dynamic system that cannot be maintained in a static condition without artificial intervention. In order to design an appropriate channel morphology for a particular stream, the stream's bankfull flow must first be determined; this is typically done based on flood frequency data and field indicators of floodflow depth and extent. Data on bankfull flow volumes will then guide the determination of bankfull channel width, channel depth and flow velocity. These parameters in turn—along with information on sediment size and valley floor gradient—can be used to design the channel's bankfull cross section and planform geometries. Analysis of historical planform data is commonly useful in determining channel planform characteristics.

"Daylight" Covered Channels. Because daylighting covered channel segments is a process of channel reconstruction, the steps in daylighting a channel are similar to those described above for recreation of channel meanders. The size and geometry of the uncovered (reconstructed) channel should be designed to achieve a sustainable, functioning stream. Improperly sized channels can lead to bank and bed erosion, to channel siltation, or to problems conveying floodflows. All of these can cause damage to nearby property.

Create or Enhance a Low-Flow Channel. The design of an excavated low-flow channel should be based on a target flow range determined by flow frequency analysis. Field data can be used to determine the flow volume at which flow becomes discontinuous at various locations throughout the system, and then individual sites can be assessed for modification. In addition to flow velocity and volume, the design process must also consider the sustainability and maintenance needs of proposed low-flow channel configurations.

Modify Streamflow. Regulation of streamflow within a system must be based on an understanding of the system's natural flow characteristics, including its capacity and stability. The natural flow characteristics of an individual stream targeted for restoration can be determined by conducting hydrologic analyses of the system, using a combination of new and historical streamflow and rainfall records. Stream capacity and stability are assessed through hydraulic and geomorphic analyses of potential project sites. Care must be taken so that modifications to existing streamflow patterns do not adversely affect the flood capacity and stability of the existing system.

Create Sediment Basins. By removing excess sediment load from a stream system, sediment basins can improve both water quality and habitat quality, but, by reducing or eliminating downstream sediment load, they can also contribute to "hungry water" syndrome and to downstream erosion. As a result, restoration plans must consider the potential downstream effects of constructing sediment basins; sediment basins should be designed and constructed in consultation with stream geomorphologists and engineers. In addition, because sediment basins are specifically designed to trap sediment, over time they fill and lose capacity. Thus, in order to continue to function effectively, sediment basins require ongoing sediment removal, and possibly other maintenance as well.

Instream Site-Specific Strategies. All of the instream site-specific strategies described in Chapter 5 rely on the construction of some variety of instream structure. The design and construction of any instream structure must consider site hydraulics, and existing and desired channel stability. The placement of any structure in a stream will have an effect on local flow. The magnitude and nature of that effect must be evaluated and addressed before the structure is installed. When improperly designed and constructed, some types of structures can lead to channel or bank erosion, or conversely, to channel siltation. Construction of instream structures can also impact stream capacity and increase the risk of flooding and property damage. Analysis of site hydraulics is crucial in determining the appropriate size and design for proposed instream measures. Inappropriately sized instream measures may not remain in place over time, and will therefore not achieve the desired effect. Augmentation of spawning gravels provides an excellent illustration of this issue. If undersized gravel is used to augment spawning gravels, the gravel is more likely to be carried away by streamflow; thus, the intended goal of the augmentation program will not be achieved, and downstream habitat quality may actually be decreased. On the other end of the spectrum, over-designed structures may result in unnecessary costs with little or no additional return.

In order to be both environmentally and financially effective, instream strategies should always be designed and implemented in consultation with stream hydrologists, engineers, and other appropriate technical experts.

Major Elements of a Streambank Restoration Project

This section provides general guidelines for the major elements in a streambank restoration project, which include:

- soils and groundwater investigations at the project site,
- site preparation and clearing,
- selection and installation of plant materials,
- planting "site finishing," and
- protecting restoration plantings.

Detailed guidelines for site-specific streambank restoration strategies should be designed on a case by case basis. Because follow-up is essential to the success of streambank restoration projects, this section also discusses aspects of restoration site maintenance, including:

- irrigation, and
- weed control.

Finally, the outcome of a restoration project must be assessed, so that future restoration efforts can build on its successes and learn from its mistakes. This is done by implementing an ongoing monitoring effort. The final portions of this section address the design and implementation of monitoring programs.

Soils and Groundwater Investigations at Project Site

Before restoration planners can finalize a detailed site-specific restoration plan, soils and groundwater studies of the potential restoration site must be carried out. The characteristics of native soils (and of any imported fill materials used on the site) exert a primary control on the establishment and success of vegetation, and should be considered when species for restoration plantings are chosen. Soil characteristics may also affect streamchannel stability (rates of channel incision and channel migration), as well as sediment budget in the stream system, and should therefore also be considered in designing restoration strategies that affect the gradient, planform, or cross section of the channel. Factors related to groundwater hydrology, including the depth to the local water table, are crucial controls on the growth of riparian vegetation; specifically, the area where riparian vegetation will succeed is generally considered to be limited to the area where the dry-season depth to the water table is $\leq$ 8 feet.

Soils studies require specialized technical skills, and should be carried out by a qualified and experienced soil scientist, or by a state-registered geologist (RG) with appropriate expertise. Soils studies should begin with a review of existing soils data for the region in which the project site is located, such as that available in reports published by the Natural Resources Conservation Service (formerly the Soil Conservation Service) (e.g., Soil Conservation Service 1968). Onsite studies should also include excavation of a selected number of soil test pits, and thorough description of soil profiles exposed in those pits, following standard pedologic procedures. Particular attention should be paid to soil characteristics which relate to the ability of the soil to support vegetation species that may be used in restoration.

Groundwater hydrologic studies, like soils studies, require significant technical expertise, and should be designed and supervised by an experienced hydrologist, by a state-certified hydrogeologist (CHG), or by an RG. In most cases, the primary goal of onsite groundwater hydrologic studies in the habitat restoration context is to determine and model the depth to the water table on the restoration site, which will establish the approximate limit of the area that can be successfully planted with riparian species. This will probably require the installation and monitoring of a number of piezometers. Hydrologic studies should be performed at the peak of the dry season, in order to assess the groundwater "worst case."

Site Preparation

Proper site preparation is essential to the success of any restoration project. The following paragraphs describe the steps in the site preparation process.

Delineate the Work Area. Prior to initiating any restoration activities, the work area should be clearly delineated by installing stakes and flagging or temporary fencing to outline the area where restoration activities are permitted. Delineating the work area

- helps to protect existing sensitive resources,
- helps to ensure that the project complies with applicable environmental regulations, and
- ensures that project activities do not infringe on adjacent properties.

Staging areas for equipment, crews, and materials should be established outside of the riparian corridor. This is particularly important when heavy equipment will be used. Construction equipment and materials should be stored in the staging area when they are not in use.

Protect Existing Vegetation and Sensitive Habitat. During restoration, every effort should be made to protect existing native vegetation and sensitive habitat, to prevent erosion and control sediment deposition, and to minimize adverse effects on fish, wildlife, and adjacent properties. Project sponsors should consult with experienced botanists to ensure that existing riparian trees are protected from disturbance; construction activities near trees require careful planning, the implementation of special practices, and continued monitoring to prevent accidental damage to trees. Fencing or stakes and flagging can be an effective way to identify and protect areas within the restoration site that are to remain undisturbed.

Prevent Erosion and Control Sediment Deposition. In general, the extent of soil and vegetation disturbance associated with restoration activities should be minimized, because increased sediment input to a stream has the potential to adversely affect aquatic species and their habitat as well as destabilizing the delicate balance of sediment transport in the stream system. Erosion and sediment control measures should be identified and implemented as part of the restoration activities. Protective measures may include:

- minimizing the extent of areas to be cleared, graded, or recontoured at any given time;
- mulching disturbed areas as appropriate, and planting with appropriate native species as soon as practicable after disturbance;
- emplacing suitable erosion-control blankets, or netting and straw mulch, as groundcover in areas designated for grading or excavation, to provide erosion protection while allowing for native plant establishment; and
- installing silt fences to protect undisturbed areas that lie downslope from areas slated for restoration activities.

Clear the Restoration Site. Site clearing involves removing undesirable species while protecting desirable native vegetation. Methods for protecting existing vegetation are described above. Undesirable plant species include non-native and invasive species that might threaten the establishment and survival of restoration plantings. Undesirable plants may be removed by hand, by mechanical means, or in extreme cases by mechanical means in combination with the use of selected herbicides. In general, herbicide use should be limited to spot applications of approved herbicides, rather than broad-scale application, and should be supervised by a California-licensed pest control advisor; wider application, or repeated application, may be required in some cases. Table 6–3 lists the removal and control methods recommended for various species of invasive exotic plants. Site clearing is most easily accomplished in the spring, when soil is comparatively soft and moist.

On some sites, site clearing may require grading activity. If this is the case, standard best management practices (BMP's) for grading and soil removal will apply. Consultation with an experienced, state-licensed grading contractor and with a certified erosion control specialist is recommended.

Selection of Appropriate Plant Materials

When selecting plant materials (seeds, cuttings, container stock, etc.) for use in restoration plantings, care must be taken to use only materials from native stock from appropriate elevations within the project's local watershed; ideal restoration planting materials are those harvested from areas as close as possible to the restoration site. By interbreeding with locally native plants, plants of non-local origin spread their genes into the local population. Over time, the composition of the local gene pool is altered; genetic contamination can affect the fitness of trees and shrubs by reducing their adaptation to the local environment. Use of locally native plant materials is key to maintaining the long-term viability of the Urban Service Area's riparian corridors, and may affect the success of individual restoration projects.

Appropriate locally native plant materials can be obtained in several ways. Plant materials can be collected, propagated, and grown by the sponsor of a restoration project, if time, facilities, and expertise are available. Live cuttings of species such as willows and Fremont cottonwood that are commonly grown from cuttings can be collected from healthy native stands at the project site or at an adjacent site. Plant materials can also be obtained from a native plant nursery that has collected propagules native to the project watershed.

Different plant species are appropriate for planting in different areas of a restoration project site. In general, planting areas are broadly designated as lower bank and upper bank. These designations relate to the elevation of an area relative to typical summer water levels. Planting area elevations are as follows:

- lower bank: 0 – 4.5 vertical feet above summer water level, and
- upper bank: > 4.5 vertical feet above summer water level.

Table 6–4 provides general guidelines regarding native plants suitable for planting in lower and upper bank areas. Ideal planting choices may vary from site to site, depending on local conditions. Detailed planting designs for individual restoration projects should therefore be developed in consultation with botanists who have local expertise.

Planting

In the Urban Service Area, as in much of north-coastal California, planting should generally be carried out in the fall, because the winter rainy season permits some establishment of new plantings before the onset of high temperatures and drier conditions in late spring and summer. Planting should be conducted by trained planters, under the supervision of knowledgeable individuals; however, the use of volunteer trainees is encouraged, and volunteers from the community can be very helpful in the planting phase of a restoration project. The following paragraphs present an overview of techniques for planting container stock and cuttings. Further information on planting can be obtained from the sources identified in Appendix D.

Container Stock. Common sizes of container for planting stock include dee-pots (2 ½ inches in diameter by 10 inches deep), tree-pot 4's (4 inches by 4 inches by 14 inches deep) and 1-gallon pots. The planting hole for container stock should be at least 1.5 times the depth and 2 times the width of the container. The sides of the hole should not be smooth or glazed—as is often the case with holes augured in wet, clay-rich soils—because roots will not penetrate this surface and will instead spiral inside the planting hole. The soil that is removed should be stockpiled. If the soil is dry, water should be applied before planting.

Prior to planting, the roots of a container stock plant should be inspected, and any matted, dead, diseased, broken, twisted, or circling roots should be pruned. Root inspection and pruning must be done very quickly because every minute of root exposure to the air results in a significantloss of root hairs. For most containerized nursery stock, vertical cuts should be made on opposite sides of the container-shaped rootball to deter root girdling.

Table 6–3. Recommended Methods for Exotic Species Control

Species	Recommended Control Method	Priority Rating[1]
Arundo donax	Cut at soil level, mulch on site or remove; herbicide on regrowth.	2
Atriplex semibaccata	Hand; put in plastic bags for removal.	2
Carderia draba	Cut and/or herbicide, treat new growth before seed set.	
Carduus pycnocephalus	Cut before seed set.	3
Carpobrotus	Hand; mechanical removal and/or herbicide; leave in place.	1
Centauria solstitialis	Cut, burn and/or herbicide before seed set.	1
Cortaderia sp.	Dig up rhizomes, burn or bag for disposal, herbicide on regrowth.	1
Cotoneaster lacteus	Cut and paint stump with herbicide, treat regrowth.	
Cynodon dactylon	Herbicide, and plant competitive native plants.	
Ditrichia graveolens	Cut and/or herbicide.	2
Eucalyptus sp.	Cut and paint stump with herbicide, herbicide on regrowth.[2]	3
Foeniculum vulgare	Herbicide.	2
Hedera canariensis	Cut and/or herbicide, treat regrowth.	
Hedera helix	Cut and/or herbicide, treat regrowth.	
Juglans californica	Cut and paint stump with herbicide, herbicide on regrowth.	3
Lepidium latifolium	Cut, herbicide on regrowth.	1
Myoporum laetum	Cut and paint stump with herbicide.	2
Nicotiana glauca	Cut and paint stump with herbicide, treat regrowth.	
Olea europea	Cut and paint with herbicide, treat regrowth.	3
Opuntia aurantiaca	Mechanical removal.	
Phalaria tuberosa	Herbicide.	2
Piptatherum	Plant competitive native grasses.	
Populus nigra italica	Cut and paint with herbicide, treat regrowth.	3
Prunus dulcis	Cut and paint with herbicide, treat regrowth.	3

Species	Recommended Control Method	Priority Rating[1]
Ricinus communis	Cut and paint stump with herbicide, treat regrowth.	3
Robinia pseudoacacia	Cut and paint stump with herbicide, herbicide on regrowth.	
Rubus discolor	Cut and/or herbicide, treat regrowth.	
Salix babylonica	Cut and paint with herbicide, treat regrowth.	2
Senecio sp.	Cut and/or herbicide, treat regrowth.	
Ulmus procera	Cut and paint with herbicide, treat regrowth.	3
Vinca major	Herbicide, treat regrowth.	
Washingtonia robusta	Mechanical removal.	
Xenthium strumarium	Cut prior to seed set.	2

[1] **Priority Ratings:**

1 = High priority, potential to rapidly invade and/or cause serious economic or ecological damage.
2 = Medium priority, moderate invasion rate and moderate potential to cause serious economic and/or ecological damage.
3 = Low priority, slow invasion rate and potential to cause serious economic and/or ecological damage.

[2] Consistent with the guidelines established in the Riparian Corridor Policy Study (City of San Jose 1994), only eucalyptus trees with trunk diameters $\leq$10 inches should be removed. Method and timing of removal (as well as subsequent revegetation) may need to consider potential impacts on sensitive wildlife species.

Table 6-4. Recommended Native Plants

Common Name	Scientific Name	Planting Elevation
Trees:		
Arroyo willow	*Salix lasiolepis*	Lower Bank
Black cottonwood	*Populus balsamifera*	Lower Bank
Blue elderberry	*Sambucus mexicana*	Upper Bank
Blue oak	*Quercus douglasii*	Upper Bank
Box elder	*Acer negundo*	Lower Bank
California bay	*Umbellularia californica*	Upper Bank
California buckeye	*Aesculus californica*	Upper Bank
Coast live oak	*Quercus agrifolia*	Upper Bank
Fremont cottonwood	*Populus fremontii*	Lower Bank
Red willow	*Salix laevigata*	Lower Bank
Sandbar willow	*Salix exigua*	Lower Bank
Shining willow	*Salix lucida*	Lower Bank
Valley oak	*Quercus lobata*	Upper Bank
Western sycamore	*Platanus racemosa*	Upper Bank
White alder	*Alnus rhombifolia*	Lower Bank

Table 6-4. Recommended Native Plants, continued

Common Name	Scientific Name	Planting Elevation
Shrubs:		
California blackberry	*Rubus ursinus*	Upper Bank
California wild rose	*Rosa californica*	Upper and Lower Bank
Coffeeberry	*Rhamnus californica*	Upper Bank
Coyote brush	*Baccharis pilularis*	Upper Bank
Narrow-leaved willow	*Salix exigua*	Lower Bank
Mulefat	*Baccharis salicifolia*	Lower Bank
Snowberry	*Symphoricarpus albus*	Upper Bank
Toyon	*Heteromeles arbutifolia*	Upper Bank

Note: *wetland species are not listed in this table because in most cases, if site conditions are correct, they will reestablish naturally without planting.*

Container stock plantings should be placed in the planting hole so that the root collar remains slightly above final grade (Figure 6–2, Figure 6–3). Most container stock will be found planted deep in the container soil; soil should be removed from the stock to the top of the first major root. When the plant is set in the planting hole, the top of the root should barely be visible at finished grade.

The planting hole should be backfilled with the native material that was stockpiled when the planting hole was dug. As soil is backfilled, it should be worked in around the roots so that they are not compressed into a tight mass, but are spread out and are supported by the new soil beneath and between them. After each 3–4 inches of soil has been placed in the hole, foot pressure should be used to gently compact the soil around the roots, with care taken not to damage the roots. If the soil is dry, continued applications of water will be necessary during and after planting. Watering after planting will also help to eliminate possible air pockets in the backfilled soil, and to settle the rootball into its final position.

Transplants. Ideally, a plant selected for transplanting will have approximately one cubic foot of rooted material; transplants must also have healthy above-ground stems. The planting hole will probably be about 6–8 inches wide in its upper portion, but it may be wider if necessary. Prior to installation, the soil within the planting hole should be firmly tamped to reduce settling. Transplants should be positioned plumb, with the root crown about ½ inch above the finished grade. Following installation, the backfill material should be firmly tamped around the root ball, and the transplant should be completely watered in.

Cuttings. Branch or shoot cuttings for planting use are normally taken at a 50° to 60° angle, using loppers, pruners, or a saw. If the entire plant will be used, the cut is made about 10 inches above the ground; in most species, this encourages rapid regeneration from the remaining trunk. Cuttings typically range from 0.4 to 2 inches in diameter, and from 2 to 4 feet in length. In wet or soft soils, cuttings can be gently tamped into the ground with a mallet. In dry or compacted soils it may be necessary to prepare a hole for cutting installation. Installation in moist soil is preferable. Between two-thirds and four-fifths of the cutting should be buried below ground (Figure 6–4). In general, the deeper the cutting is set into the soil, the better, because a shallowly planted cutting generates too few roots below ground and too many leaf shoots above ground. This leads to early death because the scanty root system cannot supply sufficient water and nutrients to support the disproportionate mass of foliage.

Seeds and Acorns. The planting site for a seed or acorn installation is prepared by digging and backfilling a planting hole, and then tamping the backfill in order to prevent settling. One buckeye seed, or as many as three acorns, may be planted at each site. Each seed or acorn should be gently pressed into the soil so that approximately half of the seed or acorn is below grade (Figure 6–5). Seeds and acorns do not need to be watered following planting.

Planting Site "Finishing"

The following steps may be necessary to ensure success of restoration plantings:

Install Irrigation Preparation. Installation of drip irrigation systems is discussed below, under ***Irrigation***. At restoration sites where drip-system irrigation will not be used, a soil berm should be constructed around each planting to form a watering basin approximately 3 feet in diameter. Chips applied as soil mulch should be backfilled into the basin, but should not come in contact with the planted stock.

Install Weed Inhibition Measures as Necessary. It may be necessary to install measures to inhibit weed growth around each newly planted tree. In some cases, mulch will suffice. In other cases, biodegradable paper mats will be necessary; a 3-foot by 3-foot square with a small, central X-cut should be used. A commercial seedling tube can be placed over the seedling and inserted into the cut opening. The tube will allow light to penetrate but will protect the seedling from being trampled, eaten by herbivores, or otherwise damaged. Because tubes may have adverse impacts, they should only be used if herbivory is an extreme hazard at an individual project site.

Water Plantings. Newly planted trees and shrubs should be watered during the planting day and shortly thereafter. As discussed above, a watering basin should be graded at the time of planting, or a drip irrigation system should be installed, as noted above. Ongoing irrigation is discussed under ***Irrigation***.

Protecting Restoration Plantings

Several options are available for protecting newly installed restoration plantings from impacts resulting from recreational and urban land use in adjacent areas. These include:

- signage,
- interpretive exhibits,
- fencing,
- barrier or screen plantings, and
- designated access routes.

Signage can be effective in discouraging disturbance of restoration sites. In areas that receive minimal use, small discreet signs can be posted at regular intervals to identify restoration sites and to request that the public not enter the site. Areas that experience more frequent use present ideal opportunities for the development of larger interpretive exhibits providing more information about the restoration project and the importance of limiting public access to the site. Benches and other features can be constructed around the interpretive exhibits to attract people to designated areas rather than the restoration site, and to provide a comfortable vantage point for wildlife viewing. Fencing can also be used to protect restoration sites from disturbance, and is especially useful in high-use areas. Fencing should be constructed of a material that will not restrict wildlife dispersal, such as post and cable. Barrier plantings fulfill the same function as fencing; dense plantings of appropriate native shrubs at the boundary of the restoration site can be very effective in discouraging

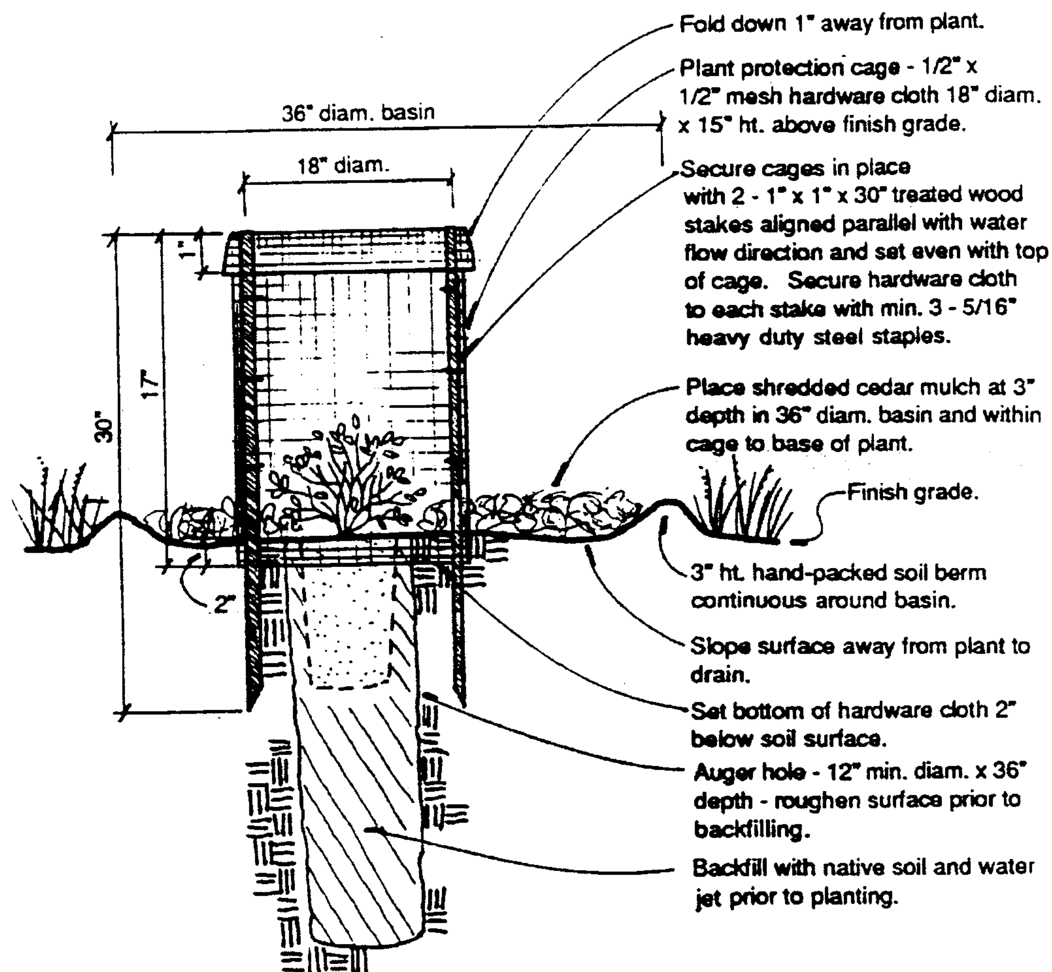
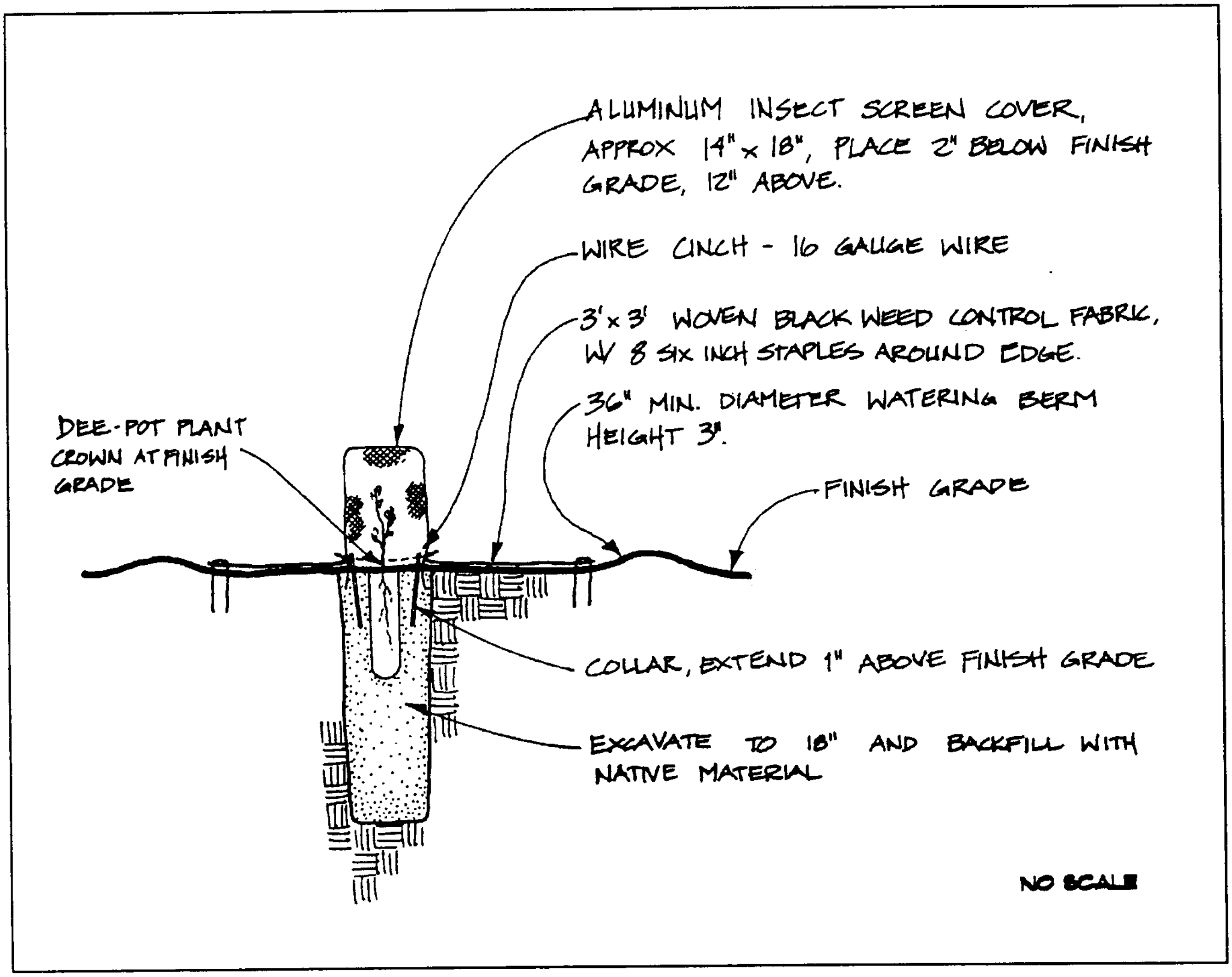


Figure 6-2
Planting Detail, 1-Gallon Container Stock



Jones & Stokes

Figure 6-3
Planting Detail, Dee-Pot Container Stock

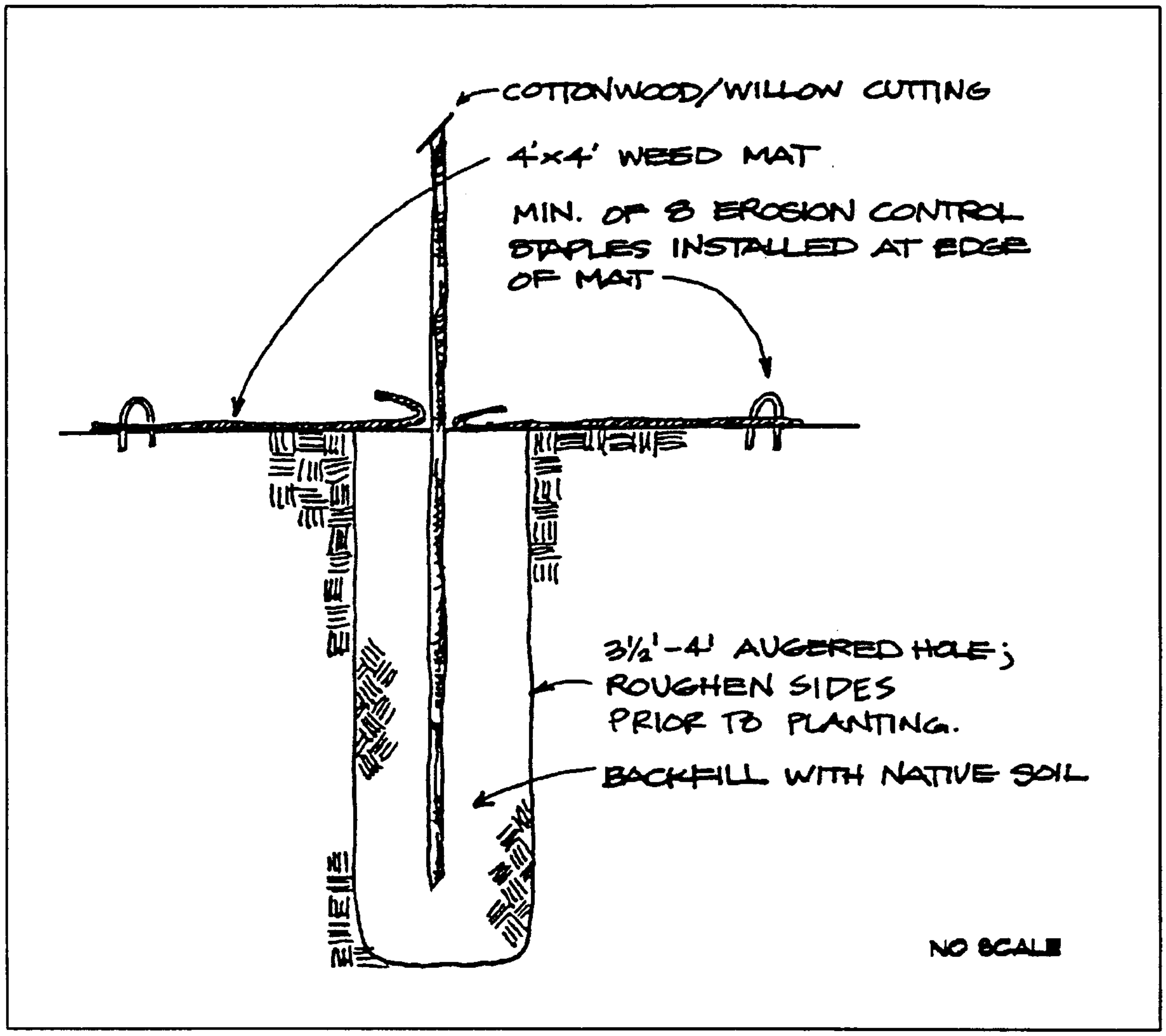


Figure 6-4
Planting Detail, Cuttings

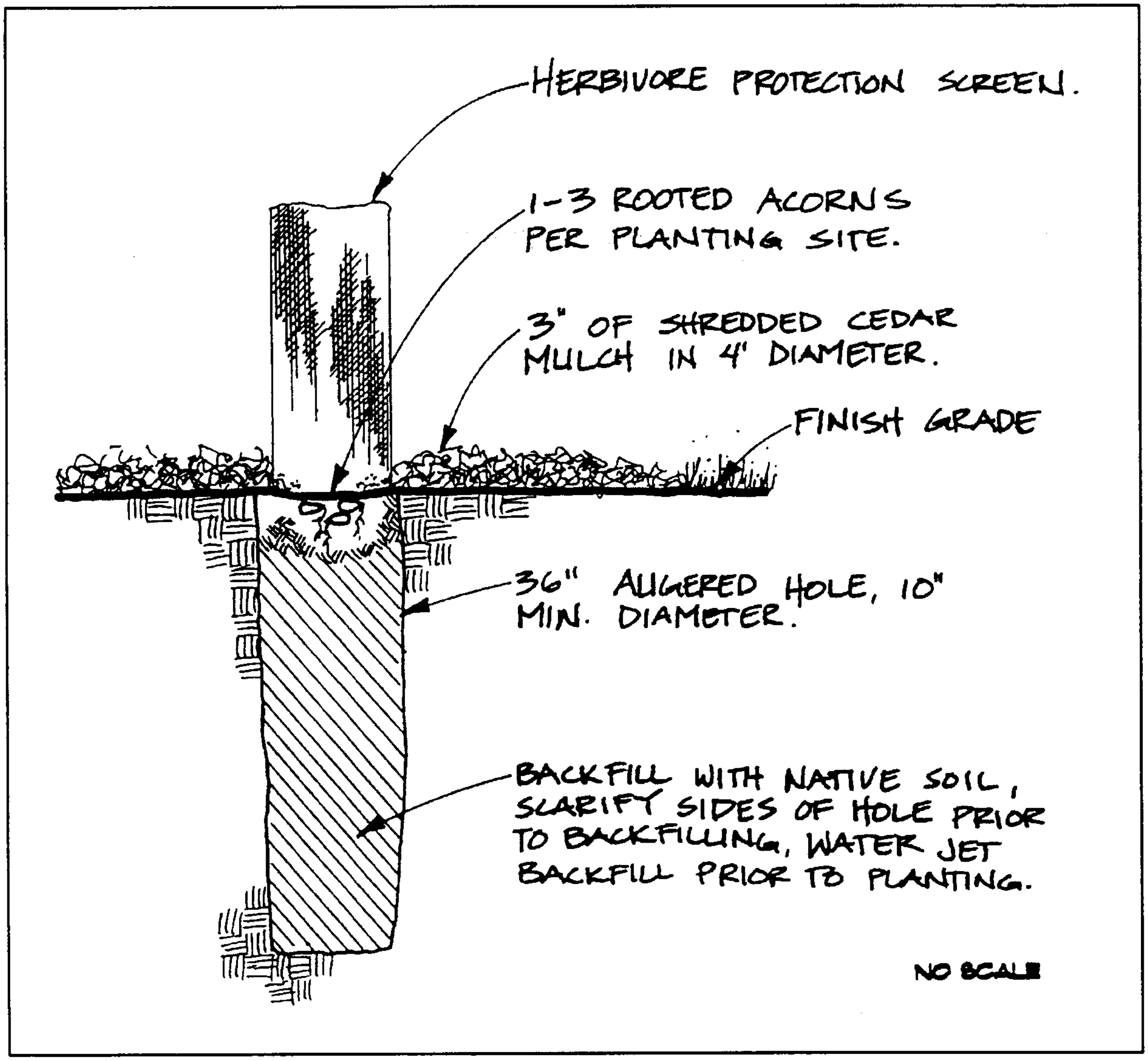


Figure 6-5
Planting Detail, Acorns and Seeds

people from entering the site. Species with thorns or spines, such as California wild rose, may be especially effective. Care should be taken to avoid the use of species that may be invasive. Finally, the construction of designated access routes or trails may also help to protect restoration sites from foot and bicycle traffic, because most if not all people will use trails rather than disturb restoration sites.

Site Maintenance

Ongoing maintenance of restoration sites is essential to the success of restoration plantings. This section describes procedures designed to help ensure that restoration plantings will survive and grow to their full potential. Typical maintenance tasks include weed control and irrigation. Watering regimes depend on local sources of water, and on ease of access to the restoration site, while weeding intensity depends on watering. In addition, as seedlings become saplings, they may become overcrowded, and, depending on specific site conditions, selective thinning may be needed.

Four maintenance periods can be distinguished:

- **Planting to Year 1:** The first year in the life of an individual planting determines whether it will grow into a thrifty plant or a sickly, suppressed plant that will pose a long-term maintenance problem. The most important maintenance steps during this period are to water, weed, and monitor growth and health.

- **Years 1-3:** The plantings should be constantly cared for through a carefully designed and implemented watering and weeding program. Depending on the species planted, and on site-specific conditions, it may be possible to discontinue irrigation after Year 1. Thinning may be required, particularly if initial planting density is high. Poorly established plantings should be eliminated, planting sites re-prepared, and new stock planted.

- **Years 4-7:** This phase comprises careful weeding, monitoring, and preventive maintenance. If necessary, plantings should be thinned. By this time, the plantings should be able to survive without irrigation.

- **Years 8-11:** Plantings will be integrated into the surrounding vegetation by additional thinning and pruning of potentially hazardous branch growth. Revegetation maintenance will be discontinued as plantings become well established.

The following paragraphs provide a general overview of specific maintenance activities. However, each restoration site will require a customized maintenance program, which should be designed in consultation with appropriate technical experts.

Irrigation. Drip irrigation systems or watering basins should be installed around each plant at the time of planting. In most parts of the Urban Service Area, it will be necessary to water seedlings for as much as 3 years to ensure that they become established. This seemingly long watering period is actually cost-effective, because it greatly increases the chances of planting success. The effort and cost of watering can be minimized by

- using appropriately designed irrigation systems,
- carefully monitoring weather and soil conditions,
- confining watering to seedling root zones, and
- keeping aggressive weed populations to a minimum.

Irrigation Methods and Water Sources: The choice of irrigation method should be made on a site-specific basis. Several methods of delivering water to plantings are commonly used in restoration site maintenance, including:

a. drip irrigation using existing water lines for water delivery;

b. manual application of water delivered by tanker truck or tractor-drawn tank;

c. manual or drip application of water delivered by tanker truck and stored onsite in drums or portable tanks; and

d. Use of timed-release water delivery systems such as DriWater.

Method **a** is appropriate for use when a water system hose bib is located within a few hundred feet of a planting site; drip irrigation can be extended from the hose bib to more distant planting sites. Methods **b** and **c** require vehicle access to the site for 2–3 years during the maintenance period. Method **d** may be helpful when site conditions render implementation of methods **a**, **b**, and **c** overly difficult or costly. Finally, more than one method of water delivery will generally be required in each management area. Systems should be mixed as dictated by site-specific conditions.

When a drip irrigation system is installed, one emitter should be placed at each tree or shrub, at the edges of the original rootball, and near the stem but not touching it. It may be possible to reuse drip irrigation equipment at subsequent revegetation sites. Hoses may be temporarily buried to avoid vandalism, but will this cause gradual deterioration and will probably limit hose reuse. If drip irrigation is used instead of periodic hand watering, the total seasonal water application will be less.

If a timed-release delivery system such as DriWater is used, specific planting guidelines may apply. The tops of the units must be mulched to conceal them from view, so that they will not be disturbed by curious members of the public. DriWater units must be regularly checked for correct function, and will need to be refilled at least every 60 days. (Where DriWater or equivalent units are installed, the following information on watering rates and schedules will not be applicable.)

Watering Rates and Schedules: Initial watering needs depend on temperature, precipitation, and soil conditions at the time of planting. In the City's Urban Service Area, newly planted trees and shrubs may need as much as several waterings during the planting day and the days immediately following. However, if planting occurs during a wet period, little initial watering may be required. In general, new plantings in the Urban Service Area should be watered semiweekly for the first month after planting, and weekly during the next 2 months.

During the first growing season, watering should be initiated when the soil surface has dried significantly. An average of 2–3 gallons of water should be applied to each seedling three times per month during the summer (June through September). Water should also be applied in the spring if soil moisture becomes limiting. Typical watering regimes specify one watering in March and two waterings per month in April, May, and October. The frequency of watering is generally more critical to seedling survival than the amount of water applied.

During the second maintenance period (Years 1–3), watering frequency can be reduced. One or two waterings per month should suffice between May and September. It may be possible to stop irrigation altogether after Year 1; if irrigation continues after Year 1, it may not be needed during the third summer.

Watering schedules and application rates should be evaluated and adjusted as restoration proceeds and experience is gained.

Weed Control. Weeds compete with desired species for limited water, nutrients, and light; a seedling must extend its roots below the weed root zone before it can survive on its own. Removing weeds around plantings thus is one of the most effective ways of increasing planting survival rates and lengthening the interval between waterings. Weed-control measures may be advisable for any restoration site where weeds are suppressing native species or preventing their establishment and growth.

Three basic methods of eliminating weeds are available:

- hand weeding,
- applying herbicides, and
- mowing before viable seed sets.

These basic methods are sometimes used in combination with one another. In riparian areas, the preferred approach within 18 inches of seedlings is hand weeding. However, when very aggressive weeds are present, applications of a selected herbicide may be necessary. The timing of herbicide applications is important to maximize their effectiveness and to reduce overall usage. Use of herbicides should always be carried out in consultation with a California-licensed pest control advisor.

Weeding activities should be scheduled to minimize labor and cost, and to maximize effectiveness. In the Urban Service Area, most weeds germinate in the late fall, winter and early spring when surface soil is moist. Weeding should begin during the fall and winter in order to remove weeds before their root systems become well established. Thorough weed removal is easier to accomplish—hence, quicker and less expensive—when weeds are not yet established. Early weeding also precludes competition for limited late spring and summer moisture, increasing the chances of planting success.

Annual grasses are a naturalized component of the plant communities in riparian corridors of the Urban Service Area and much of California; they generally cannot be completely eradicated without intensive and costly measures. Efforts to control annual grass species should typically only be made if annual grasses interfere with the establishment of native plants. Weed mats, hand weeding, and spot herbicide applications can be used to control annual grasses (and other undesirable species) around native plantings. Grassland sites may also benefit from properly timed mowing or prescription burning, which can reduce the non-native seed bank, and promote the establishment of native perennial species.

Environmental Compliance and Permitting

Restoration activities affecting any stream, wetland or other body of water may be subject to state, federal and local regulatory programs and requirements. Restoration planners should become familiar with general environmental compliance and permitting requirements, and may wish to consult with compliance and permitting experts as well. Contacting permitting authorities early in the planning phase of the project—as soon as a conceptual outline of the project has been produced—will help to ensure that all compliance and permitting requirements are met and that delays associated with compliance issues are minimized. Table 6–5 provides an overview of potential environmental compliance and permitting requirements associated with restoration activities. More detailed information is given in Appendix C.

The following basic design information should be developed prior to initial meetings with representatives of permitting and regulatory agencies:

- a site plan or map,
- a simple description of the restoration plan,
- information regarding property ownership of the site and potential access route(s) to the site, and
- the preferred month and year for project implementation.

Local agencies such as the City of San José and the District can also assist restoration planners by informing them of applicable local, state, and federal requirements.

Table 6–5. Summary of Key Project Features/Issues Triggering Need for Compliance

Environmental Laws, Polices, and Regulations	Agency	Key Project Features Triggering Need for Compliance
Federal Laws and Implementing Regulations		
National Environmental Policy Act (NEPA)		Restoration activities are subject to NEPA if they are sponsored, co-sponsored, or funded by the federal government.
Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act	USACE NRCS	Restoration activities are subject to Section 404 (and Section 10) if they are located in waters of the United States, including wetlands, and/or they are located in navigable waters, and are considered a discharge of dredged or fill material.
Section 401 of the Clean Water Act	SWRCB, RWQCBs	Restoration activities are subject to Section 401 if they involve a federal license or permit that may affect state water quality, and would result in a discharge of a pollutant into waters of the United States.
Sections 7 and 10 of the federal Endangered Species Act	USFWS, NMFS	• Section 7 – All federal agencies must consult with USFWS/NMFS to ensure that their actions, including permit issuance, do not jeopardize the continued existence of a listed species, or destroy or modify critical habitat. Incidental take authorization may be included in the no-jeopardy biological opinion. • Section 10 – USFWS and NMFS may issue incidental take permits to take listed species incidental to an otherwise lawful activity upon approval of a Habitat Conservation Plan that mitigates impacts of incidental take.
Section 106 of the National Historic Preservation Act		Restoration activities are subject to Section 106 if they are considered a federal agency proposal and occur in an area where properties are listed, or are eligible for listing, on the National Register of Historic Places.
Executive Orders and Administrative Policies		
Executive Order 11990 Protection of Wetlands		Restoration activities are subject to Executive Order 11990 if they are considered a federal agency proposal and are located within or may affect wetlands.
State Laws and Implementing Regulations		
National Pollutant Discharge Elimination System (NPDES)	RWQCBs	Restoration activities are subject to the NPDES if they result in a new or continued point source discharge of pollutants into surface waters of the United States.
Waste Discharge Requirements	RWQCBs	Restoration activities are subject to Waste Discharge Requirements if: • they result in non-point source or temporary discharge of waste that would affect surface water; • they result in discharge of waste that would affect groundwater; • they result in changes in the volume or quality of agricultural drainage.

Environmental Laws, Polices, and Regulations	Agency	Key Project Features Triggering Need for Compliance
Water Rights	SWRCB	Restoration activities are subject to water rights regulations if: • they require the diversion of water not authorized under an existing water right; • they include the purchase or transfer or water;. • they include change in use or change in point of diversion of water under an existing water right; • the activities include storing more than 10 acre-feet of water for more than 30 days.
California Environmental Quality Act (CEQA)		Restoration activities are subject to CEQA if they involve a state or local agency action that is considered a project for CEQA purposes.
Sections 2081 and 2090 of the California Fish and Game Code - California Endangered Species Act (CESA)	DFG	Restoration activities are subject to: • Section 2081- if they may result in the "take" of a species listed under CESA. • Section 2090 - if a species listed as a candidate, threatened, or endangered species under the CESA may be present in the project area, and a state agency is acting as the lead agency for CEQA compliance.
Section 1600 of the Streambed Alteration Agreement	DFG	Restoration activities are subject to the Streambed Alteration Agreement if: • they involve any activity that would divert or obstruct the natural flow or change the bed, channel, or bank of any river, stream, or lake; • they involve the use or alteration of any streambed material; • the activity occurs within the annual high-water mark of a wash, stream, or lake.
State Historic Preservation Officer Consultation under Section 106 of the National Historic Preservation Act		Restoration projects are subject to the National Historic Preservation Act if they are considered a federal agency proposal and occur in an area where properties are listed, or are eligible for listing, on the National Register of Historic Places.
Local Regulatory Compliance		
City or County approvals and entitlements		• Restoration activities are subject to City or County approval if they involve grading, building or modification of structures, special or conditional uses, modification or approval of general or specific plans (local or regional), or zoning ordinance amendment. • Restoration activities are subject to the City of San Jose's tree removal ordinance if the activity removes, or causes to be removed, any tree from any private parcel of land within the city unless required to do so by Municipal Code.

Environmental Laws, Polices, and Regulations	Agency	Key Project Features Triggering Need for Compliance
Santa Clara Water District Ordinance 83-2	SCVWD	Restoration activities will require a SCVWD permit if there will be: • excavation within a designated floodway, or upon or between the banks of a watercourse or district project. • depositing of material of any kind within a designated floodway or district project, or upon or within the banks of a watercourse. • planting of any form of flora or fauna upon or within the banks of a watercourse or a district project.

Monitoring

The restoration monitoring plan is one of the most important elements of a successful restoration project; however, development and implementation of a monitoring plan are often overlooked, perhaps because of budgetary constraints, or perhaps because of the natural tendency for a project to lose momentum after design and implementation. Jones & Stokes strongly advises that the restoration monitoring plan be considered an essential up-front component of every restoration project. The monitoring plan should include both pre- and post-restoration monitoring and should be designed to:

- provide an accurate description of pre-project conditions that will serve as a baseline for evaluating project success;
- fully assess the success of the restoration design relative to project goals and objectives;
- support adaptive management by identifying undesirable changes resulting from restoration activities and supplying information that can be used to adjust strategies in order to improve the long-term success of the project; and
- provide information that can be used to guide the development and implementation of future restoration projects.

Monitoring results should be compiled and evaluated on an annual basis, and should be summarized in a report that can be easily disseminated to interested parties.

Developing Restoration Objectives

The success of a restoration project is determined by its ability to achieve a set of site-specific restoration objectives. Developing these objectives is the first critical step in the planning, design, implementation and monitoring cycle. The objectives of a restoration project drive the planning, design and implementation process, identify the monitoring that must be done in order to assess the success of the restoration effort, and set the stage for implementation of remedial actions if the objectives are not initially met.

In general, restoration objectives should be:

- **Specific articulations of more general goals.** Larger goals may be derived from upper-level (programmatic) programs and plans such as the RRAP.
- **Clearly articulated and focused.** Objectives should be clearly and unambiguously written. Multiple objectives should be broken down into several smaller objectives in order to provide a focused framework for assessing the restoration project.

- **Realistic and achievable.** Objectives must be within the real bounds of site-specific opportunities and constraints.

- **Specific and measurable.** Objectives should be quantitative wherever possible (e.g., number of plants, percent cover, etc.). Qualitative objectives must be clearly enough expressed that their success can be evaluated.

Developing a Monitoring Plan

The monitoring plan should be developed during the planning and design stages of the restoration project. The restoration objectives, which are defined by the project sponsor in conjunction with interested stakeholders, not only provide the basic framework for the restoration design but also provide the basic criteria for assessing the success of the restoration project. The type and extent of monitoring necessary will depend on the site-specific objectives developed during the planning process, on the environmental significance of the project, and on applicable environmental and regulatory compliance requirements, and will be constrained by the level of available funding.

Key components of a successful monitoring plan include:

- identifying performance indicators for ecological functions and habitat values;
- establishing performance criteria (numerical and descriptive goals) for the indicators;
- determining levels, frequency, and duration of monitoring activities; and
- documenting and reporting monitoring results.

The following sections describe these key components. Table 6–6 gives examples of performance criteria; Table 6–7 provides examples of ways these key components can be integrated into a monitoring plan.

Identifying Performance Indicators

Performance indicators provide information about the ecological functions and habitat values associated with a restoration site. There are three types of indicators: physical, chemical, and biological. In order to provide a holistic evaluation of restoration performance, at least three site-specific indicators, including at least one indicator of each type, should be selected. However, in order to be practical and cost-effective, the monitoring effort should focus on the smallest number of indicators necessary to delineate the overall condition of the project site and the success of the restoration effort. Monitoring costs can quickly exceed the available budget unless the indicators and evaluation measures are narrowly focused, are limited in number, and are feasible for the project

Table 6-6. Examples of Monitoring Performance Criteria

Performance Criteria for Physical Indicators		**Performance Criteria for Chemical Indicators**		**Performance Criteria for Biological Indicators**	
criterion, feature, or characteristic	***what is measured?***	***criterion, feature, or characteristic***	***what is measured?***	***criterion, feature, or characteristic***	***what is measured?***
spawning gravel	abundance and quality (e.g., equal to or greater than pre-project levels?)	water temperature	suitable for native anadromous fish	"survival counts"	number or percentage of trees or shrubs per acre
water depth and velocity	depth-velocity relationship (e.g., water depth >1 foot at flows >4 cfs)	water pH	within desired site-specific range	tree and shrub populations	health and vigor rating (poor, fair, good)
		dissolved oxygen content of water	within desired site-specific range	tree and shrub populations	evidence of natural recruitment
				tree and shrub populations	percent native vegetative cover
				tree and shrub populations	percent non-native vegetative cover

Note:
numerical goals are indicated by gray shading.

sponsor to implement. Potential performance indicators for use in monitoring riparian restoration projects include:

- physical indicators, such as
  - channel width and depth,
  - rates of bank erosion,
  - water depth and velocity,
  - nature of bed material,
  - size, shape and profile of pool areas,
  - size, shape and profile of riffle areas, and
  - development and nature of bar features;

- chemical indicators, such as
  - water temperature,
  - water turbidity,
  - dissolved oxygen content of water,
  - water pH,
  - nutrient content of water, and
  - concentration of dissolved and suspended materials in water; and

- biological indicators, such as
  - species, numbers, and biomass of the invertebrate community,
  - survival, health and vigor, structure, and composition of vegetation,
  - percent vegetation cover,
  - fish and wildlife species occurrence, and
  - fisheries habitat quality.

Identifying Performance Criteria and Selecting Monitoring Activities

Performance criteria associated with each indicator are used to identify and evaluate the progress of the restoration project toward meeting the specified objectives of the restoration project. These criteria are expressed in the form of numerical and descriptive goals for each indicator; together, the numerical and descriptive goals define target parameters for a desired change or a desired future condition. The closer the link between project objectives and performance criteria, the better the monitoring plan will be able to assess the success of the restoration project and to identify steps required to modify any unsuccessful aspects of the project. The monitoring plan should clearly link performance indicators to the actual activities that will be used to monitor them. Examples of measurable performance criteria for the three types of indicators described above are summarized in Table 6–6.

Determining Desirable Levels of Monitoring

Once performance indicators and monitoring criteria have been chosen, the level of monitoring detail and the frequency of monitoring needed for the project must be established. In

Table 6–7. Examples of Indicators, Performance Criteria and Monitoring Activities for Riparian Restoration Projects.

Indicator	Performance Criteria	Monitoring Activity	Begin Monitoring	Frequency	Duration
Physical Indicators					
Water Depth and Velocity	water depth >1 foot at flows > 5 cfs	Measure depth and velocity	October	Annual	3 years
Bed Material	gravels suitable for anadromous fish spawning (average gravel size 2 inches in diameter, patches at least 6 inches thick)	Measure bed material	Pre-project, June–September	Annual for 5 years, then every 5th year	3 years, then assessed
Chemical Indicators					
Water Temperature	water temperature suitable for anadromous fish (44–64^{0}F)	Measure water temperature	Pre-project	Hourly	3 years, then reassessed.
Biological Indicators					
Survival	100 trees per acre must survive for 3 years after planting	Counts of planted trees	August/September following planting	Annual	3 years from planting
Health and Vigor	Average rating must be greater than 2 (fair) for the monitored area	Visual assessment of foliage, wood, and root crown	August/September following planting	Annual	5 years from planting, then reassessed
Cover	By year 20, native trees must cover 50% of the ground surface	Percentage cover along a line transect; aerial photograph inspection	August/September in year 4 following planting	Annual for years 4 and 5, then every 6th year	20 years from planting, then reassessed
Non-Native Species Cover	Combined relative cover provided by non-native woody species must be less than 5%	Percentage cover along a line transect; aerial photograph inspection	August/September following planting	Annual for first five years, then every 6th year	20 years from planting, then reassessed
Adult Anadromous Fish Migration	Observation of a specified number of adult fish	Visual observation of adult fish	Pre-project, October	Four times each year (October, November, February, and March)	5 years, then reassessed

general, monitoring activities can be divided into two broad categories: qualitative and quantitative. Quantitative monitoring requires the collection of numerical data, which can be time-consuming and therefore expensive. In many cases, qualitative monitoring is sufficient to evaluate the success of a restoration project.

Examples of qualitative monitoring activities include:

- photographic documentation,
- "presence or absence" monitoring,
- density estimation, and
- integrity monitoring.

In many cases, the most useful photographic monitoring technique is the creation of photo plots, which are photographs taken at fixed locations to provide physical documentation of conditions and changes over time. Depending upon the size of the site, aerial photography at specified time intervals may also be useful in assessing change over time. Presence or absence monitoring consists of periodic field observations to establish the presence or absence of a key species on the restored site. Periodic estimates of the density or the percent composition of vegetative cover give a qualitative assessment of the success of restoration plantings, and the survival of existing vegetation. Integrity monitoring relies on periodic site visits to ensure that the site has not changed dramatically, as might occur with peak flood events, fire, trespass, or vandalism.

Quantitative monitoring is typically employed when the restoration effort employs experimental or unproven techniques, when the ability to successfully recreate one or more of the habitat types in the project area is unproven, or when monitoring performance criteria are related to attaining specific numerical thresholds of plant cover, species diversity, wildlife utilization, or other factors. Examples of quantitative monitoring activities include:

- survival monitoring, or counting and recording the number of surviving trees or shrubs per unit area;

- health and vigor monitoring, or assessing and rating the health and vigor of plantings, typically using a numerical scale from 0 to 5, with 0 representing dead plants, and 5 representing plants in excellent condition; and

- vegetative cover monitoring, or using a line-intercept transect, or other similar method, to estimate the percent area covered by trees or shrubs.

Pros and cons can be advanced for both qualitative and quantitative monitoring approaches. For example, while qualitative monitoring is quick and inexpensive, the results of qualitative monitoring are purely descriptive and may thus be difficult to analyze. Qualitative monitoring is also more likely to be subjective than monitoring which addresses numerical criteria. By contrast, quantitative monitoring results in numerical data that can be rigorously analyzed for trends and changes. However, the collection of quantitative data can be both expensive and time consuming, and the analysis of quantitative data often requires specialized expertise.

All parties involved in a restoration project—including the project sponsor, the stakeholders, and all applicable local, state and federal resource and regulatory agencies—should be involved in establishing the appropriate level and detail of monitoring for the project. This decision requires thorough consideration and should not be made lightly. Factors that will weigh in the decision include:

- the appropriateness of proposed monitoring activities to provide adequate characterization of project outcomes,
- the project sponsor's ability to obtain the data required by proposed monitoring activities within the designated time frame, and
- the availability of funding to support monitoring activities.

Determining Timing, Frequency and Duration of Monitoring

Post-restoration monitoring should be carried out according to a systematic schedule. The monitoring plan should specify a monitoring start date, the time or times of year during which monitoring should occur, the frequency of monitoring activities, and the projected date for completion of monitoring.

Timing. Monitoring activities should be undertaken during the appropriate time of year for each performance indicator. For example, presence or absence monitoring for the occurrence of anadromous fish might require that monitoring activities be conducted during specific months when migrating fish are likely to be present in area streams (October, November, February, and March).

Frequency. Frequency refers to the period of time between iteration of monitoring tasks. For the first few years after implementation, restoration projects—in particular, plantings—change rapidly, and need to be monitored frequently. As the project becomes more established, it is less vulnerable to disturbance, and monitoring can be less frequent. For example, a project might be monitored on an annual basis for the first three years, and thereafter at intervals of two to five years until the project objectives have been achieved. Emergency monitoring should be implemented after catastrophic events such as floods, in order to assess damages and identify appropriate remedial actions.

Duration. In general, monitoring should begin prior to the initiation of restoration activities, in order to establish baseline site conditions; monitoring should continue for at least three years following the implementation of restoration measures. The monitoring period should extend long enough to provide reasonable assurance that the project has met its objectives, that the project will meet its objectives, or that the project likely will not meet its objectives within a designated time frame.

Documenting and Reporting Monitoring Results

Annual reports summarizing the results of monitoring activities provide the project sponsor and other interested stakeholders with documentation of the progress of the restoration effort toward achieving its objectives. In general, monitoring reports should include:

- a general description of the site,
- a description of monitoring activities undertaken,
- a discussion of monitoring results to date,
- conclusions, and
- recommendations for additional studies or remedial actions, if needed.

Copies of the report should be provided to the appropriate local, state, or federal resource and regulatory agencies, and to other interested stakeholders. The project sponsor may also wish to meet with interested parties to present the results of monitoring and to discuss the future of the restoration project.

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Appendix A. Related Programs and Policies Now in Effect, and Their Goals

Programs and Policies	Goals
Regional	
CALFED Bay-Delta Program	• Support of at-risk native species in the San Francisco Bay and the watershed above the estuary. • Rehabilitation of natural processes in the Bay-Delta system to support, with minimal ongoing human intervention, natural aquatic and associated terrestrial biotic communities, in ways that favor native members of those communities. • Protection or restoration of functional habitat types throughout the watershed for the public benefit, such as recreation, scientific research, and aesthetics. • Prevention of the establishment of additional non-native species and reduction in the negative biological and economic impacts of established non-native species. • Improvement and maintenance of water and sediment quality to eliminate, to the extent possible, toxic impacts on organisms in the system, including humans.
San Francisco Bay Wetlands Ecosystem Goals Project	• Emphasis on protecting and restoring wetlands that support threatened, endangered, and other special-status species, while ensuring adequate habitat for other wildlife. • Enhancement of the Bay's ability to support resident and migratory species.
San Francisco Estuary Project Comprehensive Conservation and Management Plan	• Restoration and enhancement of the ecological productivity and habitat values of wetlands. • Survival and recovery of listed and candidate species, as well as special-status species. • Control and reduction of pollutants entering the Estuary. • Increase in public understanding of the value of the Estuary's natural resources and the need to restore, protect, and maintain a healthy Estuary for future generations. • Increase in public involvement in the ongoing stewardship of the Estuary.
Riparian Habitat Joint Venture	• Increase in the overall breeding range and/or abundance of native riparian birds by designing and implementing restoration projects that mimic natural riparian plant diversity and distribution. • Increase in the breeding range of native birds and protection of healthy bird commununities with high productivity.

Programs and Policies	Goals
Local	
Santa Clara County General Plan	• Permanent protection and management of natural environmental resources such as wildlife, vegetation, soils, air, water, and minerals for their functional and ecological values. • Preservation and restoration of natural diversity for its inherent ecological value. • Existence of an adequate supply of high-quality water to meet domestic and economic needs.
Santa Clara County Countywide Trails Master Plan	• Efficient use of water resources (e.g., water-supply watersheds) and protection of those resources from contamination. • Existence of healthy, well-functioning creek, streamside, Bay and Bay wetlands ecosystems that provide (a) stable wildlife habitat, corridors that link habitat areas, and protection for endangered species, (b) opportunities for passive recreation and interpretive nature study, and (c) aesthetic enhancement of urban and rural settings. • Restoration, where possible, of degraded special water environments. • Plan development in rural areas which assures the long term conservation of natural resources, including water resources, and wildlife and plant communities. • Protection of the community from flooding.
San José 2020 General Plan	• Design of public improvement projects (such as road widening, bridge construction, and flood control projects) that may impact existing or proposed trails, to facilitate provision of land share • Incorporation of appropriate portions of the Countywide Trails Master Plan Map of the County's General Plan into local general plans, parks and open space master plans, and public facilities plans.
Santa Clara Basin Watershed Management Initiative	• Preservation, protection, and restoration of riparian corridors and upland wetlands within the City of San Jose's Sphere of Influence. • Preservation of habitat suitable for species of concern, including threatened or endangered species. • Protection of the community from the hazards of soil erosion, weak and expansive soils, and overall geologic instability. • Protection of the community from the risk of flood damage. • Protection of water resources because of their importance to the ecological and economic health of the region. • Provision of parkland and recreational areas to preserve significant natural resources and to meet the recreational and open-space needs of the community.

Programs and Policies	Goals
Santa Clara Valley Water District Programs	• Balance objectives of water supply management, habitat protection, flood management, and land use to protect and enhance water quality. • Protect and/or restoration streams, reservoirs, wetlands, and the Bay for the benefit of fish, wildlife, and human uses.
Santa Clara Valley Urban Runoff Pollution Prevention Program	• Provide flood control. • Reduce the amount of pollutants that enter into waterways, in order to protect the quality of water throughout the watersheds. • Protect wildlife within the riparian corridor. • Protect and restore riparian habitat.
Riparian Corridor Policy Study	• Protect and preserve riparian corridors within the Urban Service Area boundary.
San Francisco Bay Regional Water Quality Control Board – Bay Area Stream Protection Policy (draft is slated for completion in December 2000)	• Build on an area-wide understanding of stream function. • Provide guidelines for protection and restoration of riparian habitat as well as maintenance or improvement of flood retention, waters conveyance, and sediment transport capacity. • Address recommended best management practices (BMP's), such as implementation of adequate setbacks and appropriate slope design, reservation of adjacent floodplains for non-structural uses, and measures to promote water retention and minimize degradation of individual stream systems.

Appendix B-1. Plant Species Common in Riparian Corridors of the Urban Service Area

		Use	<- - - -	Remove	- - - ->
Common Name	**Scientific Name**	Native[1]	Non-native[1]	Invasive[1]	Escaped Orna-mental[1]
Grasses					
Bent grass	*Agrostis hallii*	X			
Rattlesnake grass	*Briza maxima*		X		
California brome	*Bromus carinatus*	X			
Barnyard grass	*Echinochloa crus-galli*		X		
Wild rye grass	*Elymus glaucus*	X			
Red fescue	*Festuca rubra*	X			
Meadow barley	*Hordeum branchyantherum*	X			
Creeping wild rye	*Leymus triticoides*	X			
Purple needlegrass	*Nassella pulchra*	X			
Zorro fescue	*Vulpia myuros* 'Zorro'				X
Rabbitsfoot grass	*Polypogon monspeliensis*	X			
Herbs					
White yarrow	*Achillea millefolium*	X			
Five-finger fern	*Adiantum aleuticum*	X			
Pigweed	*Amaranthus* spp.	X			
Dutchman's pipe	*Aristolochia californica*	X			
Mugwort	*Artemisia douglasiana*	X			
Western aster	*Aster chilensis*	X			
Evening primrose	*Camissonia cheiranthifolia*	X			
Large godetia	*Clarkia purpurea*	X			
Miner's lettuce	*Claytonia perfoliata*	X			
Tall cyperus	*Cyperus eragrostis*	X			

Common Name	Scientific Name	Use Native[1]	<---- Remove ----> Non-native[1]	Invasive[1]	Escaped Orna-mental[1]
Needle spike-rush	*Eleocharis acicularis*	X			
Common willowherb	*Epilobium ciliatum* ssp. *ciliatum*	X			
Western goldenrod	*Euthamia occidentalis*	X			
Wild fennel	*Foeniculum vulgare*			X	
Blue thimbleflower	*Gilia capitata*	X			
Wild licorice	*Glycyrrhiza lepidota*	X			
Oceanspray	*Holodiscus discolor*	X			
Wild iris	*Iris douglasiana*	X			
Baltic rush	*Juncus balticus*	X			
Monkeyflower	*Mimulus guttatus*	X			
Baby blue-eyes	*Nemophila menziesii*	X			
Osoberry	*Oemleria cerasiformis*	X			
Water pepper	*Polygonum hydropiperoides*	X			
Water smartweed	*Polygonum punctatum*	X			
Sword fern	*Polystichum munitum*	X			
California buttercup	*Ranunculus californicus*	X			
Watercress	*Rorippa nasturtium-aquatica*		X		
Curly dock	*Rumex crispus*		X		
Alkali bulrush	*Scirpus robustus*	X			
Olney's bulrush	*Scirpus americanus*	X			
California bulrush	*Scirpus californicus*	X			
Blue-eyed grass	*Sisyrinchium bellum*	X			
Dutch white clover	*Trifolium repens*		X		
Red clover	*Trifolium pratense*		X		
Crimson clover	*Trifolium incarnatum*		X		
Broadleaf cattail	*Typha latifolia*	X			
Narrowleaf cattail	*Typha angustifolia*	X			

Common Name	Scientific Name	Use Native[1]	<---- Remove ----> Non-native[1]	Invasive[1]	Escaped Ornamental[1]
Water speedwell	*Veronica anagallis-aquatica*		X		
Nutsedge	*Cyperus eragrostis*	X			
Willow weed	*Polygonum lapathifolium*	X			
Yellow water-primrose	*Ludwigia peploides*	X			
Vines					
Pipestems	*Clematis lasiantha*	X			
Virgin's bower	*Clematis ligusticifolia*	X			
English ivy	*Hedera helix*			X	
Honeysuckle	*Lonicera hispidula var. vacillans*	X			
Twinberry	*Lonicera involucrata* var. *ledebourii*	X			
Creeping snowberry	*Symphoricarpos albus*	X			
Greater periwinkle	*Vinca major*				X
Wild grape	*Vitis californica*	X			
Shrubs					
Brewer's saltbush	*Atriplex lentiformis*	X			
Mule fat	*Baccharis salicifolia*	X			
Coyote brush	*Baccharis pilularis*	X			
Frosty blue ceanothus	*Ceanothus* 'Frosty Blue'				X
Blue wild lilac	*Ceanothus* 'Joyce Coulter'				X
Pt. Reyes creeper	*Ceanothus gloriosus* var. *exaltatus*				X
Dwarf Ceanothus	*Ceanothus* 'Yankee Pt'				X
Julia Phelps Ceanothus	*Ceanothus* 'Julia Phelps'				X
Western creek dogwood	*Cornus sericea* ssp. *occidentalis*	X			
French broom	*Genista monspessulana*			X	

Common Name	Scientific Name	Use	<----	Remove	---->
		Native[1]	Non-native[1]	Invasive[1]	Escaped Ornamental[1]
Marsh gum plant	*Grindelia hirsutula var. hirsutula*	X			
Scarlet monkeyflower	*Mimulus cardinalis*	X			
Western chokecherry	*Prunus virginiana* var. *demissa*	X			
California coffeeberry	*Rhamnus californica* 'Eve Case'				X
Dwarf coffeeberry	*Rhamnus californica* 'Sea View'				*X*
Skunk bush	*Rhus trilobata*	X			
Red flowering currant	*Ribes sanguineum* var. *glutinosum*	X			
California wild rose	*Rosa californica*	X			
Salmonberry	*Rubus spectabilis*	X			
California blackberry	*Rubus ursinus*	X			
Poison oak	*Toxicodendron diversilobum*	X			
Trees					
California box elder	*Acer negundo* ssp. *californicum*	X			
Big-leaf maple	*Acer macrophyllum*	X			
California buckeye	*Aesculus californica*	X			
White alder	*Alnus rhombifolia*	X			
Red alder	*Alnus oregana*	X			
Eucalyptus	*Eucalyptus sp.*				X
Oregon ash	*Fraxinus latifolia*	X			
California black walnut	*Juglans californica* var. *hindsii*				X[2]
Western sycamore	*Platanus racemosa*	X			
Fremont cottonwood	*Populus fremontii*	X			
Black cottonwood	*Populus balsamifera* ssp. *trichocarpa*	X			

Common Name	Scientific Name	Use	<----	Remove	---->
		Native[1]	Non-native[1]	Invasive[1]	Escaped Ornamental[1]
Blue oak	*Quercus douglassii*	X			
Coast live oak	*Quercus agrifolia* var. *agrifolia*	X			
Valley oak	*Quercus lobata*	X			
Narrowleaf willow	*Salix exigua*	X			
Pacific (yellow) willow	*Salix lucida* ssp. *lasiandra*	X			
Red willow	*Salix laevigata*	X			
Arroyo willow	*Salix lasiolepis*	X			
Blue elderberry	*Sambucus mexicana*	X			
Peruvian pepper tree	*Schinus polygamus*			X	
California bay	*Umbellularia californica*	X			

Footnotes

[1]Non-native plants are classified into one of three categories, non-native, invasive, or escaped ornamental. Invasive species are those listed by the California Exotic Pest Plant Council as wildland pest plants of "most invasiveness" or "lesser invasiveness" (Lists A and B; 1999). Escaped ornamentals are plants that escape cultivation but do not invade riparian corridors much beyond backyards or landscaping borders. "Non-native" species are all other non-native species (i.e., those that are not invasive or escaped ornamentals). Note that some invasive species are also escaped ornamentals (e.g., Peruvian pepper tree and English ivy).

[2]California black walnut is native to the inner coast ranges near former campgrounds of American Indians (Kozloff and Beidleman 1994). Plants found along riparian corridors within the plan area were likely planted or escaped from cultivation. Some walnuts may be the exotic Persian walnut (*Juglans regia*) or hybrids between the two (Hickman 1993).

Sources: Habitat Restoration Group (1989), Hickman (1993), Kozloff and Beidleman (1994)

Appendix B-2. Fish and Wildlife Species Common in Riparian Corridors of the Urban Service Area

Common Name	Scientific Name	Native	Non-Native[1]	Non-Native; Damaging[1]
Mammals				
Mule deer	*Odocoileus hemionus*	X		
California bat	*Myotis californicus*	X		
Big brown bat	*Eptesicus fuscus*	X		
Hoary bat	*Lasiurus cinereus*	X		
Red bat	*Lasiurus blossevillii*	X		
Virginia opossum	*Didelphis virginiana*			X
Striped skunk	*Mephitis mephitis*	X		
Raccoon	*Procyon lotor*	X		
Muskrat	*Ondatra zibethica*	X		
House mouse	*Mus musculus*		X	
Deer mouse	*Peromyscus maniculatus*	X		
Western gray squirrel	*Sciurus griseus*	X		
California ground squirrel	*Spermophilus beecheyi*	X		
Audubon's cottontail	*Sylvilagus audubonii*	X		
Brush rabbit	*Sylvilagus bachmanii*	X		
Birds				
Pied-billed grebe*	*Podilymbus podiceps*	X		
American white pelican*	*Pelecanus erythrorhynchos*	X		
Double-crested cormorant*	*Phalacrocorax auritus*	X		
Great blue heron	*Ardea herodias*	X		
Great egret	*Casmerodius albus*	X		

Common Name	Scientific Name	Native	Non-Native[1]	Non-Native; Damaging[1]
Snowy egret	*Egretta thula*	X		
Black-crowned night heron	*Nycticorax nycticorax*	X		
Mallard*	*Anas platyrhynchos*	X		
Northern pintail*	*Anas acuta*	X		
Northern shoveler*	*Anas clypeata*	X		
Ruddy duck*	*Oxyura jamaicensis*	X		
American coot*	*Fulica americana*	X		
Ring-billed gull	*Larus delawarensis*	X		
California gull	*Larus californicus*	X		
Western gull	*Larus occidentalis*	X		
Forster's tern	*Sterna paradisaea*	X		
Turkey vulture	*Cathartes aura*	X		
White-tailed kite	*Elanus caeruleus*	X		
Cooper's hawk	*Accipiter cooperii*	X		
Northern harrier	*Circus cyaneus*	X		
Red-tailed hawk	*Buteo jamaicensis*	X		
American kestrel	*Falco sparverius*	X		
Osprey*	*Pandion haliaetus*		X	
Rock dove	*Columba livia*	X		
Mourning dove	*Zenaida macroura*	X		
California quail	*Callipepla californica*	X		
Barn owl	*Tyto alba*	X		
Allen's hummingbird	*Selasphorus sasin*	X		
Belted kingfisher	*Ceryle alcyon*	X		
Downy woodpecker	*Picoides pubescens*	X		
Northern flicker	*Colaptes auratus*	X		
Black phoebe	*Sayornis nigricans*	X		
Barn swallow	*Hirundo rustica*	X		

Common Name	Scientific Name	Native	Non-Native[1]	Non-Native; Damaging[1]
American crow	*Corvus brachyrhynchos*	X		
Chestnut-backed chickadee	*Parus rufescens*	X		
Bewick's wren	*Thryomanes bewickii*	X		
Ruby-crowned kinglet	*Regulus calendula*	X		
Western bluebird	*Sialia mexicana*	X		
Blue-gray gnatcatcher	*Polioptila caerulea*	X		
American robin	*Turdus migratorius*	X		
Northern mockingbird	*Mimus polyglottos*	X		
American pipit	*Anthus rubescens*	X		
European starling	*Sturnus vulgaris*			X
Hutton's vireo	*Vireo huttoni*	X		
Yellow warbler	*Dendroica petechia*	X		
Yellow-rumped warbler	*Dendroica coronata*	X		
Common yellowthroat	*Geothlypis trichas*	X		
Savannah sparrow	*Passerculus sandwichensis*	X		
Song sparrow	*Melospiza melodia*	X		
White-crowned sparrow	*Zonotrichia leucophrys*	X		
Dark-eyed junco	*Junco hyemalis*	X		
Red-winged blackbird*	*Agelaius phoeniceus*	X		
Brewer's blackbird	*Euphagus cyanocepahalus*	X		
House finch	*Carpodacus mexicanus*	X		
Lesser goldfinch	*Carduelis psaltria*	X		
American goldfinch	*Carduelis tristis*	X		
House sparrow	*Passer domesticus*			X
Fish				
Goldfish*	*Carassius auratus*		X	
Sacramento sucker	*Catostomus occidentalis*	X		
Riffle sculpin	*Cottus gulosus*	X		

Common Name	Scientific Name	Native	Non-Native[1]	Non-Native; Damaging[1]
Prickly sculpin	*Cottus asper*	X		
Carp*	*Cyprinus carpio*		X	
Mosquitofish	*Gambusia affinis*		X	
Threespine stickleback	*Gasterosteus aculeatus*	X		
California roach	*Hesperoleucus symmetricus*	X		
Brown bullhead*	*Ictalurus nebulosus*			X
Pacific lamprey	*Lampetra tridentata*	X		
Hitch	*Lavinia exilicauda*	X		
Green sunfish*	*Lepomis cyanellus*			X
Bluegill sunfish*	*Lepomis macrochirus*		X	
Rainwater killifish	*Lucania parva*		X	
Largemouth bass*	*Micropterus salmoides*			X
Golden shiner	*Notemigonus crysoleucas*		X	
Steelhead and rainbow trout	*Oncorhynchus mykiss*	X		
Chinook salmon	*Oncorhynchus tschawytscha*	X		
Reptiles				
Sharp-tailed snake	*Contia tenuis*	X		
Western skink	*Eumeces skiltonianus*	X		
California alligator lizard	*Gerrhonotus multicarinatus*	X		
Common kingsnake	*Lampropeltis getulus*	X		
Gopher snake	*Pituophis catenifer*	X		
Western fence lizard	*Sceloporus occidentalis*	X		
Common garter snake	*Thamnophis sirtalis*	X		

Common Name	Scientific Name	Native	Non-Native[1]	Non-Native; Damaging[1]
Amphibians				
Black salamander	*Aneides flavipunctatus*	X		
California slender salamander	*Batrachoceps attenuata*	X		
Western toad	*Bufo boreas*	X		
Bullfrog	*Bufo catesbeiana*			X
Pacific treefrog	*Hyla regilla*	X		
California newt	*Taricha torosa*	X		
Rough-skinned newt*	*Taricha granulosa*	X		

Footnotes

[1]Non-native species are listed as damaging if they are known to cause substantial ecological disruption through predation on native species, displacement of native species, or both.

*Denotes species found primarily in standing water habitats (such as percolation ponds and permanent or seasonal reservoirs) in the City's riparian corridors. These habitats are not typically present in undisturbed riparian corridors of the Urban Service Area.

Sources: Santa Clara Valley Water District and U. S. Army Corps of Engineers (1998), Ingles (1965), Stebbins (1985), RRM Design Group and Habitat Restoration Group (1999)

Appendix C. Applicable Regulations

This appendix provides a brief overview of the compliance requirements under federal, state, and local regulatory controls that are applicable to the implementation of the measures outlined in this plan.

Federal Laws and Implementing Regulations

National Environmental Policy Act

The National Environmental Policy Act (NEPA) (42 USC 4321, 40 CFR 1500.1) applies to any action that requires permits, entitlement, or funding from a federal agency, is jointly undertaken with a federal agency, or is proposed on federal land. NEPA requires every federal agency to disclose the environmental effects of its actions for public review purposes and for assisting the federal agency in assessing alternatives to and consequences of the proposed actions. If an action was not considered in a previously prepared NEPA document, an Environmental Assessment (EA) is typically prepared to determine whether the project may have a significant environmental effect. If the project would not have a significant effect or if mitigation incorporated into the project description would reduce the project's effect to a less-than-significant level, a Finding of No Significant Impact (FONSI) is prepared along with an EA; otherwise, an Environmental Impact Statement (EIS) is required. The EIS must consider, disclose, and discuss all major points of view on the environmental impact of matters subject to NEPA. Most riparian restoration projects would qualify for a FONSI for NEPA compliance.

Section 404 of the Clean Water Act

Section 404 of the federal Clean Water Act (CWA) requires that a permit be obtained from the U.S. Army Corps of Engineers (USACE) for the discharge of dredged or fill material into jurisdictional waters of the United States (including wetlands). USACE has established a nationwide permit program to authorize, with a minimum of administrative processing, categories of discharge activities that cause only minimal individual and cumulative adverse environmental impacts. It is likely that implementation of restoration measures outlined in the plan would be covered by Nationwide Permit 27, which includes activities in waters of the United States that are associated with the enhancement of degraded wetlands and riparian areas on nonfederal public lands. In addition, some of the restoration measures/strategies may require a Nationwide Permit 33 for temporary access and dewatering and/or a Nationwide Permit 13 for bank stabilization activities necessary for erosion control. Often, more than one Nationwide Permit is needed to authorize a project. Some projects may require an individual 404 permit. Individual Permits are issued to a specific single entity (e.g. an agency, joint-power agency, individual, or company) to authorize specific activities.

Section 401 of the Clean Water Act

If the action involves a federal license or permit that may affect state water quality, and the action would result in a discharge of a pollutant into waters of the United States, compliance with Section 401 of the CWA is required. Section 401 of the CWA requires that state water quality standards not be violated by the discharge of fill or dredged material into waters of the United States. USACE will not issue a Section 404 permit until the state, through the California State Water Resources Control Board (SWRCB) and Regional Water Quality Control Board (RWQCB), has issued a certification (or a waiver of certification) of compliance with state water quality standards.

Under Section 401 of the CWA, applicants for a federal license or permit to conduct activities that may result in a discharge of a pollutant into waters of the United States must obtain a certification from the state in which the discharge would originate or, if appropriate, from the interstate water pollution control agency that has jurisdiction over the affected waters at the point where the discharge would originate. Therefore, all actions with federal agency involvement that could affect state water quality, including actions requiring federal agency approvals, must comply with Section 401 of the CWA and applicants must obtain certification or waiver of certification that the discharge does not violate state water quality requirements. The certification must verify that the discharge will comply with the applicable effluent limitations and water quality standards. A certification obtained for construction of a facility must also pertain to operation of the facility. SWRCB, through the RWQCBs, is responsible for issuing water quality certifications pursuant to Section 401 of the CWA.

Sections 7 and 10 of the Federal Endangered Species Act

Section 7 of the Federal Endangered Species Act (ESA) (16 USC 1531 et seq.) requires federal agencies, in consultation with the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS), to ensure that their actions do not jeopardize the continued existence of endangered or threatened species or result in the destruction or adverse modification of the critical habitat of these species. Section 10 of the ESA applies to those projects with no federal involvement that require an "incidental take" permit. Section 10 of the ESA authorizes the conditions for USFWS and NMFS to issue a permit for incidental take of a listed species when there is no federal agency involved. Issuance of a Section 10(a) permit is contingent on development of a satisfactory habitat conservation plan (HCP) for the affected listed species.

All affected property owners or lessees that are party to an approved HCP would be authorized, on the issuance and pursuant to the terms and conditions of the Section 10(a) permit, to take the designated threatened or endangered species incidental to otherwise lawful activities.

Section 106 of National Historic Preservation Act

If the project is considered a federal agency proposal and occurs in an area where properties are listed, or are eligible for listing, on the National Register of Historic Places (NRHP), compliance with Section 106 of the National Historic Preservation Act (NHPA) (16 USC 470 et seq.) is required. NRHP requires federal agencies to evaluate the effects of federal undertakings on historical, archaeological, and cultural resources.

Under Section 106 of the NHPA, federal agencies are required to:

- identify historical or archaeological properties near proposed project sites, including properties listed on the NRHP and those properties that the agency and the State Historic Preservation Officer (SHPO) agree are eligible for listing on the NRHP; and
- if the project is determined to have an adverse effect on NRHP-listed properties or those eligible for listing on the NRHP, to consult with the SHPO and the Advisory Council on Historic Preservation (ACHP) to develop alternatives or mitigation measures to allow the project to proceed.

Other Federal Agency Authorities

Executive Order 11990 - Protection of Wetlands

If the action is considered a federal agency proposal and is located within or may affect wetlands, compliance with Executive Order 11990 is required. Executive Order 11990 is an overall wetlands policy for all agencies managing federal lands, sponsoring federal projects, or providing federal funds to state or local projects.

Executive Order 11990 requires federal agencies to follow avoidance, mitigation, and preservation procedures with public input before proposing new construction in wetlands. When federal lands are proposed for lease or sale to nonfederal parties, Executive Order 11990 requires that restrictions be placed in the lease or conveyance to protect and enhance the wetlands on the property. Executive Order 11990 has the effect of restricting the sale of federal lands containing wetlands; however, it does not apply to federal discretionary authority for nonfederal projects (other than funding) on nonfederal land. Compliance may be achieved in coordination with Section 404 compliance.

To achieve compliance with this executive order, the federal agency should design the project description to avoid wetlands, minimize activities in wetlands, and coordinate with USACE and the Section 404 process to determine wetland mitigation needs.

State Laws and Implementing Regulations

National Pollutant Discharge Elimination System

SWRCB and the RWQCBs regulate both point-source discharges (e.g., wastewater treatment plan discharges) and nonpoint-source discharges (e.g., urban runoff) through the National Pollutant Discharge Elimination System (NPDES) permit program. Erosion control excavations to lay back channel banks may trigger the need to comply with the program.

Waste Discharge Requirements

The owner or operator of any facility or activity that discharges, or proposes to discharge, waste that may affect groundwater quality or from which waste may be discharged in a diffused manner (e.g., erosion from soil disturbance) must first obtain waste discharge requirements permit (WDRs) from the appropriate RWQCB. If a facility or activity will discharge waste (including stormwater runoff for certain industrial or construction activities) to surface water (for example, from a pipe or confined channel), the owner or operator must obtain a National Pollutant Discharge Elimination System (NPDES) permit rather than waste discharge requirements (WDRs). Activities that do not pose a threat or nuisance to water quality may be allowed a waiver of WDRs.

Water Rights

A water right is a legally protected right, granted by law, to take possession of water occurring in a water supply and put it to beneficial use. The California Water Code makes SWRCB responsible for the permitting of water diversions and use throughout the state. The Division of Water Rights assists SWRCB with this function. SWRCB issues permits to appropriate water and issues change petitions to existing rights with terms to protect prior rights, public trust resources, and the public interest. Any person or public agency proposing to divert water for use on nonriparian land or to store unappropriated surface water of more than 10 acre-feet for more than 30 days must first obtain a permit from SWRCB to appropriate water.

California Environmental Quality Act

The California Environmental Quality Act (CEQA) applies to an action that is directly undertaken by a California public agency; is supported in whole or part through California public agency contracts, grants, subsidies, loans, or other assistance for a public agency; or involves California public agency issuance of a permit, lease, license, certificate, or other entitlement for use by a public agency. CEQA requires state, regional, and local agencies to prepare environmental impact assessments of proposed projects with significant environmental effects and to circulate these documents to other agencies and the public for comment before making decisions.

If the action was not considered in a previously prepared CEQA document or does not fall under a Statutory or Categorical Exemption, an Initial Study is typically prepared to determine whether the project may have a significant environmental effect. If the project would not have a significant effect or if mitigation incorporated into the project description would reduce the project's effect to a less-than-significant level, a Negative Declaration or mitigated Negative Declaration is prepared; otherwise, an Environmental Impact Report (EIR) is prepared. CEQA requires the lead agency to make findings for all significant impacts identified in the EIR. The lead agency must adopt all mitigation to reduce environmental effects to a less-than-significant level unless the mitigation is infeasible or unavailable and there are overriding considerations that require the project to be approved.

Sections 2081 and 2090 of the California Fish and Game Code: California Endangered Species Act

The California Endangered Species Act (CESA) prohibits the take of plant and animal species designated by the California Fish and Game Commission as either endangered or threatened. Take includes hunting, pursuing, catching, capturing, killing, or attempting such activity. Section 2081 of CESA provides the California Department of Fish and Game (DFG) with the authority to permit the take of state-listed species under certain circumstances including scientific, educational, or management purposes, as well as take incidental to otherwise lawful activities. In order to issue an incidental take permit pursuant to Section 2081(b), DFG must make the following findings:

- take is incidental to otherwise lawful activities,
- impacts of the take are minimized and fully mitigated,
- take permit must be consistent with DFG recovery programs,
- funding for mitigation and monitoring program is adequately assured, and
- action will not jeopardize the continued existence of the species.

In addition, a federal ESA Section 7 take statement or Section 10 take permit can be used as authorization to take CESA endangered, threatened, or candidate species.

No special distinction is made in CESA between state-owned and private property. Unlike the federal ESA, CESA has no separate consultation requirement for public agencies.

Section 1600 Streambed Alteration Agreement

DFG regulates work that will substantially affect resources associated with rivers, streams, and lakes in California, pursuant to Fish and Game Code Sections 1600-1607. Actions involving ground-disturbing activities within the annual high-water mark of a wash, stream, or lake require a Lake or Streambed Alteration Agreement. Authorization (known as a Lake or Streambed Alteration Agreement) is required from DFG under Section 1601 for public projects and Section 1603 for projects proposed by nonpublic entities prior to any action that substantially diverts, obstructs, or changes the natural flow of the river, stream, or lake, or uses material from a streambed.

Any person, governmental agency, or public entity proposing any activity that will divert or obstruct the natural flow or change the bed, channel, or bank of any river, stream, or lake or proposing to use any material from a streambed must first notify DFG of such proposed activity. This notification requirement applies to any work undertaken within the 100-year floodplain of a body of water or its tributaries, including intermittent streams and desert washes. As a general rule, however, it applies to any work undertaken within the annual high-water mark of a wash, stream, or lake that contains or once contained fish and wildlife or supports or once supported riparian vegetation.

DFG has revised the Section 1600 program to incorporate a CEQA review into the Section 1601 and 1603 process. If DFG notifies the applicant that the proposed project requires a Lake or Streambed Alteration Agreement, the applicant may not commence any work until a Lake or Streambed Alteration Agreement is developed and the project described in that agreement is reviewed as required by CEQA, unless it is otherwise exempt from CEQA review. The most important aspect for CEQA compliance is that the Lead Agency include DFG as a Responsible Agency in the CEQA process.

State Historic Preservation Officer Consultation under Section 106 of the National Historic Preservation Act

See discussion under **National Historic Preservation Act**.

State Lands Commission Land Use Lease

The State Lands Commission (SLC) has jurisdiction and management control over certain state-owned lands: sovereign lands that lie in the beds of tidal and navigable water bodies within the state's boundaries, and school lands that were granted to the state by the federal government to support public schools. Actions that would trigger the need for a State Lands Commission Land Use Lease are those that would affect water-related commerce, navigation, fisheries, recreation, open space, or other public trust uses.

The state cannot sell its sovereign lands, but SLC may lease the sovereign fee lands for various public trust purposes. A lease will be required for any projects involving the construction of structures on the sovereign fee lands, and for some activities that do not include such improvements. SLC leases and other agreements may be designed to encompass activities or projects that will occur over an extended period or geographic scope, provided such activities meet specific criteria.

The Reclamation Board Encroachment Permit

If the action would affect existing state flood control project facilities, including levees, dams, reservoirs, and floodways, or flood control plans, an encroachment permit must be obtained from the Reclamation Board. The Reclamation Board issues encroachment permits to maintain the integrity and safety of flood control project levees and floodways that were constructed according to the flood control plans adopted by the Board or the California Legislature. Flood control plans include project flood channels without levees and project channels with levees and an additional area outside of the project levees; any flowage areas that are part of the flood control project; areas where there are flowage easements; and in the case of designated floodways, the area between the encroachment lines. Project levees, floodways, and flood control plans are components of project works. "Project works" are defined as the entirety or any component of a flood control project within the area of the Board's jurisdiction that has been approved or adopted by the Board or the Legislature, including state or federally constructed levees, bank protection, weirs, pumping plants, any other related flood control works, or rights-of-way (ROWs).

The Reclamation Board is required to enforce appropriate standards for construction, maintenance, and protection of adopted flood control plans that will best protect the public from floods. The Reclamation Board has jurisdiction within the Central Valley and Lake County, including all tributaries and distributaries of the Sacramento and San Joaquin Rivers and Tulare and Buena Vista Basins.

The Reclamation Board may issue encroachment permits for proposed activities that may affect project works, as long as the applicant ensures that the activity maintains the integrity and safety of flood control project levees and floodways and is consistent with the flood control plans adopted by The Reclamation Board or California Legislature. "Project works" are defined as the entirety or any component, including levees, floodways, or flood control plans, of a flood control project within the area of The Reclamation Board's jurisdiction that have been approved or adopted by The Reclamation Board or the legislature. Project works include state or federally constructed levees, bank protection, weirs, pumping plants, and any other related flood control works or ROWs. Flood control plans include project flood channels without levees and project channels with levees; any flowage areas that are part of the flood control project; areas where there are flowage easements; and designated floodways.

City or County Approvals and Entitlements

Cities and counties in California have adopted local zoning ordinances and general plans that set policy on how land development will occur within their respective jurisdictions. Approvals and entitlements at the city or county level are required for many development activities. Although requirements will be similar in most cases, each jurisdiction is likely to have some unique requirements. CEQA compliance may be required for grading and building permits if they are discretionary and is normally required for approvals or entitlements.

Excavation and grading activities within the City of San Jose require a "Notice of Exemption" or "Grading Permit" from the City of San Jose, Department of Public Works. According to the Department of Public Works, the excavation and grading ordinance is intended to establish uniform standards to safeguard life, limb, property, water quality and natural resources, and to promote the public welfare. The grading permit is usually the final development step prior to breaking ground. Therefore, all Planning Department permits should be secured prior to the issuance of a grading permit.

The following documents need to be submitted to apply for a grading permit:

- Grading Permit form,
- grading plan,
- soils and geologic report (if required),
- project earthwork specifications,
- Non-Potable Water Exception (if applicable), and
- applicable city fees.

To qualify for a "Notice of Exemption," the grading project must not be in a Geologic Hazard Zone, a Flood Hazard Zone, or contain wetlands, and must as well meet several criteria listed in Attachment A of the city's grading permit.

In addition to the Grading Permit, a Haul Route Permit may be required if the project will be moving more than 10,000 cubic yards of earth.

Riparian restoration activities that include tree removal must adhere to the City of San Jose's ordinances pertaining to tree removal controls. According to the municipal code, a permit is required for activities that remove, or cause to be removed, any tree from any private parcel of land in the city unless required to do so by the provisions of Chapter 13.28 of the municipal code.

Activities which will alter current conditions of waterways under the jurisdiction of the Santa Clara Valley Water District (SCVWD) may be subject to the permitting process under Ordinance 83-2.

The following activities are prohibited by the SCVWD without a permit:

- excavation within a designated floodway, or upon or between the banks of a watercourse or district project;

- depositing of material of any kind within a designated floodway, district project, or upon or within the banks of a watercourse; and

- planting any form of flora or fauna upon or within the banks of a watercourse or a district project.

Appendix D. Additional Sources of Information

Stream Care Guides

1. *Streamside Planting Guide for San Mateo and Santa Clara County Streams*, San Francisquito Creek Watershed Coordinated Management and Planning (CRMP) Process.

2. *Stream Care Guide For Residents And Businesses,* Pequannock River Coalition, P.O. Box 392, Newfoundland, NJ 07435.

3. Habitat Restoration Group's website (http://www.habitat-restoration.com/strmcare.htm) has a listing of stream care handbooks. If this list is used, the source should be cited.

4. *Stream Care Guide Humboldt and Del Norte Counties (1997)*, and *Stream Care Guide Trinity County (1999)*, available through the website: http://www.northcoast.com/~nrs/mater.html

5. Santa Clara Valley Water District's Stream Care Guide.

6. Santa Cruz County's Stream Care Guide.

Restoration Guides

1. *Stream Corridor Restoration: Principles, Practices, and Procedures,* Federal Interagency Stream Corridor Restoration Working Group. http://www.usda.gov/stream_restoration/

2. *Restoring Streams in Cities: A Guide for Planners, Policymakers, and Citizens*. Ann L. Riley. Island Press, Washington, D.C., United States, 1998.

Books

1. *Stream Hydrology: An Introduction for Ecologists*. Nancy D. Gordon, Thomas A. McMahon, and Brian L. Finlayson. John Wiley & Sons, Chichester, West Sussex, England, 1992.
2. *Conservation Management of Freshwater Habitats*. P. S. Maitland and N. C. Morgan. Chapman & Hall, London, United Kingdom, 1997.
3. *Eco-Hydrology: Plants and Water in Terrestrial and Aquatic Environments.* Andrew J. Baird and Robert L. Wilby. Routledge, London, United Kingdom, 1999.
4. *Integrated Watershed Management: Principles and Practice*. Isobel W. Heathcote. John Wiley & Sons, New York, New York, United States, 1998.
5. *Biological Assessment and Criteria: Tools for Water Resource Planning and Decision-Making*. Wayne S. Davis and Thomas P. Simon. Lewis Publishers, Boca Ratón, Florida, United States, 1995.

6. *The Biology of Streams and Rivers*. Paul S. Giller and Björn Malmqvist. Oxford University Press, New York, New York, United States, 1998.

7. *Restoring Life in Running Waters: Better Biological Monitoring*. James R. Karr and Ellen W. Chu. Island Press, Washington, D.C., United States, 1999.

8. *Restoring Streams in Cities: A Guide for Planners, Policymakers, and Citizens*. Ann L. Riley. Island Press, Washington, D.C., United States, 1998.

9. *Water Use, Management, and Planning in the United States*. Stephen A. Thompson. Academic Press, San Diego, California, United States, 1999.

10. *What the River Reveals: Understanding and Restoring Healthy Watersheds*. Valerie Rapp. The Mountaineers, Seattle, Washington, United States, 1997.

11. *California Rivers and Streams: The Conflict Between Fluvial Process and Land Use*. Jeffrey F. Mount. University of California Press, Berkeley, California, United States, 1995.

Appendix E. Glossary of Terms Used in Stream Restoration

Abrasion. Removal of soil from a streambank by contact with a moving flow of sediment-laden water, ice, or debris.

Aggradation (v. aggrade). Tendency of a segment of streambed to build up vertically as a result of sediment deposition. Sediment may be derived from erosion on the watershed, or may be recycled from upstream channel or bank reaches.

Anadromous. Refers to migratory fishes, such as steelhead trout and chinook salmon, which hatch in rivers or streams, spend their adult lives in the ocean, and return to their natal stream to breed and die.

Annual. Refers to a plant that matures, seeds, and dies within a single growing season.

Armoring. Formation of an erosion-resistant layer of rocks on the surface of a streambed. The rock layer may be artificially emplaced as an erosion-control measure, or may form as fluid turbulence removes small particles, leaving larger materials in place (elutriation).

Bar. A deposit of sediment (boulders, gravel, sand and mud) on the bed of a stream, typically formed and modified during high-discharge flow and exposed at low water.

Base flow. The baseline discharge of a perennial stream. Base flow typically occurs during the dry season.

Base level. In geomorphology, refers to the elevation on a landscape above which erosion occurs and below which deposition occurs. Sea level functions as the ultimate base level.

Bed (see also streambed). The floor of a streamchannel.

Bedload (also bed load). The portion of a stream's sediment load that is transported by sliding, rolling, and bouncing along the streambed. Bed load is typically the coarsest portion of the load, and may include particles up to boulder grade.

Bedscarp (see also nick point). An abrupt in channel gradient that forms at a nick point and typically moves progressively upstream; the change in gradient usually forms a waterfall. A bedscarp forms where a stream is actively eroding to a new base level.

Bed slope. The gradient of a streambed.

Biotechnical bank stabilization, biotechnical slope protection. Refers to a family of techniques designed to stabilize streambanks using natural and semi-natural materials such as rocks, wood, and live plants. Biotechnical bank stabilization was developed based on the principle that engineering goals and revegetation goals could be met simultaneously, and combines basic engineering principles and practices with revegetation science applications.

Butt end. The bottom end of a cutting taken from a riparian plant, opposite the budding tip. The butt end will root if planted in soil.

Capacity. Refers to the discharge a streamchannel can accommodate, or to the total sediment load a stream can carry at a given discharge.

Caving. Collapse of a streambank, usually as a result of erosional undercutting.

Check dam. A structure placed across a drainage, downslope from a headcut, to protect the portions of a gully undergoing revegetation by controlling downslope movement of sediment.

Cutbank (or cut bank). A streambank characterized by erosion rather than deposition. On a curved reach, the cutbank occurs on the outside of a curve, opposite the point bar formed on the inside of the curve.

Cutoff. A channel which forms across the neck of a bend, cutting off a meander loop.

Daylight (v.). In stream restoration, refers to the excavation of a previously culverted, piped, or covered streamchannel, and restoration to surface flow.

Deadman. A log, concrete block, length of rebar, or other object keyed into a streambank and used to anchor a revetment.

Degradation (v. degrade). Tendency of a streambed to lower over time as a result of erosion and transport of bed materials and/or the blockage of sediment supply.

Dike (groin, spur, jetty, deflector, boom). A permeable dike is a structure designed to diminish water velocity as streamflow passes through it, so that erosion is reduced and sediment deposition occurs instead. An impermeable dike is designed to reduce bank erosion by deflecting streamflow away from a streambank.

Discharge. The volume of water flowing past a given point on a channel during a specified period of time, commonly measured in cubic feet per second (cfs).

Eddy current, eddy. A roughly circular water current that develops as a result of fluid turbulence. Eddies commonly form when streamflow interacts with irregularities along the streambank.

Facultative. E.g. *"facultative riparian species."* Refers to species that can succeed in a particular environment, but are not restricted to that environment. See also **obligate**.

Failure. Collapse; *slope failure* refers to collapse or slippage of material on a slope, commonly as a result of erosional undercutting.

Fill material, fill. Soil or other material artificially emplaced in order to bring the ground surface up to a specified elevation or gradient ("finish grade" or "finished grade").

FIRM map. Flood Insurance Rate Map. Map used to establish insurance rate structures under the National Flood Insurance Program, on the basis of historical data on flood magnitudes and recurrence frequencies.

Floodplain. Land adjacent to a streamchannel, at or above the elevation of bankfull discharge, typically inundated about 2 out of 3 years on average. The 100-year floodplain has a 1% probability of being inundated in any given year. In a narrow valley, most of the valley floor is floodplain, and will be inundated by both small and large flood events.

Flood stage. The elevation of the water surface in a stream system during high-flow (flood) events.

Fossorial. Burrowing or ground-dwelling, as "fossorial bird" or "fossorial mammal."

Grade-control structure. A structure intended to control erosion in a steep streamchannel or one which has been destabilized as a result of modification of streamflow or sediment budget. Common grade-control structures include weirs, dams, sills, and drop structures.

Groundwater. Water in subsurface soil and rock materials. In unconsolidated or loosely consolidated materials (such as soil or porous sedimentary rocks), groundwater occupies spaces between grains. In hard, consolidated materials (such as granite, metamorphic rocks, or "tight" sedimentary rocks), groundwater occupies fractures or cracks.

Groundwater flow. Movement of groundwater through subsurface soil and rocks.

Headcut. A slope break at the top of a gully, or at the top of a section of a gully. Increased gradient forms a headcut waterfall, which in turn increases local erosion rate, expanding the gully uphill.

Headcutting. Headward erosion; erosion in an upstream direction, such that the headwaters of a stream cut progressively farther into the surrounding terrain.

Headward erosion. Erosion in an upstream direction, such that the headwaters of a stream cut progressively farther into the surrounding terrain, increasing the erosional dissection of a landscape. Commonly occurs in response to active tectonic uplift. May also occur as a result of human-induced destabilization of the delicate balance between discharge and sediment budget.

Hungry water. Water containing less sediment than it can carry, such as water released from a dam or other impoundment that traps sediment and removes it from transport. Because hungry water has "excess" energy, it tends to erode the streambed, which may lead to channel incision.

Impermeable material. A material that does not permit a passage of water (or other fluid). Impermeable materials may be non-porous, but are not necessarily so.

Incised channel. A channel that has eroded into the valley floor. Commonly reflects accelerated and destructive erosion.

Infiltration. Movement of rainwater or surface runoff downward into subsurface soils and rock. Infiltration may be a major source of groundwater recharge in areas with permeable surface materials.

Key (v.). To anchor (a structure, usually) in an excavated ditch, notch, or incision.

Keyway, key. The excavation used to anchor a structure such as a check dam or deflector log.

Lifts. Layers of loose soil of a specified thickness used as fill.

Longitudinal profile. A plot showing elevation as a function of distance along a stream channel, used as a graphic representation of stream gradient. In stream hydraulics, the longitudinal profile plots water surface elevation as a function of upstream distance.

Meander. A curve or bend in a stream channel, characterized by erosion on the outer bank (cutbank) and deposition on the inner bank (point bar). Meandering channels are characteristic of low-gradient streams.

Mulch. A substance—such as straw, wood chips, or leaves—used to cover the soil surface in order to inhibit weed growth and/or prevent the loss of moisture or heat.

Nick point. The locus of an abrupt change in channel gradient; represents a point at which the stream is actively eroding its bed in response to a change in base level. See also **bedscarp**.

Obligate. E.g., *"obligate riparian species."* Refers to a species that can only succeed in a specific environment. See also **facultative**.

Overbank flow. Flow that overtops a stream's channel and moves onto the floodplain.

Pedology. The scientific study of soils.

Perennial. Refers to a plant (e.g., a grass or herbaceous species) that survives for more than one growing season.

Piezometer. Device for measuring the depth to the local water table. A piezometer is installed by drilling a small-diameter (1"–4") hole; the upper portion of the hole is cased with PVC pipe, and the bottom portion (several inches to several feet) is "screened" using slotted PVC pipe. The top of the hole is sealed with a concrete collar to prevent surface runoff from entering the instrument. The top of the casing pipe usually protrudes several inches above the ground surface, and should be enclosed in a lock-box to ensure that it is not tampered with. Water migrates into the screened portion of the piezometer and rises to the level of the local water table. The depth to the water surface (hence, the depth to the local water table) can be measured using a battery operated sounder.

Plan view. Map view or "bird's-eye" view.

Planform. The shape of some feature when viewed from above (in map view or plan view).

Point bar. Characteristic sediment deposit formed by decelerating flow on the inner bank of a meander bend.

Pool. A portion of a streamchannel where the water is comparatively deep and slow-moving.

Reach. A section, segment, or portion of a stream's length.

Rebar. Steel bar or rod used for reinforcement of concrete in construction (from "reinforcing bar"). Rebar has various uses in the habitat restoration field.

Revetment. A facing of tree trunks, logs, sandbags, gabions, etc., intended to protect a slope or streambank against erosion.

Riffle. A shallow rapid, usually located where the current crosses a meander in the active streamchannel.

Riparian. Refers to the environment associated with an active stream. E.g., *Riparian vegetation, riparian habitat.*

Riparian corridor. The habitat corridor along a stream.

Riprap. Pieces of rock, concrete, or other resistant material used to armor a slope or bank against erosion, or to stabilize a streamchannel.

Rootwad. A tree stump with roots (either live or deadwood), installed in a streambank as part of a bank stabilization program. (See **biotechnical bank stabilization**.)

Roughness. Refers to the resistance to flow created by geometric irregularities in streambed or streambank materials, by vegetation, or by other physical components of a natural or artificial hydraulic system. Roughness is commonly described by the Manning coefficient, n. Another common measure of roughness is the Chézy coefficient, C.

Scour. Erosion resulting from fluid turbulence. Tendency of turbulent water to entrain and remove material from the streambed and streambanks.

Sediment. Generally used to refer to particles physically broken down and transported from their source by the action of water, ice, or wind. Strictly defined, sediment also includes components dissolved from a parent rock source and carried in solution by surface water and groundwater.

Sediment deposition. The accumulation of boulders, gravel, sand, and mud on the streambed, streambanks, and floodplain.

Setback. Positioning of a structure at a specified distance from some natural feature such as a stream or earthquake fault, in order to avoid damage to the structure and/or interference with the operation of a natural system. For example, a setback levee permits a stream to meander on its floodplain without damaging the levee and compromising flood protection for residents of adjacent areas.

Shaded riverine aquatic (SRA). Refers to emergent riparian vegetation that overhangs a streamchannel. One important function of SRA cover vegetation is to shade the water in the channel, helping to maintain cooler water temperatures, and thereby improving habitat for coldwater native fish species such as steelhead trout and chinook salmon. SRA cover also provides a source of inchannel plant material, including leaf litter (used by shredding insect species) and woody material (an important source of cover for fish).

Shear. Defined as the force acting on a specified area, parallel to the surface. An example of shear would be the tractive force that removes particles from a streambed as flow moves over its surface.

Sheet flow. Unconfined overland runoff; surface runoff that flows over the ground as a sheetflood or thin layer of moving water.

Sloughing, Slumping. Movement of a mass of soil and/or bedrock down a streambank or other slope, as a result of slope failure. Commonly triggered by erosional undercutting.

Soil bioengineering. See **biotechnical bank stabilization**.

Streambank erosion. Removal of sediment and soil particles from a bank slope, primarily due to the action of running water. Climate, ice and debris, chemical reactions, and changes in land and stream use may also contribute to bank erosion.

Streambanks (banks). The slopes of an active channel, between which streamflow is normally confined.

Streambed. See **Bed**.

Surface runoff. The portion of rainfall that travels over the ground surface without infiltrating into the subsurface. (See **Infiltration.**)

Suspended load. Material carried in suspension (suspended in the water column) by a stream. Typically the finest-grained portion of a stream's total load.

Terrace. An abandoned floodplain or fluvial deposit now located at an elevation above that of the active floodplain.

Toe (of a slope). The change in gradient at the bottom of a slope where the slope meets an adjacent area of flat terrain; the "bottom" of a slope.

Top of bank. The break in slope at the top of a streambank, where the streambank meets the floodplain.

Urban equilibrium. The condition reached when a channel has undergone human-induced changes from its natural condition, but has (re-)adjusted to the urban influences affecting it. A stream which has reached urban equilibrium is relatively stable in planform, and has achieved a new balance of bankfull width and depth so that it (re-)approaches a graded condition, or net balance between erosion and deposition. It also has healthy riparian growth.

Velocity (of water in a stream). Water speed, speed of streamflow. The distance traveled by a volume of water in a given direction over a specified period of time. Usually expressed in feet per second (fps).

Water table. An imaginary underground surface below which subsurface materials (soil, rock, etc.) are saturated (i.e., open spaces within materials are filled with water).

Watershed. A drainage basin; the area that drains into a river or stream. The basic geographic unit of hydrologic analysis. Watersheds are important units of study for riparian restoration because activities anywhere within a watershed can affect the success or failure of a site-specific restoration project.

Weir. A barrier placed in a channel to divert fish or control the flow of water.

Sources consulted in the preparation of this glossary include Boggs (1995) and Riley (1998).

Appendix F. Evaluation of Non-GIS Site Selection Criteria

Evaluation of Non-GIS Site Selection Criteria

This evaluation form was designed to guide restoration planners in considering factors that may constrain project feasibility or success at a particular site and/or that may need to be compensated for in project design. Note that this form is structured in such a way that a predominance of "true" and "somewhat true" responses indicates a site that is highly suitable for riparian restoration. The sponsors of any proposed restoration project must establish the threshold of acceptability for various criteria; project sponsors may also wish to decide whether any specific criteria will represent such severe constraints on project feasibility or success that they should result in automatic rejection of the site.

*Complete this form for each site under consideration by circling the appropriate response for each question. This form should be completed in two phases: **(1)** answer the questions addressing high-priority criteria first; then **(2)** if evaluation of the high-priority criteria suggests that the site warrants further consideration, complete the remainder of the questions in each category. If further information is needed on any of the subject areas addressed by this form, consult Chapter 1 of the RRAP document, which gives details on where to find various subjects in the RRAP document.*

High-priority criteria are indicated by the symbol ✪.

a. Need for Project:

✪ **(1)** If no restoration takes place, this site will continue to degrade over time.	***not true . . . . . somewhat true . . . . . true***

b. Technical Feasibility:

✪ **(1)** Given existing site conditions, and any other applicable constraints, the proposed project can be implemented on this site within the required time frame.	***not true . . . . . somewhat true . . . . . true***
(2) Sufficient site-specific hydrologic data are already available to characterize baseline conditions at the site.	***not true . . . . . somewhat true . . . . . true***
(3) The project will not require extensive grading or channel realignment.	***not true . . . . . somewhat true . . . . . true***

c. Funding:

✪ **(1)** Sufficient funding is available to support project implementation.	***not true . . . . . somewhat true . . . . . true***
(2) Sufficient funding is available to support post-restoration monitoring and maintenance activities.	***not true . . . . . somewhat true . . . . . true***

d. Land Ownership: *(answer only applicable questions)*

✪ **(1)** If on public or quasi-public land, the site is owned by a local agency that will support implementation of the proposed project. — ***not true . . . . . somewhat true . . . . . true***

✪ **(2)** If privately owned, the site is owned by a landowner interested in restoring riparian habitat. — ***not true . . . . . somewhat true . . . . . true***

(3) If the site is privately owned, the landowner is willing to protect the site by establishing a conservation/public open space easement. — ***not true . . . . . somewhat true . . . . . true***

e. Regulatory Requirements:

✪ Implementation of the proposed project will not require preparation of one or more of the following:

(1) Preparation of an Initial Study in compliance with the California Environmental Quality Act (CEQA). — ***not true . . . . . somewhat true . . . . . true***

(2) Preparation of an Environmental Impact Report in compliance with CEQA. — ***not true . . . . . somewhat true . . . . . true***

(3) Acquisition of a permit pursuant to Section 1600 of the California Department of Fish and Game Streambed Alteration Agreement. — ***not true . . . . . somewhat true . . . . . true***

(4) Acquisition of a permit from the United States Army Corps of Engineers in compliance with Section 404 of the federal Clean Water Act. — ***not true . . . . . somewhat true . . . . . true***

(5) Consultation with the United States Fish and Wildlife Service under Section 7 of the federal Endangered Species Act. — ***not true . . . . . somewhat true . . . . . true***

(6) Acquisition of a District permit in compliance with Santa Clara Valley Water District Ordinance 83-2. — ***not true . . . . . somewhat true . . . . . true***

f. Interagency Coordination:

✪ **(1)** Implementation of the proposed project on this site will support the achievement of multiple goals (e.g., flood protection, wildlife and fisheries enhancement, recreation, etc.). — ***not true . . . . . somewhat true . . . . . true***

(2) Implementation of the proposed project on this site will increase the possibility for the project sponsor to attract a co-sponsor who could provide financial and/or technical assistance. — ***not true . . . . . somewhat true . . . . . true***

g. Local Support for Restoration:

✪ **(1)** There is an obvious local perception that the creek is a community value and that restorationwill increase the value of the creek to the local community. — ***not true . . . . . somewhat true . . . . . true***

✪ **(2)** A local citizen or neighborhood group is interested in implementing a restoration project on this site. — ***not true . . . . . somewhat true . . . . . true***

h. Adjacent Land Use:

✪**(1)** Existing and projected land uses do not a have significant potential to diminish the probability of project success at this site. — ***not true . . . . . somewhat true . . . . . true***

(2) No management practices that could diminish the probability of project success (e.g., channel maintenance, vegetation management) are currently used at this site. — ***not true . . . . . somewhat true . . . . . true***

(3) If implemented at this site, the proposed project has little or no potential to reduce existing channel capacity and/or to increase the potential for flooding of adjacent properties. — ***not true . . . . . somewhat true . . . . . true***

(4) The proposed project has not potential for adverseimpacts on existing infrastructure (e.g., roads, utilities) ifimiplemented at this site. — ***not true . . . . . somewhat true . . . . . true***

i. Water Quality and Stream Hydrology:

✪ **(1)** Groundwater hydrologic conditions (e.g., soil moisture, depth to water table) are suitable for the establishment and continued viability of riparian vegetation. — ***not true . . . . . somewhat true . . . . . true***

(2) Upstream water management practices (e.g., diversions, releases from upstream reservoirs) have no potential to affect stream hydrology in ways that could diminish the probability of project success if implemented at this site. — ***not true . . . . . somewhat true . . . . . true***

(3) No industrial or stormwater discharges that could have localized effects on water quality and diminish the probability of project success exist near this site. — ***not true . . . . . somewhat true . . . . . true***

(4) No industrial or stormwater discharges that could have localized effects on bank stability and diminish the probability of project success exist near this site. — ***not true . . . . . somewhat true . . . . . true***

(5) There is no evidence that debris (e.g., woody vegetation, urban trash or waste) is deposited in the project area at this site during peak flood events. — ***not true . . . . . somewhat true . . . . . true***

(6) No evidence has been observed at this site to indicate the recurrence of flood events that could result in significant bank erosion and diminish the probability of project success at this site. — ***not true . . . . . somewhat true . . . . . true***

j. Site Physical Characteristics:

(1) Site surveys observed no signs suggesting that localized channel, bank, or bed instability (e.g., undercut banks, slumping or collapsing banks, mass-flow deposits) could diminish the probability of project success if implemented at this site. — ***not true . . . . . somewhat true . . . . . true***

(2) Little or no substrate modification will be required before this site can support riparian vegetation. — ***not true . . . . . somewhat true . . . . . true***

k. Site Biotic Characteristics:

✪ **(1)** Implementation of the proposed project at this site will contribute to restoring the connectivity of the riparian corridor. — ***not true . . . . . somewhat true . . . . . true***

✪ **(2)** Implementation of the proposed project at this site will result in a positive impact on at least one spacial-status species. — ***not true . . . . . somewhat true . . . . . true***

✪ **(3)** Implementation of the proposed project at this site will result in the restoration of more than one type of riparian and/or aquatic habitat. — ***not true . . . . . somewhat true . . . . . true***

(4) No significant populations of invasive/exotic plant species that could affect the establishment of native riparian vegetation, or that could necessitate extensive preparation or maintenance activities, are present in the vicinity of this site. — ***not true . . . . . somewhat true . . . . . true***

(5) Field surveys of this site and vicinity observed no signs of undesirable wildlife species (e.g., feral cats) that could diminish the probability of project success. — ***not true . . . . . somewhat true . . . . . true***

(6) Field surveys of this site and vicinity observed no signs of undesirable wildlife species (e.g., feral cats) that could diminish the value of this restoration site for native riparian wildlife. — ***not true . . . . . somewhat true . . . . . true***

(7) No barriers to fish passage exist downstream from this site. — ***not true . . . . . somewhat true . . . . . true***

(8) This site is not located on a property that may be utilized for mitigation purposes in the foreseeable future. — ***not true . . . . . somewhat true . . . . . true***