Lower Putah Creek Watershed Management Action Plan

Phase I – Resource Assessments

Text and Appendices

Prepared for:

Lower Putah Creek Coordinating Committee

Contact:

Rich Marovich
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December 2005

EDAW

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PREFACE

The Lower Putah Creek Watershed Management Action Plan (WMAP) represents Phase I of a three-phase program for enhancing watershed resources in the lower Putah Creek watershed. The WMAP is a comprehensive science-based and community-based approach to protect and enhance resources in the lower Putah Creek riparian corridor, including tributaries, extending from Lake Berryessa to the Yolo Bypass.

The Lower Putah Creek Coordinating Committee (LPCCC), formed by a settlement agreement (Accord) between Solano County water users and Yolo County environmental advocates concerning the adequacy of flows to protect fish and wildlife resources of Putah Creek, consists of representatives of Solano and Yolo counties with interests in the protection of Putah Creek resources. The LPCCC represents the Boards of Supervisors of Solano and Yolo counties; Cities of Davis, Fairfield, Suisun, Vacaville, Vallejo, and Winters; Solano County Water Agency; Solano Irrigation District; Maine Prairie Water District; University of California, Davis; Putah Creek Council; and riparian landowners. The WMAP is one of the first actions initiated by the LPCCC, through funding by a grant from the CALFED Bay-Delta Program. The LPCCC serves as the watershed group joining several primary stakeholders together to oversee implementation of the Accord and to begin planning for protecting and enhancing of Putah Creek's resources.

This is a dynamic WMAP that landowners and other stakeholders can use as a framework and that will be updated with new information and new ideas to improve the watershed. It provides landowners and management entities with a blueprint for actions to protect and enhance resources in the lower Putah Creek watershed in a manner that is compatible with and respectful of landowner priorities, interests, and concerns.

Development and implementation of the WMAP is divided into three phases. ***Phase I*** consists of comprehensive biological, physical, and cultural resource assessments as well as summaries of stakeholder input and initial watershed enhancement actions to date. The assessments and stakeholder input summary provide the basis for identifying key issues and questions and determining potential watershed enhancement actions to be included in the next WMAP phase. They also establish a baseline for measuring future changes, evaluating the success of stewardship actions, and determining the need for modifying management approaches or assessing additional resources. ***Phase II*** is the stewardship phase that will evaluate opportunities and constraints for resource enhancement in the lower Putah Creek watershed and establish goals, objectives, and project ideas. The outcome will be an update to the WMAP including watershed enhancement actions developed through a series of meetings that present resource findings and key questions to stakeholders. ***Phase III*** is the implementation phase of the WMAP. Implementation will follow the recommended goals, objectives, and project ideas in the WMAP and will depend on funding, permits and regulatory approvals, and the support of landowners, resource agencies, and other stakeholders. While largely sequential, the three phases of the WMAP overlap to some extent. Therefore, in many cases, implementation of urgent and well-supported actions have already been initiated to reduce risks of further damage to resources and to take advantage of funding opportunities when available and to respond to individual landowners requesting assistance (e.g., bank stabilization, trash removal, fish habitat restoration, and invasive weed abatement).

Permits and regulatory approvals have already been acquired by the LPCCC for initial restoration and enhancement actions throughout the watershed, expediting implementation of projects conducted by or in coordination with the LPCCC and interested landowners. Funding for these projects has been provided by a series of grants administered by the LPCCC.

Guidance by landowners through the stewardship meetings and coordination with the LPCCC will be crucial to developing and implementing the WMAP.

The WMAP is a planning document that is not binding on individual landowners, but that reflects the collective willingness of landowners to support resource protection and enhancement projects. Implementation of specific WMAP actions will occur only with the consent of willing individual landowners affected by those actions.

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ACRONYMS AND ABBREVIATIONS

AAR	Adopt-A-Reach
AB	Assembly Bill
ACHP	Advisory Council on Historic Preservation
BAOSC	Bay Area Open Space Council
BMP	Best Management Practice
CalIPC	California Invasive Plant Council
Caltrans	California Department of Transportation
Cat Ex	Categorical Exemption
CBDA	California Bay-Delta Authority
CCR	California Code of Regulations
CDC	California Department of Conservation
CDFA	California Department of Agriculture
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFR	Code of Federal Regulations
CHRIS	California Historical Resources Information System
CRHR	California Register of Historic Resources
CWA	Clean Water Act
DCHA	Dry Creek Homeowners Association
DFG	California Department of Fish and Game
DWR	California Department of Water Resources
EA	Environmental Assessment
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
FAC	California Food and Agricultural Code
FMMP	Farmland Mapping and Monitoring Program
FONSI	Finding of No Significant Impact
FPP	Farmland Protection Program
FPPA	Farmland Protection Policy Act
FSZ	Farmland Security Zone
GIS	Geographic Information System
HCP	Habitat Conservation Plan

I-505	Interstate 505
I-80	Interstate 80
IP	Individual Permits
IS	Initial Study
IWMB	Integrated Waste Management Board
LESA	Land Evaluation and Site Assessment
LOP	Letter of Permission
LPCCC	Lower Putah Creek Coordinating Committee
MBTA	Migratory Bird Treaty Act
NAGPRA	Native American Graves Protection and Repatriation Act of 1990
NCCP	Natural Community Conservation Plan
NCCPA	Natural Community Conservation Planning Act
ND	Mitigated Negative Declaration
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NPS	non-point source
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NWIC	Northwest Information Center
NWP	Nationwide permit
OHV	off-highway vehicle
PCBR	Putah-Cache Bioregion Project
PCC	Putah Creek Council
PCC	Putah Creek Council
PDD	Putah Diversion Dam
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
RHJV	Riparian Habitat Joint Venture
RWQCB	Regional Water Quality Control Board
SAA	Streambed Alteration Agreement
SCWA	Solano County Water Agency
SID	Solano Irrigation District
SLEWS	Student and Landowner Education and Watershed Stewardship
SOD	sudden oak death

SRA	shaded riverine aquatic
SWPPP	Storm Water Pollution Prevention Plan
SWRCB	State Water Resources Control Board
UC	University of California
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
WAP	Weed Abatement Plan
WCB	Wildlife Conservation Board
Williamson Act	California Land Conservation Act
WMAP	Watershed Management Action Plan
WPCC	Winters Putah Creek Committee
YWA	Yolo Wildlife Area

1 Introduction

"Once you get down to that level, at the creek, you begin to understand why there has been such an outpouring of affection for the place."

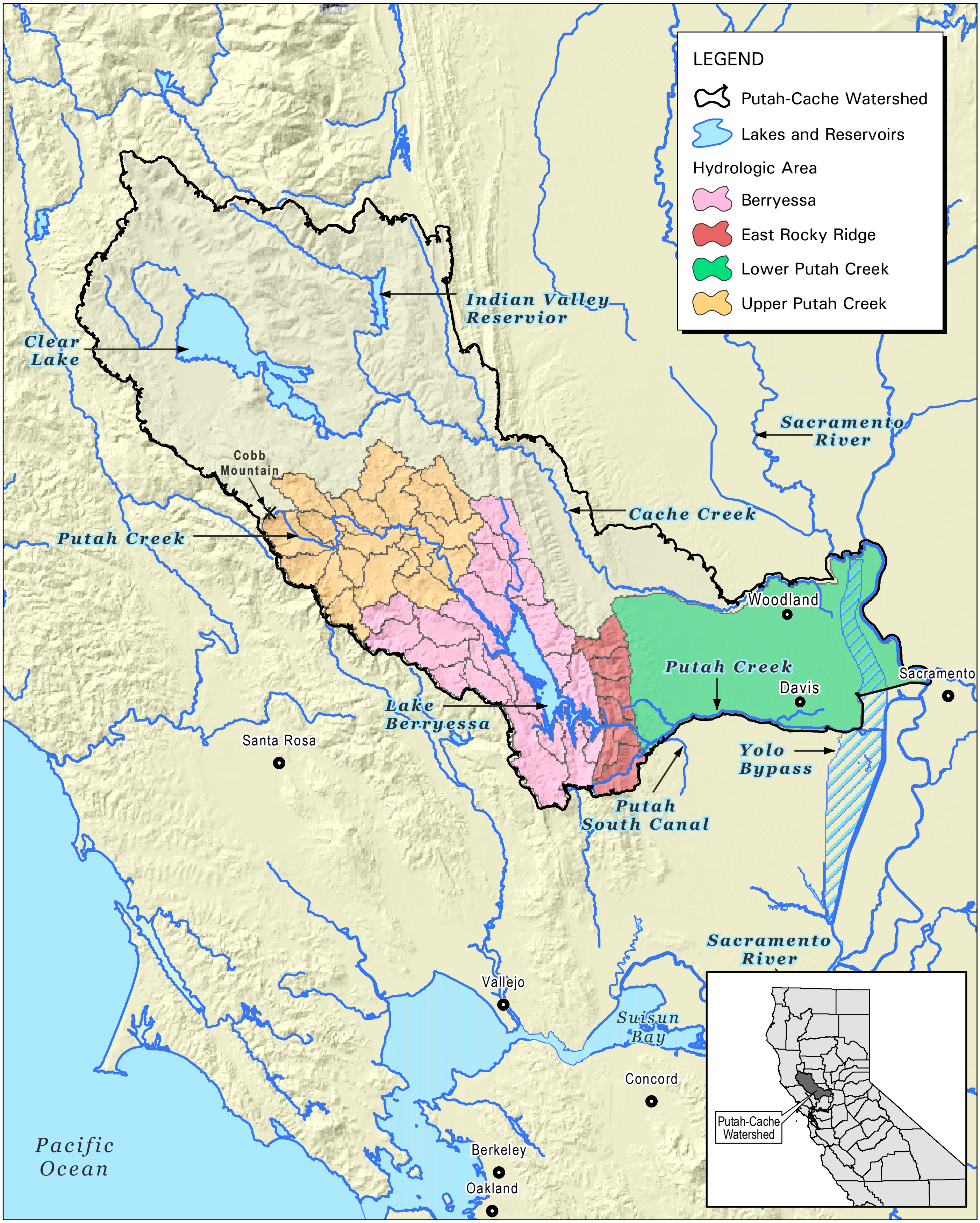
-Rob Thayer on Putah Creek, October 15, 1996

1 INTRODUCTION

The lower Putah Creek watershed is an important element in the natural, social, and economic life of the people of Yolo and Solano counties. It provides water and natural resources important to hundreds of thousands of farmers, residents, and businesses in these counties, including the residents of Winters, Davis, Fairfield, Suisun City, Benicia, Vacaville, Vallejo, and the rich farmland areas of Solano County. It also provides important habitat for hundreds of fish and wildlife species dependent on the rich natural plant communities and water in the Putah Creek riparian corridor. The greater Putah Creek watershed begins in the Coast Ranges of Lake County and drains about 600 square miles of steep coast range mountains (Exhibit 1-1). Flows converge on Lake Berryessa, which was formed by construction of Monticello Dam in a narrow pass called Devil's Gate. Regionally, the Putah Creek watershed is part of northern California's extensive Sacramento River watershed. It is located adjacent to the Cache Creek watershed, which drains the Coast Ranges north of the Putah Creek watershed. The lower Putah Creek watershed includes all of Putah Creek and its major tributaries between the Monticello Dam at Lake Berryessa and the Toe Drain of the Yolo Basin (or Yolo Bypass) which connects Putah Creek to the Sacramento-San Joaquin Delta and the ocean (Exhibit 1-2).

The Lower Putah Creek Coordinating Committee (LPCCC) was established in 2000 as part of a historic water accord (Accord) to provide water sufficient for fish, wildlife, and human needs. The LPCCC serves as the watershed group joining several primary stakeholders together to oversee implementation of the Accord and to begin planning for the protection and enhancement of Putah Creek's resources. The members include a riparian landowner, the cities of Davis, Fairfield, Suisun City, Vacaville, Vallejo, and Winters; counties of Solano and Yolo; Maine Prairie Water District; Putah Creek Council; Solano County Water Agency; Solano Irrigation District; and the University of California, Davis.

One of the first actions undertaken by the LPCCC is the development of a Lower Putah Creek Watershed Management Action Plan (WMAP) to provide a comprehensive initial assessment of lower Putah Creek's resources and to determine, with watershed stakeholders, the primary restoration and enhancement objectives to improve the health of the watershed and riparian corridor. Development of the WMAP enables a community-based, comprehensive approach to watershed resource protection and enhancement.



Source: California Department of Forestry and Fire Protection 1999, Teale GIS Solutions Group 1999

Putah Creek-Cache Creek Watershed

EXHIBIT 1-1

Lower Putah Creek Watershed Management Action Plan

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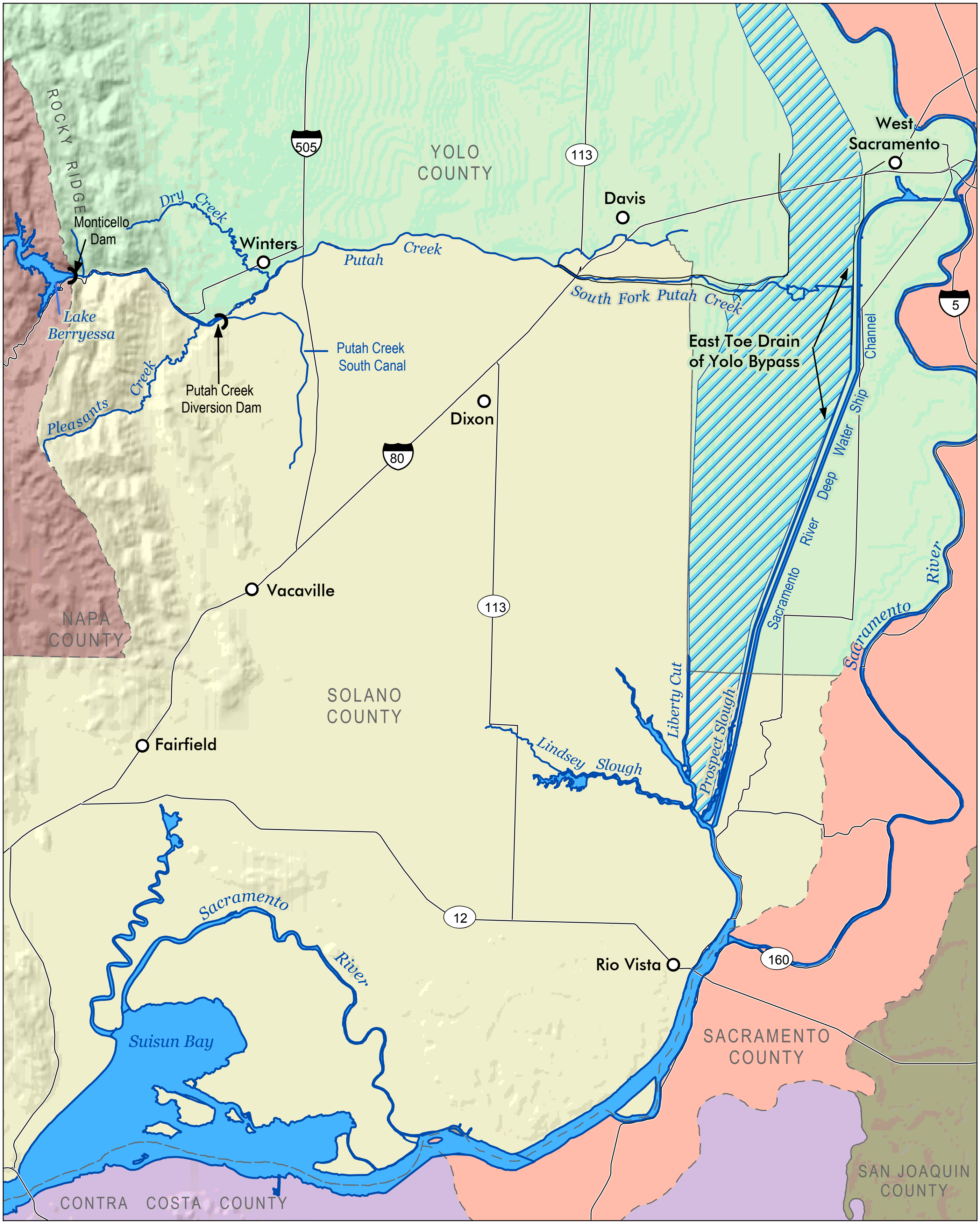

Source: Teale GIS Solutions Group 1999, U.S. Census Bureau 2002, U.S.G.S 1993

Lower Putah Creek Regional Area

EXHIBIT 1-2

Lower Putah Creek Watershed Management Action Plan

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NORTH

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1.1 PURPOSE, APPROACH, AND ORGANIZATION OF THE WATERSHED MANAGEMENT ACTION PLAN

1.1.1 PURPOSE

The purpose of the WMAP is to provide a description of the existing and historical resources in the lower Putah Creek watershed, identify stakeholders' goals and objectives for resource management and restoration, and implement those actions that are consistent with landowner interests to restore ecosystem processes and enhance aquatic and terrestrial habitats in the lower Putah Creek watershed. Although the lower Putah Creek riparian corridor represents one of the largest remaining tracts of high-quality wildlife habitat in Yolo and Solano counties and is home to a unique assemblage of fish and wildlife species native to the Central Valley, it suffers from substantial invasive weed infestations, eroding banks, habitat loss and degradation, flood-related impacts, non-point source (NPS) pollution, and other problems. Lower Putah Creek offers a unique opportunity to develop watershed management regimes to optimize benefits to fish, wildlife, and other resources in a manner compatible with and driven by, landowner interests and objectives.

The goal is to develop a dynamic WMAP that landowners can use as a framework to plan for the protection and enhancement of lower Putah Creek watershed resources for generations to come. Importantly, it is intended to provide landowners and land managers with a blueprint for actions to protect and enhance resources in the lower Putah Creek watershed in a manner that is compatible with landowner priorities, interests, and concerns.

1.1.2 APPROACH

The WMAP study area is provided in Exhibit 1-3. Lower Putah Creek watershed features and landmarks referred to throughout this document are provided in Appendix A. Development and implementation of the WMAP was divided into three phases.

PHASE I

Phase I of the WMAP consists of comprehensive resource assessments, including cultural resources, land ownership and land use, water quality, geomorphology, hydrology, fisheries, vegetation and wildlife, and invasive weeds. The results of these assessments and a summary of initial stakeholder coordination efforts are provided in chapters 2 through 8 and supplemented with information in technical appendices. Key findings and watershed management questions that arise from the resource assessments are presented in Chapter 9. Chapter 10 identifies the initial watershed enhancement programs and actions already vetted before stakeholders which are either underway now or in the near future. These and future assessments are intended to provide baseline conditions and methods for measuring future changes, the success of stewardship actions, and the need for modifying management approaches or assessing additional resources.

Source: Teale GIS Solutions Group 1999, U.S. Census Bureau 2002, U.S.G.S 1993

Lower Putah Creek Watershed Study Area

EXHIBIT 1-3

Lower Putah Creek Watershed Management Action Plan

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EDAW

PHASE II

Phase II of WMAP development will be outreach-oriented, with a focus on presenting the key findings and resource management questions identified in the Phase I resources assessments to stakeholders. Stakeholder response and input to the Phase I findings will drive the development of landowner-based visions, goals, objectives, and project ideas for management of the lower Putah Creek watershed. Other elements in Phase II may include development of a weed-abatement plan and a plant palette that can be used for future restoration and enhancement actions.

PHASE III

Phase III is the implementation phase of the WMAP. Implementation will follow the recommended goals, objectives, and project ideas in the WMAP, depending on funding, stewardship actions of landowners and management entities, permits and regulatory approvals, and the support of resource agencies and other stakeholders. Permits and regulatory approvals have been acquired by the LPCCC for many initial restoration and enhancement actions, expediting implementation of projects conducted by or in coordination with LPCCC. Some projects already underway in the lower Putah Creek Watershed include a Putah Creek Council Adopt-A-Reach (AAR) Program, FARMS Leadership program, Student and Landowner Education and Watershed Stewardship (SLEWS) program, a bird box trail, and LPCCC-sponsored invasive weed abatement, trash removal, and fish and wildlife habitat restoration projects. Additional similar projects currently proposed include fish habitat restoration, bank stabilization, and other resource assessment and enhancement projects. Future projects will be developed and implemented as more is learned about the creek's resources, needs for improvements are identified, and stakeholders update the WMAP with future recommended actions. New projects proposed by or for landowners in coordination with the LPCCC that are covered by existing regulatory approvals could result in continued financial investments by potential project funders.

The WMAP is intended to be updated with new information on a regular basis. New project ideas will be developed for inclusion in future versions of the WMAP as a result of new assessments; completion, monitoring, and analysis of existing enhancement projects; ongoing input and interest from landowners; and guidance from resource experts. In this way, the WMAP will become a continually useful plan that results in substantial benefits to the resources and community within the lower Putah Creek watershed.

There are over 200 private and public landowners in the lower Putah Creek watershed. Lands are owned by Yolo and Solano counties; the cities of Davis and Winters; the University of California, Davis; the California Department of Fish and Game (DFG); the U.S. Bureau of Reclamation, and over a hundred private landowners. Most are farmers and/or homeowners. In addition to the landowner stewardship group, there are a number of groups with interests in Putah Creek resources. These include water users, consisting of Solano County Water Agency (SCWA) and Solano Irrigation District (SID); Maine Prairie Water District and their constituents; resource agencies, including the California Bay-Delta Authority (CBDA); the U.S.

Fish and Wildlife Service (USFWS); the National Marine Fisheries Service (NMFS); the U.S. Army Corps of Engineers (USACE); the State Water Resources Control Board (SWRCB); and Regional Water Quality Control Board (RWQCB); DFG; Yolo and Solano Land Trusts; environmental advocacy groups, especially Putah Creek Council (PCC); California Audubon, and Winters Putah Creek Committee (WPCC); fly-fishing groups; and the general public.

1.1.3 ORGANIZATION

The Phase I WMAP is organized as follows:

- Acknowledgements/Preface
- Chapter 1. Introduction
- Chapter 2. Cultural Resources
- Chapter 3. Land Ownership, Land Use, and Resource Management Programs
- Chapter 4. Geomorphology, Hydrology, and Water Quality
- Chapter 5. Fisheries
- Chapter 6. Vegetation and Wildlife
- Chapter 7. Invasive Weeds
- Chapter 8. Stakeholder Planning
- Chapter 9. Key Findings and Watershed Management Questions
- Chapter 10. Resource Management Actions and Opportunities
- Chapter 11. Recommendations for Future Plan Development
- Chapter 12. Bibliography
- Chapter 13. List of Preparers
- Appendix A. Locations of Landmarks in the Lower Putah Creek Watershed
- Appendix B. Putah Creek Resource Assessment Wildlife Habitat Evaluation Form
- Appendix C. Putah Creek Invasive Weed Inventory
- Appendix D. Lower Putah Creek Plant Inventory
- Appendix E. Lower Putah Creek Avian Species
- Appendix F. Lower Putah Creek Fish Species Collected during 1991–2002 Surveys
- Appendix G. New Zealand Mud Snail
- Appendix H. Permitting and Regulatory Compliance
- Appendix I. Restoration and Enhancement Project Permit Requirement Summaries
- Map Volume: PART 1 – Putah Creek Riparian Vegetation Coverage
- Map Volume: PART 2 – Resource Assessment Maps

1.2 HISTORY AND OVERVIEW OF LOWER PUTAH CREEK WATERSHED

A watershed is defined not just by its physical features or by present land use conditions within it, but by all physical, biological, and cultural components both past and present. From the formation of the watershed by geologic and hydrologic processes long before the presence of humans to the present-day agricultural practices, Putah Creek has a rich history. Its banks, which were once home to animals such as the mammoth and to early native peoples, now provide some of the richest farmland in the world.

1.2.1 PHYSICAL SETTING

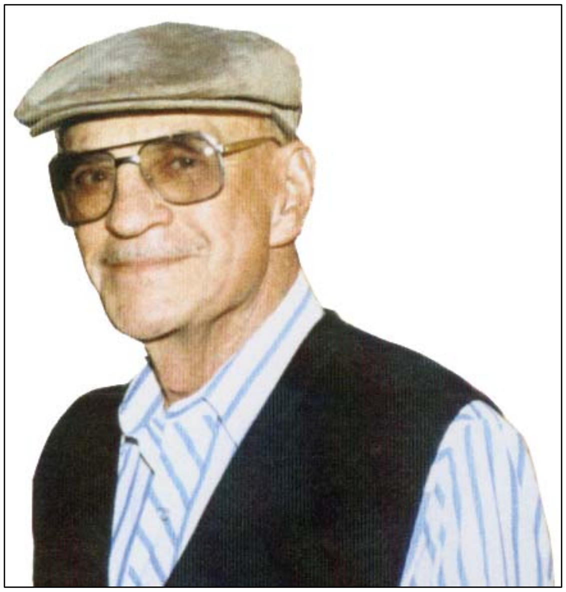
CLIMATE

The Putah Creek watershed has a Mediterranean climate of hot dry summers and mild rainy winters. Approximately 75% of the annual rainfall is received between November and March, the typical rainy season. Near the headwaters of Putah Creek in the Coast Range, 40–60 inches of rain falls annually, while the City of Davis near the terminus of Putah Creek averages about 17 inches per year. Although snow can occur in the Coast Ranges in the upper reaches of the watershed, the lower Putah Creek watershed typically has frost only a few nights per year. However, the lower reaches of Putah Creek have been known to freeze solid. George Crum (Exhibit 1-4), a resident of Winters for most of his life from 1927 until his death at the age of 82 in 2000, wrote an article for the Putah Creek News in fall 1998 where he describes ice skating on the creek in the early 1930s:

> In the early 1930s, home entertainment was not what it is today … [o]ne of my favorite places to spend time was Putah Creek. There my two brothers and I learned to hunt, fish and swim. Late one fall we had a real cold snap. The temperature fell to 17 degrees with a strong wind blowing. You can imagine what the wind chill factor must have been. My brother Robert and I had noticed that the water in our dog's dish had frozen solid. That caused us to wonder if the large ponds on Putah Creek had frozen over. We couldn't wait to find out and upon inspection we found a sheet of ice covered the ponds. We carefully ventured out to see if it would support our weight and to our amazement, we found that it would. Now all we needed were ice skates but of course we didn't have any. But where there's a will there's a way. We went home, found a pair of roller skates, removed the rollers, installed blades, and returned to the frozen ponds where we skated on ice for the first time. What fun we had! So, yes, believe it or not there has been skating on Putah Creek. (Crum 1998.)

GEOMORPHOLOGY AND HYDROLOGY

A study of the geomorphology of a region includes an examination of the physical processes that have occurred over geologic time. These physical processes determine how the creeks in a region are formed. Discussions of hydrologic conditions generally refer to how water behaves on the earth's surface, in the soil and underlying rock, and in the atmosphere. Putah Creek begins near the summit of Mt. Cobb in the Coast Ranges in Lake County and winds its way through Devil's Gate, the site of Monticello Dam, and into the Yolo Basin (Exhibit 1-1). Lower Putah Creek watershed, the emphasis of this WMAP, includes the entire reach of creek from Monticello Dam east toward the Sacramento River (Exhibit 1-3). Tributaries to Putah Creek below Monticello Dam include Thompson Creek, Cold Creek, Bray Canyon Creek, and Pleasants Creek above the Putah Creek Diversion Dam, and Pleasant Creek and Dry Creek downstream of the diversion dam.



George Crum, Writer, and Winters Resident, 1927–2000 EXHIBIT 1-4

Prior to human intervention, Putah Creek flowed out of the Vaca Mountains across a broad area, frequently changing its course. In the lower reaches of the watershed, a mildly sloping alluvial plain formed by accumulated sediment deposition from Putah Creek created the rich agricultural land of this region. Flood control measures, development, and grading for agriculture have caused the present lower Putah Creek to carve out a deeper channel. The excavation of a south fork channel for additional flood control and gravel mining upstream of the Pedrick Road bridge and the city of Winters in the 1960s and 1970s also contributed to the downcutting of the channel. At the base of the railroad bridge at Winters there is a 3-foot depth of exposed rough concrete footing beneath the smooth surface of the formed support pillar, attesting to 3 feet of incision that occurred since the bridge was built in 1906.

Prior to the construction of Monticello Dam, Putah Creek frequently overtopped its banks, causing extensive crop and property damage for early settlers. In 1871, residents began to divert Putah Creek into what is now the south fork channel (USFWS 1993). The diversion began using horse-drawn equipment and was completed by the USACE in 1940, during World War II. The south fork diversion from the old creek begins 4,000 feet upstream of the Interstate 80 (I-80) bridge and follows a relatively straight course to the Yolo Bypass.

Further changes were made to Putah Creek with the completion of the Solano Project in 1957. The project consisted of Monticello Dam and Lake Berryessa, Putah Diversion Dam and Lake Solano, and the Putah South Canal that channels water from the Putah Diversion Dam south to Solano County farms and municipalities. Water stored in Lake Berryessa is released downstream where it flows into Lake Solano.

The flooding of Berryessa Valley to create a reservoir for storage of water for irrigation came at a price to the occupants of that valley, most of whom were dry land farmers living in or near the Berryessa Valley town of Monticello. On April 8, 1948, California Governor Earl Warren wrote the following letter to Robert F. Rockwell, Chairman of the subcommittee on Irrigation and Reclamation in the House Committee on Public Lands regarding the construction of Monticello Dam:

> The construction of a Monticello Reservoir of this capacity will flood the Berryessa Valley, which is now utilized from the growing of orchards, vineyards, grain, alfalfa, corn, and pasture grasses. There is a gross area of about 16,700 acres of good agricultural land in the site for a 1,600,000-acre-foot reservoir, most of which is now in use largely for dry farming. Several hundred acres of this land, however, are now irrigated. The owners of this valley and many of the people in Napa County where it is located oppose the Monticello Dam site because these lands will be inundated and the taxable wealth lost to the county. Although it will be necessary to destroy the productivity of these 10,700 acres of land, the construction of the reservoir will make it possible to furnish water for the irrigation of about 78,000 acres of presently unirrigated lands in Solano County, including 56,500 acres in the presently unorganized district, and for a supplement supply to 5,000 acres of presently irrigated lands, and in addition furnish annually 38,000 acre-feet of water for municipal, military, and industrial uses.

In 1989, in the midst of a 7-year drought, Putah Creek went dry over a distance of more than 20 miles from the Bypass to near Winters, causing fish kills and the loss of other wildlife and riparian vegetation along the creek. The drought, however, was not solely responsible for the parched creek bed. There were no state-mandated flows for the protection of the creek environment following the completion of the Solano Project in 1957 and the drought led to more diversion of the water than was left in Putah Creek. Releases from Lake Berryessa were insufficient to keep water flowing in the creek. In addition, an old gravel extraction pit west of Winters on the north bank may have captured all of the flows in lower Putah Creek in the late 1980s leading to dewatering of the creek below Winters (Salamunovich, pers. comm., 2003).

On May 23, 2000, following 10 years of litigation related to stream flows for supporting fish and other natural resources, Putah Creek Council, City of Davis, and UC Davis signed onto an historic water accord with the Solano County Water Agency, Solano Irrigation District, and other Solano water interests to establish permanent surface water flows for the 23 miles of Putah Creek below the Putah Diversion Dam. The main elements of the Accord are:

- permanent instream flows for resident native fish,
- permanent seasonal instream flows for anadromous steelhead and Chinook salmon,
- a schedule for reduced water releases during extended droughts,
- the creation of the Lower Putah Creek Coordinating Committee,
- a one-time startup grant of $250,000, and
- perpetual funding for restoration, monitoring, and a streamkeeper.

1.2.2 BIOLOGICAL RESOURCES SETTING

Dynamic, meandering river systems in the Central Valley and surrounding foothills once supported diverse riparian communities and created habitat for an abundance of resident and migrating fish and wildlife species. Waterways such as Putah Creek created a habitat mosaic including, instream wetland edges, openings and gravel bars, early-successional vegetation, and mature forest stands, which together provide for a diverse array of wildlife.

Over 225 species of birds, mammals, reptiles, and amphibians in California depend on riparian habitats, such as those along Putah Creek, for nesting, foraging, dispersal corridors, and migration stop-over sites. Riparian vegetation is also critical to the quality of instream habitat and aquatic life. It provides shade, food, and nutrients that form the basis of the food chain (Riparian Habitat Joint Venture [RHJV] 2000). It also supplies instream habitat when high flows dislodge trees and patches of willows, creating pools where the creek bed and bank vegetation is scoured. Downed trees form logjams important for fish, semi-aquatic reptiles and amphibians, and aquatic insects. Riparian habitats may also be the most important habitat for bird species in California (Gaines 1977, RHJV 2000). Despite their importance, California has lost approximately 95% of riparian and wetland habitats because of reservoir construction, levee and channelization projects, livestock grazing, timber harvest, water pollution, introduction of non-native plant species, gravel and gold mining, and clearing for agricultural, residential, and industrial uses over the past 150 years (RHJV 2000).

Changes in the lower Putah Creek riparian corridor follow a similar history to that described above. Dense oak forests reportedly once covered the plains and alluvial fan along the creek, with high fans and terraces having more open stands of grass and oaks. Lower lying basin deposits supported tules, reeds, and other water tolerant plants (Burchan 1957 as cited in Bates et al. 1977). What was once an estimated 22,000 to 65,000 acres of riparian vegetation between Winters and the Yolo Basin with an average riparian corridor width of perhaps 1.5 miles or more (Katibah 1984, Kuchler 1977, USFWS 1993a) is now reduced to approximately 1,850 acres of riparian corridor with a width of between 100 and 1,000 feet.

With conversion of these natural communities to farmlands and other land uses, agricultural land and developed areas are now the dominant land cover types adjacent to the narrowed riparian corridor. Although trees and other riparian vegetation have re-grown along the creek and are fairly mature in some areas, the riparian corridor width is constrained by adjacent roadways, agriculture, and residential and urban development. Continuing periodic stream maintenance activities for fire suppression or flood protection also affect the riparian woodland structure, shaded riverine aquatic (SRA) cover, and plant and wildlife species composition.

The present riparian corridor contains a mixture of plant communities, including mixed riparian forest, valley oak riparian forest, foothill riparian woodland, riparian scrub, riverine wetland, open water, disturbed riparian woodland, and ruderal areas. The Putah Creek riparian habitats support a variety of wildlife, including sensitive and special-status animals such as anadromous and freshwater fishes, western pond turtle, valley elderberry longhorn beetle, giant garter snake, burrowing owl, yellow-breasted chat, and Modesto song sparrow.

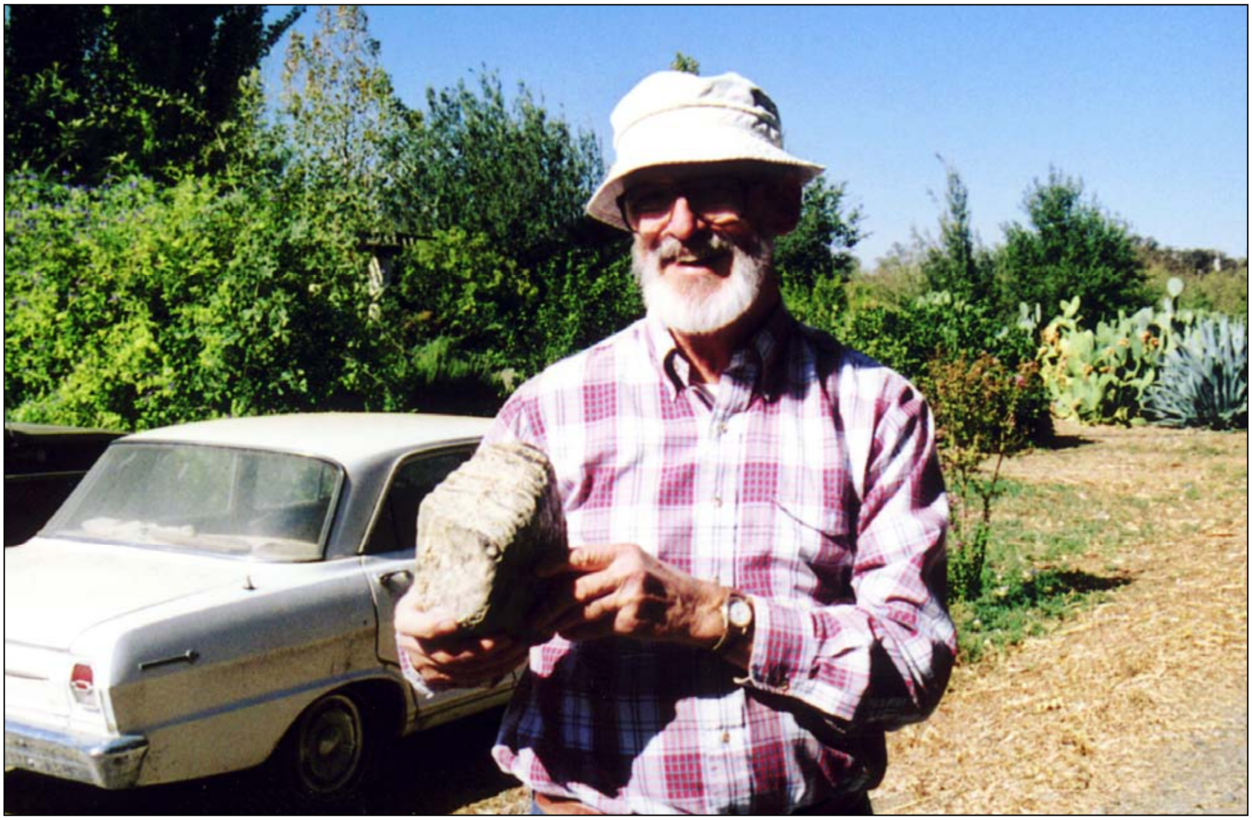
Raptors that nest adjacent to Putah Creek include white-tailed kite, red-shouldered hawk, red-tailed hawk, Swainson's hawk, and great-horned owl. The diverse array of mammals along Putah Creek and the nearby fields and hills include weasels, minks, skunks, opossums, beavers, river otters, rabbits, deer, foxes, coyotes, bobcats, and even an occasional mountain lion and black bear. Historically, Putah Creek watershed supported wooly mammoths (Exhibit 1-5).

Putah Creek flows directly across the Yolo Bypass to the East Toe Drain, then on to the Sacramento River and the Delta, and eventually its waters reach the ocean (Exhibit 1-3). Salmon, steelhead, and lamprey use this aquatic network to complete their life cycles. When the Yolo Bypass is flooded, Putah Creek's water joins directly with the Sacramento River. In these lower reaches of the creek, the Vic Fazio Yolo Wildlife Area (YWA) — one of the largest wetland restoration projects in the United States — includes nearly 16,000 acres of seasonal and year-round wetlands, riparian forest, and grasslands. The YWA is managed for flood control, wildlife habitat protection, and recreational activities such as wildlife viewing and hunting. It is also particularly popular with birders and bat watchers.

1.2.3 HUMAN HISTORY

Humans have lived in the Putah Creek basin for nearly 10,000 years, according to Marlene Greenway, U.S. Bureau of Land Management archaeologist (USFWS 1993a). The history of human involvement with Putah Creek began with Native American inhabitants and continued through the ranchero period of Mexican and Spanish settlement in the early 1800s. Wolfskill Rancho, just west of Winters was the second English-speaking settlement in California after Sutters Fort. European settlement began in the mid-1800s, leading to the agricultural practices and urban and rural development present today.

Putah Creek was first named by early native peoples who lived along its banks. Jack Forbes, professor emeritus of Native American Studies at UC Davis says that the ancient village of Poo-tah-toi appears to have been located on the north bank of what used to be called "the river of the Poo-tah-tos," near the intersection of First and A streets in Davis (Forbes 1981). Although burials have been found near this intersection and beneath several campus buildings, there is no marker. See Chapter 2, "Cultural Resources," for more information on the human history and cultural resources of Putah Creek.



Source: EDAW 2003

Landowner, Dr. Harvey Olander, retired veterinary pathologist, holding the mammoth tooth he found in lower Putah Creek

EXHIBIT 1-5

2

Cultural Resources

2 CULTURAL RESOURCES

Though small in scale relative to the major watersheds of California, Putah Creek has an exceptionally rich cultural history. From the earliest inhabitants likely to have used the watershed thousands of years ago to those farming and residing there today, the creek and tributaries have been an important part of people's existence and enjoyment of life. This chapter discusses the prehistoric through historic periods along Putah Creek, Native American ethnography, and sensitive cultural resources.

Although not necessarily limited to the Putah Creek watershed, the following prehistoric, ethnographic, and historic background sections are intended to orient the reader to the general cultural history of the Putah Creek region. This presentation of the cultural setting serves as a foundation upon which to document and interpret cultural resources that can be found along and in the vicinity of Putah Creek.

2.1 PREHISTORIC CONTEXT

Native Americans have inhabited coastal and interior portions of California for about 10,000 years. The Putah Creek watershed, with its varied topography and rich floral and faunal resources, has been an important area for settlement and subsistence for at least 5,000 years. Although no direct evidence for the earliest inhabitants has been found in the Putah Creek area, the Paleo-Indian Period (10,000 B.C. to 6,000 B.C.) saw the first entry of humans into California. Many of the earliest sites were probably located along the post-glacial coastal shoreline. Rising water levels have now covered those sites and most interior sites that remain are situated along lakeshores, or areas that used to be lakeshores. While Paleo-Indian artifacts have never been found in the Putah Creek or Solano County regions, it is likely that these people at least traveled through the region, hunting the prolific game that would have lived in the area and gathering seasonally available plant materials.

As the climate gradually shifted to seasonal and more arid conditions, Native American land use changed to exploit the growing variety and availability of various plants. By the Lower Archaic Period (6,000 B.C. to 3,000 B.C.), archaeological evidence indicates that while hunting game still played an important role in the day-to-day subsistence of the native peoples, there was an increased use of various plants for food and raw material sources. Most tools were made from local materials, and evidence for plant food processing can be seen in the milling slabs and hand grinding stones frequently found on archaeological sites. During this early period, however, there appears to be very little evidence indicating that the Putah Creek area was heavily occupied. The region may have served more as a gathering and hunting area for Native Americans living nearer to the coastal areas.

As the prevalent weather patterns gradually became more like the present-day climate, technological changes indicative of the Middle Archaic Period (3,000 B.C. to 1,000 B.C.) began to appear on archaeological sites. Although cultural changes can rarely be directly linked solely to climate shifts, one of the most important changes in Native American lifeways was brought about, in part, as an adaptation to these changes in climate. It was during this time that acorn-bearing oak trees began to proliferate throughout California. In response to the widespread availability of what would soon become a staple food, acorn processing technology became commonplace at habitation sites. Sites from the Middle Archaic period do occur in the Putah Creek area and can sometimes be divided into two different sub-periods or "patterns," with each exhibiting distinctive cultural traits. These sub-periods, identified by archaeologists in the middle 1950s, include the Windmiller and Berkeley Patterns.

The Windmiller Pattern is the earliest identified cultural pattern in the Central Valley and reflects a people heavily engaged in trade and contact with neighboring groups. Much of the evidence for these distant relations comes from burials excavated in the middle decades of the 20th century. Human interments often included items such as finely polished "charmstones," quartz crystals, red ochre used as a pigment, ornaments made from abalone shell, rectangular Olivella shell beads, and large spear points. Other distinctive items from this culture included bone fish hooks and fish spears; mortars and pestles for processing acorns; milling slabs used for grinding various seeds; a wide variety of baked clay, stone, and bone implements; ornaments; and other decorative and utilitarian objects, many produced from exotic materials obtained in trade.

The other Middle Archaic cultural manifestation typically found in the Putah Creek area is referred to as the Berkeley Pattern, which has been noted at numerous sites in the Central Valley, Bay, and North Coast Ranges regions. Much of what is known about this period comes from information recorded from excavations of human burials and larger village sites in the 1950s and 1960s. The Berkeley Pattern sites tend to include fewer artifacts in comparison to the more elaborate materials found in Windmiller Pattern burials and villages. However, the material culture still tends to be quite complex and distinctive and is distinguished by a highly developed bone tool industry. Bone needles, bird and mammal bone whistles, saws made from deer scapulae (shoulder blades), bone hairpins, and a wide variety of ground, polished, and decorated bone artifacts are frequently found on archaeological sites from this time. Mortars and pestles are common and suggest that acorns remained a staple food source. Some sites in the Bay Area contain large amounts of oyster, clam, and salt water mussel shells, while Central Valley sites predominantly include freshwater mussels gathered from local waterways.

Basic lifestyles remained largely unchanged among the early Native Americans throughout the Upper Archaic Period (1,000 B.C. to A.D. 500) although archaeological evidence points towards a marked increase in sociopolitical complexity. There was a greater complexity of trade systems with evidence for regular, sustained exchanges between groups. Exotic raw materials are found on sites from this period to a much greater degree than in previous times. Shell beads of many forms appear in greater numbers. They clearly became important trade items, and probably gained in significance as symbols of personal status. As material trade, as evidenced in the archaeological record increased, it is likely that less tangible cultural traits involving spiritual, social, and political activities and beliefs would have been exchanged as well, resulting in the forming of cultures seen in later prehistoric and early historic times.

During the Emergent Period (A.D. 500 to 1,800), a number of important social and technological innovations and changes began to appear in the archaeological and ethnographic record. The atlatl (spear-thrower) gave way to the more accurate bow and arrow. Tribal territorial boundaries became well established and were well documented in early historic accounts. It became increasingly common for distinctions in an individual's social status to have been linked to their material wealth and the exchange of goods between groups became more regularized. The clam shell disk bead, made from shells gathered from coastal regions, became the predominant unit of exchange and increasing quantities of exotic goods were transported over greater distances throughout California. However, as increased contact with European populations began to occur, Native American societies came under great pressures and the lifeways of the tribal groups still living in the Putah Creek area today were forever changed.

2.2 NATIVE AMERICAN ETHNOGRAPHY

The region including Putah Creek in the southern portion of the Sacramento River Valley, from the town of Princeton south to San Pablo Bay and Suisun Bay, was occupied by the Patwin from late prehistoric or early historic times until the Mexican and European settlements. Their traditional territory extended 90 miles in length and 40 miles wide, covering three physiographic regions from east to west: both banks of the Sacramento River and its dense tree, vine, and brush vegetation interspersed with great tule marshes; flat open grassland plains with occasional oak groves; and the lower hills of the eastern Coast Range. Most of the population was concentrated along the river in large villages and in smaller settlements along the Putah Creek and Cache Creek drainages (Johnson 1978). Villages along Putah Creek included Chemocu, Putato (or Poo-tah-toi), and Liwai where the present-day cities of Davis and Winters now stand.

The term Patwin was used by several tribelets in reference to themselves and it does not denote a political unity. The Patwin tribelets of this region spoke dialects of Southern Wintuan, a language belonging to the Penutian language family which contains other groups such as the Miwok, Maidu, Costanoan, and Yokut. Names synonymous with Patwin are Copéh (Gibbs 1853), Southern Wintun (Kroeber 1932), Southerly Wintun (Barrett 1908), and Noymok (Goldschmidt 1951).

Historically, there was a friendly trade exchange between the Patwin and neighboring tribes such as the Nisenan and Konkow to the east, the Nomlaki to the north, the Costanoan and Plains Miwok to the south, and the Yuki, Wappo, Lake Miwok, and Pomos to the west. Important items of trade included bows, obsidian, finished shell beads, whole shells, flicker headbands, red woodpecker scalp belts, cordage for netting, magnesite beads, salmon, river otter pelts, game animals, and salt (Johnson 1978). Not all relationships between the Patwin tribelets and with other tribes were friendly, however. Disputes were acted upon in the manner of feuds and provocations for battle included poaching, the most common offense, and death attributed to poisoning.

The Patwin were hunter-gatherers who relied on the valley riparian habitat along the Sacramento River, and Putah and Cache creeks (Sutter and Dawson 1986). According to Peter Moyle, professor of fish biology at UC Davis, a rich fishery also once existed at the outflow of Putah Creek into the vast Sacramento basin marsh area, which provided the river Patwin groups with salmon, steelhead, and sturgeon during periods of high water and flooding. In addition to the wealth of freshwater and anadromous fish, tule elk, deer, antelope, bear, ducks, geese, quail and other birds, turtles, and other small mammals were all hunted for food. The Patwin used tules, grasses, rushes, and willows from the creek to make their homes and baskets. Green watercress, wild clover, wild grapes, wild oats, tubers, elderberries, and manzanita berries were gathered as food (Cabalazar 1964). The seeds of sunflower, alfilaria, clover, bunchgrass, wild oat, and various other open plains plants were pounded into a meal. Another important staple for the Patwin and many other California cultures was the acorn. Pulverized acorns were leached by pouring cold water over meal spread in a sand basin. After processing it was made into soup or bread. Other plant foods collected at various times of the year included buckeye, pine nuts, juniper berries, manzanita berries, blackberries, wild grapes, Brodiaea bulbs, and tule roots. Salt was scraped off rocks (in the Cortina region) or it was obtained by burning grass found in the plains (Johnson 1978).

Coiled or twined basketry containers were extremely important items for almost all aspects of food collection, preparation, serving, and storage, as well as for baby carriers and burial accompaniment. Plants such as redbud, sedges, and willows were managed by pruning, cutting down, or burning to produce the straight shoots and roots necessary for use in basketry (Anderson et al. 1996). In addition, bone, wood, and stone were the most commonly used materials for tools. Tule balsa boats were constructed of large bundles of round tule reeds bound together with grapevines to form crafts up to 20 feet long and 6 feet wide. Four types of permanent structures were built within a village: the dwelling or family house, a ceremonial dance house, the sweat lodge, and the menstrual hut (McKern 1923). All of these were earth-covered, semi-subterranean structures (Kroeber 1932).

Native Americans of California underwent a severe decline in numbers following the incursions of European populations. The pre-contact population of Wintuan-speaking Wintu, Nomlaki, and Patwin groups was approximately 12,500 (Kroeber 1932). Some of the earliest historic records begin with Spanish mission registers of baptisms, marriages, and deaths of newly converted Native Americans. At least 7,500 Coast Miwok, Southern Pomo, Wappo, and Patwin were relocated to the San Rafael and Solano Missions north of San Francisco Bay (Johnson 1978) in the early 19th century. Many of these converts died in the missions.

The Patwin were also particularly hard hit by two devastating epidemics in the 1830s that occurred in the densely populated Central Valley and bordering foothills: malaria and smallpox. The impact of such diseases on the Patwin can be seen in the breakup of the ethnographic village Poo-tah-toi in the 1830s. The malaria epidemic of 1834 probably dramatically affected the population of the village and this may be reflected in the baptismal records of the nearby Solano mission; the last recorded Poo-tah-toi convert being documented on June 7, 1835 (Forbes 1981). Forbes suggests that at least some of the residents of Poo-tah-toi may have remained in the area in the late 1830s to work as vaqueros for the Mexican ranchos that were established along Putah Creek after the Native Americans had moved away from the area. Those that survived the epidemics of the early 1830s may have fled north to Yolotoi (now Knights Landing) and other areas less affected by the diseases and Euro-American incursions. Forbes (1981) cites evidence for such survivors in accounts from the 1880s and 1890s that mention Native Americans descended from residents of a village called Guiritoi employed as agricultural laborers in the Woodland and Davis areas.

Estimates of a decrease of up to 75% of the native population were directly attributable to these diseases. By 1923–1924, Kroeber could not find any Patwin surviving in the southern half of the region, including the entire stretch of Putah Creek. Most of the remaining Patwin were residing in or around only four communities in the Cortina and Colusa vicinities. As of 1972, the Bureau of Indian Affairs census listed only 11 Patwins for the entire territory. Only the Colusa, Cortina, and Rumsey Rancherias remain; they are described as "Wintun" and are mostly occupied by descendants of other Wintuan and non-Wintuan groups.

2.3 HISTORIC CONTEXT

Recorded history for Putah Creek and Solano County essentially began in the latter half of the 18th century with the first Spanish explorations into the area. Scouting for a suitable site for another northern California mission, Pedro Fages and Father Francisco Crespi, accompanied by a half-dozen soldiers and a Native American guide, entered what is now Solano County in spring 1772 before returning to the coastal Mission San Carlos De Monterey that summer (Beck and Haase 1974). Following Fages' and Crespi's expedition, little in the way of European travels or explorations took place in the vicinity of Putah Creek for another 30 years.

One of the most important Spanish Central Valley explorers, Ensign Gabriel Moraga of the San Francisco Company, traveled into the Putah Creek area in early fall 1808, and his diary from that expedition has been preserved and translated (Cutter 1957). An experienced explorer, this was Moraga's third trip into the interior of California. The expedition lasted for 29 days and did not report favorably on the region as one suitable for missionary or economic pursuits. Probably as a result, no further expeditions into the region were attempted for 13 years. In 1821, Luis Arguello and a large contingent of soldiers, trekked into the Central Valley intending to investigate rumors of American infiltrators and settlers in territories including the Putah Creek and Solano County areas (Beck and Haase 1974, Cutter 1957).

During the early decades of the 19th century, the influence of English speakers was minimal, but in later years large numbers of American settlers began to arrive in the Putah Creek area. By the 1840s, a substantial American settlement had been established at John Wolfskill's *Rancho Rio de los Putos*, granted to him by the Mexican government in May 1842 (City of Davis 1969). A number of other Ranchos, including *Rancho Laguna de Santol Calle*, had been granted within and in the vicinity of the Putah Creek watershed, and as a result, most of the land in what is now Yolo and Solano counties was in the hands of only a few prominent individuals. Wolfskill's Rancho, however, was unique in that it was one of only two English speaking centers in all of Alta California. The other English-speaking center was Sutter's Fort, in what is now Sacramento (Ramos, pers. comm., 2003).

While periodic Spanish explorations, the establishment of the land grant ranchos, and the subsequent farming and grazing activities of the early European settlers constitute the basic historic foundations of the region, it was the Gold Rush of the late 1840s and early 1850s that most influenced the course of historic events for the following 150 years. John Wolfskill himself played a minor role in Marshall's initial gold discovery in Coloma in 1848. En route to San Francisco to have his finds assayed, Marshall stopped by at the *Rancho de los Putos* and showed the nuggets to John and Susan Wolfskill (Ramos, pers. comm., 2003). Although the event was largely insignificant at the time, it foretold great changes that would forever alter the social and economic fabric of the region.

Although little of the Gold Rush actually played out directly in the Putah Creek area or in Solano County, the area did serve as a major transportation route for agricultural products and those heading to the gold fields in the Sierra foothills. Some placer mining did take place in Putah Creek itself and according to Ramos (2003) about 1,800 ounces of gold was removed from the creek bed. In 1873, long after the initial gold rush, John Wolfskill is reported to have found a ¾-ounce nugget in Miller Creek near present-day Lake Solano but, in general, the region has never been known to contain especially rich deposits. While the Gold Rush of the mid-19th century clearly prompted the large scale European settlement of the Central Valley, mass settlement of Putah Creek and its vicinity did not occur until after the California Pacific Railroad line was established in 1868 and the town of Davisville (Davis) was formally established in that year.

Residents in Davisville and from the Putah Creek area saw additional benefits from railroad expansion in 1868 when the California Pacific Railroad built a junction and depot on land purchased from Isaac Davis. This facility, along with branch lines extending into the Napa Valley, greatly improved transportation throughout northern California and further established the Davis area as an important agricultural center. In fact, the construction of the junction and depot was a major consideration in the decision to establish the University Farm in Davisville in 1907 (Larkey 1991).

Well before the arrival of the railroad, the Putah Creek region was recognized as a prime agricultural area thanks in large part to John Wolfskill. Although only one of many farmers and ranchers in the Putah Creek area, he was one of the most prominent and his influence on Central Valley agriculture can be seen to this day. Known as a pioneer in agricultural experimentation, early signs of Wolfskill's success can be found in an 1854 Los Angeles Star article discussing the arrival of a shipment of Mission grapes from his fields that sold for $1.25 per pound (Larkey 1991). Wolfskill's success in horticulture and viticulture established the towns of Davis and Winters as prime areas for fruit and nut cultivation. In 1937, a land donation formed the basis for a horticultural experiment station currently operating in connection with the UC Davis (Larkey 1991).

Putah Creek itself, long before the establishment of ranches, farms, towns, and railroads, was a major attraction for Native Americans and Europeans residing in the area. As agricultural endeavors, fruit orchards in particular increased in the Davis and Winters areas, the need for additional control of the waters flowing in Putah Creek became evident. A severe drought in the early and mid 1930s and severe flooding in 1935 prompted the planning and construction of a dam across the creek by the town of Winters for water storage and flood control. The Putah Creek percolation dam was finally approved and ultimately built by the Depression-era Works Progress Administration. When completed in 1938, the dam served to moderate area flooding (Larkey 1991).

Further alterations of Putah Creek in the following decades included the USACE's Putah Creek project, including construction of the Putah Creek South Fork channel in the 1940s to prevent flooding in the Davis area. Various channel-altering gravel mining operations also occurred that operated well into the 1970s. However, probably the single greatest change to the creek itself occurred with the construction of the Solano Project by the U.S. Bureau of Reclamation. The facilities included the Monticello Dam, the Putah Diversion Dam, and the Putah South Canal. By the early 1960s, the project was complete and the Monticello Dam (named for the small town it ultimately inundated) flooded the Berryessa Valley, destroying a prime agricultural valley, but creating an important water and recreational resource.

2.4 Existing Archaeological Sites

To determine if any recorded sites, features, or artifacts that could be affected by disturbances are present along and near lower Putah Creek, EDAW archaeologists conducted a record search through the Northwest Information Center (NWIC) of the California Historical Resources Information System (CHRIS) in Spring 2002. CHRIS serves as a statewide clearing house for standardized California Department of Parks and Recreation Series 523 archaeological site records and other data on archaeological and historic resources throughout California. The results of this record search document the existence of prehistoric and historic-era resources in areas previously surveyed within the watershed, and provide a basis for assessing the cultural resource sensitivity of specific areas along Putah Creek.

At least 14 archaeological sites or isolates are known within the Putah Creek corridor (Table 2-1). An additional 27 sites or isolated artifacts have been found within ¼ mile of Putah Creek, but these are situated far from any potential impacts resulting from activities related to the watershed and are not listed in Table 2-1.

The sites formally documented in the Putah Creek corridor consist of historic bridges, a historic farmstead, and several prehistoric sites and artifacts. Stevensons Bridge, constructed in 1923, was evaluated by California Department of Transportation (Caltrans) engineers and found to be eligible for listing on the National Register of Historic Places (NRHP) (Caltrans 1990). The Chambers Farmstead was recorded by archaeologists from Sonoma State University during a survey of the area in 1998. Research at the time determined that the core of the main house was built by John D. Chambers in the early 1860s. Upon his death in 1865,

Table 2-1 Sites within the Putah Creek Corridor			
Site No.	**Period**	**Site Type***	**Condition**
P-48-433	Historic	Chambers Farmstead, 1860s–1945	Partially remodeled
P-48-509	Prehistoric	Lithic scatter	Partially collected
P-48-510	Historic	Concrete bridge, 1947	Maintained, currently in use
P-48-517	Prehistoric	Battered basalt cobble, other artifacts may be present	Several plow scars
P-57-187	Prehistoric	Lithic scatter	Disturbed – pipeline and residential construction
CA-Sol-10	Prehistoric	Occupation	Partially graded
CA-Sol-19	Prehistoric	Occupation	In active orchard
CA-Sol-21	Prehistoric	Mound/occupation	In active orchard
CA-Sol-253	Prehistoric	Occupation	In active orchard
CA-Sol-255	Prehistoric	Occupation	In active orchard
CA-Sol-257	Prehistoric	Lithic scatter	Affected by road and cable excavations
CA-Yol-164	Prehistoric	Village of ku'ndihi	Tilling/disking
HRI 3/089	Historic	Yolo-Solano Bridge 1907	Currently in use
HRI 6/194	Historic	Stevensons Bridge 1923	Currently in use

* It is the policy of the California Historical Resources Information System (CHRIS) to maintain confidentiality as to the exact locations of cultural resources documented as a result of archaeological and historical investigations related to the Putah Creek watershed. The intention of this policy is to protect the resources from damage or loss. Archaeological sites such as those exhibiting evidence of concentrated prehistoric occupation and sites that may retain the ability to provide important scientific data must be protected from impacts resulting from ground disturbances. For further information on regulatory compliance and sensitive resource protection measures, please see Appendix H, "Permitting and Regulatory Compliance."

the property passed to his heirs and was later bought and sold a number of times. Additions and outbuildings were added to the property by the various owners up through around 1945. Sonoma State completed an inventory of the buildings, establishing construction dates, materials, and methods. This study concluded by evaluating the individual structures, as well as the complex as a whole, under criteria established for the NRHP. The Sonoma State study determined that none of the individual structures or the larger complex were eligible for listing, mainly due to the lack of integrity, feeling, and undistinguished design and materials.

The prehistoric resources that are known within the project corridor have been identified, in general, as relatively intensive occupation sites. Given the local natural setting that includes the proximity of potable water, habitats supporting a rich variety of flora and fauna, and the gentle nature of the terrain, it is not surprising that local Native Americans made relatively concentrated use of the area. This use is then reflected in the occupation/mound sites as reported in Table 2-1 above. While burials have not been identified in any of these sites, the possibility that they could be encountered in the area must be taken into consideration.

In general, the prehistoric archaeological sites have dark, rich midden soils that are built up during occupation. Most of these sites contain the remnants of stone and/or bone tools and tool manufacture, food remains, food processing areas, and the like. One site, CA-Yol-164, may be the remains of a village that was occupied and documented in the earliest days of European settlement in the area. Two other sites, CA-Sol-253 and CA-Sol-255, had glass trade beads along with historic artifacts, indicating that these sites also were occupied by Native Americans early in the European period. Several of these sites have been adversely affected by farming, roads, or house construction. However, enough remains that they could be identified and several of them may well be larger than is currently known. In addition, it is likely that other sites, as yet undiscovered, lay within the Putah Creek corridor. These may well have been buried by floodwater deposition, farming, or other factors, and will only be uncovered by construction, utility trenching, farming, or similar ground disturbing activities.

The cultural resources situated along and in the vicinity of lower Putah Creek vary widely in terms of cultural and temporal associations and significance as per NRHP and California Register of Historic Resources (CRHR) guidelines and how they will need to be treated during the implementation of habitat enhancement and restoration projects. Isolated artifacts do not require further research or field efforts. However, archaeological sites such as those exhibiting evidence of concentrated prehistoric occupation and sites that may retain the ability to provide important scientific data must be protected from impacts resulting from ground disturbances during project activities such as invasive weed removal.

For further information on regulatory compliance and sensitive resource protection measures, please see Appendix I, "Restoration and Enhancement Project Permit Requirement Summaries."

3

Land Ownership, Land Use, and Resource Management Programs

3 LAND OWNERSHIP, LAND USE, AND RESOURCE MANAGEMENT PROGRAMS

This chapter addresses land ownership, land use, and resource management programs along lower Putah Creek and Pleasants Creek. A mosaic of land uses, both public and private, has developed along Putah Creek and its tributaries, including diverse agricultural, recreational, scientific, and residential interests. Land ownership and land uses within and adjacent to the riparian corridor are discussed, along with resource management issues including conservation, vegetation management, and flood and fire protection.

Information for this chapter was gathered through a review and synthesis of the following geographic information system (GIS) and land use documents and data:

< *City of Davis General Plan* (City of Davis 2001),

< City of Davis land ownership and open space data (City of Davis 2003),

< *City of Winters General Plan* (City of Winters 1992),

< Farmland mapping and monitoring program data (California Department of Conservation [CDC] 2002),

< *Preliminary Draft Yolo County Habitat Conservation Plan* (Yolo County 2001),

< *Putah Creek News* (McCarthy 1999),

< Solano County land use and circulation map (Solano County 1980),

< Solano County parcel data (Solano County 2002),

< *Yolo County General Plan* (Yolo County 1983),

< Yolo County parcel data (Yolo County 2002), and

< Yolo and Solano counties land use data (California Department of Water Resources [DWR] 1989, 1994).

In addition, the following individuals or organizations were contacted for information related to specific subjects on Lower Putah Creek:

< Andrew Fulks, University of California (UC) Davis, Putah Creek Riparian Reserve Manager;
< Karen Honer, City of Winters Director of Public Works;
< Richard Marovich, LPCCC;
< Michele Ng, DWR;
< Mitch Sears, City of Davis Open Space Planner; and
< Michelle Stevens, DWR.

3.1 LAND OWNERSHIP

Most (78%) of the land within and adjacent to the Putah Creek and Pleasants Creek riparian corridors is privately owned (Table 3-1, Exhibit 3-1). Public lands account for 21.2% of the corridor and adjacent parcels, while ownership of 0.8% of the land area is undetermined.

Table 3-1
Land Ownership Distribution Within and Adjacent to Lower Putah Creek and Pleasants Creek Riparian Corridors

Land Ownership	Whole Parcels in and Adjacent to Riparian Corridor	
	Acreage	Percent of Total Acreage
Private	10,824	78.0
Public	2,934	21.2
Unknown	117	0.8
TOTAL	13,875	100

Source: Yolo County 2002, Solano County 2002

3.1.1 PRIVATE LANDS

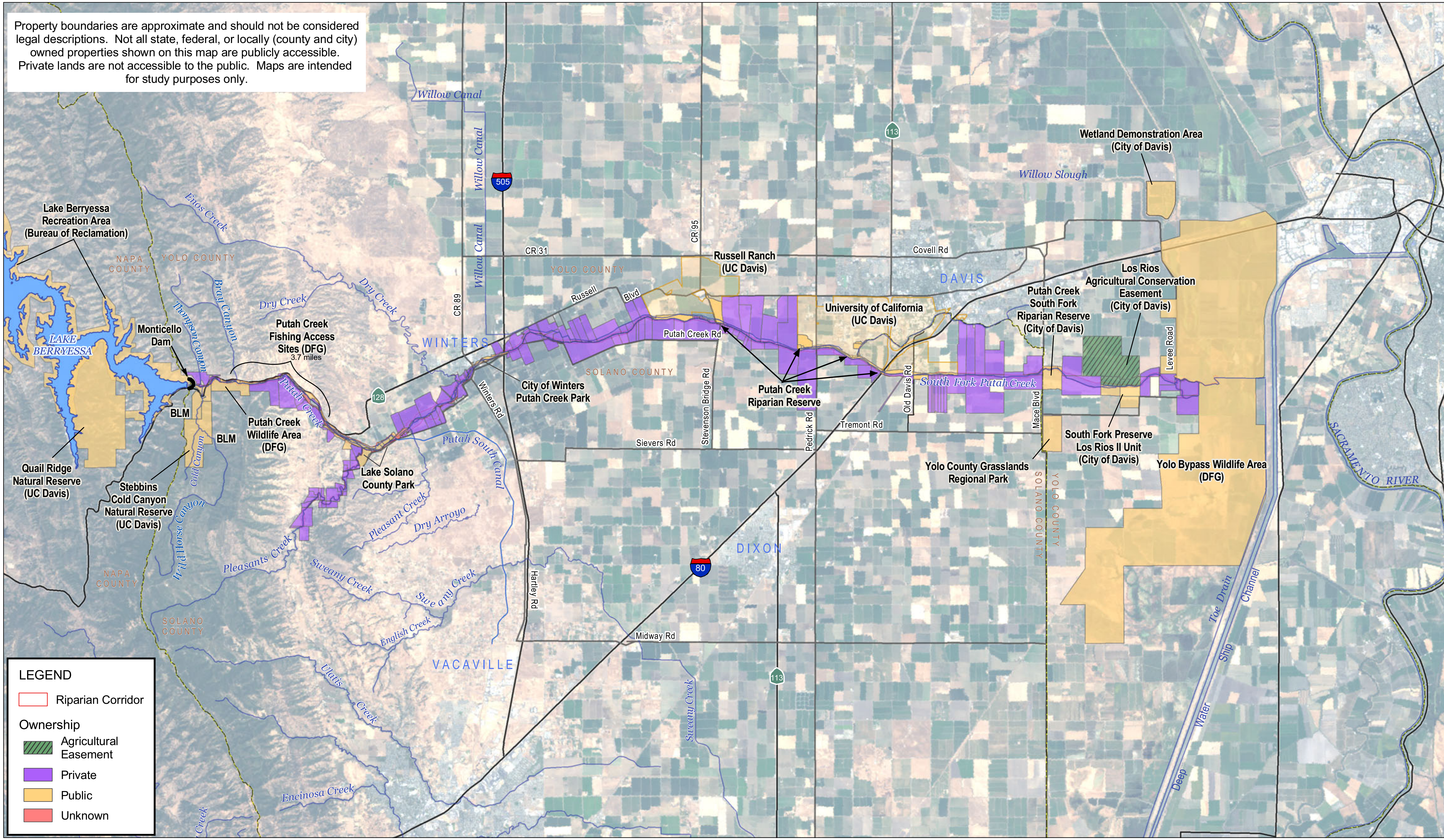
There are over 100 different private landowners that own property in and adjacent to the lower Putah Creek and Pleasants Creek riparian corridors. Private lands within and adjacent to the riparian corridors account for 10,824 acres, or 78% of the creek and creek-side parcels. A number of local and regional farming businesses are among the landowners along lower Putah Creek and Pleasants Creek, including Los Rios Farms, Nishi Farms, Glide Ranch, Mariani Nut Company, and M&L Fruit Company.

3.1.2 PUBLIC LANDS

Public lands account for 2,934 acres, or 21.2% of the parcels within and adjacent to the creek corridors. Public lands include those owned and/or managed by the State, City of Davis, UC Davis campus, UC Davis Russell Ranch, UC Regents, Bureau of Reclamation, City of Winters, State Board of Equalization, Solano Transportation, and federally-owned lands. Public land uses generally include parklands, wildlife areas or reserves, or conservation areas. The uses of public lands are further described in the section, "Public Access," below.

3.2 LAND USES

This section includes a discussion of land uses adjacent to the lower Putah Creek riparian corridor and portions of the Pleasants Creek and Dry Creek riparian corridors. Land uses and other categories discussed include urban, rural residential, riparian and native vegetation, agriculture and range land, county and city general plan land use designations, and public access areas. We defined "riparian corridor" for this chapter only based on land use designations along the creeks as designated by the DWR GIS land use data for Yolo and



Sources: USGS 2003, Yolo County 2002, Solano County 2002, UC Davis 2005

Lower Putah Creek Ownership Map

EXHIBIT 3-1

Lower Putah Creek Watershed Management Action Plan

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Solano counties (DWR 1989 and 1994). Specifically, the "riparian corridor" was defined as the mapped areas along Putah Creek that were labeled by DWR as "native vegetation," "riparian vegetation," or "open water." In the case of Pleasants Creek, the riparian corridor was defined as an approximately 200-foot wide band centered on the creek.

Table 3-2 summarizes the percent of land uses adjacent to the riparian corridor. The specific definitions of all land use designations in Table 3-2 are provided in Table 3-3. Exhibit 3-2 displays the entire riparian corridor area and adjacent lands categorized by land use, based on DWR's Yolo County and Solano County Land Use GIS data (DWR 1989 and 1994).

Table 3-2
Land Use Distribution Adjacent to the Lower Putah Creek, Pleasants Creek, and Dry Creek Riparian Corridors

Land Use	Mainstem Putah Creek (%)						Pleasants Creek Reach 7 (%)	Dry Creek (%)	All Creek Areas (%)
	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6			
Agricultural	95.8	97.7	80.1	85.7	82.4	22.9	25.6	70.0	67.9
Idle Farmland	0	0	1.3	5.7	0.4	4.3	0	10.7	2.1
Riparian Vegetation	0	0	0.3	0.1	0	0	0	0	0.1
Native Vegetation	4.1	0.5	8.5	2.1	0.4	70.8	73.9	7.2	25.1
Water Surfaces	0.1	0	3.3	0	0	1.6	0	0	0.7
Urban Uses	0	0.8	4.9	6.5	15.7	0.5	0.4	12.0	3.8
Vacant	0	1.0	1.5	0	1.1	0	0	0	0.4
No Data	0	0	0.1	0	2.7	0	0	0	0.3
TOTAL	100	100	100	100	100	100	100	100	100

Sources: DWR 1989, 1994

Table 3-3
Department of Water Resources Land Use Definitions

Land Use	Definition
Agricultural	Grain and hay crops, rice, field crops, pasture, truck, nursery and berry crops, deciduous fruits and nuts, citrus and subtropical, vineyards, semiagricultural & incidental to agriculture.
Idle	Land cropped within the past 3 years but not cultivated at the time of survey, or new lands being prepared for crop production.
Native Vegetation	Grass land; oak grass land; light, medium, and heavy brush; brush and timber; and forest.
Riparian Vegetation	Marsh lands, tules and sedges, natural high water table, meadow, trees, shrubs or other larger stream side or watercourse vegetation, seasonal duck marsh, dry or only partially wet during summer, permanent duck marsh, flooded during summer.
Urban	Residential, commercial, and industrial.
Vacant	Unpaved areas (vacant lots, graveled surfaces, play yards, developable open lands within urban areas, etc.), railroad right of way, paved areas (parking lots, oiled surfaces, flood control channels, tennis court areas, auto sales lots, etc.), airport runways.
Water Surface	Lakes, reservoirs, rivers, canals, etc.

Source: DWR 1993

3.2.1 URBAN USES

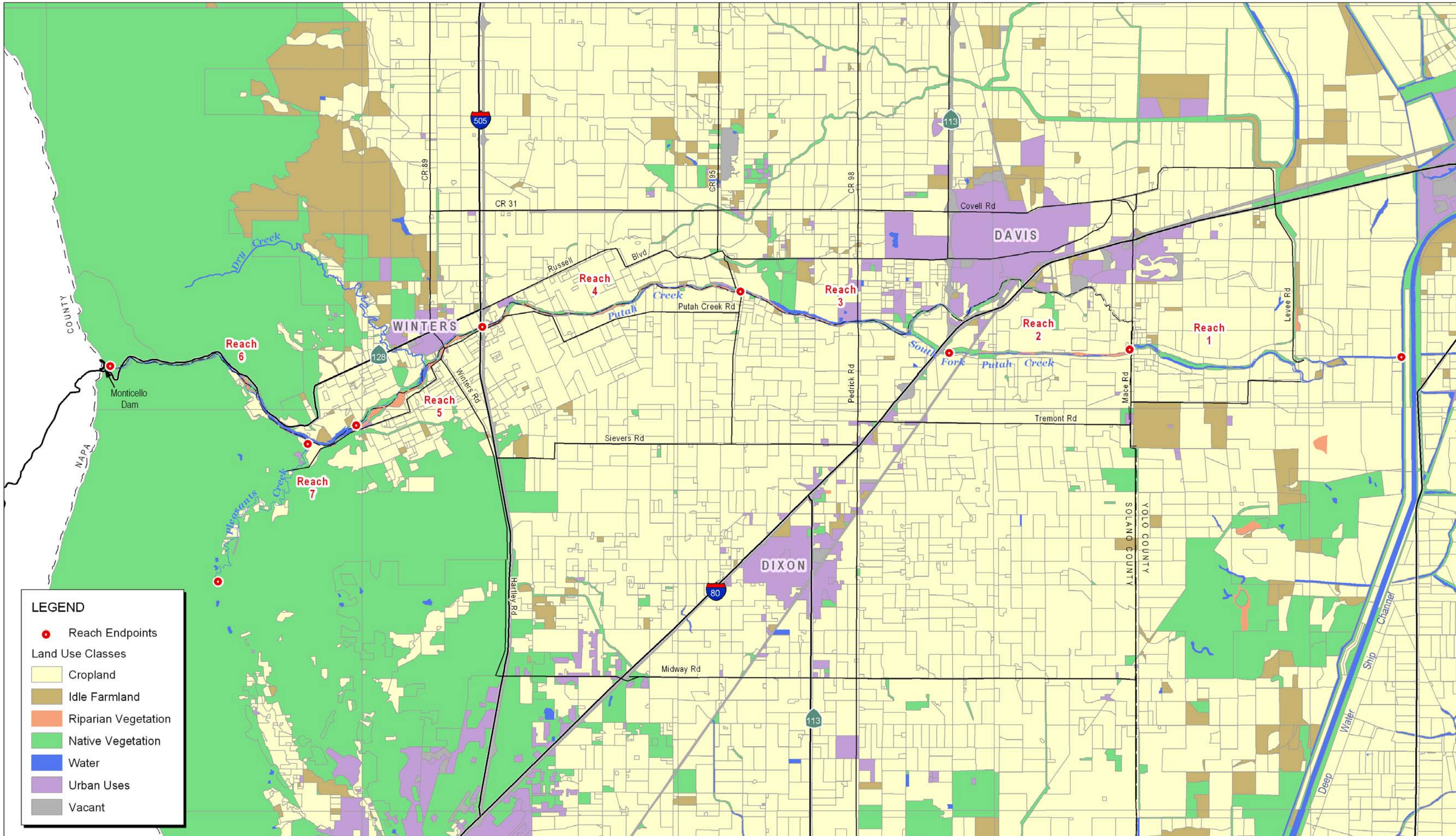
Currently, urban development in the vicinity of the lower Putah Creek riparian corridor is concentrated within the cities of Davis and Winters. Urban development accounts for approximately 4% of the land adjacent to the riparian corridors and consists primarily of low-density residential development, commercial, and light industrial uses (DWR 1989 and 1994). The majority of developed lands occurs on the north side of Putah Creek, in Yolo County. Reaches 1, 2, 6, and 7 (Pleasants Creek) have the least (under 1%) urban development in or adjacent to the riparian corridor. The City of Winters lies along Reach 5 (Exhibit 3-2) and Dry Creek, accounting for the 15.7% and 12% urban uses located adjacent to the riparian corridor in those reaches, respectively. Land owned by the City of Winters within the riparian corridor includes Winters Putah Creek Park between the Winters Car Bridge (Railroad Ave) and Highway 505. Low-density residential urban and commercial development in Winters primarily occurs adjacent to the north side of Putah Creek and residential development occurs along the east side of Dry Creek. Urban development near or adjacent to the riparian corridor in Reaches 2 and 3 of lower Putah Creek includes land owned by the UC Davis including portions of the campus, a raptor rescue center, and a university airport (Marovich, pers. comm., 2003; Yolo County 2002; Solano County 2002).

3.2.2 NATIVE VEGETATION

Per DWR's land use designations, native vegetation accounts for about 25% of land adjacent to the riparian corridor (Table 3-2). Reach 6 (the interdam reach) and Reach 7 (Pleasants Creek) have the highest percentages of native vegetation, with over 70% in each of those reaches. While most of these areas are privately owned, publicly owned lands are found in these areas, as well. The publicly owned lands are generally managed as parks, wildlife areas, reserves, or conservation areas by state, federal, or local agencies or organizations. The uses of public lands are described in the section, "Public Access," below.

3.2.3 AGRICULTURE

About 70% of lands adjacent to the riparian corridors of lower Putah, Pleasants, and Dry creeks are in agricultural production. Agricultural lands located along lower Putah Creek and Pleasants Creek are used for orchards; vineyards; row crop production including barley, wheat, and tomatoes; and for pasture. Reaches 1 and 2 have the highest percentages of farmed lands adjacent to the corridor, representing over 95% in each. Reaches 6 and 7 have the lowest percentages of farmed land adjacent to the riparian corridor, with less than 30% in each. Based on the California Department of Conservation's Farmland Mapping and Monitoring Program (FMMP) in 2000, nearly all of the agricultural lands along the riparian corridor are designated as Prime Farmland, Farmland of Statewide Importance, or Farmland of Local Importance (CDC 2001). Exhibit 3-3 displays the important farmlands along lower Putah, Pleasants, and Dry creeks.



Source: Department of Water Resources 1989, 1994

Lower Putah Creek Regional Land Use Map

EXHIBIT 3-2

Lower Putah Creek Watershed Management Action Plan

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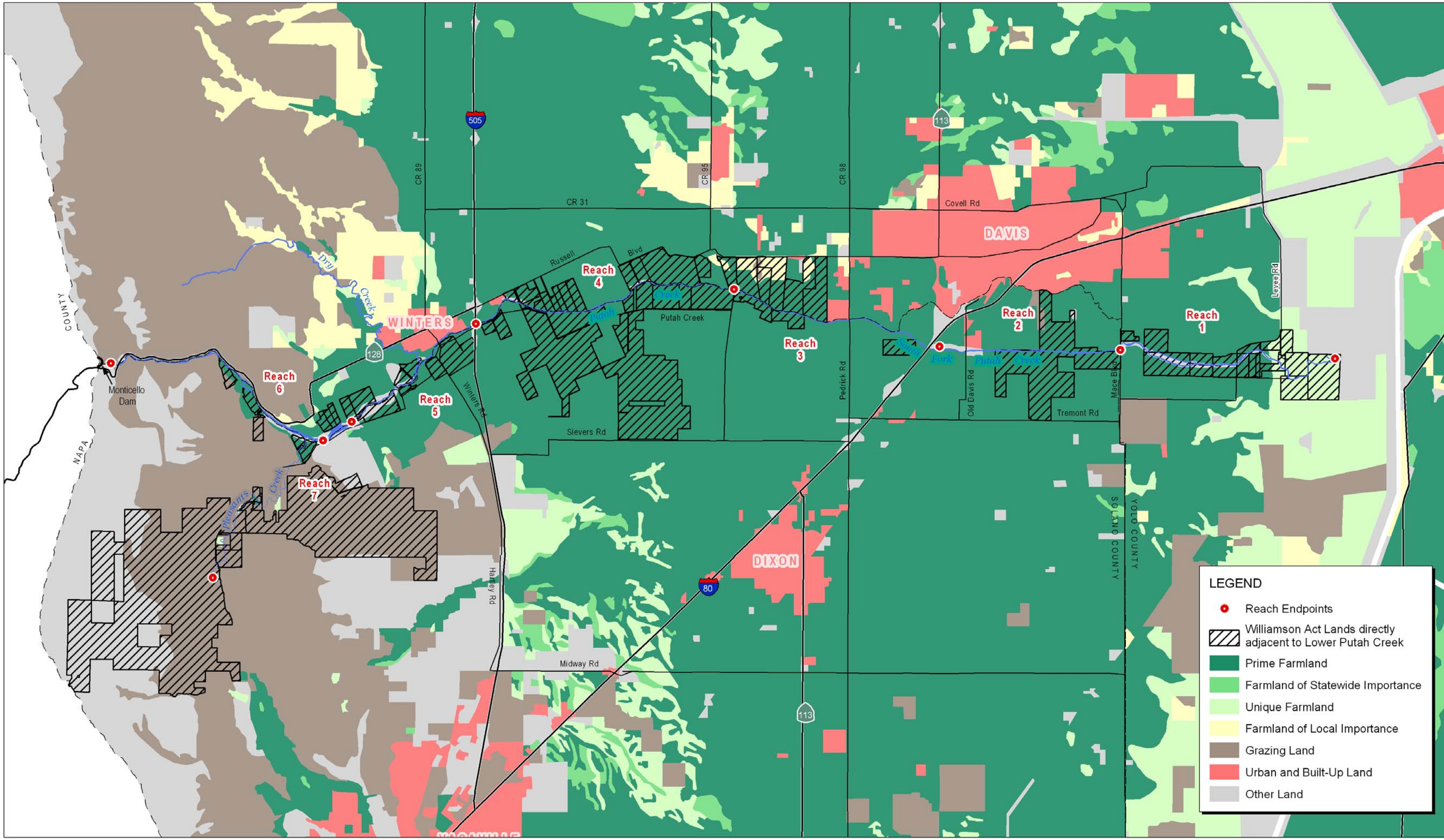

Source: Department of Conservation (DLRP) 2002, DLRP 2000, EDAW 2003.

Williamson Act Lands and Important Farmland Map

Lower Putah Creek Watershed Management Action Plan

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EXHIBIT 3-3

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WILLIAMSON ACT LANDS

Under a Williamson Act contract, the property owner is guaranteed that the property would be taxed according to its potential agricultural income, as opposed to the maximum valued use of the property, such as residential development. The State of California passed Article 13, which allows Williamson Act contracts to be used for recreational, scenic, and natural resource areas in addition to crop production. Contracts are entered for a 10-year period and can be terminated only by a cancellation or non-renewal. The restrictions of the Williamson Act contracts and the non-renewed contracts should all be evaluated when developing the watershed management plan goals and objectives.

A total of 22,735 acres of parcels within and adjacent to Putah and Pleasants creeks is under Williamson Act contracts. Exhibit 3-3 displays the parcels within and/or adjacent to lower Putah Creek and Pleasants Creek that are under Williamson Act contracts.

3.2.4 COUNTY GENERAL PLAN LAND USE DESIGNATIONS

Solano and Yolo counties have General Plan Land Use Designations, set forth in the General Plan and designed to guide future development within the County.

The Solano County General Plan Land Use designations were defined in 1980 and consist almost completely of intensive agriculture along Putah Creek. The town of Winters (Yolo County) is designated *Rural Residential* (2.5 to 10 acres per unit) and there are two areas of Open Space, which are designated as *Parks and Recreation* (Winters Putah Creek Park) and *Watershed* (near the Napa County line) (Solano County 1980).

The Yolo County General Plan Land Use Designations were defined in 1956 and are currently being revised through a new General Plan process. Yolo County's current land use designations are almost entirely *Intensive Agriculture* along lower Putah Creek, with the exception of the urban areas of Winters and Davis (Yolo County 1956).

The City of Davis General Plan land use plan designates the lower Putah Creek riparian corridor as *Creek, Slough, Channel (including levees)* (City of Davis 2001). The City of Winters General Plan designates areas along the lower Putah Creek as *Open Space, Agriculture, and Residential (rural, low, and medium density)* (City of Winters 1992).

3.2.5 PUBLIC ACCESS

Opportunities exist for the public to access publicly-owned land in and near lower Putah Creek and Pleasants Creek, as described in the sections below. However, some public lands are held for conservation or research purposes and have limited public use. Before there were bridges over Putah Creek in Winters, a ferry once operated for hire to transport persons and goods across the creek. This historic practice established a public interest in the navigability of Putah Creek for commerce under the state constitution and resulted in a public easement for navigation up to the ordinary high water mark, which is about 3 feet above the low-flow channel (Marovich pers. comm., 2003). While Putah Creek is a navigable waterway by law, it is unsuitable for recreational boating except at Lake Solano, Winters Putah Creek Park and the UC Davis picnic grounds that have been developed, in part, for this purpose. Privately owned lands are not available for public access or use without the consent of landowners; such use is considered to be trespassing.

CALIFORNIA STATE MANAGED AREAS

Yolo Bypass Wildlife Area/Putah Creek Sinks

DFG's Yolo Bypass Wildlife Area and Putah Creek Sinks are located in and to the east beyond Reach 1 at the Yolo Bypass. The Wildlife Area is approximately 15,830 acres and includes wildlife habitat, outdoor education opportunities, hunting areas, ongoing agricultural activities, and extensive areas for bird watching. The Bypass retains its historic flood control purpose, but has been restored to create permanent and seasonal wetlands for wintering waterfowl and other species (DFG 2003a). A management plan for the area is under development that would include a Pacific Flyway Visitor Center, expansion of the auto tour route, increased hunting areas, and wooded trails along Putah Creek. The current agricultural practices are planned to continue and are used as tools to structure a balanced wildlife habitat program (DFG 2001).

Putah Creek Wildlife Area

DFG manages a Wildlife Area south of Putah Creek and just east of Monticello Dam in Reach 6. The wildlife area consists of approximately 670 acres of oak woodland and chaparral and is adjacent to Stebbins Cold Canyon Reserve. The Wildlife Area includes the confluence of Cold Creek and Putah Creek. Deer and quail are attractions for nature lovers (DFG 2003b).

Fishing Access Sites

Fishing access sites owned by DFG and managed by the Yolo County Parks Department are located in the Interdam Reach on the north side of the creek. The road parallels Lake Solano and Putah Creek west of Winters on Highway 128. Five access points are located along the creek between Lake Solano and Monticello Dam. Some of the sites have picnic tables and all have parking lots. This stretch of the creek is considered to have some of the best riparian habitat in Yolo County, likely because of the year-round flow coming from Monticello Dam (Kemper 1996). A recent (October 2003) infestation of the New Zealand mud snail, the first reported from California west of the Owens Valley, was discovered by Fishing Access Site #3 and will likely result in development of creek access protocols for fishermen and other creek users. More information on the infestation is provided in Chapter 5, "Fisheries."

SOLANO COUNTY LAND

Lake Solano County Park

Lake Solano County Park is located off of Highway 128, approximately 7 miles west of Interstate 505 (I-505) on the south side of Putah Creek. Approximately 90 recreational vehicle and/or tent sites are available. The campsites have picnic tables and fire pits with grills. Wading pools, a playground, volleyball nets, paddleboat rentals, and hiking trails are all available at the park. Camping, swimming, fishing, boating, hiking, and picnicking are permitted uses. The park also has restroom and shower facilities (Bay Area Open Space Council [BAOSC] 2003).

Stevensons Bridge

An existing primary access point to Putah Creek is the historic Stevensons Bridge, located in Reach 4 between Davis and Winters. Stevensons Bridge is the only public access to Putah Creek for five miles in both directions. Illegal dumping occurs at the site, and the structure is covered with graffiti. The bridge is narrow and difficult to cross with wide loads. Stevensons Bridge is scheduled for replacement to bring it up to current engineering design standards.

University of California Managed Areas

UC Davis Putah Creek Riparian Reserve

The UC Davis Putah Creek Riparian Reserve is located along Putah Creek on the southern end of the Russell Ranch Planning Area of the UC Davis campus. Russell Ranch is largely leased for agricultural production and a portion of that property has been designated for long-term campus agricultural research. The Putah Creek Riparian Reserve is maintained as a natural reserve. It extends downstream approximately four miles along Putah Creek from the Road 98 bridge (Kemper 1996).

A management plan is currently under development for the reserve. The management plan will outline specific management goals for invasive species control, public access, restoration of riparian oak woodland and grassland habitat, and endangered species management. Current recreational uses, including walking and biking on the levee road, camping and camp fires, fishing, boating, hiking, and picnicking, will continue with some improvements to the campground and trails. Paintball, hunting, and off-highway vehicle (OHV) use will not be permitted (Fulks, pers. comm., 2003).

Stebbins Cold Canyon Reserve

Stebbins Cold Canyon Reserve is a unit of the University of California Natural Reserve System. The primary uses for the preserve are research and instruction (Kemper 1996). The Reserve is located in Solano County approximately 20 miles west of the UC Davis campus and 0.5-mile east of the Monticello Dam. Access to the reserve is via a foot trail that begins at a pipe gate located at a turnout from State Highway 128 east of the dam. The Reserve consists of 576 acres in the Cold Canyon drainage. Unlike other UC reserves, Stebbins Cold Canyon Reserve is fully open to the public for nature observation and related uses. There are no day-use or overnight facilities; it is a day-use area used mostly for hiking. Elementary and secondary schools use Stebbins Cold Canyon Reserve for field trips and university courses include visits to the land to practice field biology and ecology surveying techniques.

CITY OF DAVIS MANAGED AREAS

Davis South Fork Preserve

The Davis South Fork Preserve is located southeast of Davis on the south fork of Putah Creek (Exhibit 3-1) and consists of two separate areas. A 25-acre area on the north side of Putah Creek is open to public access. This area is restored native upland and riparian vegetation, with a paved parking lot, use restriction signs, and a ¼-mile walking trail. Future improvements would extend the trail and add interpretive signs. The second area is 85 acres on the south side of the Creek. This area is not currently open to public access and is in the final stages of restoration. Future improvements include a parking area, trailhead improvements, an interpretive kiosk, a small outdoor classroom, a looped trail system, and a self-guided tour.

Other City of Davis Managed Areas

The City of Davis also owns and/or holds easements on several parcels to the east of the South Fork Preserve that were acquired by the City in 1998. The area is primarily used for agricultural conservation and portions will be restored to improve wildlife habitat. Portions of the property are intended to stay in agricultural production with lease revenues reinvested into open space management. The City is currently assessing the property's resources and determining restoration needs and opportunities for their property.

CITY OF WINTERS LAND

Winters Putah Creek Park

Winters Putah Creek Park occupies most of an approximately one-mile long riparian corridor area on both banks between the Winters car bridge (Richard Avenue) and the I-505 overcrossing. The parcel adjacent to I-505 on the north bank is private. The park offers picnic tables, barbeques, fishing access, parking, and sanitary facilities. A conceptual plan prepared for the park includes a habitat map and plan for a recreational trail within the park boundaries. The City of Winters has been gradually implementing the plan. (Marovich, pers. comm., 2003)

3.3 RESOURCE MANAGEMENT PROGRAMS

This section includes a discussion of resource management programs or policies in place along lower Putah Creek for the purposes of flood protection and fire and fuel management.

3.3.1 FLOOD PROTECTION

Riparian corridors have the potential to flood and vegetation can increase the risk of flood damage to bridges, roadways, and adjacent areas by blocking creek flows. Landowners and managers use vegetation management techniques for flood protection. The following vegetation management procedures are being used on lower Putah Creek specifically for flood protection.

DEPARTMENT OF WATER RESOURCES

For flood control on the Sacramento River, numerous acts of Congress, the State Water Code, and the Reclamation Board all require that channels and overflow channels of the Sacramento River be maintained to prevent hazardous flood conditions. DWR has an operations and management plan for Putah Creek that includes a vegetation removal program. Woody debris can accumulate and reduce the hydraulic conveyance capacity of the creek, creating greater potential for flood hazards and damage.

DWR's Sacramento Maintenance Yard is responsible for maintaining the Putah Creek flood control project from the Yolo Bypass to approximately nine miles upstream. Within this portion of lower Putah Creek, there are four bridge crossings: Mace Boulevard, Old Davis Road, Southern Pacific Railroad, and I-80. Work entailing selective hand cutting and vegetation removal has been limited to 100 feet upstream and downstream of the bridges (Stevens, pers. comm., 2003).

There are two scales of flood maintenance planning: short term/immediate maintenance and long-term maintenance. The short-term or immediate maintenance involves selective clearing of vegetation around the Mace Boulevard bridge and under the other four bridges. Routine channel maintenance is completed every 2–3 years and was last completed in fall 2003. All required permits are obtained prior to initiation of maintenance activities (Stevens, pers. comm., 2003). Routine vegetation maintenance includes cutting, trimming, or removing the lower branches of large trees to facilitate site inspections and maintain channel capacity. DWR also cuts, mows, burns, or sprays herbicides on weeds, grasses, shrubs, and woody growth on levees to facilitate levee safety inspections. Trees less than 4 inches diameter at breast height (dbh) are selectively cut to maintain channel capacity. Larger individual trees are left to maintain canopy, and pruned up to 6 feet from the ground. Fallen trees, tree limbs, and dead or live trees that are in clear danger of falling in or across a channel, which will significantly reduce channel capacity, result in accelerated erosion, or otherwise result in an emergency are removed. Invasive species are targeted for removal, and on Putah Creek include Himalayan blackberry (*Rubus discolor*), arundo (*Arundo donax*), tamarisk (*Tamarix* sp.) and eucalyptus (*Eucalyptus* sp.). When channel capacity can be maintained, a fringe of vegetative growth 15 feet wide at the edge of the low channel is left undisturbed to retain some SRA cover (i.e., overhanging trees, shrubs and herbaceous plants) to benefit fish and aquatic organisms. Refer to Chapter 6, "Vegetation and Wildlife," for a detailed discussion of SRA cover habitat attributes.

In response to past concerns about potential effects of the vegetation management practices on riparian habitat, DWR has recently re-evaluated the plan to manage vegetation in Putah Creek 100 feet above and below the bridges at I-80, the railroad bridge, old Davis Road, and Mace Boulevard. The proposed work plan was subject to in-field discussions with resource ecologists, including representatives from the LPCCC, the UC Davis Putah Creek Reserve

Manager, DWR, and other stakeholders to refine and further define the details of the plan. The Mace Boulevard bridge crossing is of particular concern because of the low bridge height and the limited space between the underside of the bridge and the ground. Long-term and collaborative maintenance will require greater planning and discussion among interested stakeholders.

3.3.2 FIRE AND FUEL MANAGEMENT

Since 2000, at least five wildfires have occurred within the lower Putah Creek watershed (Marovich, pers. comm., 2003). Wildfires are expected to occur occasionally in the area, and efforts to contain these fires are focused on protection of lives, structures, and crops. Prescribed fire and fuel load management techniques are used for both fire protection and restoration. Prescribed fires are sometimes used, where feasible, to mimic natural succession on landscapes to restore habitats or natural communities that have been degraded.

Fire protection is also a concern for residences and other valuable structures and crops along the riparian corridor. Invasive nonnative species, such as eucalyptus and arundo, increase the potential likelihood and severity of wildfires because of their abundance and flammable nature. In addition, after a disturbance such as fire, these invasive species grow back quickly in large numbers, often preventing the re-establishment of native species within the community. A wildfire on lower Putah Creek in September 2003 (Exhibit 3-4) provided evidence of the increased risk from the presence of invasive species. Arundo on the north bank burned with such intensity that it sent embers across 100 feet of open water to ignite the south bank. Arundo also re-establishes much faster than native vegetation following a fire and has been observed to re-sprout within days even as logs still smoldered (Marovich, pers. comm., 2003). Chapter 6, "Vegetation and Wildlife," further discusses invasive weeds along Putah Creek.

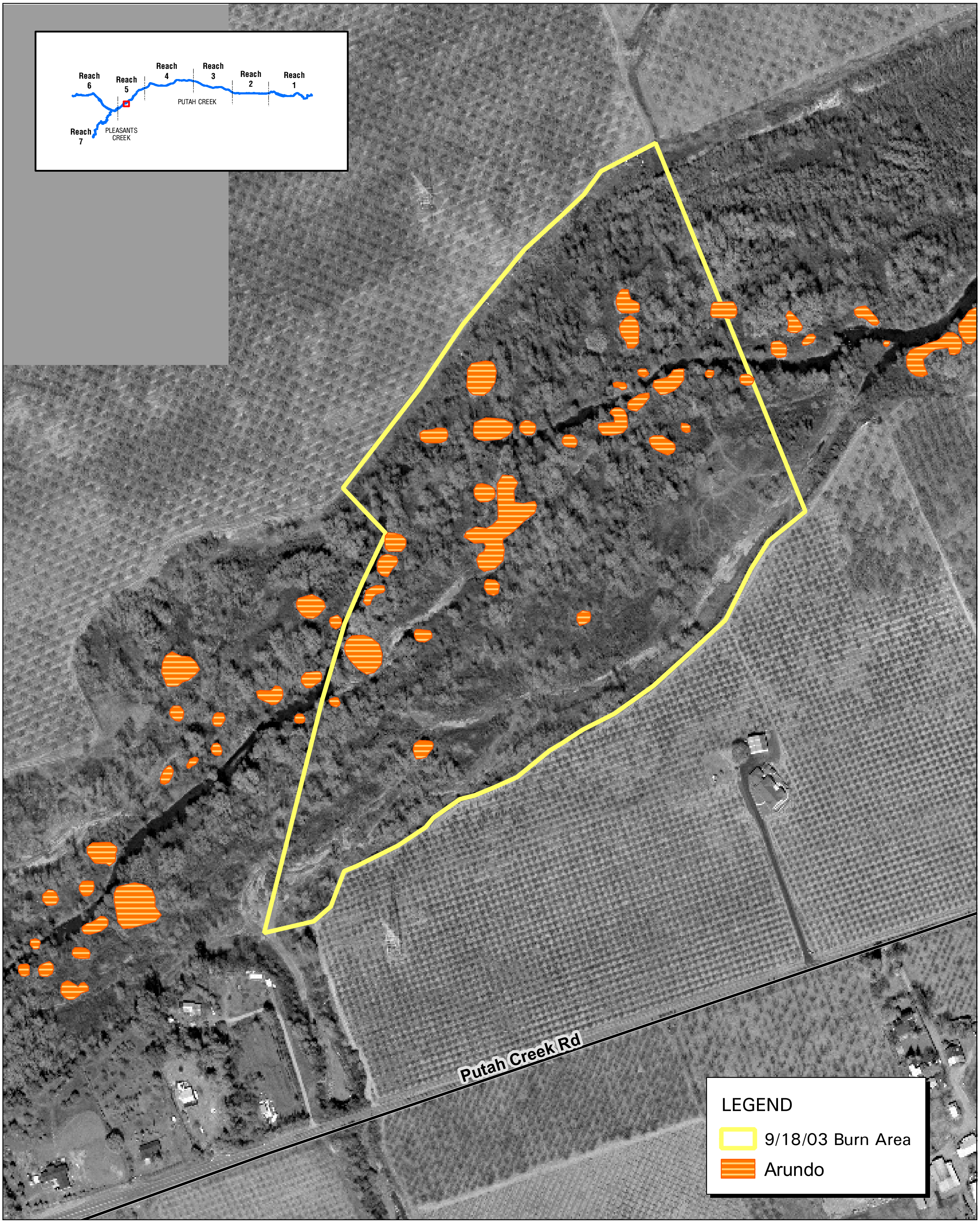
The following is a summary of the fire and fuel load vegetation management programs and techniques used by various landowners and managers within the Putah Creek riparian corridor.

UC DAVIS SOUTH FORK PRESERVE

The management plan currently under development for the UC Davis South Fork Preserve has identified prescribed burns as both a potential weed control method and restoration tool. The Preserve manager would work with the UC Davis Fire Department to schedule and staff future burns at restoration areas.

CITY OF WINTERS

The City of Winters Putah Creek Restoration Project was developed to reduce the fuel load and fire hazards, to remove blackberry and arundo, and to provide a safe and usable space for the residents of the community. The area targeted for restoration stretches from approximately 50 feet west of the County Road 89 bridge to approximately two miles east to the I-505 bridge (Honer, pers. comm., 2003).



Source: Image America 2001, EDAW 2001

September 18, 2003 Wildfire Burned Area

EXHIBIT 3-4

Lower Putah Creek Watershed Management Action Plan

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The initial restoration began with manual removal of vegetation conducted by California Department of Corrections prisoners. Although blackberry and arundo were previously removed manually, the plan schedules semi-annual herbicide sprayings to minimize, and eventually eliminate, manual removal. The City sprayed herbicides twice in 2003 to control blackberry and once for arundo (Honer, pers. comm., 2003).

City of Davis

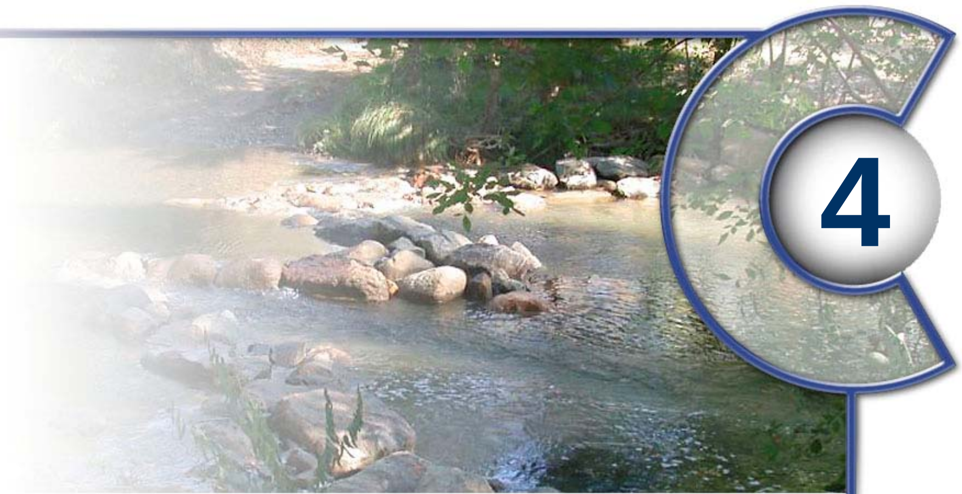
The City of Davis manages its restored open space lands to maximize the success of native grass establishment. Current management practices include mowing and prescribed burns. Grazing is also being tested to determine whether it is a viable management tool. Native grass management practices tend to reduce fire danger and intensity. Practices are applied throughout fire season (May–September).

3.4 Summary

Management of the lower Putah Creek watershed has presented opportunities and challenges. Land use patterns in the Central Valley over the past 200 years began with the establishment of homesteads, and farming and grazing enterprises that resulted in the conversion of native habitats to developed rural uses. More recent urban development pressure has constrained historic rural uses and resulted in additional losses of native habitats, including riparian habitat along creeks and rivers. This regional trend is reflected in changes in land uses along lower Putah Creek, Pleasants Creek, and Dry Creek.

Less than 2,000 acres of riparian corridor presently exists along lower Putah Creek and Pleasants Creek. This represents less than 0.2% of the total acreage (1,182,336 acres) of Solano and Yolo counties. The majority of lands along the riparian corridor in the lower Putah Creek watershed are currently designated as important farmland, while urban land accounts for a relatively small percentage and is located primarily in the City of Winters.

The complex land use pattern that has developed within the lower Putah Creek watershed would benefit from a comprehensive management plan that recognizes and incorporates public and private interests in watershed resources. A successful plan would represent a balanced view in conserving, protecting, and enhancing the natural areas within the watershed and optimizing the compatibility of adjacent land uses. Native riparian communities in the Central Valley provide important habitat for wildlife, including many species that have become rare as natural habitat areas were converted to other uses. (Chapter 6, "Vegetation and Wildlife," includes detailed discussions of the importance of riparian habitat and wildlife within the watershed.) As riparian communities continue to dwindle in size regionally, they require more protection and enhancement efforts. Agricultural and urban uses require management of resources to reduce risks related to flooding, wildfires, erosion, invasive weeds, and other issues. A functioning watershed management plan requires understanding of the resource management requirements of developed uses, including agricultural and urban uses, and continued efforts to protect and enhance rare natural habitat.



4

Geomorphology, Hydrology, and Water Quality

4 GEOMORPHOLOGY, HYDROLOGY, AND WATER QUALITY

This chapter describes the geomorphology, hydrology, and water quality conditions in the lower Putah Creek riparian corridor. Fluvial geomorphology is defined as the study of stream channel formation (channel shape, gradient, and sediment erosion and transport) as influenced primarily by hydrologic and soil-sediment properties, human influences, and the interaction of flow and riparian vegetation patterns. This chapter briefly describes what is known about the historical setting and principal natural and human-caused changes in the watershed that have occurred over time; and the key physical, chemical, and biological conditions of lower Putah Creek that define the stream's existing characteristics as they relate to existing beneficial uses and potential restoration opportunities. Baseline assessment surveys for two highly visible impact factors—erosion and trash—were conducted in summer 2002 and results of those surveys are discussed. Efforts to address these issues, such as cleanup of trash, are also discussed.

4.1 METHODS AND DATA SOURCES

Resources used for this assessment include written reports, anecdotal information, and field surveys. A number of written reports are available that collectively provide descriptive information on the complex hydrologic, geomorphic, and water quality conditions of Putah Creek, including:

- Cache Creek and Putah Creek Watersheds Toxicity Monitoring Results: 1998–1999 Final Report (Regional Water Quality Control Board [RWQCB] 2000);
- Final Hydraulic, Hydrologic, Fisheries, and Vegetation Analysis for the U.S. Fish and Wildlife Service Putah Creek Resource Management Plan (Jones & Stokes Associates 1992);
- Office Report on Measures to Control Erosion on Dry Creek, Reconnaissance Report, Winters and Vicinity, California (USACE 1995);
- Flora and Fauna of the Stebbins Cold Canyon Reserve (UC Davis 1985);
- Gravel and Temperature Surveys of Lower Putah Creek (Gus Yates, Hydrologist 2003);
- Lower Putah Creek 1997–1998 Mercury Biological Distribution Study (Slotton et al. 1999);
- Management Plan for Putah Creek Riparian Reserve (Sutter 1986);
- Measured and Simulated Temperatures in Putah Creek (Jones & Stokes Associates 1996);
- Reconnaissance Planning Report Fish and Wildlife Resource Management Options for Lower Putah Creek (USFWS 1993);

- Solano Project Water Service Contract Renewal Draft Initial Study/Environmental Assessment (CH2M Hill 1999);

- Lake Solano Sediment Removal and Management Study: Phase 1 Final Report. (Northwest Hydraulic Consultants 1998); and

- UC Davis, 2003 Long Range Development Plan Draft EIR (UC Davis 2003).

4.1.1 HYDROLOGY, GEOMORPHOLOGY, EROSION, AND SEDIMENTATION

The reports by USACE (1995), Jones & Stokes Associates (1992), and CH2M Hill (1999) contain summaries of historical and existing hydrologic conditions in Putah Creek, including surface streamflow, stage elevations, groundwater conditions, and existing management of reservoir storage water supplies. No single comprehensive geomorphic evaluation of Putah Creek currently exists. However, a few investigations and documents have been completed (Yates 2003, Jones & Stokes Associates 1992, USFWS 1993b, USACE 1995) that provide analyses of specific elements useful to the historical and current understanding of geomorphic conditions in Putah Creek. In addition, some investigators have examined certain elements or specific regions of the stream channel to understand and address specific ecological issues such as invasive weed growth, and restoration opportunities such as for fisheries analyses (Streamwise 2002, Streamwise 2003). Northwest Hydraulics Consultants (1998) conducted analyses to examine the causes and extent of sediment buildup in Lake Solano.

For this study, erosion sites were assessed from field observations of the channel by canoe and from the banks, and interpretation of aerial photographs. Field surveys were conducted in summer 2002 to identify locations of substantial stream bank erosion. Rich Marovich, Putah Creek Streamkeeper, also contributed personal knowledge of the various hydrology and geomorphology issues of the creek from his daily interactions in the watershed and with various agencies and local landowners.

4.1.2 WATER QUALITY DATA SOURCES

Routine collection of water quality samples in lower Putah Creek is limited to two programs at the U.S. Bureau of Reclamation (Reclamation) and UC Davis. Since 1975, Reclamation has conducted routine monitoring on a monthly basis for selected chemical constituents in selected streams upstream of Lake Berryessa, in the interdam reach of Putah Creek, and in the Putah South Canal terminal reservoir (CH2M Hill 1999). Solano County Water Agency (SCWA) operates the Putah Diversion Dam (PDD) and has also monitored Putah South Canal twice per year since 1981 for physical characteristics, minerals, and trace inorganic and organic compounds of toxicological significance. They also have collected weekly data for total and fecal coliform since 1989. Located downstream of the PDD, UC Davis collects samples from Putah Creek upstream and downstream of the university wastewater treatment plant (WTP) outfall for a full suite of inorganic and organic chemical analyses (UC Davis 2003). SCWA and UC Davis have deployed automated temperature loggers infrequently during several years for several months at a time and in several locations along lower Putah Creek (Jones & Stokes Associates 1996).

GROSS POLLUTANTS (TRASH)

Locations of dump sites were mapped onto aerial photographs during summer 2002 surveys and later digitized into Geographic Information System (GIS) maps. A database for mapped locations was created to document information associated with each site to assist in planning potential cleanup work. Information was also gathered from the Putah Creek Streamkeeper and the Putah Creek Council Volunteer Coordinator regarding the locations and quantities of trash collected during cleanup events.

4.2 PREHISTORIC CONDITIONS

This overview of dynamic geologic processes provides the context for understanding and describing existing stream location, channel form, and hydrological conditions in the Putah Creek watershed. It also provides context to understand past and present stream form and hydrological changes, both natural and human-induced, and provides insight into current issues such as erosion.

Movement over millions of years between the lithospheric plates (composed of crust and underlying mantle) on the Earth's surface have created extreme and varied geologic landscapes. The epochs-long interactions between the Pacific Plate and the North American Plate along the western flank of the North American continent led to uplift of the formerly low coastal lands to gradually create the Coast Ranges, a distinct landform that has been called "a nightmare of rocks" because of the jumbled, disordered mixture of rock types (Alt and Hyndman 1975).

Four major rock units characterize the Coast Ranges, including areas in which the Putah Creek watershed has formed. These include the Franciscan formation, "a jumbled mess of muddy sandstones and cherts interlayered with basalt lava flows [and] so thoroughly folded and sheared that some large outcrops look as though they have been stirred with a stick" (Alt and Hyndman 1975). The Great Valley sequence, a formation of the same age, lies atop the Franciscan formation and is composed of similar rock types but did not undergo the folding and twisting that the Fransican formation was subjected to. In between these layers is a relatively thin (1 mile or more thick) layer of black igneous rock and unusual green serpentinite that is believed to have originated in the Earth's mantle from beneath the continental crust. The final major unit is an often fossil-filled sandstone and mudstone layer that is younger than the other formations and lays over the top of them. The upper Putah Creek watershed area is formed within the steep mountain slopes formed by sandstone and shale, local areas of serpentine, and areas of volcanic rocks. As Putah Creek emerges from the mountains it enters the Central Valley, which was formed by the filling of an inland sea with thousands of feet of marine deposits, and with alluvial deposits from the Coast Ranges and the Sierra Nevada.

During relatively recent times occurring between 26,000 and 20,000 years ago, the Tioga glaciation resulted in the formation of large freshwater lakes throughout what is now northern and southern California. As the Central Valley slowly became more arid, these lakes receded and led to the formation of riparian habitat in the valley that was many times more extensive than that present at the beginning of Mexican and European settlement in the region, described in Chapter 6, "Vegetation and Wildlife."

Over the geologic timescale, Putah Creek has transported large quantities of erosive sandstone and other parent material from the mountains to the valley floor. High-flow events would enter the valley and as the streamflow slowed, large-sized alluvium deposited near the base of the mountains, forming the Putah Creek fan, and finer sediments were transported farther east onto the valley floor, providing the basis for the formation of productive agricultural soils that exist today. Samples collected from Davis to Winters reveal common traits of soils along Putah Creek, including very high levels of magnesium, low levels of calcium, little or no free lime, and no mineral sources of sulfur (Rich Marovich, pers. comm., 2005).

4.3 HYDROLOGY

The Putah Creek watershed begins in the Coast Ranges at its highest point, Cobb Mountain in Lake County at elevation 4,700 feet, and flows down to the Central Valley where it empties into the Yolo Bypass at near sea level (see Exhibits 1-1 and 1-2). Within the Yolo Basin, Putah Creek currently connects through irrigation channels to the East Toe Drain that flows along the east side of the Yolo Bypass. The Yolo Basin is a natural low-lying area and historically an extensive wetland complex that received floodwaters from the Sacramento River and coastal tributaries, including Putah Creek. Putah Creek historically flowed into the Putah Sinks, a wetland complex within the Yolo Basin. The Yolo Bypass refers to the constructed levees and associated flood control channel within the Yolo Basin that was largely developed by the early 1920s to convey flood waters from the Sacramento River and Yolo Basin tributaries to the Sacramento-San Joaquin River Delta (Delta). The East Toe Drain connects to a series of slough channels in the Delta and then out to sea.

The Putah Creek watershed is defined by two subbasins, the upper and lower Putah Creek watersheds. The upper Putah Creek subbasin is defined by the portion of the watershed located upstream of Monticello Dam, which forms Lake Berryessa. The upper watershed occupies about 600 square miles within the Coast Ranges. Precipitation in the upper subbasin is influenced by marine conditions and annual rainfall totals range from 40 to 60 inches. There is no permanent snowpack within the watershed.

The lower Putah Creek subbasin is defined as the portion of the watershed that receives drainage from downstream of Monticello Dam. The lower subbasin includes the 30-mile-long lower Putah Creek corridor contained within the relatively narrow 110-square-mile contributing drainage area. The lower subbasin is characterized by low hills at the base of the Coast Ranges to generally level topography in the Central Valley. The PDD, approximately 6 miles east of Monticello Dam, and associated Lake Solano are important features in their function for managing water resources in the basin. At the point of the PDD, SCWA diverts water from Putah Creek into the Putah South Canal for agricultural and urban uses south of the creek. Average rainfall in the lower subbasin is 17 inches at Davis.

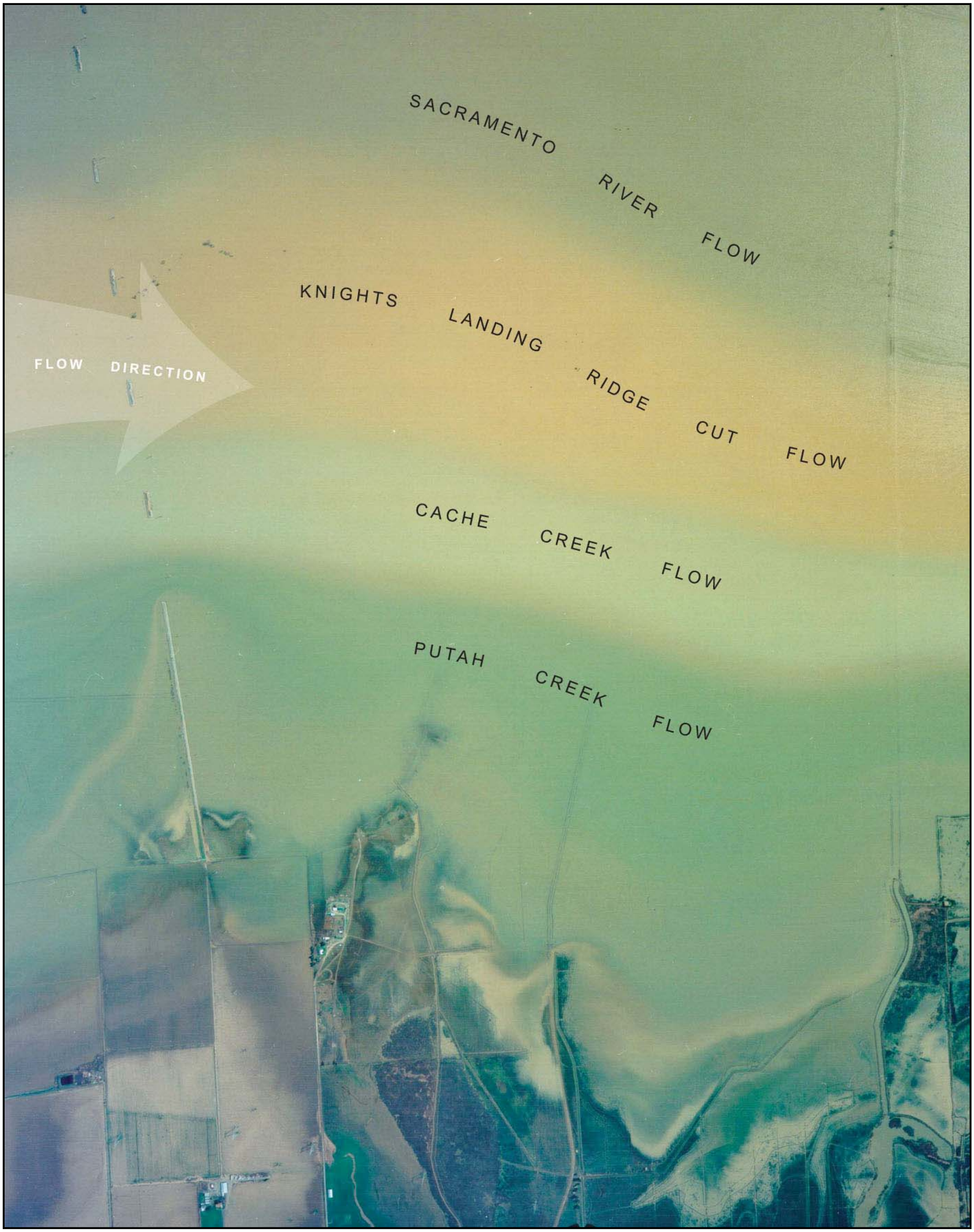
Notable tributaries to lower Putah Creek include Thompson Creek, which enters along the north side of Putah Creek just downstream of Monticello Dam, and Cold Creek, which enters slightly farther downstream on the south side. Pleasants Creek enters from the south just upstream of Lake Solano. Dry Creek is the only major tributary downstream of the PDD and Lake Solano. It enters Putah Creek from the north just upstream of Winters (see Exhibit 1-3). All of these streams are intermittent (i.e., exhibit seasonally dry channel conditions during most summers).

Putah Creek empties into the Yolo Bypass through the Los Rios Check Dam, a 30-foot-long concrete dam with wooden boards regulated to impound water for irrigation and, more recently, managed to accommodate passage of chinook salmon during fall. Putah Creek water flows through a series of treeless cut irrigation channels in the Yolo Bypass that connect to the East Toe Drain of the Bypass. The East Toe Drain is a roughly 50-foot-wide treeless cut ditch that runs parallel to the Sacramento River Deep Water Ship Channel and provides irrigation water to Yolo Basin farms and the Yolo Basin Wildlife Area. The Toe Drain is close enough to sea level to be tidal. It flows to and, during high tides, from Prospect Slough, which in turn connects to Cache Slough and then the Sacramento River, the Delta, and out to the sea. During years of substantial winter flooding, or during flow releases from the Sacramento River, some or all of the Yolo Basin becomes flooded, overtopping the network of channels. During those events, water from Putah Creek, other Yolo Basin tributaries (i.e., Cache Creek, Willow Slough) and the Sacramento River move overland in parallel, unconfined bands directly toward the Sacramento River and Delta (Exhibit 4-1).

The hydrology of Putah Creek is best described in relation to the time periods of major human interventions and development within the watershed. Hydrological conditions have changed considerably beginning in the late 1800s. Principally, hydrologic conditions can be defined in relation to the historical period prior to 1957 when Reclamation completed construction of Monticello Dam and other Solano Project facilities, the period since the Solano Project has been operational, and the recent period following implementation of the Putah Creek Water Accord (refer to detailed discussion below).

4.3.1 HYDROLOGY PRIOR TO THE SOLANO PROJECT

Prior to 1957, when Reclamation completed the Monticello Dam and other Solano Project facilities, runoff events could be very large and escape the confinement of the stream banks to cause extensive flooding along Putah Creek. Table 4-1 shows historical streamflow patterns near Winters for the periods before and after construction of the Solano Project (described below).



Source: Ted Sommer (DWR)

Natural Color Bands from Tributaries into Flooded Yolo Bypass

EXHIBIT 4-1

Lower Putah Creek Watershed Management Action Plan
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Approximate Scale 0 825 1650 FEET

NORTH

EDAW

Table 4-1
Summary of Flows at or Near Putah Diversion Dam Before and After Construction of the Solano Project

Variable	Flow (cfs)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pre-Project (1934–1956) [1]												
Max	3,957	6,468	3,506	2,729	452	156	64	32	21	45	807	5,110
Med	794	1,075	736	281	125	42	7	5	6	6	37	296
Min	45	67	151	50	17	7	2	0	2	1	3	9
Post Project (1971–1981, 1985–1990) [1]												
Max	1,239	2,239	3,403	2,020	51	43	43	34	36	20	50	85
Med	38	41	33	46	43	43	43	34	20	20	25	25
Min	25	18	26	45	33	33	33	26	16	15	26	25
Putah Creek Accord Release Schedule [2]												
Normal Year – PDD [3,4,5]	25	16	26	46	43	43	43	34	20	20	25	25
Normal Year – I-80 [3, 4, 5]	15	15	25	30	20	15	15	10	5	5	10	10
Drought Year – PDD [6]	25	16	26	46	33	33	33	26	15	15	25	25
Drought Year – I-80 [6]	2	2	2	2	2	2	2	2	2	2	2	2

1 Adapted from USFWS 1993; years post-project data selected to reflect periods similar to available pre-project conditions.
2 Solano County Superior Court 2000 and Moyle, pers. comm., 2002. Note: specific pulse flow requirements not shown.
3 Normal year rearing flows. Normal year exists when Lake Berryessa storage exceeds 750,000 acre-feet on April 1. Values are shown as daily average flow requirements. Continuous flow must be maintained from the I-80 bridge to the Yolo Bypass.
4 Spawning flows modify the normal year rearing flows, as follows: a) 3-day pulse release at PDD sometime between February 15 and March 31 every year, with minimum of 150 cfs, then 100 cfs, then 80 cfs, each for 24 hours, and following the pulse; b) 30 days of releases sufficient to maintain 50 cfs at I-80 bridge, then ramped down over 7 days to match the normal year rearing requirements.
5 Supplemental flows modify the normal year rearing flows, as follows: a) 5-day pulse is required sometime between November 15 and December 15 (timed following removal of flash boards at Los Rios dam) to maintain at least 50 cfs average daily flow at confluence with East Toe Drain, and following the pulse; b) a minimum of 19 cfs is required at I-80 bridge until March 31; and c) 5 cfs flow at East Toe Drain is required from November 1 to December 15 and from April 1 to May 31.
6 Drought year exists when Lake Berryessa storage is less than 750,000 acre-feet on April 1. Values reported in same format as for normal year flow requirements. Continuous flow is not required at Yolo Bypass.

Prior to large-scale land reclamation and draining of wetlands within the Yolo Basin and construction of the Yolo Bypass flood levees, Putah Creek flowed through the Putah Sinks during the wet season when stream flows were high. Anecdotal information on anadromous fish runs in Putah Creek and studies presented during court proceedings for the Putah Creek Accord suggest that the Putah Sink and other Yolo Basin wetlands would have likely provided effective hydrologic connections to the Delta during the wet season and to allow fish passage (Yates, pers. comm., 2003).

The physical creek channel configuration has been highly altered by human intervention to control hydrologic functions beginning with flood control efforts in the late 1800s (USFWS 1993, Jones & Stokes Associates 1992). Early efforts to control flooding in Davis began in 1870 and continued until 1940 with the excavation of the South Fork of Putah Creek from near the I-80 bridge to the Yolo Bypass. The USACE later created dams at both ends of the North Fork channel during World War II, permanently confining flows to the South Fork. USACE also removed most of the riparian vegetation and excavated the channel to form a trapezoidal shape to improve flood flow capacity from Winters to the vicinity of I-80. During the late 1940s, USACE created the lower 9-mile section of levees for the South Fork channel. The width between the levees increases from about 500 feet wide near I-80 to 2,000 feet wide where it enters at the Yolo Bypass. The effect of these activities on geomorphic conditions is described in greater detail below.

Historical records indicate that streamflow decreased dramatically following the end of the winter rainfall season in most years (Jones & Stokes Associates 1992). Channel streamflow generally diminished from the Coast Ranges foothills to the Yolo Basin. The presence of streamflow in Putah Creek after winter rains have ceased is a function of baseflow from groundwater discharge contribution, percolation into the stream bed to groundwater recharge, and consumptive uses in the form of agricultural supply diversions and evapotranspiration by riparian vegetation. Analysis of historical gauging station data suggests that streamflow persisted well into summer near the base of the mountains to below Stevensons Bridge Road in most years. However, there was likely little or no summer flow near Davis except in very wet years (Jones & Stokes Associates 1992). Flows were probably present at Winters about 82% of the time and 44% of the time at Davis. However, deep pools and short stretches of streamflow sustained by shallow groundwater discharge were most likely present during the dry years. During the period prior to wetland reclamation in the Yolo Basin and construction of the Yolo Bypass and South Fork Putah Creek and East Toe Drain channels, the original Putah Creek (north fork) channel flowed to the Putah Creek Sinks. The Putah Creek Sinks wetland complex, in addition to providing important wetland habitat functions, probably served as an effective seepage and evaporation basin, whereas the developed channels within the Yolo Bypass currently convey flows directly to the East Toe Drain.

Between mid-1800's and 1920, as agriculture expanded and the population grew, there were greater demands on creek flows and groundwater aquifers, which lowered creek flows (Shapovalov 1946). During the 1920s and 1930s, prior to construction of Monticello Dam, agricultural use of groundwater increased substantially with the advent of the deep well turbine pump and resulted in overall lowering of the shallow groundwater elevations. The lowered groundwater table near Putah Creek is presumed to reduce dry-season streamflow rates. The problem of Solano County's declining groundwater became quite severe in the extended drought period between 1928 and 1934. Between Putah Creek and the City of Dixon the groundwater table declined 20 feet and various cities throughout Solano County reached their supply limits. In response to this problem, the farmers placed soil in the Putah Creek channel near the City of Winters to impound water with the goal of improving groundwater recharge, and eventually had the Civilian Conservation Corps build a permanent concrete groundwater percolation dam that was started in 1935 and completed in 1938 (USFWS 1993). After the flood season was over each year, flashboards were installed in the spring and removed in the fall to seasonally impound water to an elevation of approximately 10 feet above the foundation. Farmers from as far away as Dixon paid into an annual maintenance fund to operate the dam, however, the dam; was eventually destroyed by a flood in 1952. A subsequent study by the U.S. Geological Survey determined that the impoundment actually had little if any effect on groundwater recharge. Rising groundwater in the spring is a normal result of natural winter recharge, so farmers may have attributed rising groundwater to the dam when there was little if any actual benefit (Marovich, pers. comm., 2004).

The remnants of the concrete structure still remain, and may hinder the movement of fish, particularly upstream migration. The LPCCC recently commissioned a geomorphology study of Winters Putah Creek Park to determine opportunities for fish habitat enhancement. Water depth was measured from Winters Road bridge to the Percolation Dam. The study recommended removal of the derelict percolation dam foundation because it poses a possible barrier to fish passage. It further concluded that removal of the dam would not significantly change upstream water elevations and would not affect streamside vegetation. The channel is 10 to 13 feet deep between the Winters Road bridge and the percolation dam and the floor of the creek rises only slightly near the dam itself. An option being considered following removal of the remnant foundation is to construct a W-shaped rock weir that would allow fish passage, and would be designed to efficiently scour and create large deep holes for fish habitat below the weir, and add oxygen to the water by turbulent mixing (Marovich, pers. comm., 2004).

Further downstream, early efforts to control flooding in Davis began in 1870 with the excavation of the South Fork by the U.S. Army Corps of Engineers (USACE) from the present day North Fork west of Interstate 80 (I-80) to the Yolo Bypass. During World War II, the USACE created dams to permanently cut off flows through the North Fork channel (i.e., the original Putah Creek channel) and confine flows to the South Fork. Then, during the late 1940s, the USACE created a 9-mile-long section of levees for the South Fork channel, extending from the North Fork to the Yolo Bypass. As late as the 1950s, USACE removed most vegetation and graded the channel between Winters and the South Fork.

The contributing factors to extreme low streamflow periods include drought conditions, overall lowering of regional groundwater levels and associated seepage of streamflow to groundwater within the channel, and riparian agricultural diversions. The Solano Project was built to substitute surface water for groundwater, to reduce long-term groundwater deficits. Though it has provided some incidental flood protection during some high rainfall events, it was not actually designed for and so cannot be functionally operated for flood control purposes. Regional groundwater levels have generally increased and stabilized since the Solano Project began operations because of availability of surface water for agriculture and a corresponding reduction in groundwater pumping. However, regional groundwater levels are currently still lower than historical conditions (USFWS 1993b), and are probably influenced by flood abatement measures and groundwater pumping.

4.3.2 HYDROLOGY FOLLOWING COMPLETION OF SOLANO PROJECT

All of the Solano Project facilities (Monticello Dam, PDD, and Putah South Canal) were completed in 1957, resulting in the current highly regulated streamflow regime. Construction and operation of Monticello Dam dramatically altered the natural high streamflow and flood regime along the stream. Lake Berryessa, with a total storage capacity of 1.6 million acre-feet, is large relative to the average total runoff and provides capacity for incidental flood water storage to reduce the predicted pre-dam 100-year flow event from 122,000 cubic feet per second (cfs) to 32,200 cfs. Table 4-1 shows a comparison of the predicted flood flow rates in Lower Putah Creek at Davis for differing recurrence intervals for the time period prior to and after construction of the Solano Project. All of the major tributaries to Putah Creek (Thompson Creek, Cold Creek, Pleasants Creek, and Dry Creek) are unregulated by dams and can exhibit highly variable flows (USFWS 1993b, USACE 1995). However, Monticello Dam was not constructed for flood control and has no authorized purpose for providing flood control; it is not specifically operated to reduce peak flows. The 200-year-flood storm event of December 2002 was a significant example of an incidental flood peak reduction that can occur when Lake Berryessa has available storage capacity. A total of 13 inches of rain fell within four days during this event, resulting in 90,000 cfs streamflow entering Lake Berryessa while regulated outflows remained at 200 cfs. Without the Dam, the cities of Winters and Davis would have been flooded (Marovich 2003a).

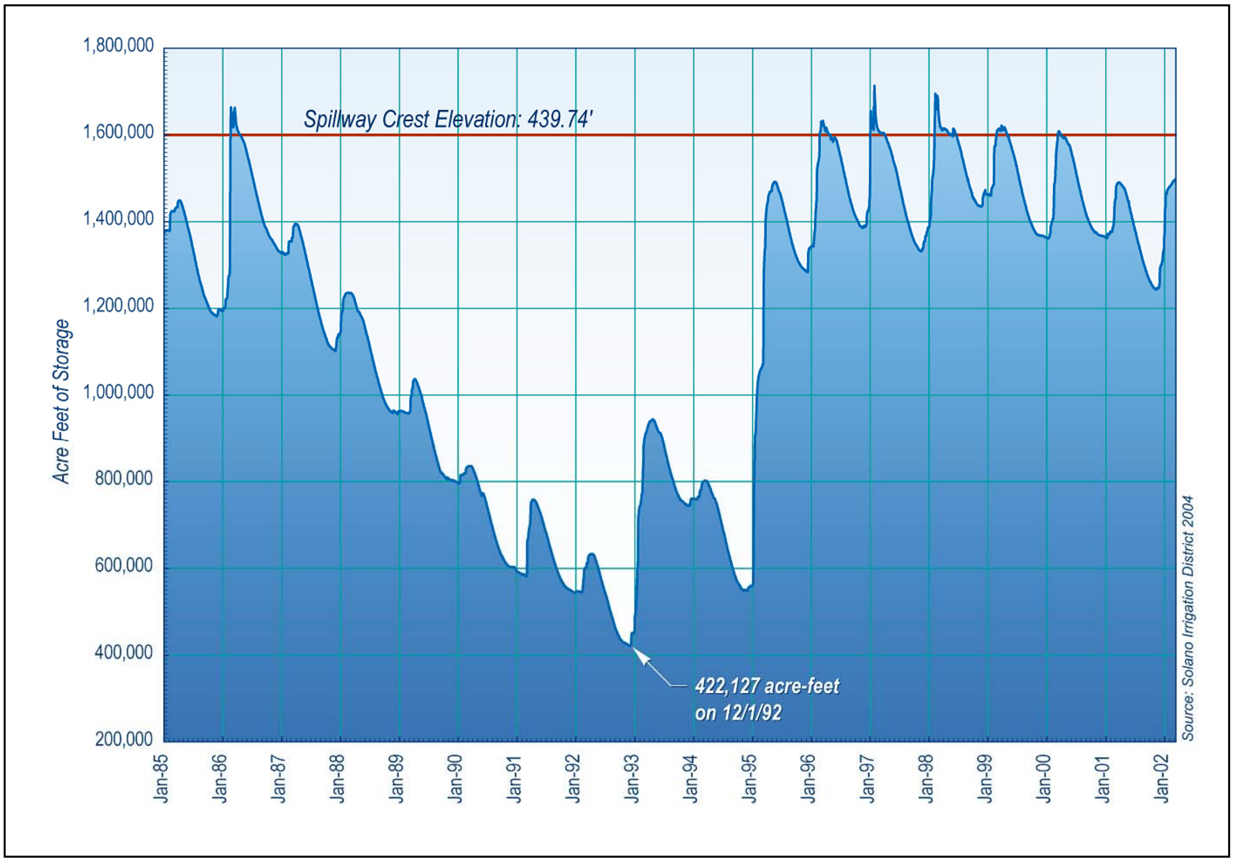
Solano Irrigation District (SID) diversions to Putah South Canal average about 207,350 acre-feet annually from Lake Solano, equivalent to about 55 percent of the total water yield in the upper subbasin. Consequently, the Solano Project has also dramatically reduced the natural fluctuations and peaks in flows (high and low) that are typical of free-flowing streams. The Solano Project also substantially reduced the total annual discharge volume flowing through lower Putah Creek from the PDD to the Yolo Bypass. Table 4-2 shows the changes in flood flows and stage elevations due to Lake Berryessa flood attenuation.

Table 4-2
Lower Putah Creek Peak Flows and Stage Elevations Near Winters for Different Recurrence Intervals Before and After Solano Project

Flood Frequency	Flows Prior to Lake Berryessa[1]	Putah Creek Elevation at Dry Creek[2]	Flows After Lake Berryessa[1]	Putah Creek Elevation at Dry Creek[2]
5-Year	53,000	126	NC	NC
10-Year	71,000	132	8,900	111
25-Year	93,000	135	16,400	113
50-Year	107,000	137	25,100	117
100-Year	122,000	137	32,200	120
500-Year	153,000	137	41,900	123

[1] Flow data are from 1994 USACE report (USACE 1994)
[2] Elevations from rating curve developed from 1974 flood plain analyses (USDA 1976)
NC = insufficient data to calculate
Source: USACE 1995

Following construction of the Solano Project, releases from the PDD to the lower reaches of Putah Creek were initially made under a "live stream" operating rule. Releases were set to equal the inflow to Lake Berryessa, or the amount of release required to maintain a flow of 5 cfs at Old Davis Road, whichever was less. In 1970, the SWRCB approved a new, 1970 release schedule that included a set of reduced release rates to be used during summer in dry years. The average annual discharge under the 1970 release schedule was much less than the estimated annual pre-project discharge. The annual discharge for normal years and dry years was only 6.1% and 5.3% of the estimated pre-project discharges, respectively. In 1978, the 1970 schedule was amended and the SWRCB adopted a yet another schedule, referred to as the 1981 release schedule (Jones & Stokes Associates 1992). However, in 1984, SWRCB reversed its decision and reinstated the 1970 schedule, which remained in effect until 2000 when the Putah Creek Water Accord was implemented (Jones & Stokes Associates 1992, Krovoza 2000). The hydrology following implementation of the Accord is provided in the section below.



Lake Berryessa Water Storage, 1985–2002 EXHIBIT 4-2

Water stored in Lake Berryessa provides for extended streamflow augmentation throughout the summer compared to historical patterns. Median flows during August through October are higher since Solano Project operations began (refer to Table 4-2). As a result of the

Accord, streamflow is now expected to always be present from the PDD to the Yolo Bypass. However, significant periods of reduced flows in the lowest reaches of Putah Creek have occurred at various times since the Solano Project became operational (e.g., during the 1987–1992 drought years). During the drought years, Lake Berryessa water levels dropped at a rate of 200,000 net acre-feet per year to a historic low of 422,127 acre-feet on December 1, 1992, representing only 2 years of water supply to water recipients (Exhibit 4-2).

The lack of water supply was a concern to water users, and the reduced flows were a concern for fish habitat and other beneficial functions of Putah Creek. Flow studies conducted in 1991 identified areas along the creek that became losing reaches (i.e., where surface water in the creek flows down and outward to a lower adjacent groundwater table) in locations that historically received groundwater recharge from an adjacent higher groundwater table. The stream receives some minor inputs of flow downstream of the PDD including Dry Creek, the Willow Canal overflow near Davis, the UC Davis aquaculture and aquatic weed laboratory facilities, and the UC Davis wastewater treatment plant. The Willow Canal begins at Cache Creek and was constructed by UC Davis around 1900 to provide irrigation water to its research farms (Marovich, pers. comm., 2003). In summer it provides a flow of between approximately 0 and 10 cfs into lower Putah Creek along the north bank east of Pedrick Road (Marovich, pers. comm., 2004). The UC Davis wastewater treatment plant discharges a continuous flow of about 2.5 cfs. Within the Yolo Bypass, lower Putah Creek flows are impounded seasonally with the installation of check boards in the Los Rios Check Dam at the confluence of Putah Creek with the Yolo Bypass. In addition, the impounded water is sometimes augmented with water pumped from the Bypass to above the check dam for the purpose of crop irrigation and maintenance of the Yolo Bypass Wildlife Area.

4.3.3 HYDROLOGY FOLLOWING IMPLEMENTATION OF PUTAH CREEK ACCORD

The seasonal instream flow and release patterns from Monticello Dam have recently become regulated through the May 2000 Putah Creek Accord (Accord) (Solano County Superior Court 2000). The Accord is intended to balance the competing uses for water between supply, demand, and maintenance of aquatic and riparian resource functions. The purpose of the Accord is to create as natural a flow regime as feasible and to maintain a living stream for the benefit of fish, wildlife, and plants from the PDD to the connection at the East Toe Drain in the Yolo Bypass. The focus of the Accord is on the protection and enhancement of native resident and anadromous fish populations and maintenance of riparian vegetation. Four functional flow requirements are set forth in the Accord pertaining to rearing flows, spawning flows for native resident fishes, supplemental flows for anadromous fishes, and drought-year flows. The rationale behind these flows is summarized in Chapter 5 under the section, "Putah Creek Water Accord." Table 4-1 shows the basic required flow regimes specified by the Accord as prescribed for "normal" and "drought" conditions.

4.4 GEOMORPHOLOGY, EROSION, AND SEDIMENTATION

Streams exhibit complex patterns of flow currents and velocities, channel shape and dimensions, alignment and meander, and combinations of riffle, run, and pool sequencing.

The geomorphic conditions depend on topography, geology, hydrology, climate, and vegetation characteristics, and can be relatively stable or rapidly changing depending on the geologic age of the region and existing forces of change. Table 4-3 lists generalized characteristic attributes of functioning alluvial streams that serve to maintain the channel and ecosystem functions of the riparian corridor. Specific comparable attributes are presented for lower Putah Creek.

Table 4-3
Characteristic Attributes of Functioning Alluvial Streams Compared to Existing Conditions for the Same Attributes in Lower Putah Creek

Characteristic Attributes of Functioning Alluvial Streams[1]	Comparative Conditions in Lower Putah Creek
Alternate bar sequences	Destroyed by channelizing prior to Solano Project
Annual hydrograph components accomplish specific geomorphic and ecological functions	Ratio of flows in tributaries and the main channel is inverted by dams except when Glory Hole spills
Channel bed is frequently mobilized	Channel bed is stabilized by vegetation due to reduced frequency of scouring flows
Alternate bars are periodically scoured deeper than their course surface layers	Rarely happens due to reduced frequency of scouring flows following Solano Project
Fine and course sediment budgets are balanced	Dams trap course sediment (mostly fine sediment now)
Alluvial channels are free to migrate	Little channel migration, lack of renewal of gravel bars and sand bars
Floodplains are frequently inundated	Floodplains mostly cut off, channel incision and trapping of sediment by vegetation results in less frequently inundated floodplain
Large floods create and sustain complex mainstem and floodplain morphology	No desire to return to massive flooding in the Winters and Davis communities; incised channel, encroachment of vegetation and lack of course sediment result in little to no accessible floodplain
Diverse riparian plant communities are sustained by natural occurrence of annual hydrograph components	Cottonwood and willow recruitment impeded by relative lack of shifting sand bars, incised channel, and altered hydrologic patterns
Groundwater is hydraulically connected to the mainstem channel	Lack of flooding reduces recharge along mainstem and shifts it to impoundment areas; regulated summer flows may increase summer mainstem recharge from historical conditions

[1]Adapted from Trush et al. 2000

These attributes will not necessarily apply equally to all streams, and may not be present at all if other constraints restrict the particular function (e.g., where a levee limits the ability of a creek channel to meander naturally, such as in an urban corridor). However, a common attribute of all watersheds is that the soil erosion, channel erosion, sedimentation, and sediment transport are natural geomorphic processes dominated by large, infrequent storm events and/or high streamflow conditions.

The goal of geomorphic analysis is to understand the past and present hydrologic, physical, and biological forces acting to define channel form and function. Geomorphic analysis considers the range of conditions from large scale and long time periods (e.g., prehistoric channel formation processes of all tributaries in an entire watershed) to localized and shorter time period studies (e.g., effects of a single environmental factor on a small area of a single channel). Geomorphic processes play a large role in shaping the characteristics, functions, and values of other resources in and adjacent to the riparian corridor including water quality, fisheries, vegetation, wildlife, land uses, and cultural resources. However, there has been no comprehensive geomorphic assessment or modeling of the channel formation processes occurring in Putah Creek, thus, the information below is based on general understanding of important factors and a limited set of site-specific analyses that have been conducted.

Channel erosion, scour, and deposition are the fundamental and visible evidence of fluvial geomorphic processes in action. Implementation of measures to manage and control erosion may conflict with natural geomorphic processes. However, providing flood control, minimizing property damage, and controlling erosion are necessary to manage a system that has been drastically altered from natural conditions and to protect urban or semi-rural environments that interface with riverine environments. The geomorphology of the Putah Creek watershed is described in relation to the major human interventions that have occurred, and locations of natural geographic and geologic features within the project area. The geomorphological conditions and erosion patterns and issues are discussed below in the context of two separate areas of the lower Putah Creek watershed:

- Monticello Dam to the PDD, including Tributaries; and
- Downstream of the PDD, including Dry Creek.

4.4.1 MONTICELLO DAM TO THE PUTAH DIVERSION DAM, INCLUDING TRIBUTARIES

Flood control measures and other channel modifications in the early 20th century discussed above caused significant changes in natural channel processes. Completion of Monticello Dam and the PDD caused major changes to natural sediment transport in the lower reaches of Putah Creek. Monticello Dam captures the majority of the sediment from the upper subbasin and the PDD was constructed downstream of several streams that have significant sediment transport loads (i.e., Pleasants Creek, Cold Creek, Thompson Creek) within this interdam reach (Exhibit 1-3). The PDD also serves as an effective sediment trap for sediment transport from these creeks. Sediment accumulation in Lake Solano has reduced the water storage capacity of the lake by about 20% with the majority of material being composed of particle sizes in the range of silts to medium sands (Northwest Hydraulic Consultants 1998). Sediment yield from the upper watershed was thought to have declined since the 1930s along with declines in the amount of land-disturbing cattle grazing and orchards (Northwest Hydraulic Consultants 1998). The reduction in grazing and orchards has taken place mainly in the Pleasants Creek watershed which is considered to be the primary source of sediment to Lake Solano (Northwest Hydraulic Consultants 1998). However, landowners report that streambank failure and/or channel incision within the Pleasants Creek channel may be more pronounced in recent decades. Specifically, lifelong residents of the area recall when the floor of the Pleasants Creek channel was 10 feet below the surrounding grade and half of its present width (Marovich, pers. comm., 2005). This condition occurred after 100 years of farming in the area and thousands of years of geological processes that shaped the channel until that time. The tripling of channel depth and doubling of width observed by landowners occurred within the last 50 years and was coincident with the construction of Monticello Dam. The altered hydrology, especially the inverse relationship of tributary flow to mainstem flow, explains the accelerated channel erosion that occurred over the same interval of time. Prior to Monticello Dam, 50-year maximum flows in mainstem Putah Creek were 10 times higher than maximum flows in the tributaries. After Monticello Dam, the tributary flows were mostly 10 times higher than mainstem flows (just the opposite), because most of the water from mainstem Putah Creek was stored in Lake Berryessa (Marovich, pers. comm., 2005). The water surface elevation of mainstem Putah Creek is now typically 20 feet lower than it was prior to Monticello Dam in peak winter storm flow events. The lower water surface elevation of mainstem Putah Creek has caused a 20 foot steeper slope of the water surface elevations entering Putah Creek from the tributaries. The steeper slope of the water in the tributaries causes higher flow velocities, and higher velocities cause greater erosion until the tributaries reach a new equilibrium channel floor elevation. The tributaries do this by downcutting or widening. The reported erosion of Pleasants Creek and other tributaries over the past 50 years can be explained as a natural adaptation of the tributaries coming into equilibrium with an altered hydrology that resulted from the construction of Monticello Dam. However, the problem arises indirectly from the dam due to higher flow velocities in the tributaries. Measures that reduce flow velocity in the tributaries can therefore compensate for the altered hydrology and begin to control tributary erosion (Marovich, pers. comm., 2005). The conditions in Pleasants Creek and actions that have been taken to reduce bank loss are described below.

Some sediment is transported out of the system via water diversions to the Putah South Canal. The dramatic reduction in large peak flow events downstream of Lake Berryessa and diversion of water to the Putah South Canal also reduces the quantity and size of downstream sediment movement to and through Lake Solano. Transport of sediment bedload downstream of PDD to the lower reaches during large flow events does occur as evidenced by large deposits immediately downstream of the dam; however, the quantity and rate of this transport has not been quantified. Flows above approximately 4,000 cfs were determined to be sufficient to mobilize sandy bed sediments within Lake Solano (Northwest Hydraulic Consultants 1998). The dramatic reduction in large peak flow events downstream of Lake Berryessa also reduces the quantity and size of remaining downstream sediment movement to and through Lake Solano. Overall, the report concluded that it is difficult to discern whether there is any long-term trends in sediment accumulation rates in Lake Solano and that there has been no significant change since 1973.

EROSION AND SEDIMENT ISSUES IN THE INTERDAM REACH, INCLUDING TRIBUTARIES

The primary area of concern for soil erosion and bank failure problems between Monticello Dam and PDD is in Pleasants Creek (Reach 7) (Exhibit 4-3a and 4-3b). Information from long-time residents in the Pleasants Creek area indicate that channel incision has been dramatic and the invert elevation (i.e., elevation of the low-flow channel) has declined by about 20 feet since the mid 1900s, with recent lateral erosion and bank failure resulting in the creek widening by as much as 50 feet in the past decade (Exhibit 4-3a) (Marovich, pers. comm., 2003b). The erosion experienced in the Pleasants Creek watershed and other Putah Creek tributaries has now reached a point of causing adverse and catastrophic losses of soil and damage to facilities that are generally deemed unacceptable. In some areas, the erosion has left unstable slopes that are susceptible to future continued erosion. And in general, the visual observations of channel conditions in many areas indicate that similar erosion will continue.

Numerous factors are associated with channel incision including hydrology, channel hydraulic form and function variables, soil conditions, and riparian vegetation conditions. The relatively wetter periods that have occurred during the late 1990s and larger streamflow events may be a factor in the apparent increased erosion. However, it is also apparent that in-channel high-velocity flows along streambanks are causing bank undercutting and mass failure of slopes. Excessive near-bank flows that cause undercutting, particularly on outside curves of the channel, creates vertical slopes that then readily slump or fall into the channel. Rosgen (2001) and others suggest that natural stream functions such as those described in Table 4.3 that tend to reduce streamflow velocity along the streambanks is a major factor in minimizing tendencies for undercutting and mass wasting of streambanks. Pleasants Creek appears to lack these features and there is a high rate of bank failure. In addition, human interventions in the channel (e.g., culverts, bridges, hardscaping, rip-rap) tend to concentrate flow direction, velocity, and erosive power which often increases downstream erosion.

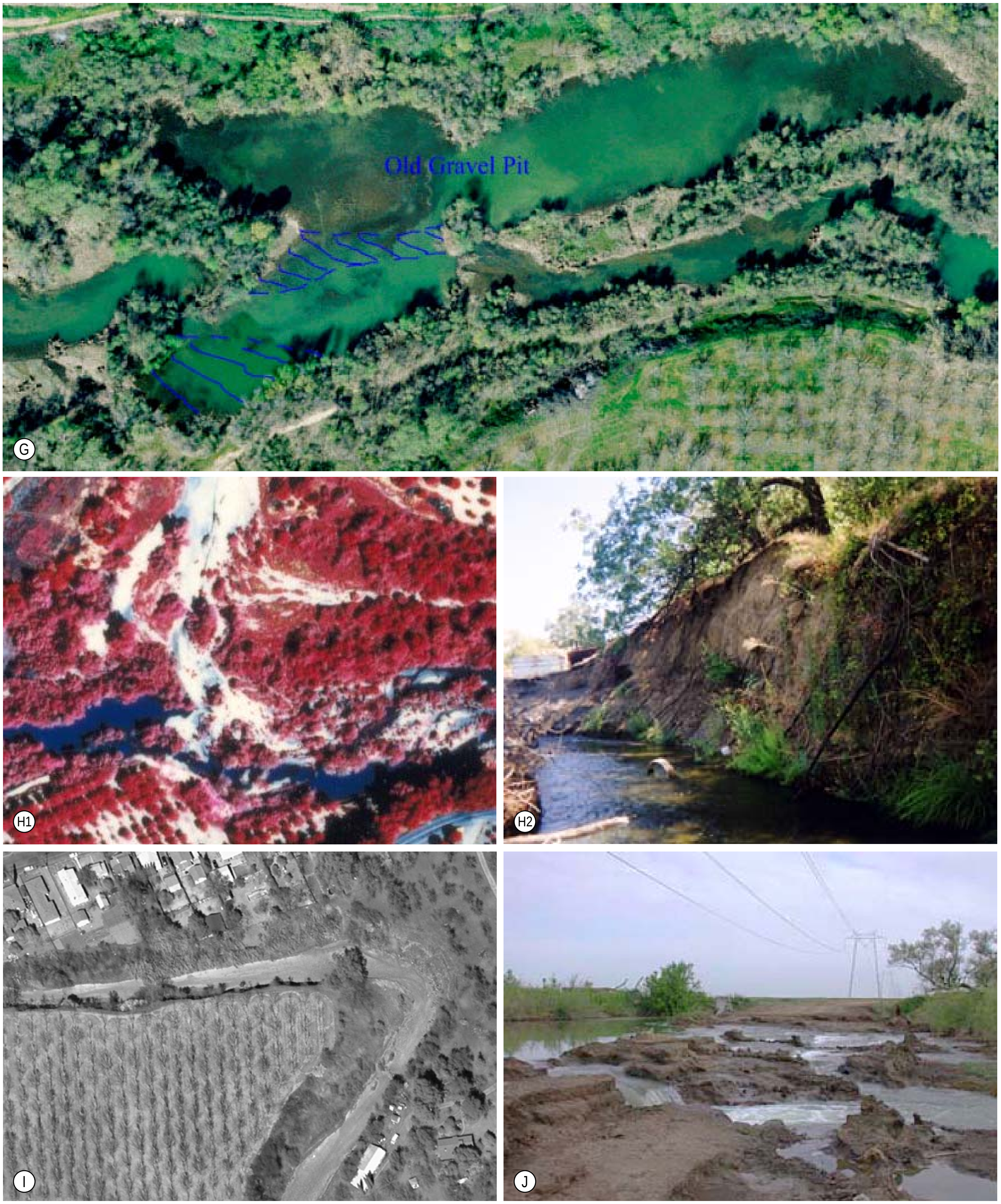
Pleasants Valley Road was constructed in the bottom of the valley alongside the creek and numerous bridges and their abutment structures within the channel create streamflow energy concentration zones with associated changes in erosion and deposition. Solano County has repeatedly installed riprap revetment and provided repairs to failing banks, bridges, and roadways alongside Pleasants Creek (Exhibit 4-3a). In December 2003, the 50-year-old Pleasants Creek bridge scheduled for replacement was washed out during a major rainstorm and 200-year flood event. The bridge is now being replaced and riprap is being installed to try to abate further erosion. Long-term riparian vegetation patterns, particularly of invasive species such as arundo, also can direct streamflow to other streambank sections that are then susceptible to erosion. Dense vegetation growth can also prevent overbank flooding of the floodplain that isolates and redirects high flows to the erosion-prone slopes, and thereby not allow the floodplain inundation process to naturally reduce velocity and erosive energy (Exhibit 4-3a).

(A) Pleasants Creek bridge failure following December 2002 major storm, (B) Pleasants Creek incised channel and failing banks, (C) road failure along Pleasants Creek in area revetted following a previous failure (note road lines were not yet repainted), (D) lateral erosion and bank failure on Pleasants Creek where invasive arundo blocked channel (California Department of Forestry crews removing the arundo in 2002), (E) rock removed from confluence of Cold Creek with Putah Creek following December 2002 event, (F) sediment buildup in Lake Solano at Putah Diversion Dam in 1997.

Source: LPCCC 2003; EDAW 2003

Erosion, Bank Failure, and Sedimentation Problem Areas

EXHIBIT 4-3a



(G) aerial view of old gravel pit captured by Putah Creek near Winters, (H1) aerial view of erosion and sediment deposition at Dry Creek confluence, (H2) Bank failure where Dry Creek delta and arundo infestation forced Putah Creek into bank below Putah Creek Road (bottom right of H1), (I) aerial view of Dry Creek bank erosion at meander bend just upstream from confluence with Putah Creek, (J) Road 106A earthen crossing washout in 2003.

Source: EDAW 2003

Erosion, Bank Failure, and Sedimentation Problem Areas

EXHIBIT 4-3b

EDAW

Other creeks in the interdam reach have experienced substantial erosion. Thompson Creek has also experienced substantial erosion and bank failure events in the past, most recently following the construction of an apparently unapproved dirt road (Marovich, pers. comm., 2003). In addition, large sediment deposits sometimes move down Cold Creek into Putah Creek. Cold Canyon is a largely undisturbed watershed used as a nature preserve (UC Davis 1985). The erosion occurring along Cold Creek is therefore largely, if not entirely, natural. The most recent event was during the large December 2002 rainstorm, in which a large sediment load from Cold Canyon was deposited into Putah Creek. The deposit was of concern to SCWA, and the agency subsequently removed approximately 13,000 cubic yards of rock material from the channel area (Exhibit 4-3a).

The most likely human-made factor of erosion problems in the Putah Creek tributaries is the increased flow gradient of tributary flow during large storm events resulting from the reduction of backwater from the mainstem of Putah Creek. Prior to the Solano Project, large flow events in the upper watershed entered the lower creek channel and raised overall river stage that likely caused backwater conditions at the junctions of the tributaries. Following the Solano Project, the majority of upper watershed runoff is now retained in Lake Berryessa and tributary flows comprise the large majority of flow in Putah Creek (USACE 1995). The associated lower Putah Creek river stage elevations are substantially lower during these events allowing the high-velocity and erosive flows to continue downstream unhindered by backwater. The erosion that has occurred in these previously inundated backwater areas may have eroded the bottom of the channels and subsequently promoted head-cutting farther into the tributary watersheds (USACE 1995).

There are actions that can be taken, and some measures have been implemented in the Pleasants Creek channel to reduce the adverse effects of near-bank scour and undercutting. The stream restoration firm Streamwise implemented measures in 2003 and 2004 under grant funds from the USFWS Partners for Wildlife program, private landowners, and the LPCCC to stabilize severe erosion problems on Pleasants Creek (i.e., the Hoskins property). The project implemented features to reduce the effects of near-bank streamflows including grading of the streambank to create gentle slopes not prone to undercut and anchoring root wads to the shoreline to direct flows away from the banks. Arundo was also removed in 2003 within portions of the project reach. A variety of innovative constructed flow-training and streambank stabilization features (e.g., rock and log vanes, root wads, weirs, gabions, groynes) have been effectively used in river restoration activities to direct erosive streamflow energy away from streambanks (Rosgen 2001). Larger grade control features such as rock weirs can also be installed to halt channel incision and restore pool-riffle sequences that effectively reduce flow velocity, allow sedimentation, and create plunge scour pools to dissipate energy and slow flow downstream of the feature.

4.4.2 DOWNSTREAM OF PUTAH DIVERSION DAM, INCLUDING DRY CREEK

Downstream of the PDD, changes to channel form have largely been defined by diminished sediments moving downstream past the dams, direct manipulation of the channel for flood protection and gravel mining operations, and creation of the South Fork channel. However, the changes are complex and not completely understood because of the numerous and significant changes caused by human interventions over many years. This section provides a discussion of the current understanding of past actions and current fluvial conditions and their apparent effects on channel formation downstream of the PDD.

Historically, Putah Creek had only one channel. Between 1871 and 1940, in the reach from Winters to the vicinity of I-80, farmers and the USACE removed riparian vegetation and excavated the channel, forming a trapezoidal shape to improve flood flow capacity and control flooding in Davis. By 1940, the excavation of the South Fork of Putah Creek was completed from near the current I-80 bridge to the Yolo Basin. This artificial new channel became the functioning channel of the stream. By the late 1940s, USACE blocked the North Fork off completely and established the South Fork as the only true stream channel.

Creation of the South Fork channel was successful in diverting water but resulted in the rapid incision of the channel in the years that followed. The newly excavated South Fork channel was lower and shorter than the natural North Fork channel. This resulted in an increase to the gradient of the stream and thus led to faster flow rates than would normally occur. The increased rate of flow scoured the creek bed all the way upstream to the Winters percolation dam, which acted as a grade control structure, preventing further upstream channel scour (Sutter 1986). Extensive groundwater pumping and associated reductions in the groundwater table elevation also have apparently resulted in land subsidence in some areas and this change may have caused slight changes in the slope of the Putah Creek channel, contributing further to the pattern or locations of channel scour and streambank erosion (USFWS 1993).

Concurrent with blockage of the North Fork channel to creek flows, USACE also cleared the channel and constructed levees in the late 1940s from approximately I-80 where the North Fork and South Fork diverge, downstream to the Yolo Basin. The relatively straight levee banks promote rapid passage of flood flows and transport of any remaining sediment to the Yolo Basin. However, they also effectively limit natural floodplain formation and functions.

Following completion of the Solano Project in 1957, water released from the PDD became relatively sediment-free, or "sediment-starved." When sediment-free water flows over existing sediment it has an increased capacity to entrain, or pick up and carry, particles that it flows over. This process alteration may contribute to continuing channel scour and erosion along lower Putah Creek. Changes in bank erosion, channel incision, and sedimentation patterns associated with sediment-starved water flow can be a significant factor to fluvial geomorphic processes and the condition of resources (e.g., fisheries, riparian vegetation, land uses, infrastructure) dependent on geomorphic and hydrological processes. A discussion of the existing channel substrate condition, the lack of gravels, and what that means in terms of spawning by anadromous fish is provided in Chapter 5, "Fisheries."

Dry Creek, entering Putah Creek at Winters, has experienced substantial downcutting (approximately 10 feet) over the past decades as well. The reasons for the downcutting could be a combination of the lack of a moderating backwater effect as described for the tributaries above PDD and overall lower Putah Creek channel invert elevations at the Dry Creek – Putah Creek confluence (USACE 1995). Since the Solano Project became operational, storm-event flows that used to coincide in both Putah Creek and Dry Creek are now present only in Dry Creek because available storage in Monticello Dam attenuates flows in lower Putah Creek but not Dry Creek (Streamwise 2002 and USACE 1995). Long-term resident and retired editor of *The Winters Express*, Newton Wallace, who has lived in Winters since 1947, remembers Dry Creek as a grassy swale until the Solano Project eliminated high flows and trapped sediment flowing down Putah Creek. He remembers Dry Creek floodwaters backing up to the first 90-degree bend, indicating that there may have been concurrent flooding of Putah Creek and Dry Creek (Marovich, pers. comm., 2003). Where previously high-flow events in Dry Creek would encounter backwater conditions of an inundated Putah Creek channel with relatively low velocity and erosive energy, Dry Creek flows can now rush down the channel unabated all the way to the confluence, causing erosion and channel incision in Dry Creek (USACE 1995). The backwater effect conditions do still occur, however, when uncontrolled spills flow from Lake Berryessa during flood stage events when the reservoir exceeds capacity. The incision in Dry Creek is deepened further by the downcutting that has taken place in lower Putah Creek, although the historical incision at this location of Putah Creek may be much less of a factor than the lack of a moderating backwater effect because the channel is only about 3 feet lower than it was at the turn of the century (Marovich pers. comm. - based on measurements taken at the railroad bridge crossing in Winters).

During the 1960s and 1970s, substantial amounts of gravel mining occurred along lower Putah Creek at two locations: from the PDD to a point about 3 miles downstream and in the vicinity of Pedrick Road (Exhibit 1-3) (USFWS 1993). Gravel mining occurred near the PDD until the late 1960s when concerns about undercutting of the dam brought an end to the activity. Channel surveys in 1972 indicated that mining had left a wide, relatively flat channel with a few artificial berms and levees (Jones & Stokes Associates 1992). Gravel was mined near Pedrick Road (Reach 4) by UC Davis until the late 1970s, with isolated mining occurring as late as 1984. The widened channels left by gravel mining operations may now result in a more rapid warming of releases from the PDD.

Vegetation clearing activities apparently continued in the lower Putah Creek channel by state and federal agencies from the 1940s until 1975 when vegetation clearing policies were changed to reduce the amount of vegetation that was being cleared from the Putah Creek channel (USFWS 1993). Since the reduction in vegetation clearing activities, the creek bed has stabilized, cover has increased, and a more natural stream channel has been created (USFWS 1993, Moyle 1991). DWR currently clears vegetation in the channel near bridges to prevent the occurrence of debris jams during high flows and maintain a flood conveyance capacity of 60,000 cfs. DWR vegetation clearing policies are discussed in more detail in Chapter 3, "Land Ownership, Land Use, and Resource Management Programs," section 3.2, "Land Uses."

An important additional factor affecting channel form and function concerns the changes in riparian vegetation growth patterns, particularly the introduction and growth of invasive weeds, including arundo, tamarisk, and perennial pepperweed. The historically extensive floodplain was dominated by cottonwood and willow species that flourished in concert with the natural floodplain processes. Arundo and tamarisk are generally adapted to the lower streamflow regime, and possess aggressive growth and competition factors that allow dense stands to become established. There are areas of dense stands, particularly arundo, that are clearly associated with changes and location shifts of the low-flow channel. Streamflow passing through these dense stands is slowed allowing sediments to deposit on the floodplain more than would occur through the more open vegetation pattern of willows, cottonwoods, and grasses. This sedimentation effectively raises the elevation of the floodplain which reduces the frequency of floodplain inundation by streamflow, thereby further reducing the scour of the invasive weed colonies and seed dispersal and competition by other more favorable vegetation. The infestations of these weeds continue to expand within the channel without high-flow scouring events. The result in many areas is stabilization of gravel or sediment bars that might otherwise be entrained and distributed to other locations on the channel bottom. Additionally, creek flows are often diverted into opposing banks by dense infestations or stabilized gravel bars, or slowed by dense infestations. As a result, some areas are experiencing increased lateral erosion of streambanks leading to bank failure, as discussed below. In locations where perennial pepperweed dominates, such as in Reach 1, the weed is altering the surface soil chemistry such that few native riparian trees and shrubs become established. Like tamarisk, perennial pepperweed appears to be extracting salts from deep soil and depositing them on the soil surface with leaf litter. The soil, weakly held by the perennial pepperweed roots, is then prone to erosion (DiTomaso 2003). Invasive species are discussed in detail in Chapter 7, "Invasive Weeds."

Recent analyses of historical mapping of lower Putah Creek from three recent time periods (i.e., 1905, 1947–1951, and current conditions) were conducted to describe channel alignment locations and changes (Yates 2003). This analysis suggests that the locations of channel alignments have been relatively stable over the period of analysis. Some of the apparent stability may be a result of the widespread channel straightening and grading activities in the early 1900s to improve flood control (USFWS 1993).

EROSION AND SEDIMENT ISSUES DOWNSTREAM OF THE PUTAH DIVERSION DAM, INCLUDING DRY CREEK

Immediately downstream of the PDD, sediment and debris buildup is becoming a problem for flow conveyance. Through typical releases from the PDD are sediment-starved, higher-flow releases are not always lacking in sediment. Following major flooding events or when one or more floodgates are opened, substantial amounts of fine sediment and varying sizes of woody debris can move through the dam. Much of the sediment is deposited immediately downstream of the dam. Native riparian forest trees and shrubs have colonized the deposits, along with invasive arundo. The native riparian habitat provides important wildlife habitat that is valued and protected by DFG. However, the formation further slows and backs up the water that is released, threatening the integrity of the PDD. As a result, SCWA has recently initiated studies to explore ways of facilitating sediment and debris to move downstream in a manner that increases flow conveyance while protecting habitat quality.

In the reaches downstream of the PDD, several major problem sites where channel incision and/or vulnerable stream banks have been exposed to erosive flows have resulted in habitat impairment or caused new areas of bank loss. Exhibits 4-3a and 4-3b show key areas with identified erosion problems in these reaches. Primary erosion and bank failure problem areas include the confluence of Dry Creek and Putah Creek, upstream locations on Dry Creek, and some locations along Putah Creek. Channel incision on Dry Creek upstream from the confluence with Putah Creek is causing steep bank sloughing on Dry Creek. A major bend in the creek a few hundred yards upstream of the confluence, known as Meander Bend, was treated within the past decade to protect against failing banks. The treatment included grade control rocks and rock vanes along the toe of the bank to reduce bank toe erosion, and some banks have recently been planted with vegetation in an attempt to stabilize them. Although these structures substantially protected the banks in 1997 and during subsequent high-flow events, there are several scour pools that appear to be forming adjacent to and downstream of the structures that may result in toe erosion and bank failure in the future.

At the confluence with Putah Creek, extensive arundo growth has developed in and stabilized the rich delta of fine sediment and gravels deposited by Dry Creek. The combination of the stabilized delta and dense arundo growth have forced the Putah Creek channel southward and into the southern bank, resulting in undercutting of the bank and bank failure. The stability of Putah Creek Road, near the top of the bank, was threatened if measures to abate the problem were undertaken in 2005. Funded by grants from the DWR Urban Streams program, and DFG's Wildlife Conservation Board, the LPCCC and Streamwise, a stream restoration firm, restored the creek to its historic channel alignment and stabilized the creek bank using natural materials (Exhibit 4-4).

Farther downstream, near Pedrick Road, the earthen Willow Canal that brings water from Cache Creek to provide irrigation for farms has failed at least twice in recent years, resulting in a load of sediment being dumped into Putah Creek. Although not a source of erosion, a seasonal temporary farm road crossing is constructed each year at Road 106A near the west levee of the Yolo Bypass has been a source of imported sediment in the past. Problematic washouts, and downstream transport of the imported fill used to construct the road, occasionally occurs during high-flow events (most recently December 2002).

Similar to conditions in Pleasants Creek, there are existing locations where channel scour, erosion, and streambank loss are unacceptable and restoration actions have been taken to address specific sites. An example of an innovative "W-weir" was installed downstream of I-505 (i.e., the Hasbrook property) to replace a low-water crossing by the stream restoration firm Streamwise and is shown in section 5.4, "Spawning Habitat in Lower Putah Creek." As described above, the weir configuration directs the erosive flow force toward the center of the channel and away from the streambanks. The weir also reduces overall channel incision by creating a grade control that prevents downcutting and creates a plunge pool downstream for further energy dissipation.

Stabilized and seeded (native creeping wildrye) streambank along south bank of Putah Creek at confluence with Dry Creek, in December 2005, following channel realignment in September to protect Putah Creek Road (see Exhibit 4-3b.(h) showing failing bank prior to realignment).

Putah Creek water flows clear within a day following the opening of the realigned creek channel. Removal of the arundo-stabilized gravel delta at the mouth of Dry Creek and the configuration of new channel are intended to protect the south bank of Putah Creek and enable gravel to move further downstream, providing much-needed spawning habitat for Chinook salmon and other anadromous fish.

Source: Rich Marovich 2005

Channel Realignment and Bank Stabilization at Putah Creek – Dry Creek Confluence

EXHIBIT 4-4

4.5 SAWATER QUALITY

Water quality is a common interest of stakeholders and justifies many public funding opportunities. Putah Creek provides drinking water for 300,000 customers of the Solano Project, and storm water runoff affects water quality in the lower Sacramento River, the San Francisco-Bay Delta, and the California Aqueduct. The water quality section includes a discussion of the beneficial uses of Putah Creek water, water quality principles and issues, water quality stressors (including temperature, mercury, and aquatic toxicity), and gross pollutants (trash).

4.5.1 BENEFICIAL USES OF LOWER PUTAH CREEK

The RWQCB identifies and designates beneficial uses of surface and groundwater resources in the Basin Plan (see Appendix H, "Permitting and Regulatory Compliance") for the management of water quality (RWQCB 1990). The state law defines beneficial uses of waters for the protection of water quality to include "… domestic; municipal; agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves" (Water Code Section 13050(f)). Existing or potential beneficial uses of a water body are used to guide water use decisions and water quality monitoring. The most recent Clean Water Act Section 305(b) report (SWRCB 2003a) that describes the conditions of water resources in the state identifies Lower Putah Creek as fully supporting the existing and potential designated beneficial uses including the following:

- municipal and domestic water supply (e.g., SCWA/SID diversions to the Putah South Canal),
- agricultural water supply (e.g., SCWA/SID and other riparian diversions),
- water body contact (i.e., swimming) and non-contact (e.g., canoeing) recreation,
- warm freshwater habitat (e.g., important native resident fishery and habitat below PDD),
- warm water fish habitat for spawning,
- wildlife habitat,
- cold freshwater habitat (e.g., important salmonid fishery and habitat above and below PDD), and
- cold freshwater habitat for spawning (this habitat is not an officially designated "existing" or "potential" beneficial use of Putah Creek within the Basin Plan; however, cold water spawning activity does occur in lower Putah Creek in association with the blue-ribbon trout fishery).

4.5.2 WATER QUALITY CONCEPTS AND ISSUES

Water quality conditions are defined by a wide variety of physical, chemical, and biological factors. The factors of concern for water quality tend to vary depending on the type of water body, location within a watershed, natural background water quality conditions, beneficial uses or aquatic life occurring there, seasonal conditions, and numerous other considerations. The physical, chemical, and biological properties of water can have direct and dramatic effects on the vitality of aquatic organisms, water-dependent aquatic habitat, human health, recreation, agriculture, and other uses of the water. The relationships are typically complex, and there is a level of uncertainty in any given aquatic system regarding how factors interrelate. Controllable factors such as land management actions, reservoir operations, water diversions, and waste discharges (e.g., stormwater, domestic wastewater, agricultural runoff) are also important factors to water quality conditions. These uncertainties complicate the management of water quality and have resulted in a complex regime of federal and state programs to protect beneficial uses.

OVERALL WATER QUALITY CONDITION AND ISSUES OF CONCERN

Water quality factors of concern can be broadly classified in a variety of ways depending on their ecological effects, physical, chemical, and biological properties, seasonal pattern, and types of source loads. Overall, lower Putah Creek's current physical and chemical water quality conditions have been characterized as good (USFWS 1993, RWQCB 1998). However, the overall availability of data is insufficient through most of Lower Putah Creek to make a comprehensive assessment and comparison of water quality conditions at different locations. Thus, a set of water quality issues were identified for consideration in this WMAP based on existing reported information, general water quality principles, anecdotal knowledge of existing field conditions, and likely water quality factors that could be affected by watershed management activities including water temperature, erosion and sedimentation, and gross pollutants (trash). In addition, there has been considerable attention focused on urban waste discharges from the municipal and university areas of Davis that occur along the lowest reach of Putah Creek and potential effects of a variety of inorganic and organic constituents (e.g., total dissolved solids; nutrients, including nitrogen and phosphorus; turbidity; biochemical oxygen demand; and organic carbon). Considerable attention has also recently been directed at the regional issue of mercury contamination and other toxic compounds (e.g., pesticides such as diazinon) and their potential effects on aquatic organisms and bioaccumulation in the food chain.

IMPORTANT TEMPORAL FACTORS FOR WATER QUALITY CONDITIONS

Water quality conditions are dependent on interrelated hydrologic, climatic, physical, and ecological conditions of the region on both a seasonal and long-term time scale. There are well-known seasonal relationships of many water quality variables to climate (e.g., temperature, algae growth) and hydrology (e.g., streamflow- and runoff-dependent erosion and sedimentation, stormwater runoff constituents). Seasonally low summer streamflow conditions result in the least amount of waste assimilation capacity for contaminants that enter the stream channel. During winter, streamflow is much higher and is influenced more by storm water runoff. Channel erosion typically is most prominent during winter high-flow conditions, and winter water quality conditions are influenced by contaminant sources from runoff in the surrounding watershed such as, potentially, sediments from soil erosion and construction sites, oils and grease from automobiles and paved areas, nutrients from agricultural fields and livestock boarding areas, trash, and organic litter (e.g., leaves and grass clippings).

This report focuses on existing water quality conditions in Putah Creek since the Solano Project became operational. Comparisons to pre-Solano Project conditions are made if they are relevant for understanding current issues, but they are generally limited because of the lack of information on water quality conditions during that period.

IMPORTANT LOCATION FACTORS FOR WATER QUALITY CONDITIONS

Some well-known water quality relationships are strongly dependent on location within the channel. For instance, the presence and rate of flow, and increases in temperature as water traverses from upper to lower Putah Creek, and sediment transport are examples of variables that depend on the location in the creek channel. Operations of Monticello Dam and PDD, and their resulting flow regimes, created distinct hydrologic regions and associated water quality differences within the creek. However, there is very little data collected in lower Putah Creek between Monticello Dam and the urban area of Davis, and the ability to assess true water quality conditions is limited. However, streamflow differences between the interdam reach and the comparatively low-flow reaches downstream of the PDD can be expected to strongly influence the concentration, dilution, movement, dispersion, and environmental fate of any contaminants that may enter the creek. Point source and relatively concentrated nonpoint source contaminant loadings described below also are expected and known to exhibit distinct locational water quality effects.

Urban stormwater runoff from the City of Winters is the only substantial and relatively distinct nonpoint source discharge in lower Putah Creek upstream of the Davis municipal area. Within the Davis area, the locations of point source wastewater discharges include the UC Davis Center for Aquatic Biology and Aquaculture (allowable discharge of 2.1 cfs), the Aquatic Weed Research Facility (allowable discharge of 0.1 cfs), and hydraulics facility (allowable average flow of 0.02 cfs, peak flow of 0.06 cfs) (UC Davis 2003). The waste discharges from these UC Davis facilities are all permitted through the Central Valley RWQCB to control discharge quality. The fish hatchery located just upstream of Pedrick Road discharges into a holding pond that in turn discharges to Putah Creek, and the aquaculture facility effluent drains to a percolation/evaporation pond with any remaining flows draining to Putah Creek via a storm drain originating near the airport. Both are regularly monitored and results indicate that other than elevated levels of nutrients, these outfalls have minimal impacts on the creek. Discharges of tertiary treated (i.e., oxidized, filtered, and disinfected) wastewater from the UC Davis WTP outfall located west of Old Davis Road fluctuate depending on the time of year, but average about 2.5 cfs on an annual average basis. The UC Davis WTP was designed to treat up to about 4.1 cfs of inflow and is expected to reach the maximum handling capacity of some of the treatment units within the next few years. The current UC Davis WTP was constructed in 2000 and provides considerable water quality improvement compared to the secondary-only treatment units of the previous facilities. UC Davis implements an industrial source control and monitoring program on the campus to control discharges of contaminants such as metals and organic compounds that may enter the wastewater from academic research facilities (UC Davis 2004). The UC Davis WTP was designed for modular expansion to accommodate planned increases in campus wastewater discharges over the years, and is currently in the process of implementing the first phase of an expansion that would increase the treatment capacity to about 5.9 cfs.

Nonpoint source loadings that may contribute potential contaminants include mercury discharge sources from the upper watershed, relatively unknown influences of agricultural activities along the lower reaches below PDD, illegal dumping problems in various places throughout the watershed (discussed in detail below), and identifiable stormwater discharge outfalls near the municipal centers of Winters and Davis.

4.5.3 Assessment of Water Quality Factors or Issues

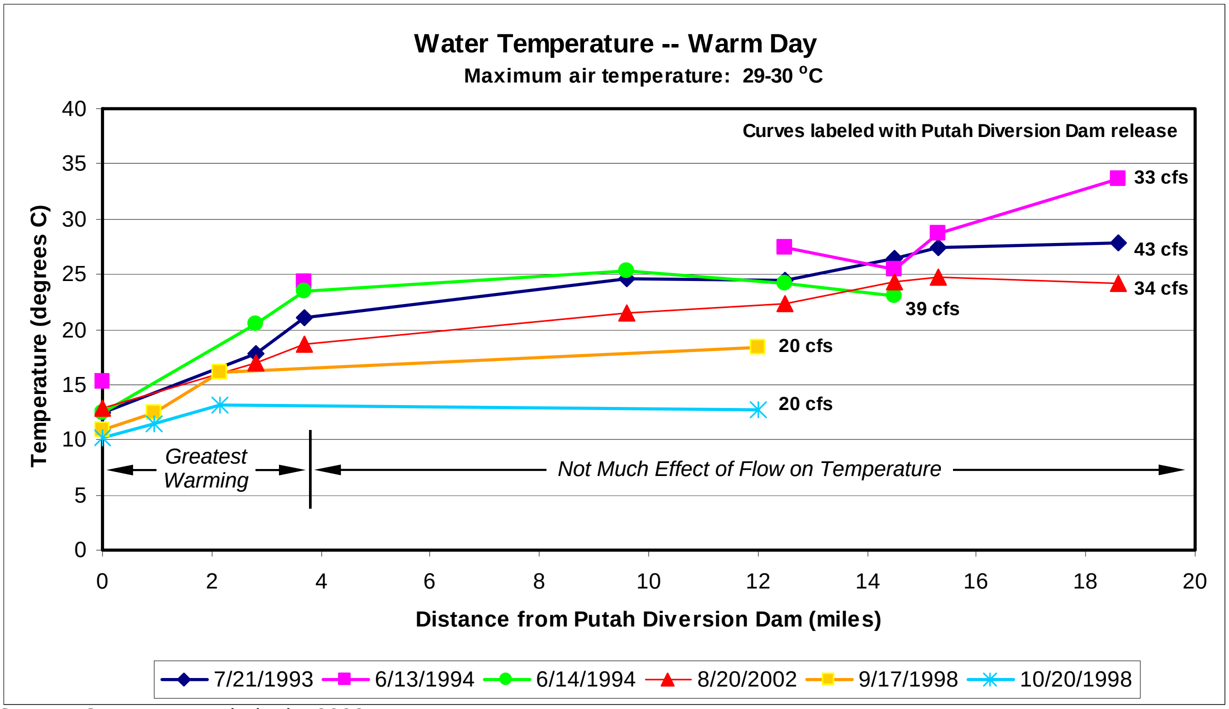
This section assesses of the initial set of water quality factors or issues identified as important to resources in the lower Putah Creek watershed. The factors or issues evaluated include those for which there is some data or information to begin to formulate conclusions such as determining seasonal temperature patterns or understanding the source of specific contaminant issues including mercury, aquatic toxicity, and the gross aesthetic (and potential contamination) issue of illegal dumping and trash discharges. The discussion also includes an assessment of data gaps that may need to be considered prior to undertaking certain management actions. Factors or issues discussed in this section include temperature, mercury, aquatic toxicity, and gross pollutants (trash).

Temperature

Seasonal water temperatures in Putah Creek are important, especially to fish. For successful spawning, many fish depend on temperatures within a certain range. For instance, many native resident fish such as pikeminnow and Sacramento sucker depend on relatively cool temperatures to spawn in winter through spring. Similarly, fall-run chinook salmon need cool water to migrate into the creek in fall. If the water downstream in Putah Creek is too warm, the fish may fail to enter the creek. Table 5-1 in Chapter 5, “Fisheries,” provides information on the ranges tolerated by each species during spawning. Exhibit 5-20 in Chapter 5, “Fisheries”, shows the average temperatures in April at different locations along lower Putah Creek.

Several years of seasonal water temperatures in Putah Creek have recently been evaluated by hydrologist Gus Yates (2003) for the LPCCC. Various data collection efforts have confirmed that the cold water released from the bottom of Lake Berryessa flows rapidly downstream to Lake Solano with relatively little change in temperature. In addition, rapid travel time continues through Lake Solano with only minimal additional heating such that release flows from the PDD to lower Putah Creek are consistently low in the range of 12°C to 15°C (54°F to 59°F) throughout the year (Jones & Stokes Associates 1996). The daily diurnal (i.e., changes over 24-hour day/night cycle) variation of the maximum and minimum temperatures also follows a constant pattern of about 3°C to 5°C (5°F to 9°F) that is relatively independent of streamflow, location, or background temperature conditions during summer.

Exhibit 4-5 shows the mid-day grab sample temperature data and changes that occur downstream of the PDD over a range of streamflow and peak summer months in different years of collection (Yates 2003). Yates reported that most of the warming downstream of the PDD occurs within the first 4 miles above the I-505 bridge. The warming that occurs in this reach is the natural heat gain of the relatively small flow that is released from PDD relative to the amount diverted to the Putah South Canal. In addition, there are several wide channel areas between the PDD and Winters thought to be associated with historical gravel mining that may allow additional heating of the water from direct exposure to sunlight. The relatively constant temperatures occurring by Stevensons Bridge are most likely because of groundwater discharges to the channel that have a relatively constant temperature. Little additional warming occurs downstream of the Stevensons Bridge area as the water becomes about as warm as it can possibly become under the given climatic and flow influences. As discussed further in Chapter 5, "Fisheries," the relatively high peak summer temperatures in the lower reaches of Putah Creek well downstream of the majority of cold water releases from the PDD is an important factor that favors spawning and dominance of introduced fish species over native species in those reaches.



Source: Gus Yates Hydrologist 2003

Longitudinal Temperature Profiles along Lower Putah Creek, 1993–2002

EXHIBIT 4-5

In association with the legal actions surrounding the Accord, UC Davis contracted to have a temperature model developed for lower Putah Creek downstream from the PDD that was used to evaluate the effectiveness of various management actions at improving water temperature conditions (Jones & Stokes Associates 1996). The report indicated that for the mid-summer peak water temperature season, increased flow releases from the PDD would produce only minor decreases in water temperatures, amounting to a reduction of about 5–7°F between the PDD and the I-505 area. The model data suggested that available heat input is sufficient to warm the additional flow quantity to equilibrium temperatures by the time water has reached I-505. In running the model to compare the removal of extensive beaver dams and associated pools that were present at the time the model was developed with effects from additional releases from the PDD, the model predicted that equal or greater reductions in water temperatures could be achieved by removing the beaver dams than by increasing in flow. Yates determined that the wash-out and elimination of numerous long, deep pools during the high winter high-flow events of 1995 and 1997 resulted in considerable temperature reductions in the creek (Yates 2003). Many pools historically were products of beaver dams that made the channel wider and slowed the water movement allowing additional solar heating to occur. When the beaver dams and pools were removed, the water remained cooler farther downstream.

Yates also concluded that the rate of water temperature warming downstream of the PDD would be greatly slowed by creek improvements that increase channel shading or reduce channel width in areas exposed to direct sunlight. Some additional conclusions from Yates were that the time of year appears to have the largest consistent influence on creek water temperatures, and that the maximum daily air temperature and long-wave radiation do not appear to be as important of a factor for Putah Creek temperatures as they are for other Central Valley streams (Yates 2003). The time of year matters because the creek trends east-west and the angle of incidental sunlight on the water surface, as well as ambient temperatures, are dramatically different between warm summer months, and fall and winter months. Although not stated in the Yates report, this finding would also indicate that riparian vegetation lining the south bank of the stream may also be an important consideration for water temperature moderation due to the maximum shading influence possible on the water surface relative to the sun angle.

MERCURY

Putah Creek below Lake Berryessa is listed as impaired by mercury on the SWRCB Clean Water Act Section 303(d) list of water quality limited segments within the state (SWRCB 2003b). Two studies of mercury contamination in fish have been conducted in Putah Creek. The need for the studies originated from concerns over UC Davis discharges and onsite drainage from the Laboratory for Energy-related Health Research (LEHR) site as potential sources of mercury. A survey in 1997 for mercury and lead concentrations in different fish species in Putah Creek was conducted by the Agency for Toxic Substances and Disease Registry (ATSDR) at five locations along Putah Creek. The agency found that all largemouth bass samples contained mercury and that some of these contained concentrations of mercury that are a health concern to pregnant or nursing women (ATSDR 2003). Other fish species did not contain toxic metals at levels of public health concern. The limited sampling and analysis in 1997 found that elevated levels were widespread throughout the creek and unrelated to the university. As a follow-up to their results, ATSDR representatives planned to meet with local health officials to develop and implement a plan for providing information on toxic metal concentrations in Putah Creek. Concerns over the accuracy of study's conclusions prompted further investigations and led to the additional study described below.

The Department of Environmental Health and Safety at UC Davis conducted a 2-year study of mercury effects on aquatic biota in lower Putah Creek (Slotton et al. 1999). Samples were collected in fall 1997 and 1998 to determine potential spatial variability in mercury contamination within the creek and provide a large new database of mercury concentrations in Putah Creek organisms. The UC Davis study collected data at 11 sampling sites throughout the length of lower Putah Creek between Monticello Dam and the Yolo Bypass. Sites were generally distributed every 3 to 4 river miles and chosen to characterize potential sources of total recoverable and methyl mercury. Adult, juvenile, and larval fish, as well as aquatic insects and crayfish samples, were analyzed to compare relative mercury exposure, uptake, and accumulation. The study confirmed that many of the Putah Creek fish species contained mercury concentrations at levels of potential concern, depending on the exposure criterion used. The larger individuals of the top predatory species were the most contaminated. The data further indicate that certain Putah Creek crayfish may represent a hazard for both human and wildlife consumption and that certain small or juvenile fish may represent a chronic hazard to fish-eating wildlife.

The UC Davis study found that neither the town of Winters, agricultural fields, nor the UC Davis expanse of the creek were found to significantly alter biological mercury trends in any of the organisms sampled. The approximately 3-mile stretch of Putah Creek adjacent to and downstream of UC Davis frequently contained among the lowest relative levels. Highest relative levels occurred in selected biota from just below Lake Berryessa, in and downstream of Lake Solano, and near the Yolo Bypass. Study results suggest that Lake Berryessa, continues the primary source of contamination in lower Putah Creek.

AQUATIC TOXICITY (PUTAH CREEK AND CACHE CREEK INFORMATION)

The Central Valley RWQCB conducted a study in 1998–1999 to evaluate natural background aquatic toxicity levels in the Putah Creek and Cache Creek watersheds (RWQCB 2000). For the lower Putah Creek watershed, the main concerns were the impacts of the UC Davis WTP and LEHR Superfund Site; however, samples were also collected from Lake Berryessa. A total of six sites were sampled over 12 months with four sites chosen to bracket the UC Davis WTP and LEHR sites and the other two sites placed above and below Lake Berryessa. Study results were generally inconclusive. The researchers found that while there were minor incidences of toxicity, most of the incidences were watershed-wide and could not be directly attributed to the areas of concern. Study results indicate that aquatic toxicity may not be contributing to the loss of native aquatic species, but those instances observed should be further investigated.

Water quality constituents typically of concern in domestic wastewater production and discharge include organic loading, nutrients, and toxic constituents. As noted above, the UC Davis WTP was constructed in 2000 and produces tertiary treated wastewater that has considerably reduced the concentrations of some constituents compared to the previous secondary-treatment plant. Tertiary treatment includes filtration that reduces the discharges of suspended solids and organic matter that would otherwise reduce dissolved oxygen levels in the creek by stimulating bacterial growth and decay of the organic matter. The new WTP also reduces overall nitrogen content in the wastewater that could otherwise stimulate nuisance aquatic algae growth.

UC Davis received a permit from the RWQCB in January 2003 to allow discharge of effluent to the Arboretum Waterway in the UC Davis campus as a means to reduce effects to Putah Creek and improve circulation and water quality in the campus water feature. The Central Valley RWQCB recently assessed water quality monitoring data for Putah Creek near the discharge and wastewater effluent. Their evaluation indicated the wastewater could contribute chlorine residual, electrical conductivity, ammonia, nitrate, aluminum, copper, cyanide, iron, lead, dichloromethane, and dioxin in excess of regulatory discharge limits (UC Davis 2003). The electrical conductivity (EC) drinking water quality standards include a range of values for aesthetic taste control. EC is naturally elevated in the groundwater supply, and further salt input occurs with wastewater discharges and other campus sources such as runoff and evaporative cooling water discharges or water softeners. UC Davis has identified that the high background levels are the primary cause of salt in the wastewater, and little improvement would result from eliminating other campus non-wastewater sources. UC Davis is also challenging the RWQCB on the EC discharge limit that was imposed on the WTP as being not applicable to Putah Creek because the creek is not used as a domestic drinking water source downstream from the discharge.

The regulatory thresholds for what is considered a "potential" for exceedence for the other inorganic and toxic constituents are very strict and based on conservative assumptions of frequency of detection, effluent concentration, and receiving water conditions. UC Davis WTP staff have been successful at identifying problem sources for some of the exceedences (e.g., copper, aluminum) and implementing control measures such as adding chemical filtration aids during the wastewater treatment process that enhance the removal of constituents within the filtration process. The RWQCB permit process requires UC Davis to make progress on controlling the discharge of the other constituents for which the source discharges, or causes, appear to be infrequent and unknown. Some constituents (e.g., dioxin, cyanide, lead, dichloromethane) have been detected infrequently, and because of the relatively short data record since the plant became operational in 2000, additional monitoring to establish the long-term understanding of the potential frequency and causes of these contaminants will likely be needed to provide reliable control.

TRASH

The gross pollutant contribution of trash within and along a creek diminishes water quality as well as its aesthetic qualities and constitutes blight. The main components of illegal dumping along Putah Creek include household trash and appliances, concrete debris, metal pipes and culverts, abandoned vehicles, and agricultural debris. Trash surveys completed during summer 2002 documented 49 trash sites, ranging from a few items to large piles of debris and automobiles. The total area mapped with trash amounted to 0.82 acre, or 35,516 square feet. Exhibit 4-6 shows the locations of trash mapped during the surveys and any associated information. (Landowners indicate that additional sites are yet to be mapped.)

Trash Characterization and Locations

Putah Creek has long been used as a local dumping area, probably for as long as humans inhabited the creek and region, and beginning prior to the advent of local landfills. All dumping into and along the Putah Creek channel is illegal. Several illegal dump sites occur along roadways and by bridges. Many dump sites on agricultural lands apparently started as attempts to fill gullies in the channel banks when irrigation water escaped from flooded fields.

Agricultural waste, including prunings and waste from walnut processing, sometimes provides temporary wildlife habitat. Quail are known to use prunings for temporary cover. Further studies are needed to determine the extent of use of these areas by wildlife species.

More restrictive dumping requirements at landfills, coupled with greater costs for disposal, may also be a current reason for continued illegal dumping along Putah Creek. Mattresses are now required to be fumigated before donating to charitable organizations, and more restrictive laws have been implemented for the disposal of tires, television sets, computer monitors, refrigerators, and freezers in public landfills. These items are dumped in Putah Creek with increasing frequency. Easy access and recreational use of the creek can also be associated with littering and illegal dumping. Some recreational users leave behind litter from the day's activities.

In some cases, trash items in the project area have originated from upper watershed locations when high-flow events caused Lake Berryessa to spill through the Glory Hole, a funnel-shaped outlet that allows water to bypass the dam when it reaches capacity (1,602,000 acre-feet). The Glory Hole spills on average once every 7 years. This picture shows the Glory Hole spilling in 2003.

The creek's main ongoing illegal dumpsites are found in the Winters area where Putah Creek Road is close to the top of the bank. Ongoing dumping in Putah Creek is clearly associated with vehicle access. Many illegal dump sites can be found adjacent to orchards and other farmland where private, unsecured roads parallel the creek. Other places where public roads come close to the top of the creek banks, such as bridge crossings, are readily accessed for illegal dumping. These include crossings at Mace Boulevard, Old Davis Road, Pedrick Road, Stevensons Bridge Road, and I-505. Dumping along roads that parallel the creek usually occurs where there are gaps in riparian vegetation. Infilling sparsely vegetated areas along the road with native riparian vegetation would discourage waste dumping and trespassing.

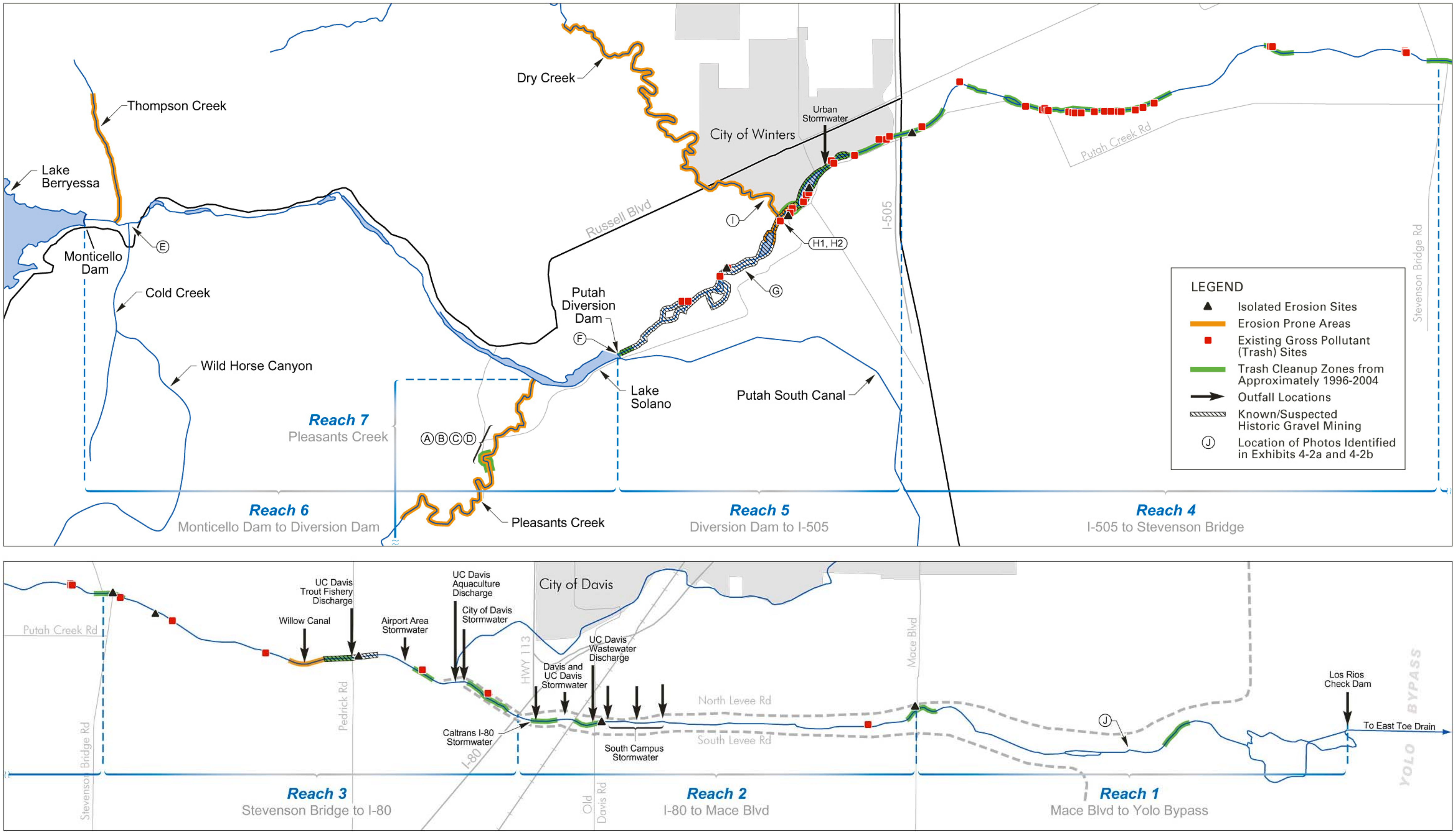
In 2001, the Winters Putah Creek Committee in cooperation with Solano County Department of Environmental Management installed a vehicle barrier at the I-505 bridge crossing over Putah Creek to restrict vehicle access and reduce illegal dumping. The LPCCC is seeking to install a farm gate at the southwest corner of the creek crossing at Mace Boulevard in Davis to reduce vehicle access.

Commonly found items along the creek include water heaters, household furniture, toys, car parts, industrial equipment, remodeling debris, and miscellaneous household goods and garbage. In addition, wastes from slaughter of cattle have also been dumped at the Mace and I-505 creek crossings and dead chickens from illegal cock fights have also been found at the I-505 bridge crossing. Chemical drums may have rolled into the creek from nearby farms and floated downstream. Stolen cars have been dumped into the stream channel and Lake Solano. Several entire cars or parts of them have been retrieved from Putah Creek.

Trash Removal Efforts

The Putah Creek Council began sponsoring creek cleanup events in the early 1990s. Others, like the Davis Fly Fishers, Davis Boy Scouts, California's Advocate for the Public Interest (CALPIRG), Dixon High School students, and others have also conducted periodic or regular cleanups in the creek. Beginning about 1998, the Putah Creek Council and Winters Putah Creek Committee collaborated with the Solano County Department of Environmental Management, the California Coastal Commission, the UC Putah Creek Riparian Reserve; and at different times, the cities of Davis and Winters and Yolo County, to conduct annual fall cleanups as part of the Coastal Commission's Fall Coastal Cleanup events, which became the Coastal and Creek Cleanup Days. The cleanups were focused primarily on public lands, including the UC Davis Putah Creek Riparian Reserve, City of Davis South Fork Preserve, and Winters Putah Creek Park. Solano County acquired a grant and has since removed several illegally dumped vehicles from Lake Solano.

With formation of the LPCCC in 2000, Putah Creek Streamkeeper and LPCCC have become directly involved in coordinating and seeking out grant funds for cleanups. Beginning in 2001, the Putah Creek Council and Winters Putah Creek Committee, in collaboration with the LPCCC and Putah Creek Streamkeeper, began to collaborate on regular spring cleanup events to complement the fall events and broadened the focus to include private lands of willing and interested landowners.



Source: EDAW 2004

Erosion, Source Discharges, and Characteristic Trash Sites

EXHIBIT 4-6

Lower Putah Creek Watershed Management Action Plan
P 1T136.02 01/04

0 0.5 1
MILES
NORTH
EDAW

Since 1998, over 2,500 hours by more than 500 volunteers have been spent removing an estimated 150 cubic yards (30 tons) of trash at approximately 20 public and private property sites during annual fall and spring clean-up events sponsored by the Putah Creek Council and Winters Putah Creek Committee. In addition, over 1,000 tons of trash have been removed since 2001 from four private properties using funds provided by the CalEPA Integrated Waste Management Board (CIWMB), in coordination with the LPCCC and Putah Creek Streamkeeper. Several additional sites have been proposed and funded for cleanup. Several programs and groups have funded cleanup efforts including, CIWMB Farm and Ranch Solid Waste Cleanup Abatement Grant Program, California Bay-Delta Authority, the Coastal Commission, and the Putah Creek Council. In addition, numerous local businesses in Davis and Winters have generously donated refreshments and goods to support the cleanups, and local landfills have donated drop boxes and waived disposal fees.

Yolo County Waste Management Programs

Yolo County does not have a program for cleaning up dumpsites on private property. If illegal dumping occurs in the county right-of-way, alongside county roads, or on other county property, the county will have it removed (Moore, pers. comm., 2003). Rural areas around Davis have the option of paying for Davis Waste Removal garbage pick-up service with once a week pick-up service available. There is limited service available for curbside recycling pick-up. Rural areas around Winters can also pay a monthly fee for Davis Waste Removal services. There is no curbside recycling offered for rural Winters. Other Yolo County programs include:

<u>Household Hazardous Waste Drop-Off Day:</u> Program for Yolo County residents to dispose of hazardous wastes at the Yolo County Central Landfill, limited to 125 pounds of solid waste or 15 gallons of liquid waste, not for business or agriculture.

<u>Other Hazardous Waste Programs:</u> Used motor oil, oil filters, and automotive and household batteries can be recycled at the Yolo County Central Landfill or the Esparto Convenience Center.

Businesses in Yolo County generating smaller amounts of waste are eligible for the Conditionally Exempt Small Quantity Generator (CESQG) Hazardous Waste Collection Program.

Yolo County Central Landfill is participating in an innovative strategy to manage solid waste. The controlled land-filling may be able to provide energy generation from solid waste, as well as significant environmental and solid waste management benefits.

As of 2003, the Yolo and Solano Resource Conservation District (RCD) is eligible to apply for funds from the Farm and Ranch Cleanup Program through the Integrated Waste Management Board (IWMB). The Streamkeeper has assisted in preparation of proposals to IWMB, and the RCD has administered the awarded funds. Priority is given to actively-farmed properties that are located adjacent to waterways.

5

Fisheries

5 FISHERIES

This chapter summarizes the historical and current conditions for fisheries in lower Putah Creek. It discusses special-status fish species, introduced and invasive fish and invertebrates, the history of fisheries and stream conditions in lower Putah Creek from the pre-Euro-American settlement period to present, and analyses of spawning habitat and shaded riverine aquatic (SRA) cover habitat in lower Putah Creek. Chapter 4, "Geomorphology, Hydrology, and Water Quality," includes discussions of environmental factors relevant to fisheries (e.g., temperature, mercury). Appendix F provides a list of the common and scientific names of fish species known from lower Putah Creek that are discussed in this chapter.

The primary sources of information for this chapter were both published and unpublished reports on the fish, fisheries, ecology, and natural history of the Putah Creek watershed, along with information provided by specialists knowledgeable on lower Putah Creek fisheries. The primary sources of information were Dr. Peter Moyle, Patrick Crain, Thomas R. Payne and Associates, Dr. Michael Marchetti, Katie Small, Gus Yates, and Ken Davis. Information from Dr. Moyle included studies, presentations, personal communications, and the book, *Inland Fishes of California – Revised and Expanded* (Moyle 2002a). Dr. Michael Marchetti conducted dissertation research on Putah Creek, culminating in scientific papers used in compiling this report. Mr. Yates' report, *Gravel and Temperature Surveys of Lower Putah Creek* (2003), funded by the CALFED Bay-Delta Authority, was used to describe the existing channel substrate and potential spawning habitat conditions in lower Putah Creek. Dr. Moyle, Patrick Crain, and Katie Small also provided analyses and preliminary interpretations of fish sampling data collected between 1990 and 2002 by Thomas R. Payne and Associates fish biologists and UC Davis fish biologists. Ken Davis supplied information on the locations of New Zealand mud snail infestations, an invasive aquatic organism discovered in Putah Creek for the first time in October 2003. The methods used for assessing SRA habitat cover are provided along with the results of that assessment.

5.1 SPECIAL-STATUS FISH SPECIES

This subsection briefly describes native special-status fish species and regulatory requirements pertaining to fish. Laws and regulations pertaining to fisheries are provided in Appendix H, "Permitting, and Regulatory Compliance."

Special-status species include species in the following categories: species listed or proposed for listing as Threatened or Endangered under the federal Endangered Species Act (ESA) or the California Endangered Species Act (CESA); species considered as candidates for listing as Threatened or Endangered under ESA or CESA; species identified by DFG as Species of Special Concern; and species that are fully protected under the California Fish and Game Code.

A total of seven special-status fish species occur or have the potential to occur in lower Putah Creek and are described below. Of the seven species, only Steelhead-Central Valley

Evolutionarily Significant Unit (ESU) is listed as a federally Threatened species. The USFWS de-listed Sacramento splittail from it's federally Threatened status on September 22, 2003. NMFS determined that listing is not warranted for Central Valley fall/late fall-run chinook salmon. However, it is still designated as a candidate for listing because of concerns over specific risk factors. The four remaining species (Pacific lamprey, Sacramento-San Joaquin roach, hardhead, and Sacramento perch) are considered Species of Special Concern by DFG and/or Federal Species of Concern by NMFS or USFWS. Brief descriptions follow for the special-status species with potential to occur in lower Putah Creek.

5.1.1 STEELHEAD

The Central Valley steelhead ESU (*Oncoryhnchus mykiss*) is a Federally threatened species. The Central Valley steelhead includes all naturally spawned populations of steelhead in the Sacramento and San Joaquin rivers and their tributaries (USBR and DWR 2003). Steelhead have a complex life history, including the capability to be anadromous or resident (called rainbow trout) (NMFS 2002 as cited in USBR and DWR 2003). Anadromous species spend most or a portion of their adult life in the ocean and then migrate back into freshwater to reproduce. Spawning and rearing habitat for steelhead typically occurs in perennial streams with clear, cool to cold, fast-flowing water with a high dissolved oxygen content and abundant gravels and riffles (Bovee 1978 as cited in USBR and CDWR 2003). After spending 1–4 years in the ocean, adult steelhead return to their home streams to spawn (Moyle 2002a). Migration into freshwater begins in August and peaks in September–October, after which the steelhead hold until flows are sufficiently high to enable migration into tributaries (Moyle 2002a). Spawning begins in late December and peaks in February–March (Busby et al. 1996). Steelhead eggs hatch in 3–4 weeks (at 50–59°F), and fry emerge from the gravel 2–3 weeks later (Moyle 2002a). After steelhead fry emerge from spawning gravels, they continue to grow and mature in freshwater for 1–3 years before emigrating to the ocean (Moyle 2002a). Unlike salmon, steelhead do not necessarily die after spawning and can spawn more than one time. In central California, most spawning steelhead are 3 years old, with one year spent in the ocean (Busby et al. 1996). Anadromous steelhead are considered to have historically spawned in the upper tributaries flowing into Putah Creek above the Berryessa Valley (now Lake Berryessa) but there have been no recently confirmed reports of anadromous steelhead in the creek. Migratory rainbow trout with a steelhead-like life history continue to spawn in the upper tributaries (Moyle, pers. comm., 2003).

5.1.2 CHINOOK SALMON

Central Valley fall/late fall-run chinook salmon ESU (*Oncoryhnchus tshawytscha*) is a Federal Candidate Species. Fall-run chinook salmon is the most widely distributed and most numerous run occurring in the Sacramento and San Joaquin rivers and their tributaries (USBR and DWR 2003). Chinook salmon is an anadromous fish species that requires cold, freshwater streams with suitable gravel for reproduction. After spending 2–4 years maturing in the ocean, chinook salmon return to their natal streams to spawn (Moyle 2002a). After spawning, eggs generally hatch in 6–12 weeks, and newly emerged larvae remain in the gravel for another 2–

4 weeks until the yolk is absorbed. Juveniles typically rear in fresh water for up to 5 months before migrating to sea. Unlike steelhead, adult chinook salmon die after spawning (Moyle 2002a). Chinook salmon have historically spawned in Putah Creek and, after decades of sparse occurrences, returned to spawn in larger numbers in lower Putah Creek in fall 2003. Descriptions of historic occurrences of salmon in lower Putah Creek and the recent (2003) historic run of salmon are provided in the subsections that follow.

5.1.3 SACRAMENTO SPLITTAIL

Sacramento splittail (*Pogonichthys macrolepidotus*) has been de-listed from its Federal Threatened status but remains a California Species of Special Concern. This large cyprinid (minnow family) is endemic to California and occurs in sloughs, lakes, and rivers of the Central Valley (Moyle 2002a). Sacramento splittail spawns on terrestrial vegetation and debris on floodplains inundated by high spring flows (Moyle 2002a). In wet years, Sacramento splittail are commonly found in the Putah Creek Sinks, in the region where Putah Creek crosses the Yolo Bypass, and the Bypass provides valuable spawning and rearing habitat for splittail (Sommer et al. 1997; 2001). In spring 2004, 24 juvenile splittail were caught in Putah Creek in the reach downstream of the County Road 106 crossing during surveys (Moyle, Crain, pers. comm., 2004).

5.1.4 PACIFIC LAMPREY

Pacific lamprey (*Lampetra tridentada*) is a Federal Species of Concern. Pacific lamprey is an anadromous species that occurs in tributaries from Japan to Alaska to Baja California and spawns in gravel substrate (Moyle 2002a). After spending up to perhaps 3–4 years in the ocean, adult Pacific lamprey move up into spawning streams in early March to late June, with some reports of upstream migration as early as January and February (Moyle 2002a). Pacific lamprey die after spawning; however some adults have been known to survive and spawn again a year later (Moyle 2002a). After eggs hatch in approximately 2–3 weeks, the detritus-eating larvae remain for perhaps 5–7 years in the streams before reaching adulthood and returning to sea (Moyle 2002a). Pacific lamprey are currently present in Putah Creek.

5.1.5 SACRAMENTO-SAN JOAQUIN ROACH

Sacramento-San Joaquin roach (*Lavinia symmetricus* sp. *symmetricus*) is a California Species of Special Concern. It is one of six subspecies of California roach. Sacramento-San Joaquin roach is a small native minnow found throughout the Sacramento-San Joaquin river drainage (with the exception of the Pit River) and tributaries to the San Francisco Bay (Moyle 2002a). Sacramento-San Joaquin roach is abundant in a large number of streams but is now absent from many stream reaches where it once occurred. Sacramento-San Joaquin roach is generally found in small, warm streams. Dense populations are also frequently sighted in isolated pools in intermittent streams. However, within a watershed, roach can be found in a diversity of habitats, from cool headwater streams to warm water areas characterizing many lower stream reaches. It appears to be excluded from many waters by piscivorous (fish-eating) fishes, especially in habitats occupied by introduced piscivorous fishes. Roach is tolerant of relatively high water temperatures (86–95°F) and low oxygen levels, a characteristic that enables it to survive in conditions too extreme for other fishes (Moyle 2002a). Roach reach maturity at 2 or 3 years of age. Spawning occurs between March through early July, when water temperatures exceed 60°F (Moyle 2002a). Sacramento-San Joaquin roach is currently present, but uncommon, in lower Putah Creek and the inter-dam reach. It occurs mainly in the Pleasants Creek tributary (Moyle, pers. comm., 2003).

5.1.6 HARDHEAD

Hardhead (*Mylopharodon conocephalus*) is a California Species of Special Concern. It is a large minnow that resembles pikeminnow. It prefers clear, deep pools and runs with sand-gravel-boulder substrates and slow water velocities. Most of the streams in which it occurs have summer temperatures in excess of 60°F. However, hardhead tends to be absent from streams that have been severely altered by humans and where introduced species, especially sunfish, predominate (Moyle 2002a). Hardhead is widely distributed in low to mid-elevation streams in the main Sacramento-San Joaquin river drainage. Despite its widespread distribution, hardhead populations are increasingly isolated from one another, making them vulnerable to local extinctions (Moyle 2002a). As a result, hardhead is much less abundant than it once was (Moyle 2002a). Hardhead is no longer present in lower Putah Creek (Moyle et al. 1998).

5.1.7 SACRAMENTO PERCH

Sacramento perch (*Archoplites interruptus*) is a Federal Species of Concern and a California Species of Special Concern. It is the only native centrarchid (sunfish) in California. Historically, Sacramento perch was found below 300 feet in elevation throughout the Central Valley, the Pajaro and Salinas rivers, and Clear Lake (Moyle 2002a). Along with the Sacramento pikeminnow (formerly squawfish), it was the dominant piscivorous (fish-eating) fish in waters of the Central Valley. However, Sacramento perch has been extirpated from most of its former range because of the introduction of 11 species of sunfish (Moyle 2002a). Adults do not remain on nests and unguarded eggs are vulnerable to predation. Sacramento perch formerly inhabitated sloughs, slow-moving rivers, and lakes; however, it is now mostly found in reservoirs and farm ponds. Sampling during the 1980s and 1990s indicated that Sacramento perch were no longer present in lower Putah Creek (Moyle et al. 1998). They were re-introduced into the creek in 1997 but failed to become established. However, a small population exists in a pond that drains into Putah Creek (Moyle et al. 2003). Subsequent sampling suggests that Sacramento perch have been unable to maintain a self-sustaining population in lower Putah Creek (Salamunovich, pers. comm., 2003).

5.2 INTRODUCED AND INVASIVE SPECIES

The presence of introduced and invasive fish and invertebrates reflects the history of management objectives and decisions made over time that have altered stream conditions in ways that affect the numbers, types and distribution of fish and aquatic organisms in a stream. An understanding of some of the relationships and needs of these species will help in determining future objectives and decisions for Putah Creek that benefit both fisheries as well as human needs.

5.2.1 Introduced and Invasive Fish

For the purposes of this report, introduced (or exotic), non-native fish are defined as those fish native to other regions of the country or world and introduced intentionally (e.g., for sportfishing, food, mosquito control), or as byproducts of human activity (e.g., release of pet fish, ballast water releases) into California and Putah Creek. Native fish include those that have been in California and Putah Creek for hundreds or thousands of years. Introduced fish are considered invasive if they can drastically reduce, displace, or lead to the extirpation or extinction of native fish species in certain areas or even an entire ecosystem. Determining whether an introduced species is invasive depends both on environmental conditions and whether the species is ecologically similar to the native species (Moyle 2002a). In general, introduced fish often coexist with native fish in relatively undisturbed habitats, while the native species remain dominant (Moyle 2002a). However, introduced species tend to dominate native species in environments highly altered by human activity. If aggressive predatory introduced fish are present (e.g., green sunfish, largemouth bass), they may further threaten native fish populations. Putah Creek is an example of a creek modified by human activities and characterized by a greater diversity and quantity of introduced species than native species (Moyle et al. 2003). However, recent changes to flow releases from PDD are intended to tip the balance in favor of larger native species populations, as is discussed later in this chapter.

An example of the relationship between introduced and native fish species is in the San Joaquin River system where green sunfish are widely distributed in foothill streams. In the undisturbed regions, green sunfish occur only as scattered large adults while native minnows remain abundant. However, where a stream section is dammed or modified in these regions, green sunfish quickly take over and native species become uncommon (Moyle 2002a). Green sunfish are considered invasive in the disturbed areas. However, it important to note that habitat modification could also be responsible for the reduction of native species. Despite poor habitat conditions, native species would likely be present in all disturbed habitats if introduced species were absent (Moyle 2002a).

The reason introduced species generally have negative effects on native species populations stems from the following five types of interactions: competition, predation, habitat interference, disease, and hybridization (Moyle 2002a). *Competition* between an introduced and a native species for limited resources (usually food and space) reduces and sometimes eliminates the native species. *Predation* by introduced fish on native fish is another way that introduced species directly reduce or eliminate native species populations. Larval and juvenile native fishes are particularly vulnerable to predation by introduced species. In lower Putah Creek, largemouth bass are known to feed on native fishes (Moyle et al. 2003). *Habitat interference* occurs when an introduced species' activities change or manipulate the characteristics of the habitat it occupies. These changes can cause native species to leave or suffer reductions in populations (Moyle 2002a). Common carp are known to cause habitat interference by digging up aquatic plants. This increases the amount of suspended matter in the water which, in turn may reduce or eliminate native fish populations that require clear water for sight feeding or breeding. *Diseases*, including parasites, can be brought in by introduced species, especially if they were not quarantined prior to introduction. The diseases may kill or weaken native species that are not immune to them (Moyle 2002a). *Hybridization* (cross-breeding) can occur between two closely related species or subspecies typically producing sterile offspring that cannot reproduce, and result in the reduction or elimination of the native species population.

General declines in native fishes in California and in Putah Creek reflect a changing ecosystem. Measures to protect native fish in Putah Creek could help improve the ecosystem, benefiting both native and valued introduced game species.

5.2.2 INVASIVE AQUATIC INVERTEBRATES

Invasive aquatic invertebrates are introduced invertebrates that can drastically alter the ecology of a body of water such as a lake, stream, estuary, or entire watershed, and as a result, alter, reduce, or eliminate both native and introduced aquatic flora and fauna. Invasive invertebrates can have negative effects on an ecosystem by modifying the food chain and competition, creating habitat interference, and introducing new diseases (see "Introduced and Invasive Fish" subsection above for more discussion on these concepts). Three invasive aquatic invertebrates that may affect or are affecting lower Putah Creek are the Chinese mitten crab (*Eriocheir sinensis*), Asian clam (*Corbicula fluminea*), and New Zealand mud snail (*Potamopyrgus antipodarum*).

CHINESE MITTEN CRAB

The Chinese mitten crab is native to mainland China and coastal areas along the Yellow Sea (Metzler 2003). The crab was first collected in the south San Francisco Bay by commercial shrimp trawlers in 1992 (DFG 1998). By 1998, the mitten crab had spread throughout the Bay and up into the Sacramento River system (Metzler 2003). The Chinese mitten crab reduces the structural integrity of banks and levees, damages fishing nets, clogs fish salvage screens, disrupts ecological structure and function, and is a potential public health concern. The Chinese mitten crab is considered a potential health concern because it is a secondary host to the Oriental lung fluke, which causes tuberculosis-like and influenza-like symptoms in humans who are the final host (Portland State University 2003). However, there is currently no evidence of the presence of Oriental lung fluke in California populations (Moyle, pers. comm., 2003).

Thomas R. Payne and Associates staff captured two Chinese mitten crabs in Putah Creek at Stevensons Bridge on July 8, 1998, and three additional mitten crabs were captured on October 14 and 15, 2002, one each at Los Rios Check Dam, County Road 106A, and Mace Boulevard (Salamunovich, pers. comm., 2003). At present, there is not much concern about the Chinese mitten crab affecting Putah Creek. Mitten crabs are found in low abundance throughout the San Francisco Bay Estuary. Like many new invaders, their populations exploded at introduction but have now tapered off dramatically (Moyle, pers. comm., 2003).

ASIAN CLAM

The Asian clam (*Corbicula fluminea*) is native to temperate and tropical southern Asia, the southeast Asian islands, central and eastern Australia, and Africa (USGS 2000). The first collection of Asian clam in the United States occurred in 1938 along the banks of the Columbia River near Knappton, Washington (USGS 2000). The clam has since spread throughout the United States and is now found in 38 states and the District of Columbia. Ecologically, the Asian clam alters benthic substrate and competes with native species for limited resources. Asian clams are dominant in some riffles along Putah Creek, but their impacts on the creek are presently unknown (Moyle, pers. comm., 2003).

NEW ZEALAND MUD SNAIL

The New Zealand mud snail (*Potamopyrgus antipodarum*) is a small, 0.01- to 0.2-inch-long (0.25 to 5 mm), aquatic mud snail native to lakes and streams of New Zealand. Information on the mud snail and current protocols for minimizing its spread are provided in Appendix G. Removed from the native predators and parasites of its native range, the mud snail has the potential to harm river and stream ecosystems in areas it has been introduced to in North America. It was first reported in England in 1859 and is now widespread there and in several other countries in Europe (Zaranko et al 1997). It is also widespread in Australia. The New Zealand mud snail was first reported in North America in 1987 when it was discovered in the Snake River near Twin Falls, Idaho (Taylor 1987). Since then it has been found in the Columbia and Yellowstone rivers, in the Grand Canyon sections of the Colorado River, and in Lake Ontario. It was first detected in California in the Owens River in 2000. The New Zealand mud snails found in the western U.S. are clones that are genetically similar to specific clones found in Australia and the North Island of New Zealand. The western U.S. populations are dominated by female mud snails that are capable of producing asexually (Dybdahl 2002, Crosier et al. 2004).

The invasive mud snail was first discovered in Putah Creek by Sacramento aquatic biologist Ken Davis on October 30, 2003. By December 2003, the known infested area of Putah Creek was an approximately half-mile-long zone near Fishing Access Site #3 (Appendix G). Based on samples taken, the average density as of November 2003 was about 1,000 mud snails per square yard.

Following detection in lower Putah Creek, the snail was found in the lower Mokelumne River in December 2003 and an 11-mile stretch of the lower Calaveras River-Mormon Slough in January 2004 (Bergendorf 2004). There is no reported documentation as to how the mud snails may have been introduced or spread in California. It has been speculated that the mud snail may have been transported to lower Putah Creek on fishing or boating equipment previously used in infested locations, although other vectors may have accounted for its introduction.

The New Zealand mud snail inhabits both fresh and brackish water and has been found in water up to 26 parts per thousand (ppt) salinity (Winterbourn 1970), with tolerance to higher salinity levels for short duration (i.e., 7 days at 30 ppt) (Hylleberg and Siegismund 1987). However, experimental work indicates that it is active only in water below 17.5 ppt (Winterbourn 1970). The New Zealand mud snail can form dense populations of 500,000 or more individuals per square meter (Richards 2003, Riley 2002). It is as yet uncertain how much of an impact the New Zealand mud snail may have on fish and wildlife populations and ecosystems or on infrastructure such as drinking water conveyance systems. However, documented evidence thus far indicates there may be cause for concern that impacts to ecosystems or infrastructure may occur. Monitoring, education to prevent its spread, and research on whether and how to control the mud snail is on-going.

Preliminary studies indicate the New Zealand mud snail alters primary production (i.e., algae growth) and can result in algal blooms, possibly through nutrient enrichment (Riley 2002). Macroinvertebrates composition and production are also altered in areas where it has been introduced. Kerans (2001) found that 25% to 50% of the macroinvertebrate assemblage consists of the New Zealand mud snail in studies in Yellowstone National Park, with negative correlations found between the snail and mayfly, stonefly, and caddis fly taxa. Hall et al. (in preparation) found that 65% to 92% of the total invertebrate biomass in three Yellowstone Rivers in 2000–2001 studies were New Zealand mud snails. Cada (2003) and Anderson (2002) have found that brown trout and other fish, particularly sculpins, have shown reduced growth in areas infested by the snail, attributed to the reduced densities of macroinvertebrates those fish favor as food. Additionally, the fish have been found to avoid eating the New Zealand mud snails, indicating that the mud snail is not an alternative source of forage. The mud snail appears to be largely indigestible to fish and birds present here because of the mud snail's small size, its shell, and an operculum that it closes tightly, thus protecting its inner body from external digestive fluids (Buttermore 2003). It survives the stomachs of trout for 2.5 to 5 hours (Dwyer 2001) and can survive 20–50 days out of water (Winterbourn 1970). In addition to known and potential impacts to biological systems, the mud snail may become problematic in some drinking water systems or other water conveyance infrastructure. The mud snail has been reported to pass through water pipes and emerge from domestic taps (Ponder 1988) and to block waterpipes (Cotton 1942).

Researchers have found no way thus far to eradicate the mud snail. Fishermen are especially key in preventing the spread of the mud snails to other streams, although it is conceivable that birds and other wildlife could also spread the mud snail. Mud snail posters (Appendix G) were posted along lower Putah Creek by the Putah Creek Council (PCC), LPCCC, and fishing groups within weeks after its discovery to help educate fishermen and the public regarding the mud snail and precautions that should be taken to prevent the spread of this invasive species. Fishing access sites in the vicinity of the infestation were temporarily closed to the public in an effort to contain the infestation and prevent its spread to other areas along Putah Creek and other waterways. However, the signage and closure were insufficient to stop the spread of the snail along Putah Creek. As of June 2004, the New Zealand mud snail has been detected 6 miles downstream of the PDD during ongoing surveys by Ken Davis. Mr. Davis has also found several juveniles in drift material (Marovich, pers. comm., 2003), indicating that to be a primary dispersal mechanism.

5.3 History of Fisheries on Putah Creek

This subsection provides a historical account of Putah Creek and its fisheries from the period prior to Euro-American settlement to the present. The historical account is divided into sections that are based on periods of different human modifications to the creek and information limited to certain years and time periods. Conditions from four periods are described: (1) prehistoric (prior to mid-1800s), (2) Euro-American settlement (late 1800s through 1950s), (3) Solano Project (1960s to Putah Creek Accord (2000)), and (4) Putah Creek Accord. The Solano Project period is further divided into subsections describing conditions in the interdam reach and lower Putah Creek below the PDD, areas that developed unique characteristics following construction and operation of the Solano Project. The Putah Creek Water Accord is focused on lower Putah Creek below the PDD.

5.3.1 Prehistoric Conditions (Prior to Mid-1800s)

There is no written documentation from this period. Much of this information is based on the assumptions of fisheries experts and existing scientific evidence, such as current fish distributions, habitat conditions and species assemblages of native fish in relatively pristine areas.

Stream Conditions

Prior to Euro-American development in the region, Putah Creek flowed out of the mountains spreading out to the Sacramento Valley to the east and southeast, depositing a delta-like sheath of silts, sands, and cobbles moved by major flood events. As this sediment deposition elevated the creek bed, Putah Creek changed its course often, leaving levee-like strips of gravel flanking the channel and finer silt deposits outside of these strips. Subsequent flood events overtopped these natural levees as the creek sought new configurations. This process caused the creek to meander radially across the alluvial fan, depositing sediment as it went (Thomasson et al. 1960).

Prior to Euro-American settlement, lower Putah Creek was flanked by a continuous broad corridor of riparian forest from the Coast Ranges to the Yolo Basin where the creek emptied into an extensive marsh dominated by tules (*Scirpus* spp.) (Kuchler 1977, Katibah 1984). Historical maps and detailed soil surveys indicate that the riparian forest of lower Putah Creek was quite extensive. It covered an estimated area of between 22,000 and 65,000 acres from the site of present-day Winters to the Putah Creek Sinks (Kuchler 1977, Katibah 1984). In most years following winter and spring storms, lower Putah Creek flooded its extensive floodplain riparian forest and the tule marshlands in the Putah Creek Sinks, with portions remaining impassable except by boat for much or all of the wet season (Derby 1849).

The lower Putah Creek watershed was home to the Patwin people, who settled in this area because of the natural abundance of fish and game and its reliable source of water (Russell and Coil 1940). Archaeological studies indicate that the Patwin relied on resident fish for food, such as Sacramento perch, thicktail chub, Sacramento pikeminnow, and tule perch (Kroeber 1932, Schultz and Simons 1973). They also harvested anadromous fish such as Chinook salmon and sturgeon (Schultz 1994).

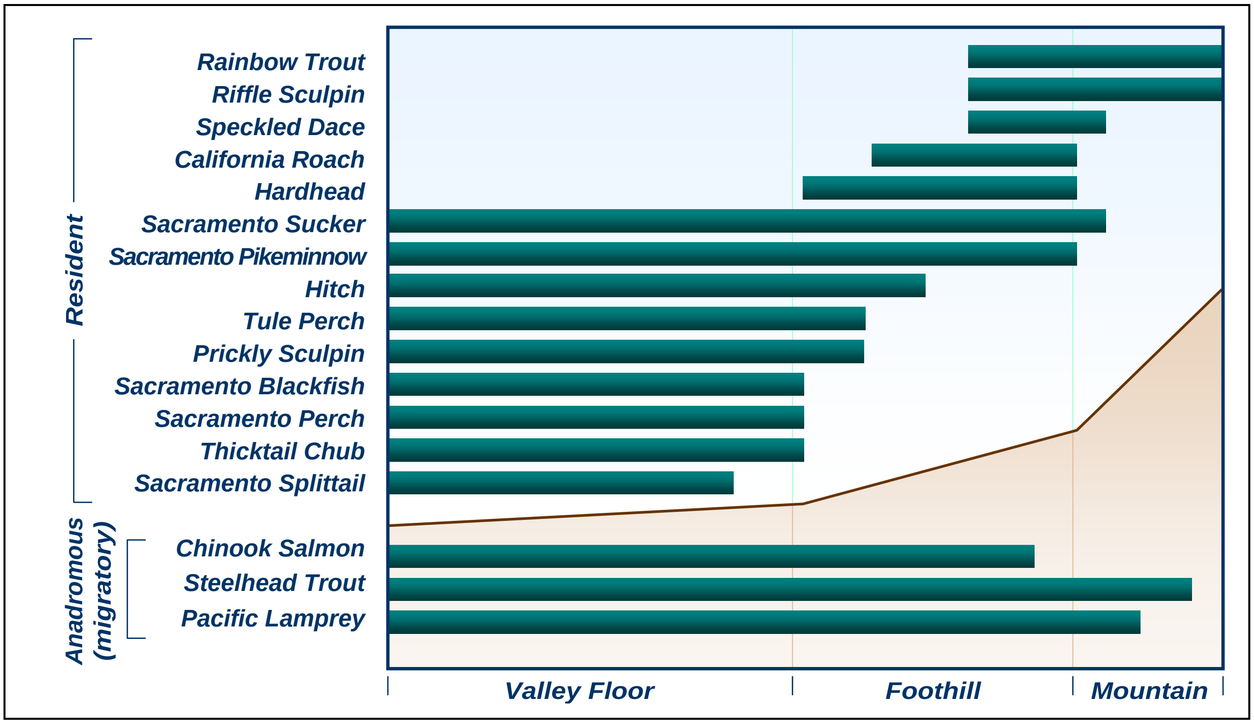
FISHERIES

The historical distribution of common native fishes in Putah Creek reflects the historical distribution of common native fishes in the Central Valley drainage (Moyle et al. 1998). Central Valley streams have headwaters in mountain areas and flow through steep canyons and deep pools in the foothills before flowing into slow-moving rivers or lakes on the valley floor. The habitats found in mountains, foothills, and the valley floor contained distinct assemblages of fish that had wide or narrow zones of overlap, depending on the gradient of the stream and other environmental conditions. In tributaries to the Sacramento River, the overlap among regions with distinct assemblages (often called zones) was fairly broad. Four assemblages can usually be recognized in Central Valley streams: (1) the rainbow trout assemblage, (2) the pikeminnow-hardhead-sucker assemblage, (3) the California roach assemblage, and (4) the deep-bodied fishes assemblage (Moyle 2002a). Each of these assemblages and their likely historical distribution in Putah Creek are described below.

Historically, Putah Creek supported populations of all native resident fishes of the Sacramento Valley in a series of assemblages that change with elevation (Exhibit 5-1) (Moyle et al. 1998). Anadromous fishes, including steelhead, fall-run chinook salmon, and Pacific lamprey, were also present in low numbers (Moyle et al. 1998).

Rainbow Trout Assemblage

The high elevation reaches of Putah Creek near Cobb Mountain supported the rainbow trout assemblage. This zone is characterized by clear streams at high elevations where stream gradients are high (usually a total drop of at least 15 feet for every mile of stream). The water is cold, seldom exceeding 21°C (69.8°F), and is saturated with oxygen. Stream bottoms consist mostly of cobbles, boulders, and bedrock. The banks are well shaded and frequently undercut; logs and root wads often extend into the water, creating pools and other cover. There are few submerged or emergent aquatic plants, except where streams flow through boggy alpine meadows. In the high elevation reaches, the dominant native fish was rainbow trout, but sculpin (usually riffle sculpin), Sacramento sucker, and speckled dace were often part of this assemblage. California roach also may have been found in these reaches (Moyle 2002a). California roach are found in upper Pope Creek, a tributary of Lake Berryessa. (Moyle, pers. comm., 2003).



Source: Moyle et al. 1998

Historic Distribution of Common Native Fishes in the Central Valley Drainage of California, Including Putah Creek

EXHIBIT 5-1

Pikeminnow-Hardhead-Sucker Assemblage

The foothill area of Putah Creek supported the pikeminnow-hardhead-sucker assemblage, which occurred at elevations between about 270 and 1,700 feet (Moyle 2002a). This area would most likely have been the stretch of Putah Creek southeast of Cobb Mountain to the location of the present-day PDD. The pikeminnow-hardhead-sucker fish assemblage zone is characterized by streams that have average summer flows greater than 10 cfs; deep, rocky pools; and wide, shallow riffles. Water quality is usually very good (high clarity, low conductivity, high dissolved oxygen, and summer temperatures between 19 and 22°C [66.2 to 71.6°F]), with complex habitat created by stream meanders and riparian vegetation. However, some streams may become intermittent in summer, or have such reduced flows that fish are confined to pools. Summer water temperatures in such streams may exceed 25°C (77°F) and may track air temperatures closely.

Sacramento pikeminnow (formerly squawfish) and Sacramento sucker were usually the most abundant fishes of this assemblage. Other fishes that were part of this assemblage include hardhead, tule perch, speckled dace, California roach, riffle sculpin, and rainbow trout. Anadromous fishes (mainly chinook salmon, steelhead rainbow trout, and Pacific lamprey) had spawning grounds in the same zone (Moyle 2002a). The Berryessa Valley, which is now filled by Lake Berryessa, and its tributaries supported spawning grounds for chinook salmon and

Pacific lamprey that would migrate upstream during high winter flows (Moyle 2001b). Steelhead probably continued up through the Berryessa Valley and spawned in Putah and Pope Creeks (Crain, pers. comm., 2003).

California Roach Assemblage

The California roach assemblage occurred in small, warm tributaries such as Pleasants Creek, to larger streams that flowed through open foothill woodlands of oak and foothill pine (Moyle 2002a; Moyle, pers. comm., 2003). Streams that supported the California roach assemblage are located in the foothills in much of the same region that contained the pikeminnow-hardhead-sucker assemblage. The streams were usually intermittent during summer, so fish were often confined to stagnant pools that may have exceeded 30°C (86°F) during the day. In winter and spring the streams were swift and subject to flooding. The primary permanent resident in this zone was the California roach. Because of its small size and tolerance of low oxygen levels and high temperatures, roach survives where most other fish cannot. During winter and spring, Sacramento sucker, pikeminnow, and other native minnows may have used the streams for spawning and rearing (Moyle 2002a).

Deep-Bodied Fish Assemblage

A deep-bodied fish assemblage occupied the warm waterways of the valley floor, including slow-moving channels, oxbow and floodplain lakes, swamps, and sloughs (Moyle 2002a). This zone would have occurred in the floodplain of Putah Creek that begins where the PDD is now located, and continued east through the Yolo Basin to the Sacramento River.

Fishes of the deep-bodied fish assemblage were found in a variety of habitat types ranging from stagnant backwaters and shallow tule beds to deep pools and long stretches of slow-moving river water (Moyle 2002a). Sacramento perch, thicktail chub (*Gila crassicauda*), tule perch and juvenile fishes predominated in the weedy backwaters while specialized adult cyprinids such as hitch (*Lavinia exilicauda*), Sacramento blackfish, and Sacramento splittail occupied large stretches of open water. There was also an abundance of large pikeminnows and suckers in this zone, which migrated upstream to spawn in tributaries in the spring. Anadromous salmon, steelhead and lampreys passed through this zone on their way upstream to spawn (Moyle 2002a).

5.3.2 EURO-AMERICAN SETTLEMENT PERIOD CONDITIONS (LATE 1800S THROUGH 1950S)

STREAM CONDITIONS

Historic hydrology and geomorphology of Putah Creek are discussed in section 4.3.1, "Hydrology Prior to the Solano Project." Riparian vegetation was continually removed along Putah Creek to accommodate the expansion of agriculture in the area (Shapovalov 1946), but the greater effect on fish was likely due to vegetation removal in the channel itself that was performed by the USACE. The narrowing of the riparian corridor and removal of overhead shade cover allowed for greater warming of the water. The flood control modifications also likely reduced flow velocities and increased the ratio of still to flowing water by widening the channel and eliminating floodplains within the incised channel (Marovich, pers. comm., 2003). The lower flow velocities and higher ratio of still to flowing water would have increased the residence time of water in the channel, resulting in higher average water temperatures that also favored exotic fish (Marovich, pers. comm., 2003). These alterations probably increased habitat for introduced warmwater species such as common carp, bluegill, and smallmouth bass, because they thrive in environments that have been modified/disturbed (i.e., by vegetation removal, channel modification), whereas native species generally do not do well in disturbed environments.

Leo Shapovalov, a DFG biologist, described summer baseflow conditions in upper and lower Putah Creek in his 1940 report (Shapovalov 1940). Shapovalov's descriptions, considered together with a review of historical topographic maps and interviews of historical witnesses, documented that there was perennial flow throughout the following reaches of Putah Creek and perhaps additional reaches: (a) upper Putah Creek from the confluence with Capell Creek to Devil's Gate (approximately 7 miles long—this stretch of Putah Creek is now at the bottom of Lake Berryessa), (b) between the present day sites of Monticello Dam and the Pleasants Valley Road Bridge over present day Lake Solano (approximately 6 miles long), and (c) lower Putah Creek near Stevensons Bridge. Shapovalov's data documented that in most years there were permanent pools and surface flows over short reaches where emergent groundwater entered the creek in the vicinity of Stevensons Bridge (Shapovalov 1940). Records from the DWR Putah Creek Cone Investigation (1955) and the USGS Water Supply Paper 1464 (Thomasson et al. 1960) also support Shapovolov's findings (Jones & Stokes Associates [JSA] 1992). During the July–October period of 1949–1954, DWR and USGS recorded stream flows at Stevensons Bridge when no flow occurred at both Winters and Davis (DWR 1955; Thomasson et al. 1960).

In 1959, Reclamation completed the Solano Project consisting of two water storage facilities and a water delivery system: Monticello Dam, PDD, and Putah South Canal. Water deliveries began on May 15, 1959. The project resulted in the highly regulated streamflow regime that currently exists in lower Putah Creek. Details of the Solano Project and the effects it had on the hydrology of Putah Creek are provided in Chapter 4, "Geomorphology, Hydrology, and Water Quality."

FISHERIES

The first formal records describing fish species in lower Putah Creek were developed by ichthyologists from Stanford University and the California Academy of Sciences and published in 1912. Researchers collected a diverse assemblage of native fish, including Sacramento splittail, hardhead, and thicktail chub. These fish and other Putah Creek native fish were large (8 inches as adults), long-lived species that would have required permanent water to maintain these populations of fish during the period that they were collected (Trihey & Associates 1996).

Many non-native fishes were introduced or spread into the creek starting in the late 19th century. Species such as white catfish, bluegill, smallmouth bass, and common carp eventually came to dominate the fisheries in the creek. Smallmouth bass were in the foothill reach along with carp (escapees from ponds in the Berryessa Valley) and probably catfish as well (Moyle et al. 1998; Moyle, pers. comm., 2003).

5.3.3 SOLANO PROJECT PERIOD CONDITIONS (1960S TO PRESENT)

The Solano Project was completed in 1959. It enabled provision of important water resources for thousands of farmers, rural homes, and urban residences and businesses throughout Solano County, as well as recreational opportunities users throughout the region. A description of the Solano Project and its impor tance to water users can be found in "The Solano Water Story – A History of the Solano Irrigation District and the Solano Project (Rubin, Kahn and Kahn, 1988). However, it also greatly modified Putah Creek and its fisheries. Putah Creek waters were impounded by the Monticello Dam, flooding the Berryessa Valley and creating Lake Berryessa. PDD, constructed 6 miles downstream from Monticello Dam, impounded flows in the "interdam reach," creating Lake Solano. This subsection provides an account of the changes that occurred to Putah Creek and its fisheries following completion of the Solano Project, including changes to fisheries taking place following implementation of the Putah Creek Water Accord.

PHYSICAL CHANGES TO LOWER PUTAH CREEK

Altered flow regimes have profound effects on the ecology of streams (Marchetti and Moyle 2001). These include changes in physical characteristics such as channel structure, sediment transport, and thermal regime, and changes in biological characteristics such as species diversity, trophic structure, and community composition. Usually, the most obvious ecological effect of stream regulation is a collapse or change in fish populations (Marchetti and Moyle 2001).

The Solano Project resulted in major changes to hydrological and geomorphological patterns in the creek, discussed in more detail in Chapter 4, "Geomorphology, Hydrology, and Water Quality." It also resulted in three separate fish communities in Putah Creek: the upper watershed reach, consisting of Lake Berryessa, the upper creek, and tributaries above Monticello Dam; the interdam reach, between Monticello Dam and PDD; and lower Putah Creek below the PDD. The fish in the upper watershed and interdam reaches, amounting to approximately 90% of the total Putah Creek watershed area became isolated from each other and separated from the fish below the PDD, as PDD is impassable to migrating fish). Lake Berryessa covers nearly 14 miles of the original Putah Creek channel (Moyle et al. 1998). Putah Creek now supports a cold-water trout fishery extending downstream from Monticello Dam to 1 to 2 miles below the PDD, with cool-water habitat down to about Pedrick Road (Road 98) and warm-water habitat from Pedrick Road to the Yolo Bypass.

INTERDAM REACH

The interdam reach is a 6-mile-long section of lower Putah Creek beginning at Monticello Dam and ending at the PDD. The PDD created the Lake Solano, an approximately 1.5-mile-long reservoir. Water from Putah Creek is impounded at PDD. Between Monticello Dam and Lake Solano, several fishing access sites were established following creation of a cold-water trout fishery, discussed below. The access sites are owned by DFG and managed by the Yolo County Parks Department. (Chapter 3, "Land Ownership, Land Use, & Resource Management Programs," includes discussions of recreational areas and opportunities.)

Stream Conditions

With construction and operation of the Monticello Dam, the cold water released from the bottom of Lake Berryessa converted the interdam reach from a warm water reach to a cold-water reach (USFWS 1993). Sediment transport patterns to and through this reach were greatly altered as sediment from the upper watershed was impounded above Monticello Dam and sediment from interdam tributaries including Thompson Creek, Pleasants Creek, and Cold Creek began filling the newly created Lake Solano. A portion of the capacity of Lake Solano was quickly lost due to sediment accumulation soon after the lake was formed. In recent years, Lake Solano has reached equilibrium where sediment inflows are equal to sediment outflows during high-water events with little effect on capacity (Northwest Hydraulics, 1998). Year-round flows from Monticello Dam and a lack of vegetation clearing may have led to what is now considered some of the best riparian habitat in the region (Kemper 1996).

Fisheries

The interdam reach is typical of stream reaches below many dams. Prior to construction of the Monticello Dam, this portion of the creek was a perennial stream that supported populations of native fishes and introduced game fish such as smallmouth bass and channel catfish. Following construction of the dam, however, the reach became a year-round cold-water trout stream because cold water is released from the bottom of Lake Berryessa (USACE 1993, Shapovalov 1947).

The interdam reach is managed by DFG during spring and summer as a "put and take" fishery for hatchery-reared rainbow trout. The winter fishery is primarily for wild, naturally spawned rainbow trout and hatchery-origin brown trout. On an annual basis, DFG indicated that this reach has one of the highest rates of angler use per mile of any similar-sized stream in the state (USFWS 1993) (Exhibit 5-2). Currently, the creek supports a relatively healthy and productive cold-water fishery, including a population of naturally reproducing rainbow trout (USFWS 1993).

To help maintain the quality of the trout fishery, the interdam reach has twice been subjected to chemical treatment with rotenone, in 1955 and 1971, prior to stocking with rainbow trout (USFWS 1993). Treatment was focused on carp and native fishes on the false assumption that

Local fly fishing enthusiast Bernie Weston and rainbow trout caught in late 2003 in the interdam reach. The Putah Creek interdam reach, between Monticello Dam and the Putah Diversion Dam at Lake Solano, is widely known for trout fishing.

A 30-inch adult chinook salmon that was captured in the boulder riffle/pocket water area 100 feet below Putah Diversion Dam in October 2003.

Source: Steve Spiller, Thomas R. Payne and Associates, 2003

Trout Fishing and Salmon Returning

EXHIBIT 5-2

EDAW

they compete with trout. The rotenone treatment probably had little to do with the success of the fishery; the fishes that were poisoned do not typically thrive in cold water anyway (Moyle, pers. comm., 2003). Cold flows and heavy planting was likely all that was needed to promote a trout fishery (Moyle, pers. comm., 2003).

Despite past efforts with chemical treatments, trout still share the interdam reach with native and non-native non-game fish today. Fish inhabiting the interdam reach can be divided into three categories: introduced game fish, introduced non-game fish, and resident native fish. Introduced game fish stocked by the DFG include rainbow trout, brown trout, and brook trout. Before 1973, DFG stocked fingerling rainbow trout that presumably developed into the naturally reproducing population that currently exists (USFWS 1993). Catchable rainbow trout were planted in 1962. Brook trout were planted in 1966 (Salamunovich, pers. comm., 2003). Catchable-sized rainbow trout have been stocked on a yearly basis since 1973. DFG records show that between 1961 and 1985, 81% of the stocking were rainbow trout, 18% were brown trout, and 1% were brook trout. However, there are no longer brook trout in lower Putah Creek (Moyle, pers. comm., 2003).

The native fish that still persist in the interdam reach today include hitch, California roach (Sacramento-San Joaquin subspecies), Sacramento pikeminnow, Sacramento sucker, three-spine stickleback, and riffle sculpin. In October 2003, New Zealand mud snail was discovered in this reach, near Fishing Access Site #3 (see Section 5.2, "Introduced and Invasive Species") raising concerns about potential impacts to trout and other fish species.

LOWER PUTAH CREEK DOWNSTREAM OF PUTAH DIVERSION DAM

Stream and fisheries conditions in lower Putah Creek downstream of the PDD have been affected and shaped by several factors, including aforementioned flood control grading and vegetation removal, gravel mining, blocking off of the North Fork channel, construction of the South Fork, construction of the Solano Project, operation of the PDD, and, in May 2000, settlement and implementation of the historic Putah Creek Water Accord. This subsection discusses the stream and fisheries conditions following operation of the Solano Project and following implementation of the Accord.

Stream Conditions Prior to Water Accord (1960s to 2000)

Construction and operation of the Solano Project had major effects on flows and sediment conditions downstream of the PDD. These are discussed in detail in Chapter 4, "Geomorphology, Hydrology, and Water Quality," and in the subsection, "Spawning Habitat Conditions in Lower Putah Creek," below. In general, the Solano Project substantially decreased total annual discharges through lower Putah Creek compared with pre-project conditions. Prior to construction and operation of the Solano Project, the estimated average annual flow was about 375,000 acre-feet, with most of the discharge occurring during the wet season (December through April) (Jones & Stokes 1992). Following operation of the project, the minimum normal and dry year annual releases required (by a 1970 SWRCB decision) were about 22,000 acre-feet and 19,000 acre-feet, or 6 percent and 5 percent of the estimated pre-project discharges, respectively. However, actual flows had been much higher due to reservoir spills. Actual releases averaged 82,600 acre-feet (23% of pre-Solano Project conditions) between 1971 and 1981 (Jones & Stokes 1992). The Project also modified summer hydrological conditions, extending streamflow throughout summer, such that median flows in August through October were higher than during pre-project conditions, and flows were generally present from the PDD to the Yolo Bypass in most years. (See Table 4-2 in Chapter 4, "Geomorphology, Hydrology, and Water Quality.") However, significant periods of reduced flows in the lowest reaches of Putah Creek occurred at various times since the Solano Project became operational. The 1987–1992 drought years were the driest 6-year period on record for the Putah Creek drainage. At the same time, surface water diversions and increased groundwater pumping were further reducing Putah Creek flows due to a shortage of surface water supplies (Sanford, pers. comm., 2003). The reduced releases during drought years, coupled with reduced recharge from the adjacent groundwater table, resulted in the complete dewatering of long stretches of the creek, major fish die-offs, and raised concern for fish habitat and other beneficial functions of Putah Creek.

The impoundment of gravel upstream of the dams has resulted in a lack of gravel substrate in Putah Creek downstream of the PDD. In addition to the reduction in sediment movement downstream following completion of the Solano Project, gravel mining occurred along Putah Creek during the 1960s and 1970s from the PDD to a point 3 miles downstream, and in the vicinity of Pedrick Road (USFWS 1993). It also occurred sporadically in between those two areas and to a lesser extent elsewhere (Marovich, pers. comm., 2003). Channel surveys in 1972 indicated that mining had left a wide, relatively flat channel with a few artificial berms and levees (JSA 1992).

Vegetation clearing activities in the creek channel by state and federal agencies continued through the 1960s and early 1970s. After 1975, when vegetation clearing policies were changed (USFWS 1993), the creek bed stabilized, riparian woodland cover increased, and a seemingly more natural stream channel was created (Moyle 1991).

Lower Putah Creek below the Diversion Dam exhibits a very different character than the interdam reach does. The primary difference is warmer summer water temperatures resulting from low summer flows, deepening of the channel from gravel mining and flood control work, beaver activity, and narrowing of the riparian corridor. In summer, lower Putah Creek is characterized by flowing stretches and more permanent deep pools. Flows to these reaches come from the PDD and are enhanced to a limited extent by flows from the Willow Canal, and by waste water effluent, specifically from the aquaculture facility and sewage treatment plant on the UC Davis campus. Rising groundwater, when present, can also contribute up to 20 cfs depending on the season and hydrologic year (Sanford, pers. comm., 2003). During winter and spring, flows can increase substantially following rainfall events. In years of heavy rainfall, peak flows may result from uncontrolled spills from Monticello Dam when Lake Berryessa is at capacity or by inflow from tributaries upstream or downstream of PDD. Tributaries downstream of Monticello Dam include Thompson Creek, Cold Creek, Pleasants Creek, and

Dry Creek, all of which are largely unregulated and can contribute high flows to lower Putah Creek.

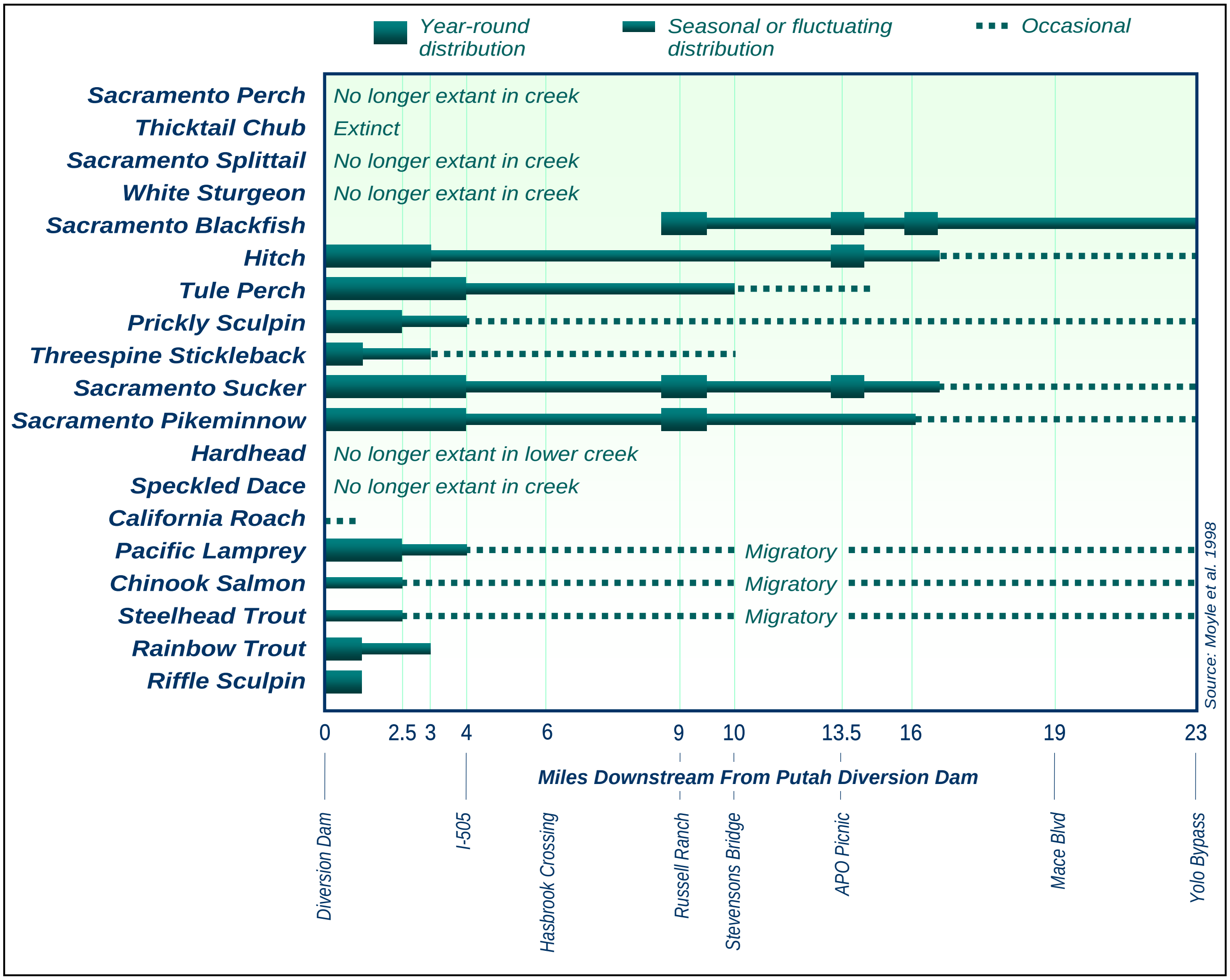
Fisheries Prior to Water Accord (1960s to 2000)

About 40 species of fish have been reported from lower Putah Creek below the PDD, including 17 permanent residents (LPCCC 2003, Moyle 1991, Marchetti and Moyle 2001). The fish species could be divided into four categories: anadromous fish, resident native fish, introduced resident game fish, and introduced resident non-game fish. Sightings of anadromous fish, including spawning activity by small numbers of chinook salmon, occurred when there were adequate late fall and winter flows in Putah Creek, the Yolo Bypass, and the Sacramento River. In addition, based on surveys conducted since the early 1990s, Pacific lamprey larvae are caught in most years (LPCCC 2003).

Native resident fishes in the creek included mainly Sacramento blackfish, hitch, prickly sculpin, riffle sculpin, Sacramento pikeminnow, Sacramento sucker, three-spine stickleback, and tule perch (USFWS 1993). Introduced game species in the creek provided many opportunities for angling. These included species such as brown trout, largemouth bass, smallmouth bass, bluegill, green sunfish, warmouth, white and black crappie, white catfish, channel catfish, black bullhead, and common carp (USFWS 1993, Moyle 1991). Spotted bass were recently discovered in lower Putah Creek although they have long been known to occur in Lake Berryessa (Moyle, pers. comm., 2004).

Two introduced species used as biological agents to control insects by the state, mosquito fish and inland silverside, were extremely abundant in the lower creek. These species served as important prey for piscivorous fish and birds. Goldfish and bigscale log perch populations were likely the result of accidental releases, and other introduced species such as fathead minnow golden shiner and red shiner may have become established as a consequence of discarded fishing bait. Mosquitofish were deliberately introduced into Putah Creek (one of the first sites where they were introduced for mosquito control in California). Silversides came from the Willow Canal (Moyle, pers. comm., 2003). However, any of these species may also have colonized the lower creek from downstream areas during high-flow periods (USFWS 1993).

Exhibit 5-3 depicts the typical distribution of native fish in lower Putah Creek between 1980 and 1995. Of the 19 fish listed, five were listed as no longer present in the creek and one is extinct. Native fish that are no longer present in the creek include thicktail chub, Sacramento splittail, white sturgeon, hardhead, and speckled dace. Hardhead and speckled dace are probably present in the basin above Lake Berryessa (Salamunovich, pers. comm., 2003). Sacramento perch were absent and were re-introduced into the creek in 1997; however, they are not established (Moyle et al. 2003). Most native fish remaining in the creek were prominent mainly in the first 4 miles downstream of the PDD. Four others, including hitch, tule perch, Sacramento sucker, and Sacramento pikeminnow were found to occur seasonally to year-round extending downstream from the Diversion Dam to Stevensons Bridge (tule perch) and downstream of Old Davis Road (hitch, sucker, and pikeminnow). Sacramento blackfish, unique in distribution among the native fish, tended to occur seasonally to year-round in the

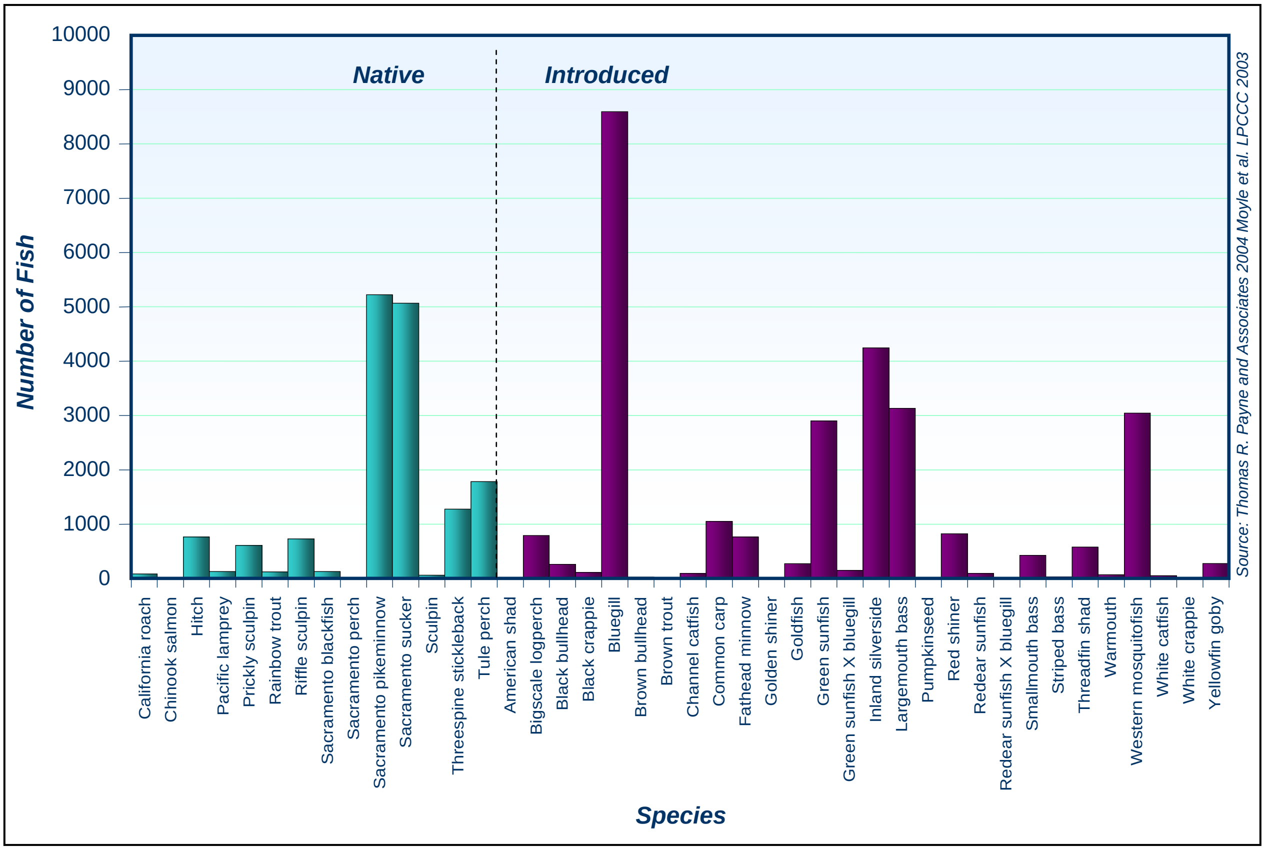


Typical Distribution Pattern of Native Fishes in Lower Putah Creek, 1980–1995

EXHIBIT 5-3

downstream half of lower Putah Creek. Sacramento blackfish is an unusual native fish species because it occurs in warm, usually turbid waters of the Central Valley floor in habitats that are otherwise dominated by non-native species (Moyle 2002a).

Based on lower Putah Creek fish sampling data, 39 species of fish and two hybrid types were collected in lower Putah Creek between 1991 and 2002 (Moyle et al. 2003). Thirteen of these species are native to the creek and 26 species are introduced (Exhibit 5-4). The hybrid types were crosses between introduced species, including bluegill and redear and green sunfish. The most common native fish in the creek included Sacramento pikeminnow, Sacramento sucker, and tule perch, all resident fish. The ten remaining native fish in the creek included eight more resident fish and two anadromous fish. The resident fish included California roach, hitch, prickly sculpin, riffle sculpin, rainbow trout, Sacramento blackfish, Sacramento



Cumulative Fish Catches for Lower Putah Creek, 1991–2000 EXHIBIT 5-4

perch, and three-spine stickleback. The two anadromous fish included Pacific lamprey and fall-run chinook salmon. Common introduced species in the creek included bluegill, green sunfish, largemouth bass, western mosquitofish, and inland silverside.In May 1999, Pacific lamprey were first observed spawning by John Hasbrook, a landowner east of Winters (Putah Creek News 1999). Tim Salamunovich of Thomas R. Payne and Associates observed spawning lampreys upstream of Winters near Dry Creek about one week later (Salamunovich, pers. comm., 1999). The crossing was recently (2003) reconfigured into a "W-weir" by the stream restoration firm Streamwise to maximize spawning habitat for anadromous fishes (Exhibit 5-5) (Marovich 2003).

Regarding the lamprey observations, Tim Salamunovich reported the following: "Canoed Putah Creek from Solano Dam downstream to Old Davis Road on Wednesday and Thursday. Thought you might be interested to known that we saw three Pacific lampreys, 14–18 inches in length, about 1,000 feet downstream of Dry Creek confluence. Two were holding in a shallow riffle area and a third was upstream about 30 feet at the pool tail out constructing a nest under a small limb in the stream. The lamprey was actually picking up the large gravels (4–5 inches)

Before: Pacific lamprey were first observed in 1999 spawning at this low water crossing on the Hasbrook property in Reach 4. In response to this benefit, other landowners have recently expressed interest in installing or augmenting gravels on their properties to provide spawning habitat for anadromous fish.

After: To enhance fish habitat and structural stability, the Hasbrook crossing was re-configured to a W-weir and additional rock was added in September 2003 by the restoration firm, Streamwise. The rocks rise toward the bank to protect against erosion and are submerged at the upstream end to provide for fish passage even at low flows. The project was funded by the USFWS Partners for Wildlife program in cooperation with the LPCCC.

Source: Marovich 2003, EDAW 2003

Anadromous Fish Spawning Habitat Restoration Site

EXHIBIT 5-5

and moving them out of the nest to form the circular "pot." Very interesting to watch. It was amazing how industrious the lamprey was and quite "single-minded" as it continued it nest building despite our presence and movement near its nest." (Salamunovich, pers. comm.,1999). The locations of the two lamprey spawning sites are provided in Subsection 5.4.4, "Potential Spawning Habitat."

During the 1990s, fall-run chinook salmon were only occasionally present in the creek in very low numbers. Chinook salmon were observed spawning near Stevensons Bridge in December 1997 and January 1998 (Sherwin 1998). Chinook salmon juveniles were sampled in spring 1995 at Dry Creek, Old Davis Road, and Mace Boulevard; in spring 1997 at Pedrick Road; and in March 1998 at Mace Boulevard (DWR 2003). However, in late fall 2003, one of the largest runs of chinook salmon occurred in the creek since the completion of the Solano project and is discussed in Subsection, "Post Accord Conditions," below. An estimated 100 fish produced over 30 redds. Steelhead were sometimes reported to occur downstream of the PDD but the reports are unconfirmed (Moyle and Crain 2003).

Fish Distribution in Response to Wet and Dry Year Flow Releases

Species' ranges are a component that can be used to directly evaluate the health of a stream (Moyle et al. 2003). Optimally, a stream is healthiest when all the species in the stream are native to the stream and there are no introduced species, especially no invasive species. In lower Putah Creek, fish sampling by Peter Moyle and Thomas R. Payne and Associates from 1991 to 2002 indicates that the number of introduced species exceeded the number of native species at all but one sampling site. However, the number of individual native fish exceeded the number of introduced fish at many sites, depending on the year (Moyle et al. 2003). Overall, introduced species outnumber native species 26 to 13 species (excluding hybrids) in lower Putah Creek. Once established in a system, introduced fish are difficult to extirpate. However, modifying stream characteristics such as flow volume, channel form, substrate type, riparian corridor width and structure, and overhead vegetation can affect water temperature, water velocity, and other attributes that increase spawning and rearing habitat for most native species while reducing habitat conditions for introduced species. Thus, while introduced species may not be eliminated, conditions can be modified to tip the balance in favor of native species, leading to an increase in their population sizes and distribution.

In their study on the effects of flow regime on fish assemblages in lower Putah Creek, Moyle and Marchetti found that when stream flow increased, the numbers of native fish increased while the numbers of non-native fish decreased (Marchetti and Moyle 2001). Their results indicated that variability in hydrology between years and seasons had a large effect on the fish assemblages in lower Putah Creek. Conditions for native species improved during years with large peak flows in winter and sustained flows in summer, while conditions for non-native species improved during years without high peak flows and with intermittent summer flows (Marchetti and Moyle 2001). High winter and spring flows created conditions that favored reproduction by the native fishes, which typically spawn from mid-February through mid-April. Increased summer flows, such as those resulting from the Accord, also favor native fishes by providing longer reaches of cool flowing water where juveniles could find suitable conditions for rearing. These flows simultaneously reduce the favorability of the habitats for spawning and rearing of non-native fishes. Most of the non-native fishes are summer spawners and favor warm (>75.2°F), quiet water (Marchetti and Moyle 2001).

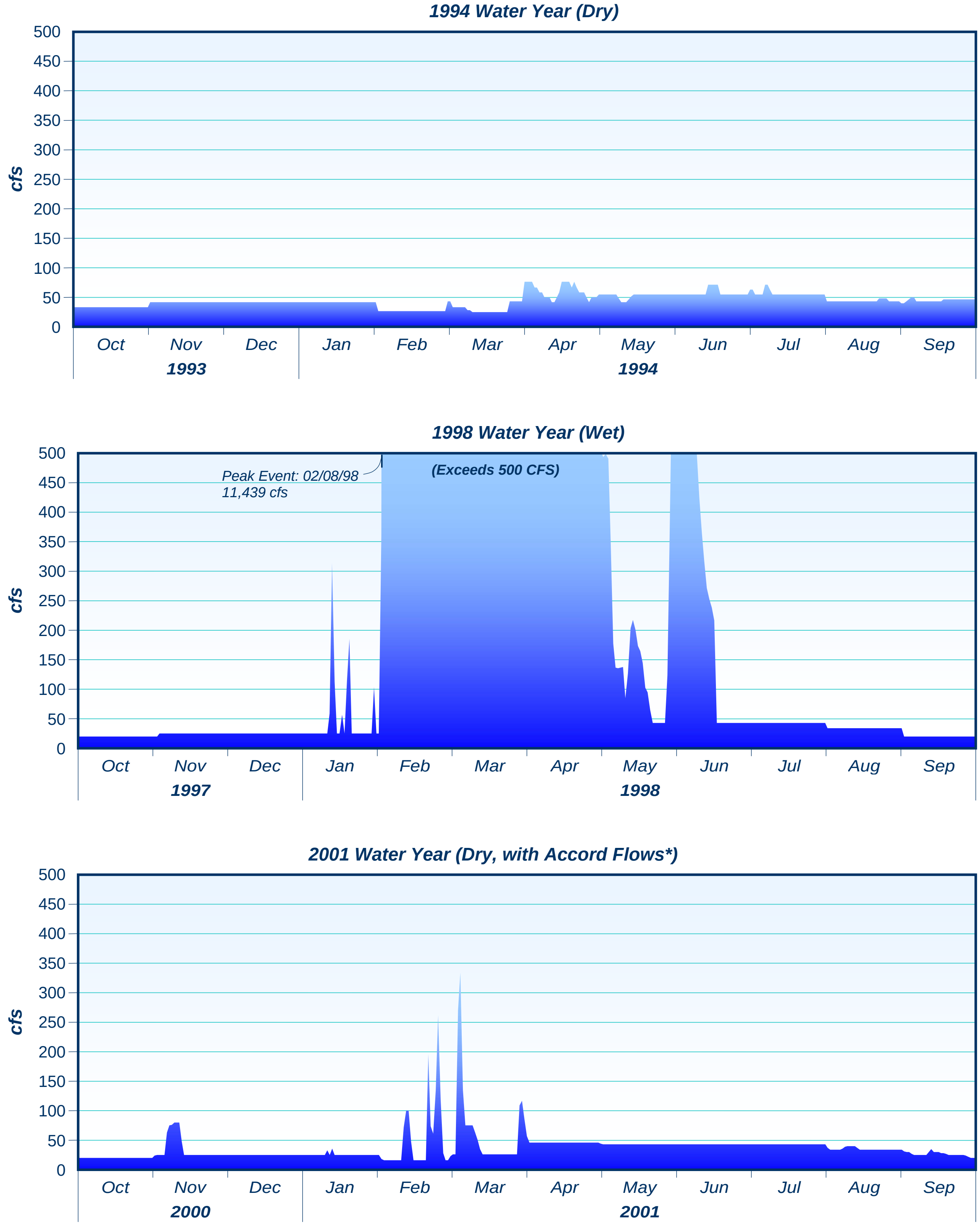
The distribution of native and non-native fish in lower Putah Creek following wet and dry water years reflects Marchetti and Moyle's findings. In studies conducted by Dr. Peter Moyle on Putah Creek, a water year is defined by two parameters: the number of days with PDD releases greater than 50 cfs, and the number of days over 1,000 cfs. A release of 50 cfs is approximately double the quantity of water needed to maintain a continuous flow throughout the creek. An average daily release of 1,000 cfs is equivalent to a flood event. These parameters are used to designate three water year categories: dry, moderate, and wet. Table 5-1, below, provides the criteria for determining water years. Flow releases from the PDD during representative water years are shown in Exhibit 5-6.

Table 5-1
Criteria for Determining Water Year[1] Types in Lower Putah Creek

Water Year Type	PDD Average Daily Releases Exceeding 50 cfs (number of days)	PDD Average Daily Releases Exceeding 1,000 cfs (number of days)
Dry	Less than 30/year	--
Moderate	At least 30/year	Less than 30/year
Wet	At least 50/year	At least 30/year

[1] 1994 Water Year begins October 1, 1993, and ends September 30, 1994.
Source: Moyle et al. 2003

Exhibit 5-7 shows that the percentage of native fish in lower Putah Creek increased in response to the wet year flows of 1996–1999. The characterization of wet, moderate, and dry years is Exhibits 5-8 and 5-9 show the distribution and proportion of native and non-native fish sampled in lower Putah Creek in 1995 and 1999, respectively. Exhibit 5-10 shows the locations of fish sampling sites from 1991 to present. The fish distribution exhibits highlight the proportion of the common native (i.e., Sacramento pikeminnow, Sacramento sucker, and tule perch) and non-native (i.e., bluegill, green sunfish, green sunfish-bluegill hybrid, and largemouth bass) species that occur most frequently. The years shown are representative of fish population patterns following dry (e.g., 1994) and wet (e.g., 1998) years. In general, native fish species were more numerous in the reaches below the PDD and introduced species were more numerous in the lower reaches. However, in a year (e.g., 1995) following a number of dry years, native fishes were mostly concentrated near the Diversion Dam and the number of native fishes declined sharply a short distance downstream from the Dam. In contrast, introduced non-native fish were abundant and dominated all reaches except immediately downstream of the Diversion Dam. Bluegill was the most abundant fish overall in lower Putah Creek in 1995. Both native and non-native fish were present in generally small numbers in all locations in the creek where they did not dominate.



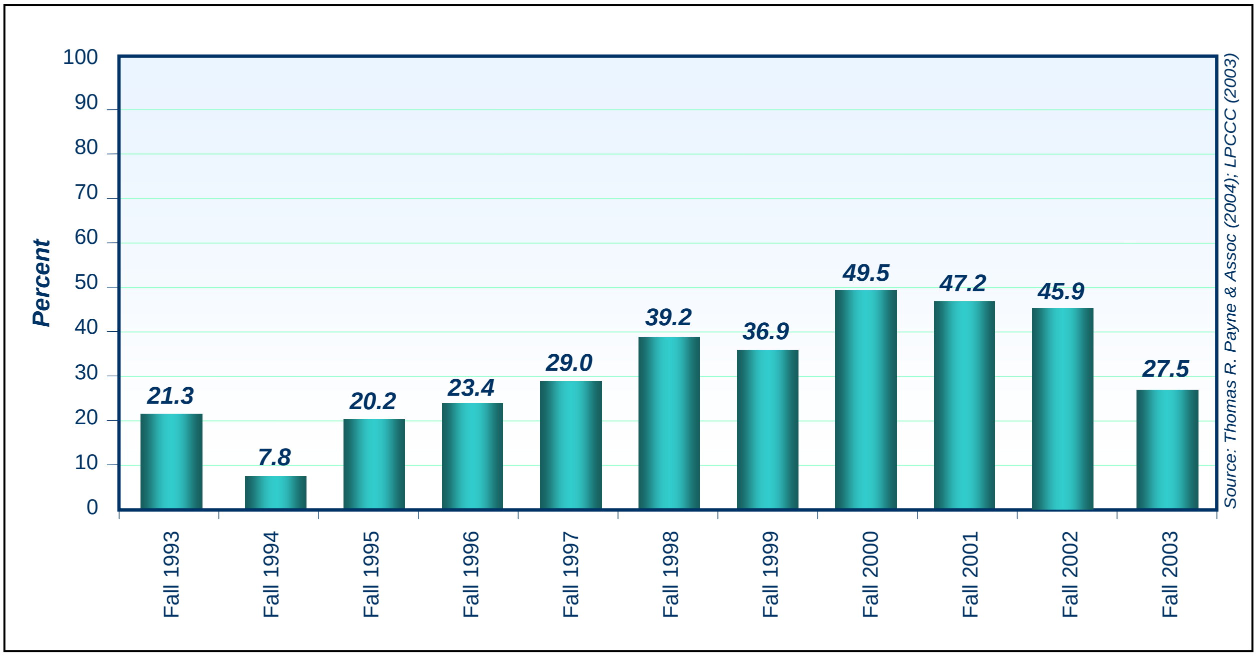
* Accord flow requirements were in effect; however, peak flows in 2000-2001 were natural occurrences unrelated to Accord pulse flow requirements

Source: Solano Irrigation District 2004

Flow Releases from Putah Diversion Dam During Representative Water Years

EXHIBIT 5-6

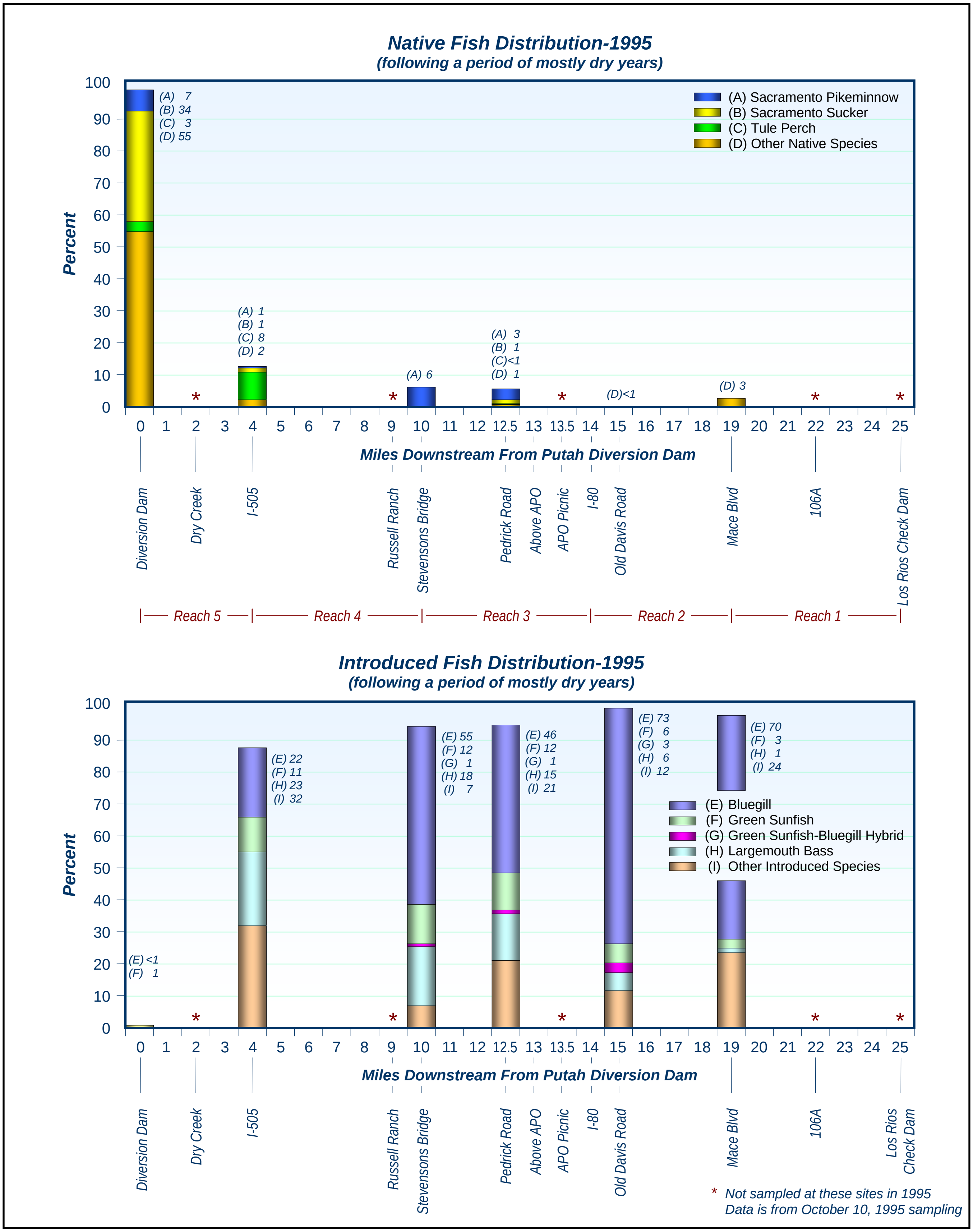
EDAW



Percentages of Native Fish in Lower Putah Creek Over Time EXHIBIT 5-7

Exhibits 5-8 and 5-9 show the distribution and proportion of native and non-native fish sampled in lower Putah Creek in 1995 and 1999, respectively. Exhibit 5-10 shows the locations of fish sampling sites from 1991 to present. The fish distribution exhibits highlight the proportion of the common native (i.e., Sacramento pikeminnow, Sacramento sucker, and tule perch) and non-native (i.e., bluegill, green sunfish, green sunfish-bluegill hybrid, and largemouth bass) species that occur most frequently. The years shown are representative of fish population patterns following dry (e.g., 1994) and wet (e.g., 1998) years. In general, native fish species were more numerous in the reaches below the PDD and introduced species were more numerous in the lower reaches. However, in a year (e.g., 1995) following a number of dry years, native fishes were mostly concentrated near the Diversion Dam and the number of native fishes declined sharply a short distance downstream from the Dam. In contrast, introduced non-native fish were abundant and dominated all reaches except immediately downstream of the Diversion Dam. Bluegill was the most abundant fish overall in lower Putah Creek in 1995. Both native and non-native fish were present in generally small numbers in all locations in the creek where they did not dominate.

In 1999, representative of a year following a number of wet years, the proportion of native fish was dramatically larger, with native fish, primarily pikeminnow and Sacramento sucker, dominating throughout the upper half of lower Putah Creek, from the Diversion Dam to Pedrick Road. Introduced species were dominant only in the lower half of lower Putah Creek. Again, both native and non-native species were found in all sampling locations. Sacramento sucker was the only native species that was present (although in high numbers only in Reaches 5, 4, and part of 3) throughout the entire creek in most of the years (1991-2002) that were



Source: Moyle et al. 2003; LPCCC 2003; EDAW 2003

Fish Distribution, 1995

EXHIBIT 5-8

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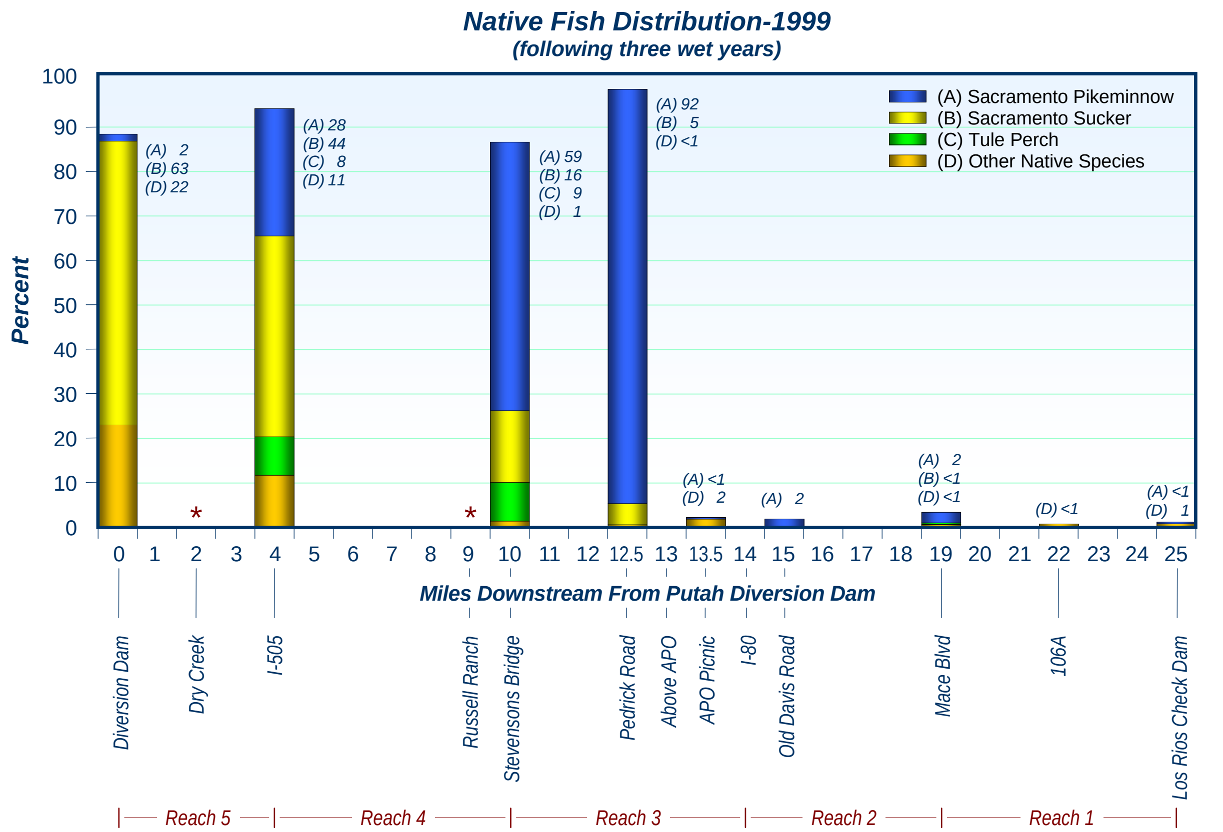
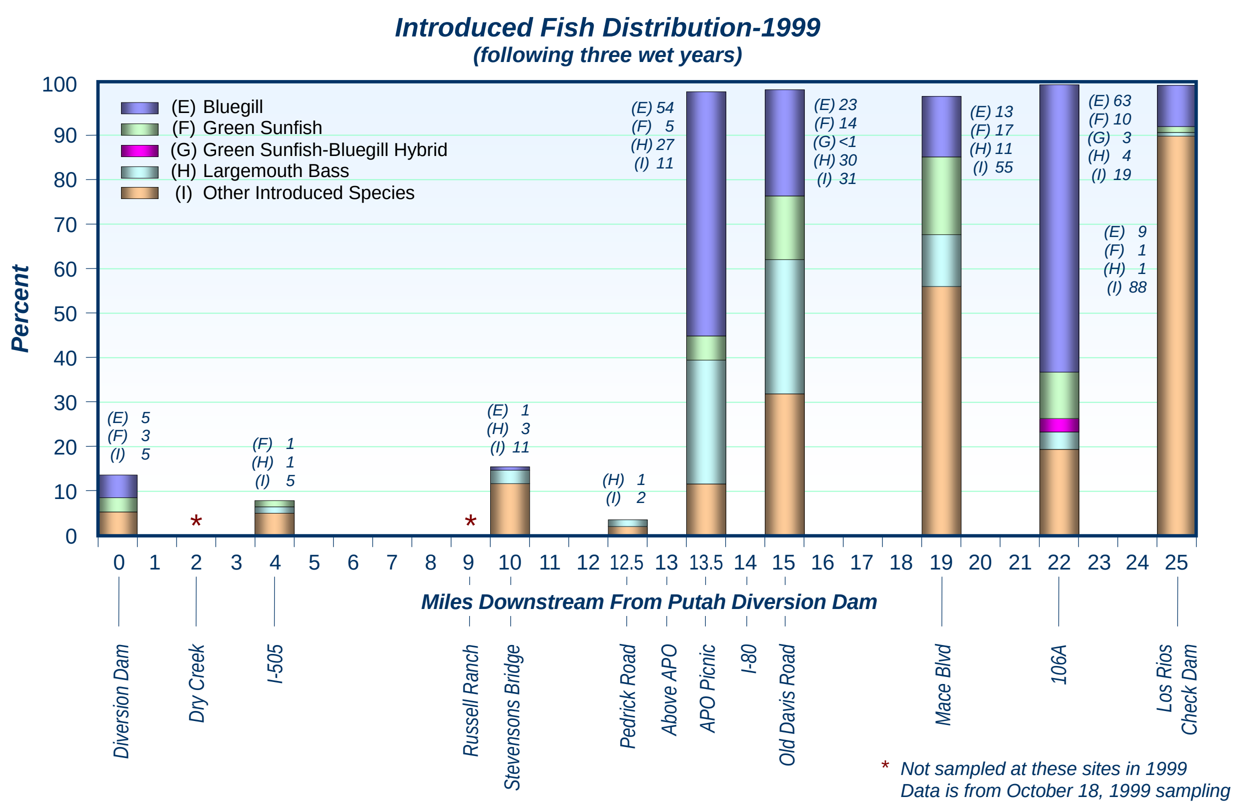
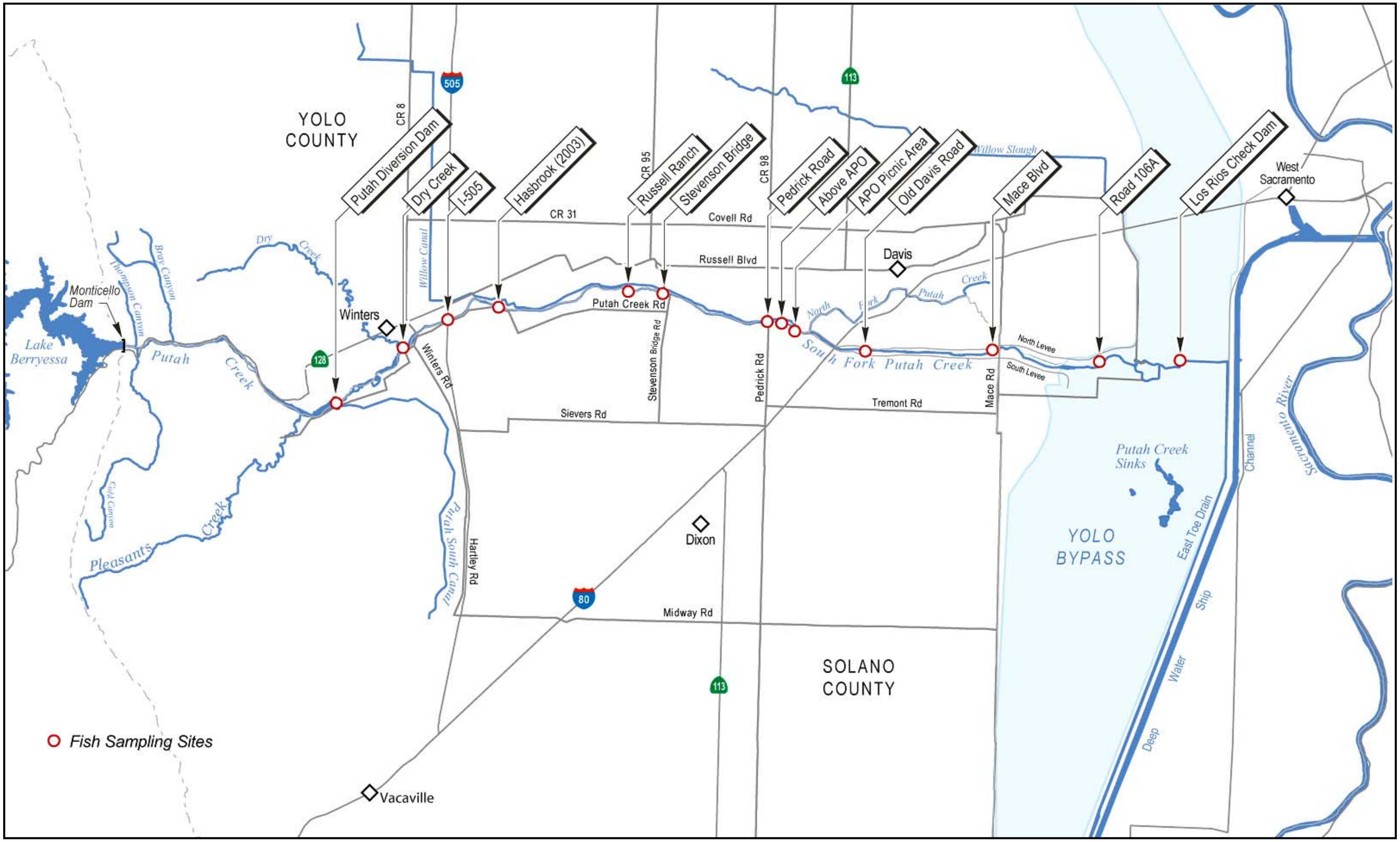




Source: Moyle et al. 2003; LPCCC 2003; EDAW 2003

Fish Distribution, 1999

EXHIBIT 5-9



Source: LPCCC 2003

Fish Sampling Sites

EXHIBIT 5-10

Lower Putah Creek Watershed Management Action Plan
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sampled. Sacramento pikeminnow was the next most widely distributed native species, occurring in Reaches 3, 4, and 5 in all years, but occurring infrequently in Reaches 1 and 2. Table 5-2 summarizes water-year types in Putah Creek, 1989–2003.

Tule perch was present in all years in Reach 4 (Interstate 505 [I-505] to Stevensons Bridge) and less frequently about 4 miles upstream and downstream of that reach. No other native species were present as frequently as Sacramento sucker, pikeminnow and tule perch. Introduced species that were present throughout the entire creek in most years sampled include bluegill, green sunfish, largemouth bass, and mosquitofish. Native species that were restricted to the upper reach (Reach 5) below the PDD included rainbow trout, restricted to the upper 6 miles (i.e., PDD to Dry Creek) and threespine stickleback, restricted to the upper 4 miles (i.e., I-505 and above). Introduced species that were limited to the lower 6 miles of the creek (i.e., Reach 1, Mace Boulevard and below) include American shad, striped bass, threadfin shad, and yellowfin goby.

Table 5-2
Characterization of Water Years, 1989–2003

Water Year[1]	No. days over 50 cfs	No. days over 1,000 cfs	Water Year Type
1989	12	0	dry
1990	8	0	dry
1991	10	0	dry
1992	8	0	dry
1993	33	2	moderate
1994	0	0	dry
1995	49	5	moderate
1996	77	39	wet
1997	78	42	wet
1998	137	73	wet
1999	88	30	wet
2000	43	0	moderate
2001	28	0	dry
2002	25	0	dry
2003	95	8	moderate

[1] 1994 Water Year begins October 1, 1993, and ends September 30, 1994.

Source: Moyle et al. 2003

Further assessments of native fish distributions are provided, relative to temperature conditions during spawning, below in Section 5.4.3, "Temperature."

5.3.4 PUTAH CREEK WATER ACCORD

This section summarizes the Putah Creek Water Accord signed in May 2000, including the rationale for flow and release requirements specified by the Accord, and stream and fish conditions after the new flows were implemented in 2000. Additional details on the Accord, including the specific details of the flow and release requirements, are provided in Chapter 4, "Geomorphology, Hydrology, and Water Quality."

BACKGROUND

From 1987 to 1992 the worst 6-year drought on record hit the region and the "dry year" release schedule was put into effect in the latter years (Sanford, pers. comm., 2003). Lake Berryessa was drawing down at a rate of about 200,000 net acre-feet per year. Significant riparian diversions - opposed unsuccessfully by the Solano water interests - continued to affect flows in the drought years. In summer 1989, long stretches in the downstream reaches of lower Putah Creek began drying up and major die-offs of fish began occurring (Moyle et al. 1998). The remaining fish were temporarily saved through a combination of interim court-ordered flows; the purchase of water by the City of Davis, Yolo County, and UC Davis; negotiated temporary releases of additional water by the Solano Irrigation District (SID); continued discharge of effluent into the creek by UC Davis; and other emergency measures (Moyle et al. 1998). Attempts to negotiate a permanent solution to the problem failed and on August 15, 1990, the PCC, joined later by UC Davis and the City of Davis, sued SCWA, SID, and other Solano Project member entities for additional water (Moyle et al. 1998, Krovoza 2000). The PCC sought and obtained an injunction briefly increasing releases during summer 1990. Those releases kept some parts of the creek from drying up but the injunction was lifted in fall. As legal maneuvers continued in 1991, most of the lower section of the creek dried up, except for the reach immediately below the Diversion Dam and a few large pools fed by effluent and groundwater. The drought continued in 1992, but water donated by UC Davis and the Alhambra Pacific Company kept the creek flowing. By December 1992, Lake Berryessa had reached its lowest water storage level (Exhibit 4-2). The storage level dropped to 430,000 acre-feet or about 25% of its total capacity. This equaled only about 2 more years of water supply for the water users. The drought finally ended in 1993 and higher flows resumed in the creek (Moyle et al. 1998).

During the Putah Creek Trial in March and April 1996, the plaintiffs sought a dam release schedule based on a model of instream flows for Putah Creek created primarily by Dr. Peter Moyle and Michael Marchetti. The stream flow recommendations from this model had four components: 1) living space flows for the entire creek, 2) resident native fish spawning and rearing flows, 3) anadromous fish flows, and 4) habitat maintenance flows. In an attempt to balance competing demands for water, Judge Park only ordered implementation of the first two components of the stream flow recommendation. The decision was for a 50% increase in the minimum release schedule from the PDD, equal to approximately 10,000 additional acre-feet of water per year. However, the Solano parties appealed the decision (Moyle et al. 1998) and 4 years later the lawsuit was resolved via a settlement agreement (Accord) (Krovoza 2000).

On May 23, 2000, a settlement (the Accord) was reached between the Solano County parties and the Yolo County-based parties. It created a new permanent release schedule that satisfied both parties. Three of the six main elements of the Accord directly affect flows to benefit the creek's fish and the remaining three pertain to management of lower Putah Creek (Krovoza 2000). The Accord elements include:

(1) Flows for resident native fish, which include important spawning and rearing components and guarantee a continuous flow to the Yolo Bypass;

(2) Flows that will attract and support salmon and steelhead;

(3) A drought schedule that provides enough water to maintain Putah Creek as living stream but provides water users relief from other flow requirements;

(4) Creation of the Lower Putah Creek Coordinating Committee (LPCCC);

(5) Habitat restoration and monitoring funds for the creek; and

(6) A term requiring Solano County Water Agency to notify riparian water users of the amount of riparian water available in any given year and to prevent illegal water diversions in excess of the amount of riparian water available.

POST-ACCORD STREAM CONDITIONS

Following the Accord, the new flow schedule went into effect immediately. The new flow schedule is based on a model created by Dr. Peter Moyle and other fish experts, for Putah Creek instream flows that favor native resident and anadromous fishes. (See Table 4-2 in Chapter 4, "Geomorphology, Hydrology, and Water Quality.") Part of the basis for this model is a study on the effects of flow regime on fish assemblages in lower Putah Creek (Marchetti and Moyle 2001), discussed previously in the Subsection, "Fish Distribution in Response to Wet and Dry Year Flow Releases." The first 2 years following implementation of the Accord were moderate (2000) and dry (2001) water years.

Due to favorable hydrologic conditions from at least 2000 to 2002, the flow requirements of the Putah Creek Accord were largely met by natural conditions (i.e., without releasing additional stored water). Key exceptions include the pulse flow releases in fall and spring. During the first few years, the fall pulse flows were largely unsuccessful in attracting upstream migrants. The primary affect of the Accord flows on fisheries in those years may have been from the spring pulse. Fall 2003 appears to be the first evidence that salmon attraction flows, coupled with fortuitous natural runoff events, succeeded in attracting fall migrants. This is described in more detail later in this chapter. Following is a summary of the new flow release schedule.

Release Schedule

This subsection provides a summary of the components and rationale for the new flow regime. The components of the new flow regime are rearing flows, spawning flows, supplemental flows, and drought year flows (Moyle 2002b). Details on the flow release schedule and instream flow requirements are provided in Table 4-2 in Chapter 4, "Geomorphology, Hydrology, and Water Quality."

Rearing Flows

This is a baseline flow regime designed to maintain a year-round living stream from the PDD to the Toe Drain. It is intended to provide cool-water habitat for native fishes for at least several miles below the PDD, even under the worst drought conditions. It also provides enough water to support introduced fishes (e.g., largemouth bass, catfishes, and bluegill) in the lower reaches. These flows overcome past limitations in which the stream dried up during summer in extreme drought years, except for a few large pools and a short section below the PDD (Moyle 2002b).

Native Fish Spawning Flows

Spawning flows consist of a short pulse in February–March, lasting three consecutive days, followed by a month-long release of higher than baseline flows. The purpose of these flows is to provide spawning opportunities for native fishes in winter and spring if there was insufficient rain to provide for them naturally. Native fishes, such as Sacramento sucker, are stimulated to spawn by hydrological changes that deepen spawning riffles and flood shoreline habitat for rearing. The pulse would bring the fish upstream and the increased flows would allow them to spawn and rear. Dr. Moyle predicted that these flows, in combination with baseline rearing flows, would greatly increase the abundance and distribution of native fishes in the creek (Moyle 2002b).

Supplemental (Pulse) Flows

Supplemental flows are designed to primarily benefit the migration of fall-run chinook salmon. The Accord includes a requirement for a minimum flow beginning in November and a 5-day pulse flow to occur at an optimal time (based on monitoring) in November or December to attract and enable adult fall-run chinook salmon to migrate up Putah Creek from the Toe Drain. The Accord also specifies a minimum flow that follows the pulse flow and continues through the end of May. The springtime minimum flows are designed to benefit juvenile salmon for rearing and to enable them to return back to the Toe Drain and sea (Moyle 2002b).

The supplemental flow regime, although designed primarily to benefit salmon, seems to benefit lampreys and may be adequate for rearing juvenile steelhead as well. Adult steelhead may make it up the stream under high winter flows, but it is likely that in most years flows from December to February are too low to attract steelhead, unless water is spilling from Lake Berryessa (Moyle 2002b; Moyle, pers. comm., 2003).

Drought Year Flows

These flows are to be implemented during severe droughts, when all flows but the minimum flows can be eliminated for 2 years. During droughts, normal flow regimes outlined in the subsections above are not in effect every year. Droughts are defined as periods in which the total storage in Lake Berryessa is less than 750,000 cfs on April 1 of any given year. Severe droughts are defined as periods in which Lake Berryessa holds less than 400,000 acre-feet of water on April 1. Under the drought year flow regime, normal flows are implemented in every third year of an extended drought unless the drought is severe. During extended (e.g., 3 or more years) severe droughts, normal flows are not implemented until the first year immediately after Lake Berryessa storage exceeds 400,000 acre-feet.

The drought year flow regime seeks to strike a reasonable balance between human water demands and the minimum needs of fishes during droughts. While the stream and its fish will not receive more than minimum flows during most drought years, periodically they regain priority for water if the drought continues. The drought regime also recognizes that during drought conditions, native fish can persist under minimal flow conditions without reproducing. Native fishes can persist if competition and predation from introduced fishes is limited or if suitable habitat refuges exist for the native fishes (Marchetti and Moyle 2001). Even before the settlement, small numbers of native fishes managed to persist through extreme drought conditions that dried up most of the creek. The minimum flows provided under the new schedule are expected to enable native fishes to have a higher level of persistence than prior to the Accord.

The drought schedule requires that a continuous flow be maintained in the reach from PDD to Interstate 80 (I-80) (a 15-mile stretch) at all times. Thus, the reaches of Putah Creek closer to the Diversion Dam, which are the reaches dominated by resident native fishes, will not go dry, protecting native fish from lengthy droughts. The non-native species, which tend to dominate in the reaches nearer to and below I-80, will not receive as much protection from the drought year flow schedule. However, introduced fish may repopulate those reaches from upstream populations following the end of drought cycles (Moyle 2002b).

FISHERIES AFTER WATER ACCORD (2000 TO PRESENT)

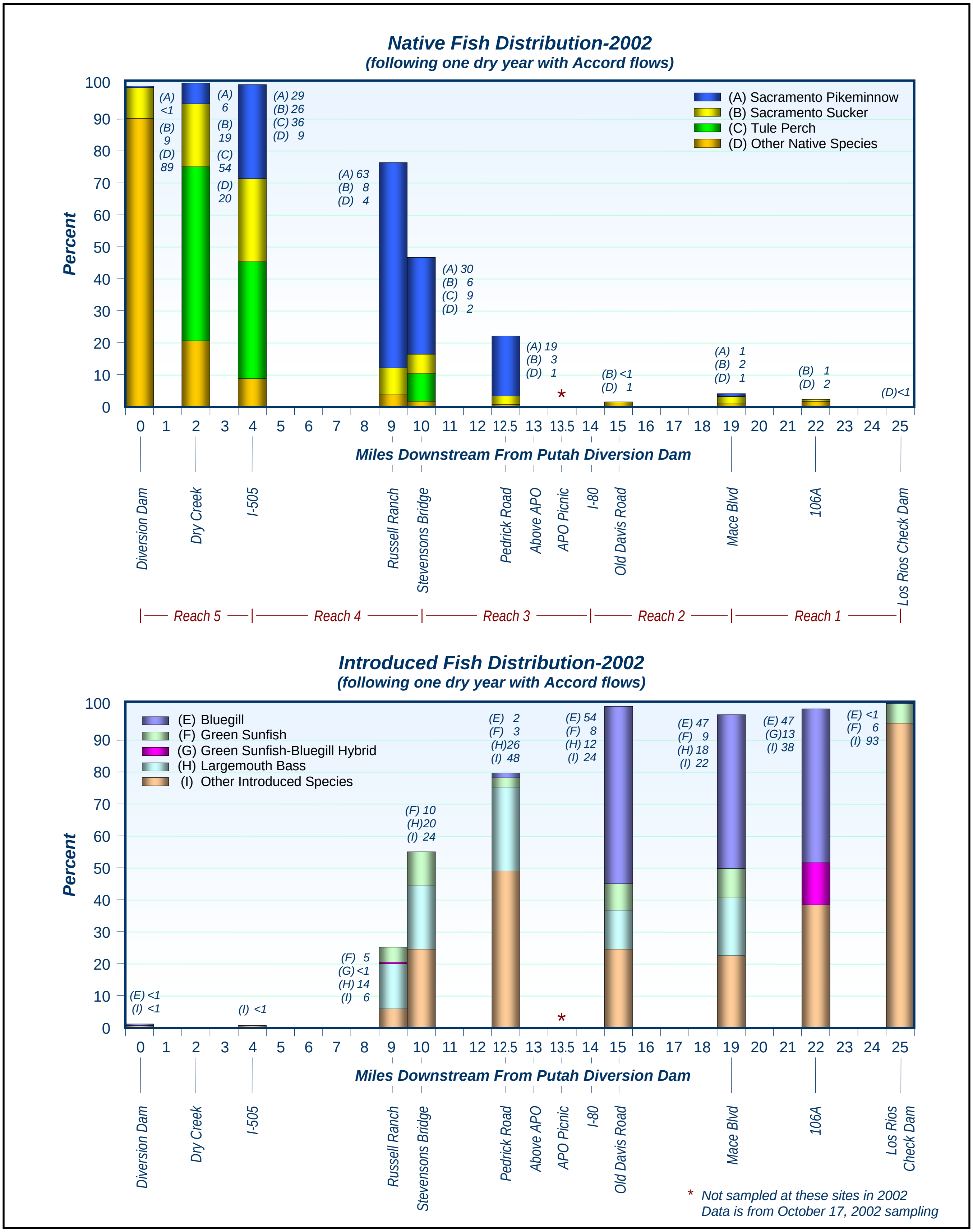
This subsection describes lower Putah Creek fisheries in the nearly 4 years following implementation of the Putah Creek Accord flow schedule. The description is based on observations by Dr. Moyle, Patrick Crain, and others, and on the most recent available data (Moyle et al. 1998; Moyle 2002b; Moyle et al. 2003; Moyle and Crain 2003; Marchetti and Moyle 2001). In addition to the assessments provided in this subsection, native fish distributions are preliminarily assessed relative to temperature conditions during spawning in the Subsection, "Temperature," later in this chapter.

Thus far, fisheries sampling data through 2002 have been analyzed following implementation of the Accord flows. However, based on these initial data and other observations, it appears that the distribution and abundance of native fish in lower Putah Creek may be substantially greater following dry years with the new Accord flow schedule than following dry years under the old flow regime. Exhibit 5-11 shows the distribution of native and introduced non-native fish in lower Putah Creek in 2002, following a dry year (Exhibit 5-6). Exhibit 5-7 shows the percent of all native fish sampled throughout lower Putah Creek between 1993 and 2002. The percent of native fish sampled throughout lower Putah Creek in fall 2002 was 46%, much higher than during the mid-1990s. However, while the mid-1990s samples were taken during a period of several mostly dry years, the Accord period dry years thus far are following a period of mostly wet years, so it may be too soon to draw conclusions stating that the Accord flows were a primary reason accounting for the higher proportion of native species. This is because fish populations can increase or decrease over a period of years in response to changing flow patterns.

Exhibit 5-11 shows a high proportion of native species still present 10 miles downstream of the PDD. The distribution of native fish was much more extensive than in 1995 (Exhibit 5-8), following a period of mostly dry years. In 1995, native fish were concentrated near the Diversion Dam, and the abundance of native species was very low downstream of the dam. Introduced fish dominated about 90% of the creek. In addition to this, downstream pools at Stevensons Bridge and Pedrick Road that had relatively few native fish during pre-Accord conditions now have an abundance of native fish. Even in areas that remain dominated by warm-water non-native fishes there are now more native fish than there were prior to the Accord. These results may be beginning to confirm Dr. Moyle's predictions (Exhibit 5-12) of an increase in the distribution of native species downstream of the PDD following implementation of increased flow releases, in comparison to the limited distribution characterizing native fish populations in the creek prior to the Accord, between 1980 and 1995 (Exhibit 5-5).

It is probably premature to conclude that the regulated spring pulse flows likely made a difference in enabling increased spawning by native resident fishes. During the two dry years (2001 and 2002) following implementation of the Accord flow schedule, with regulated spring pulse flows in place, Sacramento pikeminnow, Sacramento sucker, and tule perch (all common native resident fishes) all spawned (Crain, pers. comm., 2003). However, the degree to which the regulated spring flows made a difference in enabling the spawning is uncertain, since rising groundwater also contributed substantially to the spring flows during this period (Sanford, pers. comm., 2003). Also, some spawning by native fish did occur in dry years prior to provision of regulated spring pulse flows, such as in 1994 (Salamunovich, pers. comm., 2003).

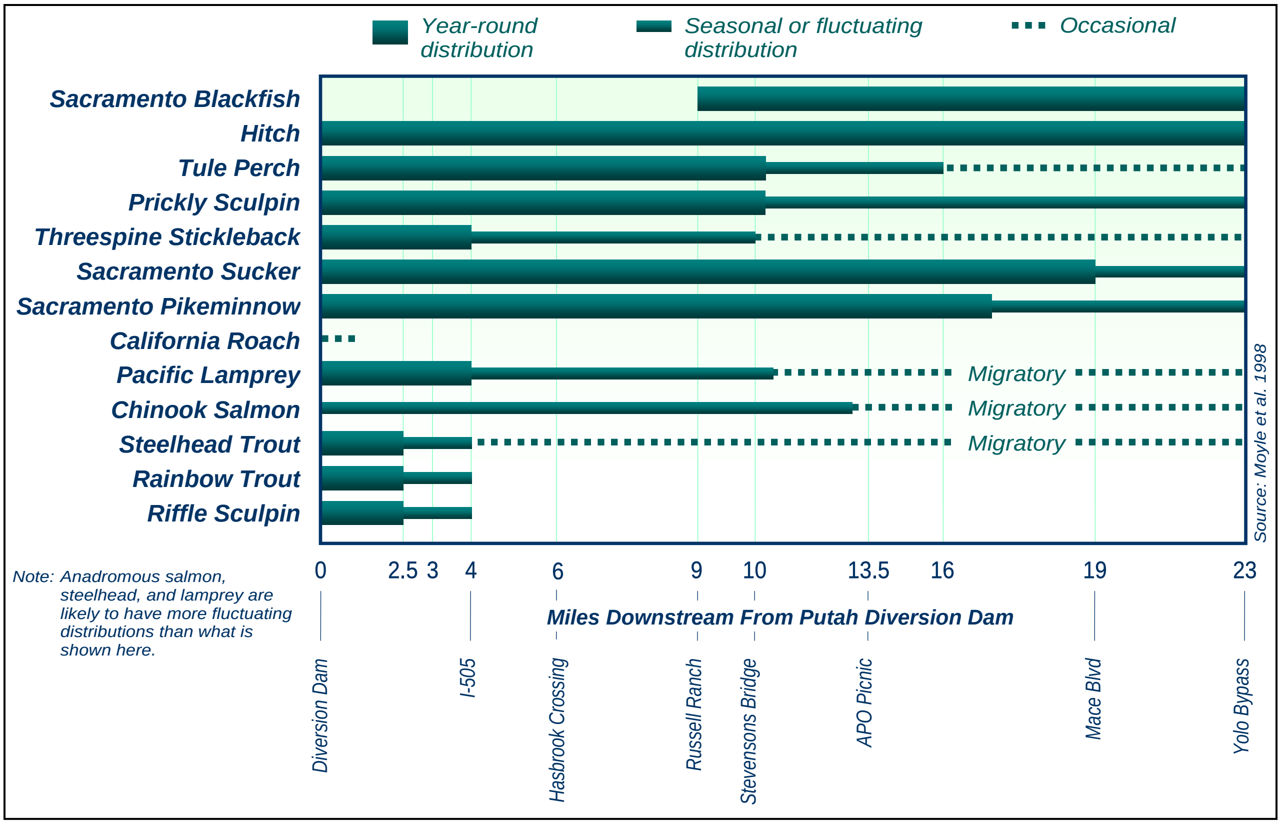
The most recent result of the new flow releases is that fall-run chinook salmon are migrating up the creek to spawn. An estimated 70 adult fall-run chinook salmon migrated up lower Putah Creek in fall 2003, resulting in the biggest salmon run in the past 40 or more years (Moyle, pers. comm., 2003; PCC 2003). The 2003 run followed 3 years of few to no salmon found on the creek despite implementation of the pulse release and other supplemental releases, and removal of the check boards at Los Rios Check Dam in the Yolo Bypass, all to attract and enable the salmon to migrate up into Putah Creek from the Toe Drain. For the first 3 years after the new release schedule was implemented, there were no reported observations of chinook salmon spawning, yet there were small numbers of juvenile salmon



Source: Moyle et al. 2003; LPCCC 2003; EDAW 2003

Fish Distribution, 2002

EXHIBIT 5-11



Predicted Native Fish Distribution with New Flow Releases EXHIBIT 5-12

sampled that may have resulted from salmon spawning in the creek (LPCCC 2003) or that may have originated from the release of small numbers of classroom-reared fish in Winters (Crain, pers. comm., 2003).

Then, on October 16, 2003, a 30-inch adult chinook salmon was captured by fish biologists with Thomas R. Payne and Associates below the PDD, and several test redds were observed (Salamunovich, pers. comm., 2003) (Exhibit 5-2). The known fish passage barriers at the time were large and seemingly insurmountable. Los Rios Check Dam downstream in the Yolo Bypass was still closed and a 6- to 8-foot-high beaver dam was present one-quarter mile downstream of Road 106A (Exhibit 5-10). From November 30 to December 5, following removal of Los Rios Check Dam, flow releases were increased to support salmon migration. The attraction flows lasted long enough to bring some fish up from the Sacramento River (Moyle, pers. comm., 2003). On December 8, Tim Salamunovich of Thomas R. Payne and Associates reported that his crew observed additional salmon and redds in the creek (Salamunovich pers. comm., 2003). On December 10, Dr. Moyle and his associate, Pat Crain, surveyed the creek by canoe from the PDD to Winters, in response to Tim Salamunovich's reports. Dr. Moyle reported the following:

> I am pleased to report that that last week's augmented flows to Putah Creek designed to bring spawning chinook salmon up the creek, worked this year. The flows are down again, but the attraction flows lasted long enough to bring some fish up from the river. This afternoon (10 December), Pat Crain and I canoed from the Putah Creek Diversion Dam downstream to Winters to look for salmon. We were alerted to their presence by Tim Salamunovich (Thomas R. Payne and Associates) whose crew was working on the creek and reported seeing salmon and their redds on December 8. Below the diversion dam, we talked to an angler who told us he had seen about six salmon in the concrete pool where the water from the creek is released from the dam. Sure enough, we could see at least 4 salmon cruising around, a large (ca. 20 lbs) bright red male and three females. No place to spawn there, of course. On the path leading down to the creek we found the head of a salmon, with a fishing hook and line still attached to its mouth. I assume such fishing is legal there, as long the fish is caught in the mouth and not snagged. Still, it would be nice to see the salmon left alone for a few years, to see if we could build up populations. In the gravelly areas below the dam, we spotted 4 more salmon and a couple of redds in water about 25–30 cm deep. A female was sitting on one redd, her tail white from having scraped away the skin while digging her nest. For the next mile, there seemed to be redds in most of the small areas where there was large gravel. We counted eight redds altogether although some were in such shallow water (<20 cm) they had presumably been abandoned when the flows dropped. We saw only four salmon and they were very skittish, bolting into cover at our approach. One large male we observed on a redd from some distance away because its dorsal and tail fins were out of the water. After this, there was a long stretch of either large pools or shallow sandy runs, with no gravels suitable for spawning. In the big pool area, there was a large beaver dam that was being actively managed by beaver and would presumably be a barrier to movement under the present flows, but passable under the earlier releases. More gravel was encountered at the mouth of Dry Creek and we observed two more redds there, one with a female still in attendance, despite shallow water (ca. 25 cm). Altogether we saw 13 live salmon and 12 redds, which suggests that more salmon are or were present in this reach. We have not yet checked out areas downstream of Winters but there is a report of at least one salmon below the Stevenson Road bridge. Thus it is likely the salmon are spawning in most areas where there is suitable gravel. Great day to be on the water, cool, a few sprinkles of rain, complicated clouds, and lots of birds. (Moyle and Crain 2003).

On December 17 and 18, Dr. Moyle and Pat Crain again surveyed the creek from the PDD to I-80 and found over 40 redds at just over 30 locations and observed a total of at least 19 adult chinook salmon (Moyle and Crain 2003; Moyle, pers. comm., 2003). Dr. Moyle estimated that the salmon run consisted of about 70 spawners.

> It looked to Pat and I that the salmon had used virtually all of the gravel patches with the right combination of coarse gravel, fast water, and depth. As we canoed down stream we could look ahead of us and often predict a redd location, if a salmon fin did not give it away first (Moyle and Crain 2003).

Moyle and Crain continued the survey by walking and wading from I-80 to Old Davis Road, but did not see any redds, nor suitable gravel except in some bars high above the flow (Moyle, pers. comm., 2003). An analysis of hydraulic conditions and substrate types in lower Putah Creek was conducted by hydrologist Gus Yates in 2003, and the results of his analysis are summarized in Section 5.4, "Spawning Habitat in Lower Putah Creek." Yates also determined locations of suitable spawning habitat for the native fishes of lower Putah Creek, including fall-run chinook salmon, based on criteria provided by Dr. Moyle. The predicted suitable spawning locations for salmon are indicated in Exhibit 5-13, along with the locations of redds surveyed in 2003. Table 5-3 summarizes the hydraulic and substrate characteristics of the redd sites. The vast majority, 24 (60%) of the 40 redds observed and reported by Moyle and Crain (2003) were located in gravel substrate under a maximum of 14 to 24 inches of water. An additional eight (20%) redds were located in patchy gravel under a maximum of 16 to 22 inches or water, and three (13%) redds were in sand and gravel under a maximum of 17 to 21 inches of water. Only two redds were located in sand and one was located in claypan with no overlying material. However, many redds located in gravel and other substrates were placed down into the clay substrate (Moyle, pers. comm., 2003). A discussion of redd occurrences compared to predicted suitable habitat is found in the subsection 5.4, "Spawning Habitat in Lower Putah Creek," below.

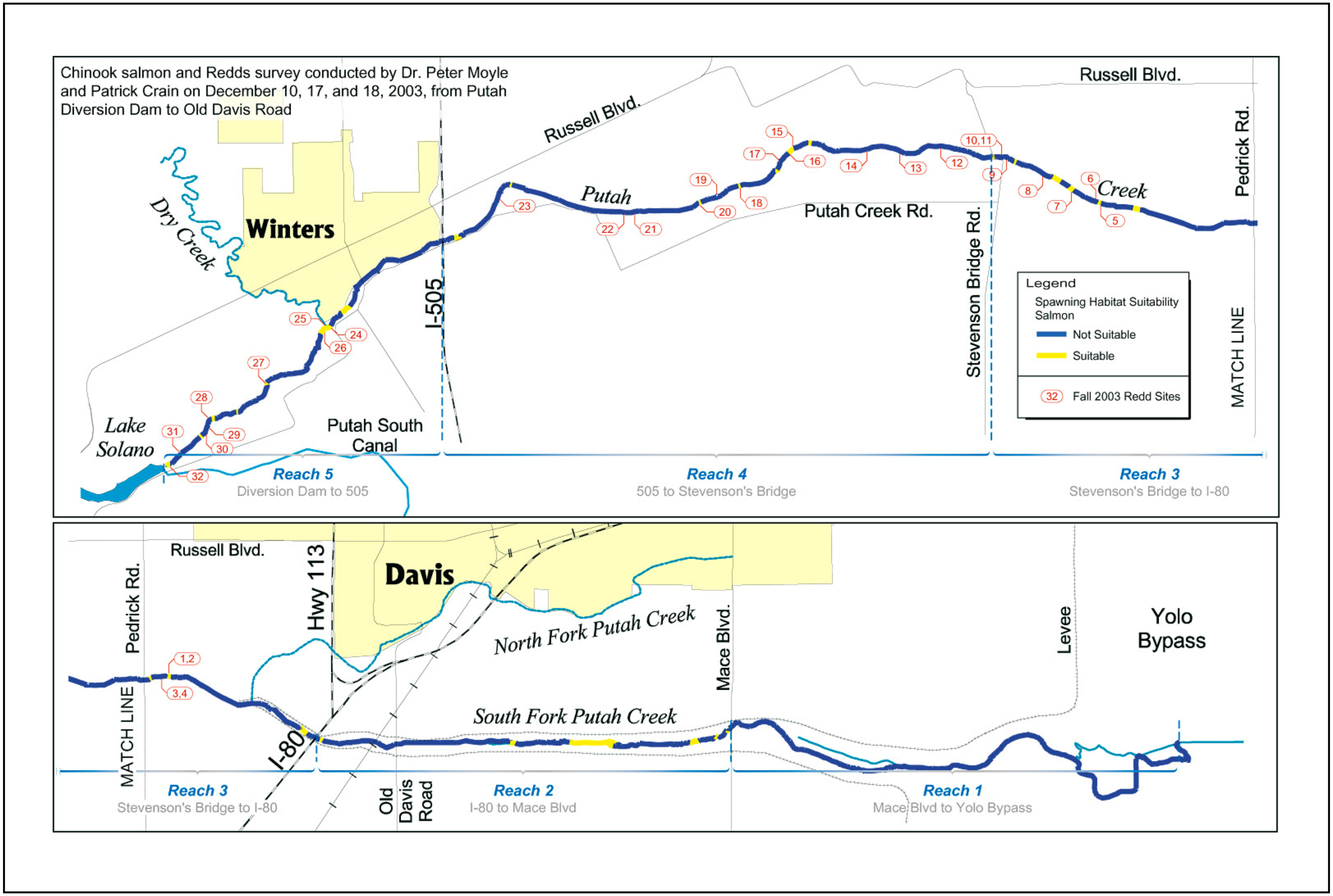
The lack of suitable gravel spawning sites is a constraint for salmon spawning. The observations of salmon at the concrete pool below the PDD indicated that most or all spawning locations downstream had likely been utilized by the migrating salmon and further confirmed Dr. Moyle's determination that Putah Creek is currently limited by a lack of suitable gravel substrate for salmon spawning (Marovich, pers. comm., 2003).

Adult steelhead have yet to be observed in the creek. Based on 2003 electrofishing surveys, rainbow trout are only routinely found in the creek from the PDD to Dry Creek. The lowest point at which trout have been observed in summer is the Hasbrook crossing about 6 miles downstream. This indicates that suitable habitat may be favorable to salmonids, 2 miles farther downstream from the PDD than previously thought (Marovich, pers. comm., 2003).

Table 5-3
Characteristics of Fall 2003 Salmon Redd Sites in Lower Putah Creek

Substrate	Hydraulic Condition						All Hydraulic Types	
	Pool		Riffle		Run			
	# Redds	Maximum Water Depth	# Redds	Maximum Water Depth	# Redds	Maximum Water Depth	# Redds	Maximum Water Depth
Claypan	0	—	0	—	1	12 in.	1	12 in.
Gravel	3	17 in.	8	16–21 in.	13	14–24 in.	24	14–24 in.
Patchy gravel	6	16–22 in.	0	—	2	16–19 in.	8	16–22 in.
Sand	2	17 in.	0	—	0	—	2	17 in.
Sand and gravel	2	17–18 in.	0	—	3	17–21 in.	5	17–21 in.
Total	13	16–22 in.	8	16–21 in.	19	12–24 in.	40	12–24 in.

Data Sources: Moyle and Crain 2003; Yates 2003.



Source: Moyle and Crain 2003; Yates 2003

Fall Run Chinook Salmon Redd Sites Observed in 2003 Compared to Predicted Suitable Spawning Habitat

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5.4 SPAWNING HABITAT IN LOWER PUTAH CREEK

This subsection summarizes information primarily from a lower Putah Creek spawning habitat and gravel study conducted by hydrologist Gus Yates (2003), along with an assessment by EDAW biologists and water quality specialists of temperature data provided by SCWA (2003). The main purpose of Yates' study was to document the distribution and texture of unconsolidated sediment along the bed of lower Putah Creek so that assessments could be made regarding the adequacy of existing streambed gravels to support present or future fish populations. This subsection includes the following components:

- spawning criteria for native fish, including trout and steelhead, chinook salmon, Pacific lamprey, and native resident fish;
- hydraulic conditions, including pool, riffle, and run characteristics and distribution;
- potential spawning habitat for native fish; and
- water temperature characteristics related to spawning.

5.4.1 SPAWNING CRITERIA FOR NATIVE FISHES

All native fishes in lower Putah Creek require certain hydraulic conditions for spawning, and most require a gravel substrate. However, the hydraulic requirements as well as the gravel texture and thickness requirements vary among species. Hydraulic conditions refer to habitat type, flow, and water depth. In the Yates (2003) spawning and gravel study, spawning requirements were grouped into several categories based on known or suspected similarities in spawning requirements. Table 5-4 provides the best available information characterizing the substrate criteria, hydraulic criteria, and other spawning habitat requirements of native anadromous and resident fishes as compiled by Dr. Peter Moyle (Moyle 2002a, Yates 2003).

In general, much more information is available for salmonids than for other native fish. Native salmonid species in lower Putah Creek include fall-run chinook salmon, rainbow trout, and steelhead. The fall-run chinook salmon and steelhead are anadromous. Gravel texture and redd size for these species vary somewhat based on fish size. A redd is a fish nest built in gravel substrate. In general, the female excavates a depression in the gravel and deposits her eggs. A male or several males then fertilize the eggs and the female then covers the eggs with gravel.

Native species also include Pacific lamprey, an anadromous species, and resident fish including primarily cyprinids (Sacramento blackfish, hitch, and Sacramento pikeminnow), catostomids (Sacramento sucker), gasterosteids (threespine stickleback), and embiotocids (tule perch). Tule perch bear live young, and blackfish and sticklebacks spawn on vegetation. As a result, sediment texture is not important for these species; however, suitable hydraulic conditions must still be present. In general, native fish species appear to be less particular about water depth than flow and substrate conditions. Native species are likely to spawn using the best available site, even if it is less than optimal (Yates 2003). Water temperature is an important factor for spawning, but temperature data for lower Putah Creek are limited and were not included as part of the analysis for potential spawning habitat in Yates' study.

Table 5-4 Spawning Site Criteria for Native Fish in Lower Putah Creek							
Fish	Hydraulic Conditions			Substrate Conditions		Redd	Spawning Temperatures
	Type	Depth (ft)	Velocity (ft/s)	Gravel Texture	Gravel Thickness		
Rainbow trout Steelhead Chinook salmon	Riffles or pool tailouts preferred	0.3–4.9 (trout and steelhead) 0.8–3.3 (salmon)	0.6–5.1 (trout and steelhead) 1.0–2.6 (salmon)	Fines <0.04 in (<1 mm) less than 14% by weight Fines <0.4 in (<10 mm) 12-40% by weight D50 less than 10% of fish length (less than 4% of length preferred) 1-10 in (25-250 mm) typical grain size (large) 0.4-5.0 in (10-130 mm) typical grain size (small)	>12 inches (?) Perceptible flow through gravel	Redds dug by agitating gravel to create a depression and decrease percentage of fines Preferred gravel size related to adult fish size.	10-15°C (50-59°F) 5-19°C (41-66.2°F)
Pacific lamprey	Riffles or pool tailouts preferred	1.0–2.7	0.4–2.8	Similar to salmon, but not as particular	Unknown	Redds dug by individually moving larger stones to downstream edge of depression	12-18°C (53.6-64.4°F)
Sacramento blackfish	Pool edges	>2	Slow	Unimportant	Unimportant	Sticky eggs deposited on roots and vegetation	12-24°C (53.6-75.2°F)

Table 5-4
Spawning Site Criteria for Native Fish in Lower Putah Creek

Fish	Hydraulic Conditions			Substrate Conditions		Redd	Spawning Temperatures
	Type	Depth (ft)	Velocity (ft/s)	Gravel Texture	Gravel Thickness		
Sacramento pikeminnow	Riffles	>1	1.0–2.5 (?)	0.4–2.0 in (10–50 mm) dominant size	Unimportant	Clean off surface and lay sticky eggs	15–20°C (59-68°F)
Hitch	Riffles	>1	1.0–2.5 (?)	Clean, fine-to-medium gravel (0.4–2.0 in (10–50 mm) dominant size)	Unknown	Eggs not adhesive but sink into gravel	14–18°C (57.2-64.4°F)
Sacramento sucker	Riffles	>1	1.0–2.5 (?)	0.4–2.0 in (10–50 mm) dominant size	Unimportant	Sticky eggs adhere to gravel or debris	12–18°C (53.6-64.4°F)
Threespine stickleback	Pools and backwaters	0.7-3	Slow	Soft or mixed bottom material	Unimportant	Build nests of vegetation	Below 23–24°C (73.4-75.2°F)
Tule perch	Slow-moving waters and backwaters		Slow	Unimportant	Unimportant	Females give live birth in area with dense plant cover	Below 22°C (71.6°F)

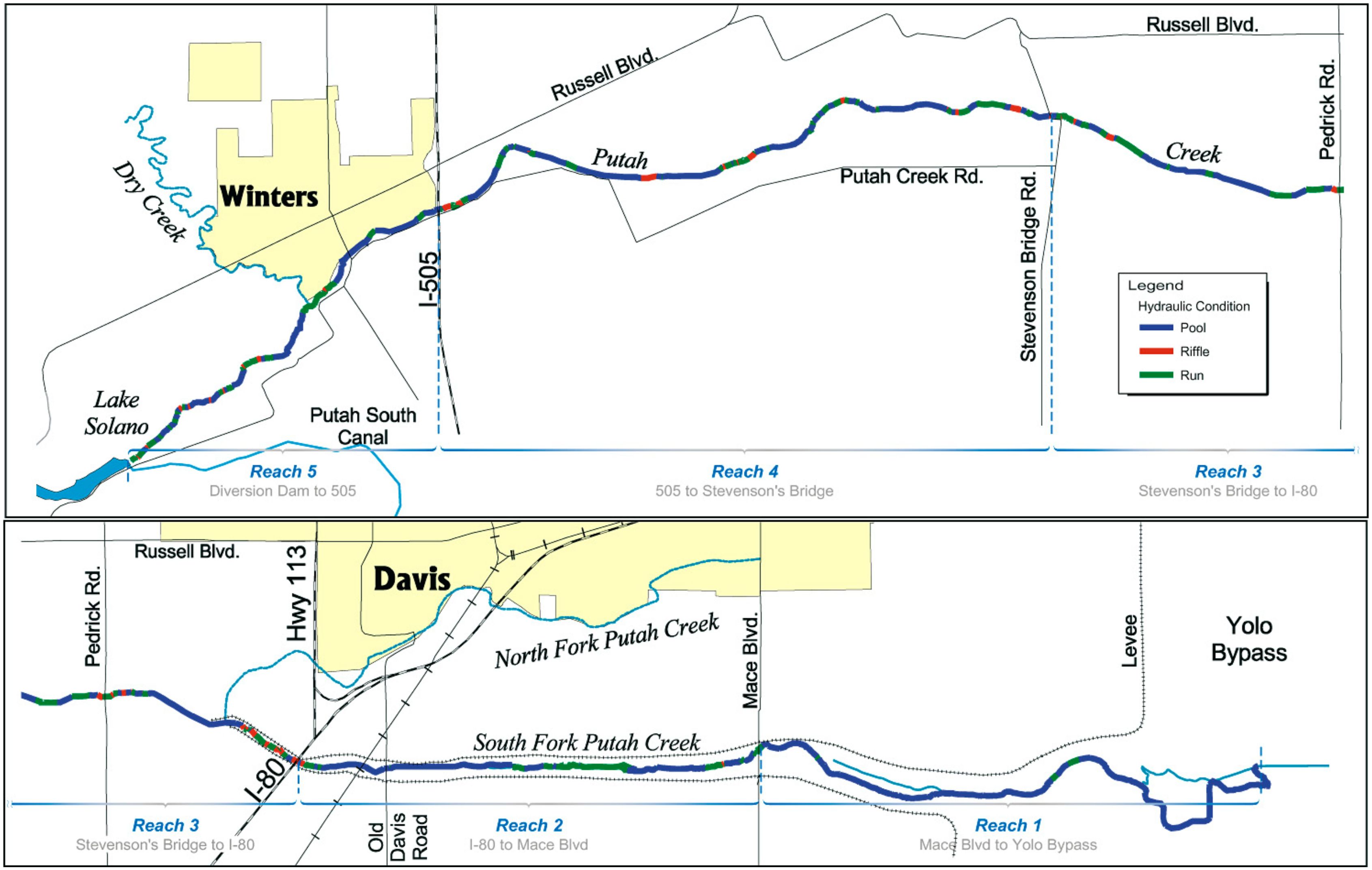
Sources: Moyle 2002, Kondolf 2000, Yates 2003

Based on the data available, an assessment is of the effects of temperature on suitable spawning habitat for native fish is provided in Subsection, "Temperature," below.

Fish species that spawn on gravels with moderate flow velocity (i.e., 1.0–2.6 ft/s) include pikeminnow, sucker, hitch, salmon, steelhead, and rainbow trout (Table 5-4). These species have the following preference ranges for gravel size/texture (diameter): 0.4–2.0 inches (10–50 millimeters) for pikeminnows, suckers, and hitch; and 1–10 inches (25–250 millimeters) for salmon, steelhead, and rainbow trout (Table 5-4). All species prefer fairly clean gravel. Studies of salmonid spawning in other areas have found salmon prefer to have no more than 10% of the gravel (by weight) be characterized by fine material measuring less than 1 millimeter in diameter, to ensure adequate flow and oxygen delivery through the gravels. Fine material less than about 0.4 inch (10 millimeters) can also block the emergence of salmon fry from the gravels, especially if the fine material is deposited after spawning has occurred. A few observations of natural gravels used by salmon to build redds indicate that material smaller than 0.4 inch (10 millimeters) typically comprises between 14% and 40% of the redd (Kondolf 2000). In lower Putah Creek, currently available gravels generally are less than 3 inches in size; however, a mixture of gravels ranging from 1 to 10 inches are probably more desirable for salmon spawning (Moyle, pers. comm., 2003).

5.4.2 HYDRAULIC AND SUBSTRATE CONDITIONS

A characterization of pools, riffles and runs was conducted during summer surveys, when flows were between 20 and 43 cfs (Yates 2003). The distribution of those low-flow hydraulic conditions along lower Putah Creek are shown in Exhibit 5-14 (Yates 2003). The distribution of substrate types is provided in Exhibit 5-15 (Yates 2003). The maps are divided into two segments: the reach from PDD to Pedrick Road (top of map) and the reach from Pedrick Road to the Yolo Bypass (bottom of map). Note that some of the shortest segments may not be visible at the scale of the exhibits. Table 5-5 shows the total length in river miles occupied by pool, riffle, and run conditions subdivided by substrate types (Yates 2003). Clay-silt (claypan) is likely the underlying bed material in most creek locations. However, it is overlain by unconsolidated sand and gravel along most of the creek (Yates 2003). In Reach 5, between PDD and I-505, the substrate is mostly gravel or a mixture of sand and gravel, with some exposed claypan. In Reach 4, from I-505 to Stevensons Bridge, the substrate along about half of the length is patchy gravel with claypan exposed between patches. The remainder of the reach is characterized by a gravelly substrate with some sand mixed in. From Stevensons Bridge to the split with the north fork of Putah Creek just upstream of I-80, in Reach 3, the substrate is mainly a mixture of sand and gravel. From the north fork split to Mace Boulevard (Reach 2), the substrate varies and includes all eight substrate types. Below Mace Boulevard, the substrate is mostly exposed claypan with some patches of a sand and gravel mixture (Yates 2003).



* Hydraulic condition determined during summer surveys when flows were 20–43 cfs.

Source: Yates 2003

Distribution of Low-Flow* Hydraulic Condition

EXHIBIT 5-14

Lower Putah Creek Watershed Management Action Plan
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MILES
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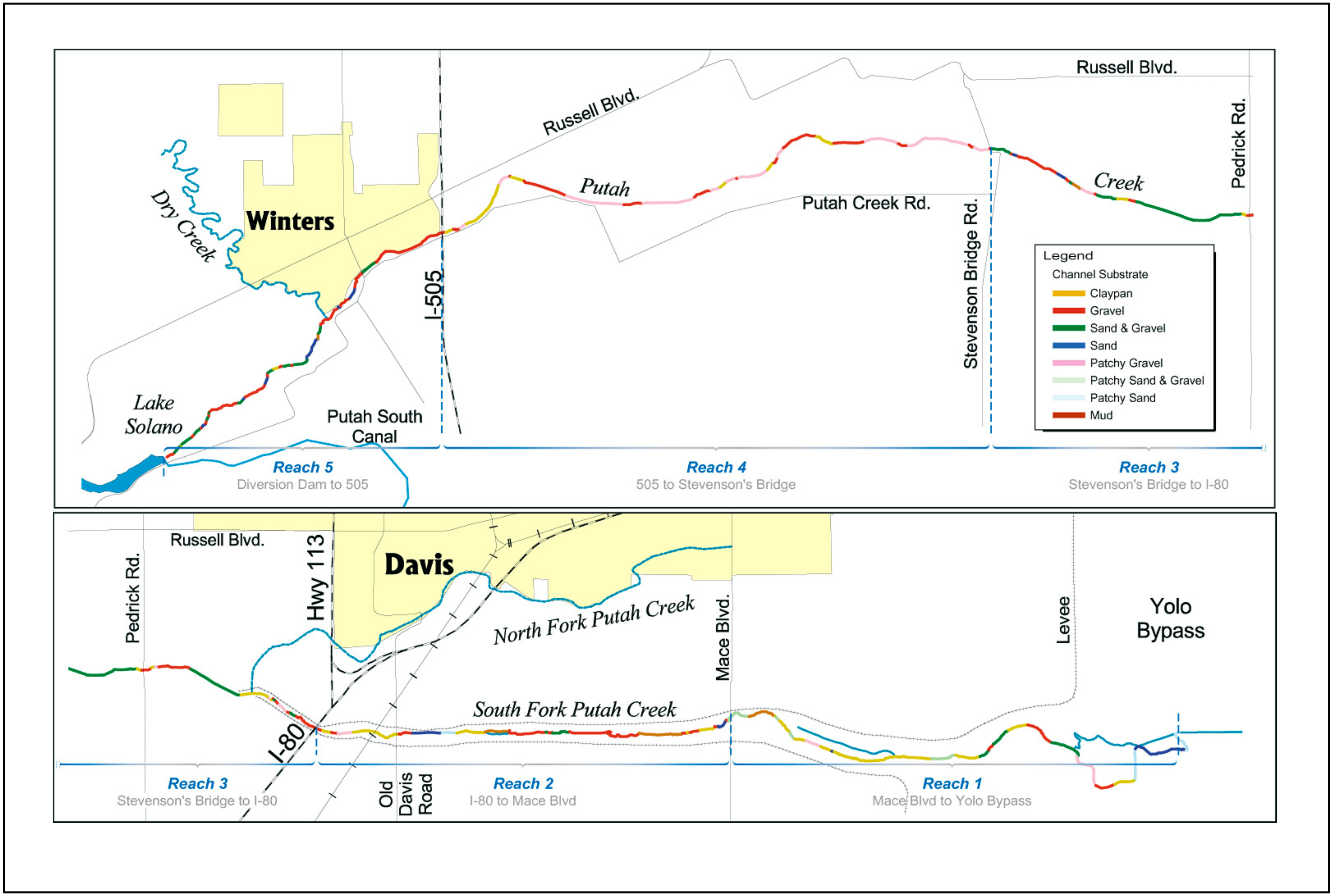

Source: Yates 2003

EXHIBIT 5-15

Distribution of Channel Substrate Type

Lower Putah Creek Watershed Management Action Plan

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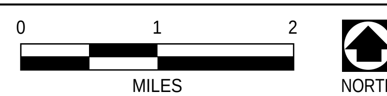

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Table 5-5 Cumulative Length of Combinations of Hydraulic Condition and Substrate along Lower Putah Creek				
	Hydraulic Type (in miles)			
	Pool	Riffle	Run	Total
Clay-silt ("claypan")	4.09	0.27	0.55	4.91
Gravel	3.76	1.01	3.28	8.06
Sand and gravel	2.97	0.00	1.12	4.09
Sand	1.57	0.00	0.14	1.71
Mud	1.13	0.00	0.00	1.13
Patchy gravel	3.28	0.04	0.72	4.05
Patchy sand and gravel	0.55	0.00	0.10	0.65
Patchy sand	0.71	0.00	0.00	0.71
Total	18.07	1.33	5.91	25.30
Source: Yates 2003				

POOLS

Pools are areas where the creek is deep and flows are slow moving. Pools occupy about 18 miles (72%) of the creek, the largest percentage of the creek's length. About 7.5 miles (42%) of the cumulative pool length in lower Putah Creek are characterized by a clay-silt (claypan), sand, mud, or patchy sand substrate. An additional 6.7 miles (37%) of pools are characterized by a gravel or sand and gravel substrate, and the remaining 3.8 miles (21%) of pools are characterized by patchy gravel or patchy sand and gravel. Beaver dams, especially in dry years, can dramatically increase pool habitat. By 1992, following several dry years, roughly 90% of the creek between PDD and river mile 0.0 was pool habitat largely caused by over 30 beaver dams. By the late 1990s, most of the beaver dams had washed out and the number of dams has remained relatively unchanged since that time (Sanford, pers. comm., 2003).

RIFFLES

Riffles are shallow areas extending across a relatively steeper sloping streambed such that water flows relatively swiftly across the streambed and makes a rushing sound (Yates 2003). Riffles are relatively short and occupy only about 1.3 miles, or 5% of the creek, but they are scattered throughout Reaches 3, 4, and 5 between PDD and I-80. They are scarce downstream of I-80. The vast majority of the cumulative riffle length in lower Putah Creek, 1.0 mile (75%) is characterized by a gravel substrate, with an additional 0.04 mile (3%) characterized by patchy gravel. The remaining 0.27 mile, or 20% of riffles, is characterized by a clay-silt (claypan) substrate.

RUNS

Runs are relatively shallow portions of a stream that are characterized by moderate velocities, a fairly smooth surface, and generally non-turbulent flow. A run is usually too deep to be considered a riffle and too shallow and fast to be considered a pool (Yates 2003). Runs are variable in length and not consistently sequenced with either pools or riffles. Runs occupy about 6 miles, or 23% of the creek length (Yates 2003). The vast majority, or 4.4 miles (74%), of the cumulative run length in lower Putah Creek are characterized by a gravel or sand and gravel substrate. An additional 0.8 mile (14%) of runs is characterized by patchy gravel or patchy sand and gravel. The remaining 0.7 mile (12%) of runs is characterized by a clay-silt (claypan) or sand substrate.

Hydraulic conditions change with increasing flow. Surveys for hydraulic conditions were completed by Gus Yates during the summer when flow was supplied by steady releases from the PDD. Flows ranged from 20 to 43 cfs, depending on the month and location of the survey. Flows during the spawning season (generally winter through spring) are often higher, with correspondingly greater width, depth, and velocity, depending on runoff events and especially whether Lake Berryessa is spilling. The relative proportions of increase in width, depth, and velocity depend on channel geometry at a given site. Rating curves relating each of these variables to flow have been developed for 12 sites by SCWA and reveal general patterns. These sites are almost all located in runs where flow is relatively narrow, the channel is neither deep nor shallow, and the current is swift but not turbulent. These characteristics fit the spawning site suitability criteria for most of the fish species and the flow-depth-velocity relationships at the gauge sites. They are therefore fairly representative of conditions present at many of the potential spawning sites (Yates 2003).

5.4.3 TEMPERATURE

This subsection includes an assessment of lower Putah Creek water temperature conditions based on fish spawning habitat requirements reported by Dr. Moyle, (Moyle 2002a), and temperature information provided by the Solano County Water Agency (SCWA 2003). Chapter 4, "Geomorphology, Hydrology, and Water Quality," includes a discussion of additional temperature data for the peak summer conditions. Water temperature is a critical component of spawning requirements. For instance, if spawning conditions are all suitable except for water temperature, a species may still not spawn. Water temperature requirements for spawning vary among species. However, many different native fish species have similar temperature requirements for spawning. Most native species generally spawn during winter and spring. Fall-run chinook salmon are the exception because they spawn primarily in the fall (late-September to December). Suitable spawning temperatures for native species addressed above are as follows (Table 5-4): steelhead/rainbow trout (50–59°F), fall-run chinook salmon (41–66.2°F), Pacific lamprey (53.6–64.4°F), Sacramento blackfish (53.6–75.2°F), Sacramento pikeminnow (59–68°F), hitch (57.2–64.4°F), Sacramento sucker (53.6–64.4°F), tule perch (below 71.6°F), and threespine stickleback (below 73–75°F) (Moyle 2002).

April is considered to be representative of an important seasonal period when many of the native fish species are actively spawning in lower Putah Creek (Crain, pers. comm., 2003). Exhibit 5-20 shows the monthly average maximum and average hourly temperatures recorded during April, based on 1997 and 1999–2002 data provided by SCWA (2003) at sites downstream of the PDD. The data indicate that the creek water gradually increases in temperature as it moves downstream, rising by about 15°F from 49°F to 63°F by the time it has flowed to the Stevensons Bridge area. The creek water temperature does not rise much more as the water continues downstream to the Yolo Bypass. There is also very little difference (i.e., approximately 2 to 3°F) between the average daily temperature and the peak afternoon temperature. Groundwater, which contributes up to a quarter of the total flow, may also affect the water temperature in some years (Sanford, pers. comm., 2003).

Based on the limited available data, water temperatures in April appear to generally reach or exceed the upper range of suitable spawning conditions for Pacific lamprey, hitch and Sacramento sucker by the time the water reaches Stevensons Bridge (upper end of Reach 3) and continuing down into the Yolo Bypass. The temperatures in those reaches (Reaches 1, 2, 3, and perhaps the lower portion of 4) are still somewhat within the range of Sacramento pikeminnow, but well within the range of tule perch, blackfish and threespine stickleback. A synthesis of Yates' determination of potentially suitable spawning habitat and this temperature assessment suggest that Pacific lamprey, hitch and Sacramento sucker currently may have suitable spawning habitat only in Reach 5 and some or all of Reach 4, ending at or near Stevensons Bridge. Thus, suitable spawning habitat for Pacific lamprey, hitch, and Sacramento sucker may be less than 0.7 mile, rather than 1.4 miles, based on temperature limitations. This appears to be consistent with the analysis of Dr. Peter Moyle's et al. (2003) analysis of native fish species distributions between 1991 and 2002. It is also likely to be truer of dry years, when

5.4.4 Potential Spawning Habitat

The locations of reaches potentially suitable for spawning by the four groups of native fishes were identified by Yates (2003) by selecting the segments that met the substrate, depth, and velocity criteria identified in Table 5-4. Those potentially suitable areas were subsequently sampled to determine whether gravel texture was also suitable for spawning. The cumulative length of suitable channel for each fish category is provided in Table 5-6, subtotaled by the type of hydraulic condition. Temperature conditions were not included in the initial determination of potentially suitable spawning habitat, but are considered in the Subsection, 'Temperature,' below, based on limited data.

Overall, there are nearly 9 miles of riffle, run, or pool areas that appear to be potentially suitable for spawning for at least one category of fish. However, the actual length is lower, since the same location may be recorded as suitable for more than one group of fish. The great majority of potentially suitable sites are located in reaches classified as runs (Yates 2003). Most of the gravel along lower Putah Creek is of finer texture than is normally utilized by steelhead, salmon, and lamprey for spawning. This is further supported by the use of a high proportion of the predicted suitable spawning sites for redds by the salmon that migrated up

Putah Creek in fall 2003, and the selection of sub-optimal conditions for several redds, as described in the Subsection, "Fisheries After Water Accord (2000 to present), above. The selection criteria used to identify potentially suitable spawning segments were approximate. However, with additional information or new estimates of spawning requirements, the location of potentially suitable habitat areas can be refined (Yates 2003). Following are Gus Yates' assessments of potentially suitable habitat for each fish group.

Table 5-6
Cumulative Length of Potentially Suitable Spawning Habitat along Lower Putah Creek

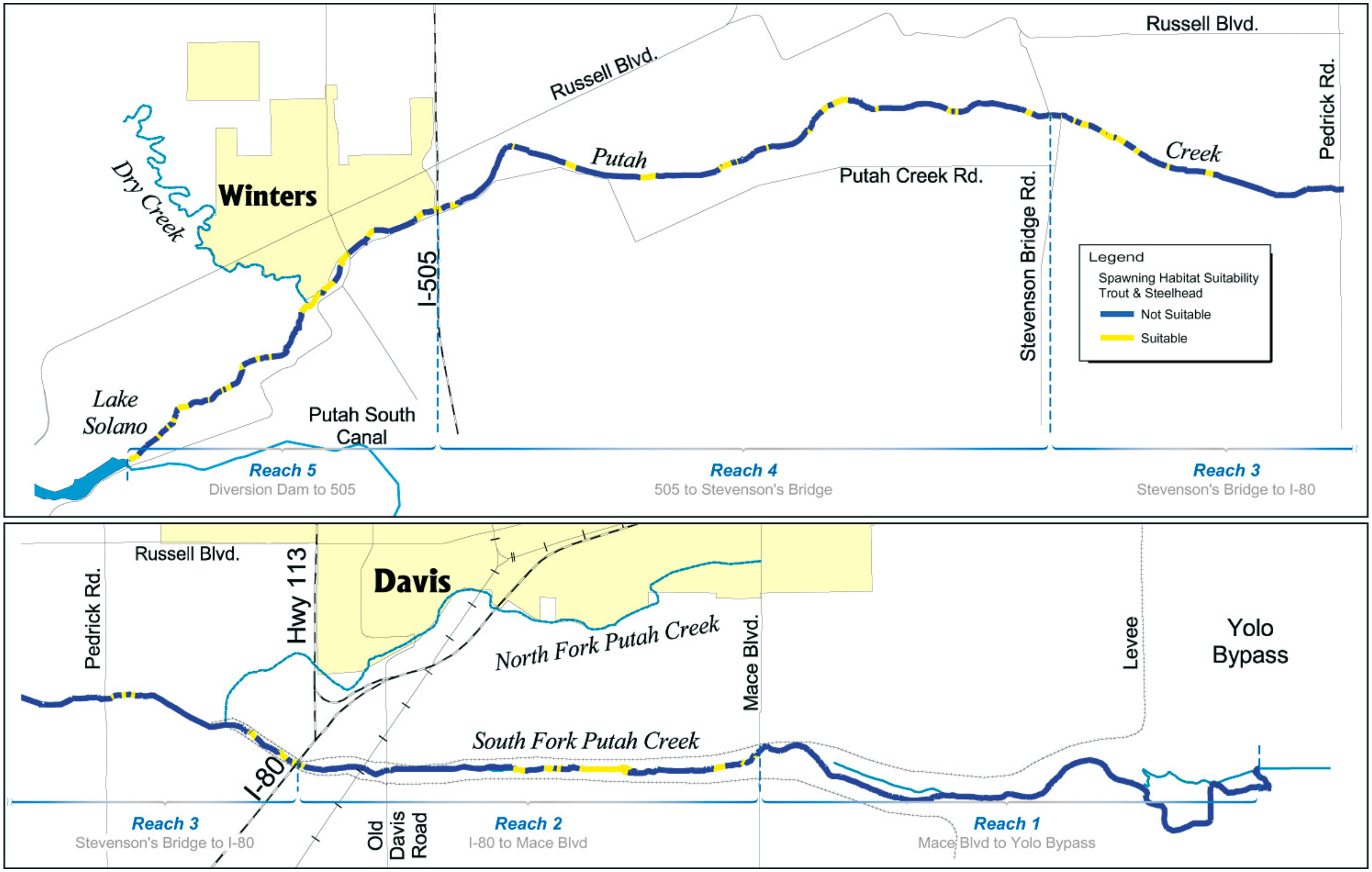
Substrate Type	Miles of Spawning Habitat			
	Pool	Riffle	Run	Total
Chinook salmon	0.00	0.19	1.67	1.86
Rainbow trout/Steelhead	0.24	0.83	2.91	3.98
Pacific lamprey	0.06	0.19	1.42	1.67
Hitch, Sacramento sucker, Sacramento pikeminnow	0.00	0.11	1.31	1.42
Source: Yates 2003				

RAINBOW TROUT AND STEELHEAD

The locations of channel segments that meet the criteria for trout and steelhead are shown in Exhibit 5-16. The criteria are a water depth between 0.4 feet and 5.0 feet, a velocity between 0.6 feet per second (ft/sec) and 4.9 ft/sec and a gravel substrate. Areas with these characteristics total about 4 miles of creek channel. They are distributed as short segments located between the PDD and Mace Boulevard (reaches 2–5), mainly in runs. The total length of potentially suitable spawning reaches for trout and steelhead is more than double the total length for any of the other fish categories because of the broader depth and velocity tolerances for trout and steelhead (Yates 2003).

CHINOOK SALMON

The distribution of potentially suitable spawning habitat for salmon is shown in Exhibit 5-17. The combined length of those segments is 1.86 miles, about half of the total length for trout and steelhead. The depth and velocity ranges for salmon are within the ranges for trout and steelhead, and the gravel texture and thickness are the same, so the suitable segments for salmon are a subset of those for trout and steelhead (Yates 2003). The suitable spawning locations for salmon are also distributed throughout the same reaches as trout and steelhead (Yates 2003). The segments identified as potentially suitable include the location where salmon were seen spawning in 1998, a half-mile downstream of Stevensons Bridge (Yates 2003).



Source: Yates 2003

Distribution of Suitable Spawning Habitat for Trout and Steelhead Based on Water Depth, Velocity, and Substrate

EXHIBIT 5-16

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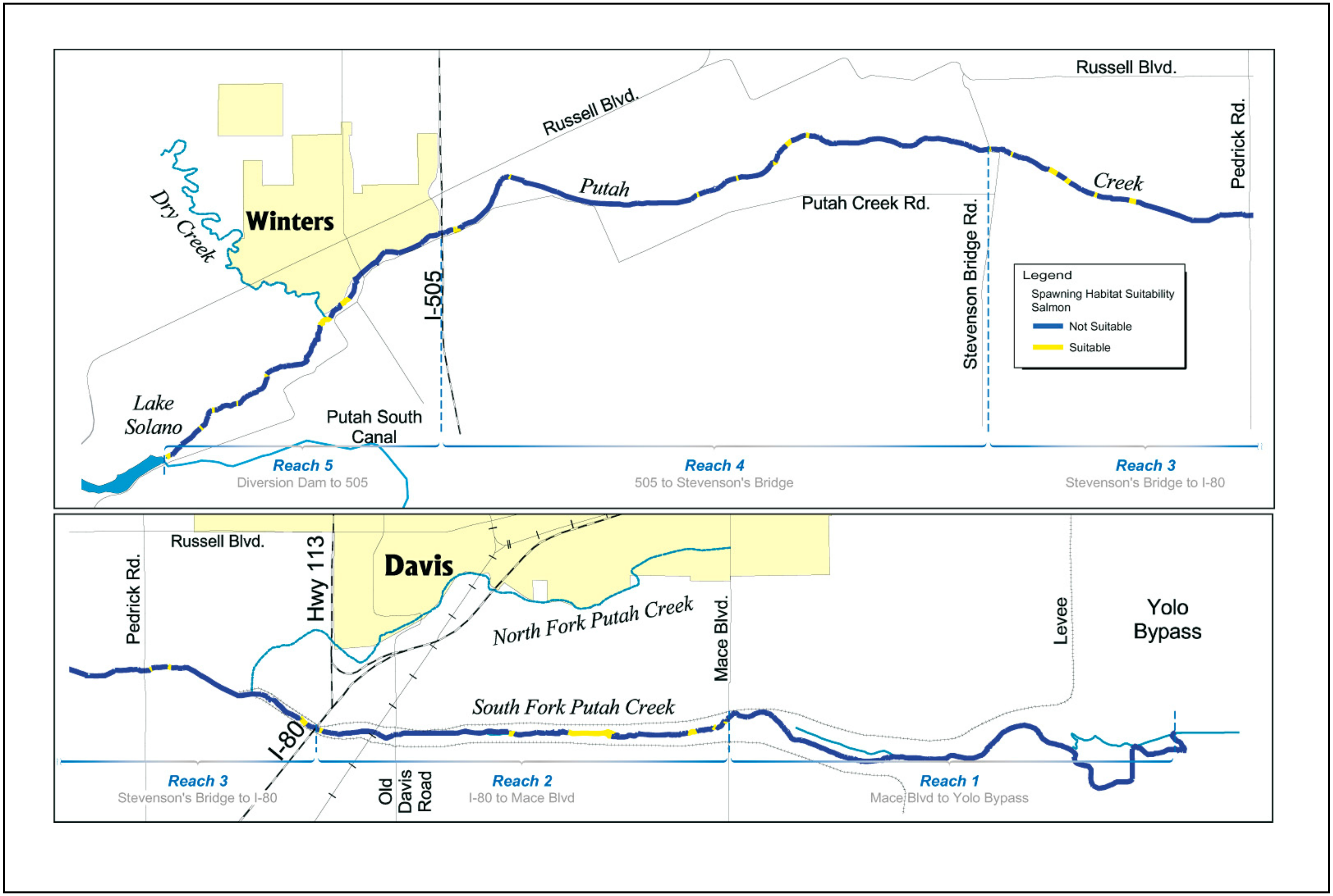

Source: Yates 2003

Distribution of Suitable Spawning Habitat for Salmon Based on Water Depth, Velocity, and Substrate

EXHIBIT 5-17

Lower Putah Creek Watershed Management Action Plan

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EDAW

Following the return of the first substantial salmon run in decades, in 2003, the use of potential suitable spawning sites could be compared. Exhibit 5-13 shows the location of redds in comparison to the potentially suitable spawning sites. Based on the survey by Moyle and Crain (2003) of lower Putah Creek from the PDD to Old Davis Road, it appears that the salmon used all suitable sites with the right combination of coarse gravel, fast water and depth (Moyle, pers. comm., 2003). All redds were found between the PDD and just downstream of Pedrick Road. No redds were recorded below the North Fork Putah Creek juncture. A total of 19 (48%) out of 40 redds surveyed by Moyle and Crain (2003) were located in areas determined by Yates (2003) to be suitable. An additional 4 (10%) redds were located within 100 feet of sites considered to be suitable. The majority, or 16 of the redds in these areas were located in gravel, while the remaining 7 were in patchy gravel.

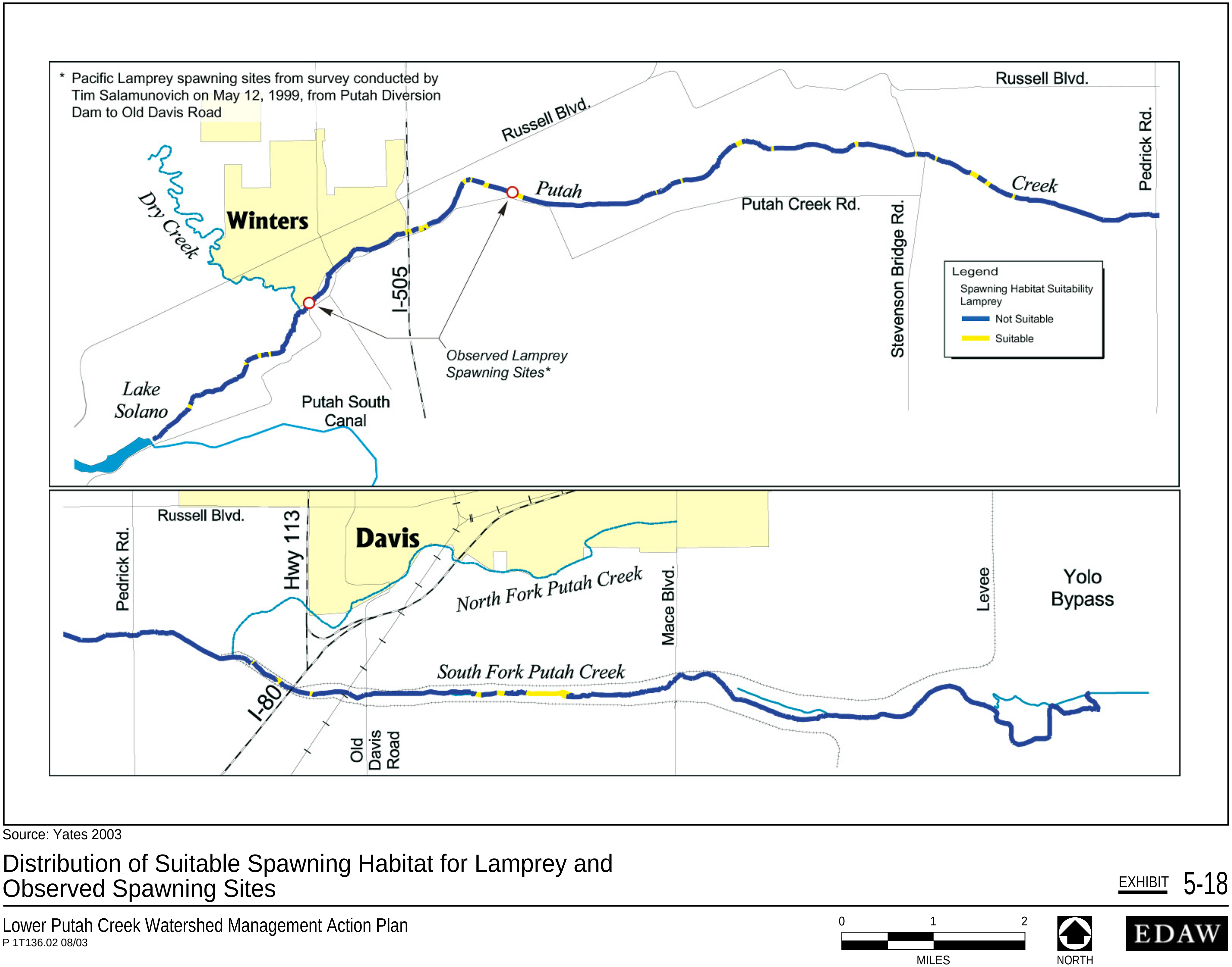
The maximum depth of water at redd sites identified as potentially suitable was 14 to 24 inches and the hydraulic conditions included 8 pools, 1 riffle and 14 runs. The remaining 17 (42%) redds not located in areas determined to be suitable were nonetheless characterized by substrate and hydraulic conditions largely similar to those considered to be potentially suitable. They included 8 redds in gravel, 6 in patchy gravel, 2 in sand and gravel, and only 1 in claypan. The maximum depth of water at redd sites not identified as potentially suitable was 12 to 21 inches and the hydraulic conditions included 5 pools, 7 riffles and 5 runs. Further discussion of the return of fall run chinook salmon in large numbers to lower Putah Creek in 2003 is provided in the subsection, Fisheries After Water Accord (2000 to present).

PACIFIC LAMPREY

Segments of potentially suitable spawning habitat for Pacific lamprey are shown in Exhibit 5-18. The depth and velocity ranges for lamprey are a subset of the ranges for trout and steelhead. Unlike the salmonids, however, lamprey were assumed to be able to utilize patchy gravel substrate, as confirmed by their use of the low road crossing (Exhibit 5-5). The total river miles of potentially suitable lamprey spawning habitat is about 1.7 miles, similar to the total for salmon. Slightly more than half of the individual stream segments suitable for lamprey are also suitable for salmon. The lamprey segments are scattered throughout lower Putah Creek in all reaches from the PDD to Mace Boulevard (Yates 2003). Observations of lamprey spawning in the creek are described in subsections Lower Putah Creek Downstream of PDD and Fisheries Prior to Water Accord (1960s to 2000).

SACRAMENTO PIKEMINNOW, HITCH, AND SACRAMENTO SUCKER

The locations of creek segments potentially suitable for spawning by Sacramento pikeminnow, hitch, and Sacramento sucker are shown in Exhibit 5-19. The criteria for these species are similar to those for lamprey and, therefore, the 1.4 total miles of suitable sites is also similar (Yates 2003).



Source: Yates 2003

Distribution of Suitable Spawning Habitat for Lamprey and Observed Spawning Sites

EXHIBIT 5-18

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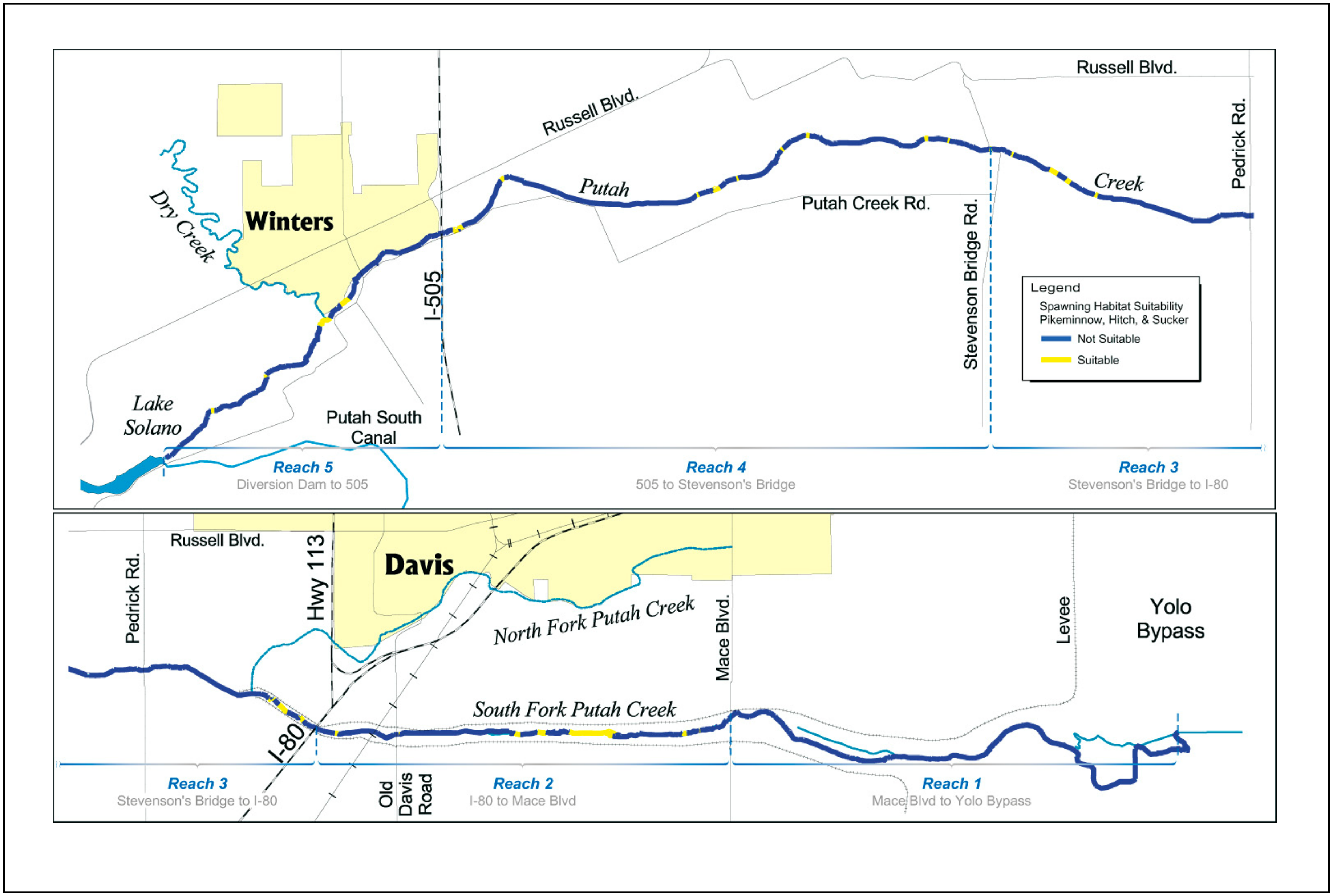

Source: Yates 2003

Distribution of Suitable Spawning Habitat for Pikeminnow, Hitch, and Sucker Based on Water Depth, Velocity, and Substrate

EXHIBIT 5-19

Lower Putah Creek Watershed Management Action Plan

P 1T136.02 08/03

0 1 2 MILES

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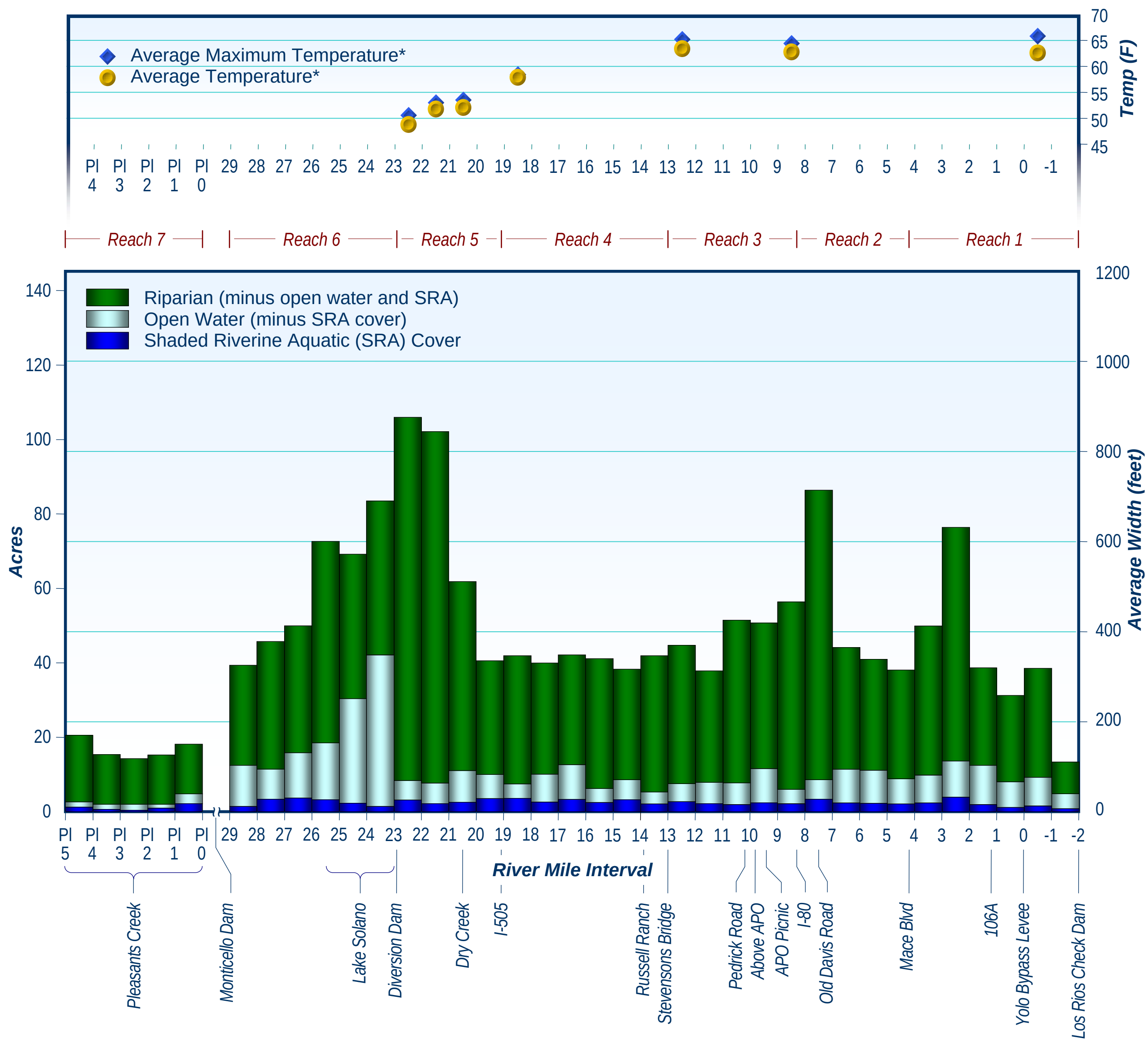


* Temperature data are the average maximum temperatures in April and average hourly temperatures recorded in April based on 1997 and 1999-1002 data provided by SCWA.

Source: SCWA 2003, EDAW 2003

Average Size of Habitat Types and Water Temperatures in April* by River Mile

EXHIBIT 5-20

smaller releases from the PDD are likely to result in quicker heating of downstream water. In wet years, and likely with Accord flows, the water remains cooler further downstream. Any additional enhancement to improve the channel form, SRA cover, and the riparian corridor are likely to add to this effect.

Based on the fish data (LPCCC 2003), the first 4 miles downstream of the PDD typically have a much higher proportion of Sacramento sucker than areas near Russell Ranch and Stevensons Bridge. The dominance among native species switches from Sacramento sucker in Reach 5 to Sacramento pikeminnow in the lower portion of Reach 4 (Exhibits 5-8 and 9) in non-drought years. In dry years, the shift occurs further upstream (Exhibit 5-11). Sacramento sucker, as with all native fishes, drops off sharply in population size beginning in Reach 3 and continuing downstream. In years of drought prior to the Accord flows, the population drop was much further upstream, within the first 4 miles or less. However, with the Accord flows, native fish appear to be increasing in population size, such that the Sacramento pikeminnow, and to a lesser extent the Sacramento sucker and tule perch, account for a relatively high percentage (over 20%) of total fish abundance (native and introduced) well into Reach 3, before dropping off in population. The Accord releases from PDD could result in the maintenance of cooler water temperatures further downstream then prior to their implementation. However, due to the limited amount of temperature data available, and the short time period since Accord flows have been implemented, additional temperature data and further fish sampling and analyses would need to be conducted to confirm whether the Accord flows are reducing water temperatures and increasing the extent and quantity of suitable spawning habitat for native species in lower Putah Creek.

5.5 SHADED RIVERINE AQUATIC COVER HABITAT ASSESSMENT AND CHANNEL AND RIPARIAN CORRIDOR SIZE ANALYSIS

SRA cover habitat is the interface between riparian vegetation and an adjacent aquatic environment. Both overhead (i.e., riparian trees and shrubs) and instream (i.e., undercut banks, submerged vegetation, roots, low-hanging branches, vegetative debris) SRA cover habitat are important to maintaining suitable habitat for native fish because they regulate water temperature and water quality, provide food and shelter, and can provide native fish with some protection from non-native predatory fish. The width of the creek channel and the extent of the riparian corridor are also important attributes for fisheries, because they influence flow velocity, water depth and water temperature. For instance, a wide open water area may be mostly unshaded and heat up relatively quickly. Since the water does not cool down, this can result in warm water from the wide area all the way downstream, thus affecting the type of fish that can live there. Similarly, a wide, dense multistory riparian corridor can provide insulation against warm air moving across the creek corridor, thus reducing convective heating of the water. In shaded reaches of lower Putah Creek, cool microclimates persist even on hot days (Marovich, pers. comm., 2003).

EDAW evaluated SRA cover habitat along lower Putah Creek using two methods. The first was a qualitative assessment conducted in the field. The second method involved analyzing aerial photographs and estimating shaded aquatic areas versus open (i.e., unshaded) water areas along Putah Creek using Geographic Information Systems (GIS). The riparian corridor width was also assessed. Each of these methods is described below.

The qualitative SRA cover assessment was conducted in summer 2002 concurrently with the vegetation and wildlife habitat assessment described in Chapter 6, "Vegetation and Wildlife." At 75 sampling locations approximately 0.5 mile apart, five habitat attributes that are important components of SRA cover habitat were classified as good, fair, or poor. Based on these results, the overall habitat quality for the wildlife group was rated as optimal, moderate, low, or absent. The habitat attributes for SRA cover habitat included:

< Riparian shrubs and trees that overhang and shade the creek.
< Herbaceous and low-growing plants (e.g., sedges) that overhang and shade the creek.
< Natural banks that support riparian vegetation rather than concrete levees or rip-rap.
< In-stream vegetation and debris such as logs, branches, and leaves.
< Under-cut banks and exposed tree roots that create cover.

The aerial photograph SRA cover, creek channel, and riparian corridor assessment was conducted by using high resolution aerial photographs (flown in 2001) to delineate and calculate areas of open water, shaded water, and riparian corridor using GIS. Because the vegetation often obscured the creek bank, the precise edge of the water was estimated based on areas where the bank was visible. Although this method quantifies the approximate acreage and average width (per river mile) of vegetation overhanging the creek, it does not include an assessment of the quality of the habitat because other components, such as natural banks or in-stream debris were not visible on the photographs. In other words, a large area of SRA cover habitat does not necessarily mean that it is high-quality habitat. This method also did not include an assessment of shading based on the sun's angle to the creek. So, while the method provides a reasonable estimation of the relative differences in total SRA cover habitat between reaches, it is not likely to be an accurate estimate of the actual shaded area over the creek. The riparian corridor generally was delineated as the area extending to farmland and levees. This delineation is described in more detail in the methods subsection in Chapter 6, "Vegetation and Wildlife." The riparian corridor assessment does not take into account the fact that the area includes tall and short vegetation cover or, in some areas, little to no cover.

5.5.1 SRA Cover, Creek Channel, and Riparian Corridor Assessment Results

Exhibit 5-20 shows the total acreage and average width of overhead SRA cover, open water, and riparian corridor, summarized by river mile. Table 5-7 provides a summary of SRA cover and open water habitat type acreages and proportions, by reach. Table 5-8 provides a summary of SRA cover, open water, and riparian corridor dimensions by river mile.

Table 5-7 SRA Cover and Open Water Habitat By Reach			
Reaches	SRA Cover (acres)	Open Water Area (acres)	SRA Cover Percent of Open Water
Reach 1	11.7	57.1	20%
Reach 2	10.2	40.8	25%
Reach 3	11.1	40.4	27%
Reach 4	18.2	52.1	35%
Reach 5	11.3	34.9	32%
Reach 6	16.8	140.2	12%
Putah Creek Total	79.1	365.4	22%
Pleasants Creek (Reach 7)	5.1	13.0	39%
Source: EDAW 2004			

Lower Putah Creek has a total of approximately 79 acres (22%) of SRA cover habitat out of 365 acres of open water habitat in Reaches 1-6, based on the aerial photograph analysis. Most sampling locations along lower Putah Creek were characterized as having moderate SRA cover habitat. In general, the sampling locations are characterized by good to fair amounts of high (e.g., trees and shrubs) and low (e.g., sedges) vegetation that overhang the water, instream vegetative debris (e.g., leaves, branches, logs), and naturally eroding banks with undercuts. Following is a summary of the assessment of SRA cover habitat extent and quality, and the creek channel and riparian corridor extents, by reaches.

REACHES 1, 2, AND 3

Reaches 1, 2, and 3 have a moderate proportion (20–27% by reach) of SRA cover to total water area, and the quality of the SRA cover is considered moderate overall. The creek channel in these reaches varies from a low of about 40 feet wide, on average, in the Yolo Bypass ditches, to an average of about 85 feet wide through most of Reach 2 and about 65 feet wide through most of Reach 3. Also in Reaches 1–3, the riparian corridor ranges from an extremely narrow swath averaging under 100 feet wide along each bank in the Yolo Bypass portion of Reach 1, to moderately wide (i.e., average width of 120–320 feet wide) along each of the upstream banks in Reach 1 and all of Reaches 2 and 3.

REACHES 4 AND 5

Reaches 4 and 5 have the highest percentage (32–35% by reach) of SRA cover along the mainstem of lower Putah Creek. Like Reaches 1, 2, and 3, SRA cover habitat quality in Reaches 4 and 5 is considered moderate overall. The creek channel is moderately wide in those reaches, averaging between approximately 45 and 105 feet wide, and the riparian vegetation is relatively dense adjacent to the channel. The riparian corridor in Reaches 4 and 5 range from an average of 120 to 150 feet wide on each bank, in the downstream stretches, to a higher range of 210–400 feet wide on each bank, on average, in the upper 3 miles of Reach 5, between the PDD and Dry Creek confluence.

Table 5-8 SRA Cover, Open Water, and Riparian Corridor Habitat by River Mile							
River Mile Interval	SRA Cover (acres)	Open Water (acres)	SRA Cover % of Open Water	SRA Cover Avg. Width (ft)	Open Water Avg. Width (ft)	Riparian Corridor[1] (minus water, SRA) (acres)	Riparian Corridor[1] (minus water, SRA) Avg. Width (ft)
-2 to -1	0.94	5.8	16%	6	34	10.24	71
-1 to 0	1.40	8.2	17%	13	63	26.12	124
0 to 1	0.93	6.5	14%	9	57	18.77	192
1 to 2	1.93	12.5	15%	16	87	26.43	217
2 to 3	3.90	13.7	29%	32	81	62.89	519
3 to 4	2.37	9.8	24%	20	62	40.02	331
4 to 5	2.16	9.1	24%	17	56	30.09	241
5 to 6	2.30	11.6	20%	18	74	31.17	246
6 to 7	2.39	11.6	21%	19	75	33.28	270
7 to 8	3.35	8.6	39%	28	44	78.12	643
8 to 9	2.24	6.3	36%	18	32	53.01	417
9 to 10	2.41	11.7	21%	20	76	39.36	323
10 to 11	1.93	7.8	25%	16	48	44.10	362
11 to 12	2.19	8.0	28%	18	47	30.20	248
12 to 13	2.74	7.6	36%	22	40	37.69	308
13 to 14	2.07	5.3	39%	17	27	36.92	303
14 to 15	3.30	8.8	38%	27	44	30.33	245
15 to 16	2.46	6.4	39%	20	32	35.35	288
16 to 17	3.38	12.9	26%	27	77	30.07	244
17 to 18	2.62	10.2	26%	21	62	30.24	247
18 to 19	3.65	7.6	48%	30	32	34.89	285
19 to 20	3.56	10.1	35%	29	54	30.73	252
20 to 21	2.78	12.2	23%	21	70	55.86	420
21 to 22	2.26	7.9	29%	18	45	97.24	781
22 to 23	3.24	8.6	38%	26	43	99.89	807
23 to 24	1.43	42.8	3%	12	337	42.07	342
24 to 25	2.34	30.8	8%	19	232	39.39	321
25 to 26	3.41	19.4	18%	27	126	57.00	448
26 to 27	3.74	16.1	23%	30	101	34.70	282
27 to 28	3.38	11.6	29%	28	67	34.73	283
28 to 29	1.48	13.0	11%	12	91	28.02	222
Putah Creek Total	**78.6**	**365.6**	**22%**	**20**	**75**	**1,283**	**334**
Pl 0 to Pl1	2.1	4.6	46%	18	22	13	110
Pl 1 to Pl2	0.9	2.0	47%	8	9	13	110
Pl 2 to Pl3	0.4	2.0	21%	3	13	12	102
Pl 3 to Pl4	0.6	2.0	31%	5	11	14	111
Pl 4 to Pl5	1.0	2.1	48%	10	11	15	148
Pleasants Creek Total	**5.1**	**12.7**	**40%**	**9**	**13**	**67**	**115**
[1]Riparian corridor values do not include open water or SRA habitat acreage/widths.							

REACH 6

Reach 6 has the lowest percentage of SRA cover (12% of total water area) in lower Putah Creek. This is primarily due to the large expanse of open water in Lake Solano. In addition, Lake Solano has the most areas of low quality SRA cover habitat in lower Putah Creek. In general, most of the habitat attributes described above were classified as fair or poor around Lake Solano.

REACH 7, PLEASANT CREEK

SRA cover in Pleasants Creek (Reach 7) is characterized as contributing 39% to the total water area. However, from the qualitative field assessment, it is clear that most of Pleasants Creek dries up in summer; therefore the SRA cover estimate for Pleasants Creek is unlikely to be valid during summer months. SRA cover habitat was characterized as poor, primarily since aquatic habitat was frequently absent during the time of the survey in late summer. However, because these areas are upstream of the PDD, and anadromous fish are currently unable to pass the Dam, SRA cover habitat in that area may be less important. The riparian corridor along Pleasants Creek is generally extremely narrow, averaging only about 51 to 75 feet wide along each bank.

5.6 FISH PASSAGE ISSUES

Salmon, lamprey and steelhead migrating up lower Putah Creek to spawn, and later returning to sea have to make it past obstacles. Two structures, the PDD and Monticello Dam, completely block migration into historic spawning and rearing areas in the interdam reach and as far upstream as the Berryessa Valley. To migrate into Putah Creek, anadromous fish return through San Francisco Bay, north to San Pablo Bay, through the Carquinez Strait into Suisun Bay and up the Sacramento River into Cache Slough just upstream from Rio Vista. From Cache Slough they swim through Prospect Slough and into the manmade East Toe Drain of the Yolo Bypass (Exhibits 1-1, 1-2, and 1-3). After swimming up the East Toe Drain they reach the Lisbon Weir—a mound of rock that captures water at low tide. At high tide both water and fish pass over the rocks. After about another 1½ mile, the fish swim into the treeless, excavated Yolo Bypass ditch where Putah Creek connects to the East Toe Drain. After swimming 2 miles across the Bypass channel the fish reach the first major obstacle, the Los Rios Check Dam, a 12-foot-high, 30-foot-long concrete box that serves as a seasonal check dam in the Yolo Bypass to create a head of water for irrigation pumping and to flood the Yolo Basin Wildlife Area. The Los Rios Check Dam is currently being managed to optimize the migration of fall run chinook into lower Putah Creek by removing boards in fall in conjunction with pulse flow releases from the PDD, as discussed in the subsection, Putah Creek Water Accord, above (Exhibit 5-21).

(A) Los Rios Check Dam waterfall (approx 7 ft. tall) across boards, (B) boards are removed at Los Rios Check Dam in fall timed with pulse releases from the Putah Diversion Dam to enable passage of chinook salmon and other anadromous fish, (C) Los Rios Check Dam following removal of boards, (D) collapsed Winters percolation dam looking upstream (west), (E) Putah Diversion Dam, (F) beaver dam (January 2004) downstream of Mace Blvd. Photo credits: Dave Feliz (Los Rios Check Dam photos); US Bureau of Reclamation (Putah Diversion Dam); UC Davis Department of Wildlife, Fish, and Conservation Biology (beaver dam).

Source: Dave Feliz (CDFG) 2003; UC Davis 2004; USBR 2004; EDAW 2003

Putah Creek Fish Passage Issues

EXHIBIT 5-21

Swimming upstream past the check dam, fish may reach one to several beaver dams over the next 20 miles of lower Putah Creek. The beaver dams are typically broken up and washed downstream during high flow events, but during dry and moderate rainfall periods, the dams can persist for years. If flows are insufficient to overtop or bypass the dams during migration periods, the fish may have difficulty in passing over or around them. Increased flow releases (e.g., from storm events) from the PDD during spawning have assisted the fish in passing the beaver dams often by flooding side channels faster than beavers can plug them. Just 3 miles upstream of the Los Rios Check Dam, fish pass the location of the Road 106A seasonal earthen road crossing. The crossing is installed annually in spring for farm operations and the road and culverts are removed in fall, which allows for fish passage upstream. During late season rainstorms, Road 106A can fail, as occurred in the spring of 2003. (See Exhibit 4-3b in Chapter 4, "Geomorphology, Hydrology, and Water Quality."). The culverts underlying Road 106A are considered a possible impediment to fish passage (DWR 2003).

After swimming upstream about 21 miles from the Los Rios Check Dam, the migrating fish encounter the percolation dam in Winters (Exhibit 5-21). The 100-foot-wide concrete structure was built in 1936 and collapsed during a flood in 1951. (See the subsection, Hydrology Prior to the Solano Project, in Chapter 4 for more details.) The Winters percolation dam continues to partly obstruct passage, especially during low flows and when debris clogs passageways through the dam. Passing the percolation dam, the fish swim another 4 miles before reaching the PDD, a gated concrete weir 29 feet tall and 910 feet wide (Exhibit 5-21).

The PDD currently prevents further passage to the interdam reach. If passage is someday achieved by a bypass channel or other means, the fish would have access to historic spawning areas in the interdam reach and could swim another 6 miles upstream before reaching Monticello Dam, a concrete dam 304 feet high and over 1,000 feet wide that prevents further migration from the interdam reach to the historic Berryessa Valley, now filled by Lake Berryessa, and the upper Putah Creek watershed.

6

Vegetation and Wildlife

6 VEGETATION AND WILDLIFE

This chapter provides an assessment of the existing plant communities and wildlife habitats present along the lower Putah Creek and Pleasants Creek riparian corridors. It presents a qualitative evaluation of habitat quality for groups of wildlife species and discusses the importance of riparian habitat to wildlife. For this chapter, habitat is defined as the native environment of an animal or plant, including attributes that provide shelter, food, nesting substrates, or other important elements for plants or animals to grow, survive, and reproduce. The riparian corridor is defined as the area in which typical stream-dependent vegetation (e.g., willows, Fremont cottonwood, and valley oak) grow or can grow, because of the presence of surface water or shallow groundwater. Riparian habitat is one of the most important habitat types for wildlife species because of its rich, complex mixture of vegetation, water, food, and shelter. In California, where hillsides and grasslands are typically dry in summer, riparian habitat is especially important to animals and plants dependent on the availability of summer water. Over the past 200 years, hundreds of thousands of acres of riparian forest have been cleared for development and agriculture. As a result, the existing riparian forest habitat in the state represents approximately 5–10 percent of the total riparian acreage estimated to occur two centuries ago (Barbour et al. 1993, Hunter et al. 1999, RHJV 2000).

This chapter further assesses the suitability of riparian habitats to support sensitive biological resources; analyzes the biological significance of the area in view of federal, state, and local laws and policies; and describes measures to protect sensitive resources.

6.1 METHODS

A survey of vegetation and wildlife habitats was conducted during summer 2002. A total of 75 sampling locations was established at approximately 0.5 mile intervals along lower Putah Creek, from Monticello Dam to the Los Rios Check Dam on the west side of the Yolo Bypass, and along Pleasants Creek, from Lake Solano to approximately 4 miles upstream. The sampling locations were visually assessed from public roads or from canoes when road access was unavailable. The area encompassed by each sampling location varied based on access and visibility, but generally included a zone approximately 300–500 feet long. An example of the sampling datasheet is provided in Appendix B.

At each sampling location, plant communities were classified and their percent cover of the total visible area was estimated. The approximate length of area visible from the sampling location and the ranges of channel width and riparian corridor were estimated in the field using aerial photographs printed at a scale of 1:1,200 (i.e., 1 inch=100 feet). Vegetation structure and species composition data were taken at each sampling location, including the dominant species in different canopy layers. Canopy layers included the herb (ground) layer, shrub (under 15 feet tall), subcanopy (smaller trees not reaching uppermost canopy), and the upper canopy (large trees). However, comprehensive vegetation mapping was not conducted for the entire riparian corridor of lower Putah Creek and Pleasants Creek. A vegetation map of lower Putah Creek was produced as part of the Sacramento River Riparian Mapping Project by the California State University, Chico Geographical Information Center (GIC 2000) and is included in a separate map volume. In some locations, the vegetation types on the GIC map differ from those determined during 2002 surveys because of the time of data collection, as well as differing vegetation classifications, mapping methodologies, and scales of mapping.

Existing vegetation structure and other habitat attributes provided the basis for classifying habitat quality at each sampling location for wildlife groups that included: tree-nesting raptors, other nesting birds (ground/low, shrub, tree, and cavity nesters), and semi-aquatic reptiles (i.e., pond turtles). These wildlife groups were selected because they represent a range of wildlife species with habitat requirements that could be generalized and efficiently measured. The quality of SRA habitat and the connectivity of corridors for animal movement were also evaluated. The SRA cover assessment is discussed in more detail in Chapter 5, "Fisheries."

To classify habitat quality, a checklist of three to five important habitat attributes was developed for each group of wildlife species with sufficiently similar habitat requirements. The value of each habitat attribute was rated as good, fair, or poor. The overall habitat quality for the wildlife group was rated as optimal, moderate, low, or absent. In general, *optimal* habitat included habitat with all necessary habitat attributes present and classified as good. *Moderate*-quality habitat included two or three attributes classified as good, with the remaining attributes classified as fair. *Low*-quality habitat included one attribute classified as good, or all attributes classified as fair. If all attributes were classified as poor, then habitat was considered *absent*. The habitat attributes for each group are described below.

6.1.1 RAPTORS

Raptors that nest adjacent to Putah Creek include, but are not limited to, white-tailed kite, red-shouldered hawk, red-tailed hawk, Swainson's hawk, and great-horned owl. These raptors have similar habitat requirements in that they build platform nests in trees. Other raptors that are known to occur along Putah Creek, such as ground-nesting northern harriers or cavity-nesting American kestrels, have more specialized habitat requirements, and are not included in this group for purposes of the habitat assessment.

Habitat Attributes:

- Tall/mature trees for nests. For example, valley oak, cottonwood, willow, sycamore, and walnut are preferred trees for Swainson's hawk. *Eucalyptus* are also commonly used by raptors.

- Open fields or pastures for foraging adjacent to nesting habitat. Alfalfa, fallow fields, beet, tomato, other low-growing crops, and pastures are some of the preferred foraging habitats for Swainson's hawk.

- Low amount of disturbance in the area.

6.1.2 OTHER NESTING BIRDS

Nesting non-raptorial birds are divided into the following four categories based on their typical nest position:

- Ground/low-nesters – These include species such as song sparrow, lazuli bunting, spotted towhee, and California towhee. They typically build nests 0 to 4 feet above ground.

- Shrub-nesters – These include species such as bushtit and black-headed grosbeak. They typically build nests 4–10 feet above ground.

- Tree nesters – These include species such as western wood-pewee, yellow-billed magpie, and Bullock's oriole. They typically build nests 10 feet or more above ground.

- Cavity-nesters – These include species such as western bluebird, ash-throated flycatcher, and tree swallow. They use cavities for nesting at various heights depending on availability.

Nest position is one of many characteristics that can be used to classify birds into similar groups. Other classification methods include ones based on taxonomy (e.g., warblers), land cover type (e.g., birds associated with riparian woodland), or foraging guild (e.g., seed eaters). Nest position was selected as the classification method for this study cause it allows for a habitat-based analysis that is more refined than using land cover type, and is measured easily and rapidly.

The first three attributes listed below were evaluated for all four groups of land birds collectively. The fourth attribute, which refers to nest substrate availability, was evaluated for each group separately.

Habitat Attributes:

- Complex structure (e.g., presence of herbaceous, shrub, and canopy layers) and high plant diversity.

- Wide riparian corridor.

- Low apparent density of predators, disturbance, or attractants for predators. Considerations might include cats near residential areas, or trash piles and picnic areas which may attract rats, raccoons, or other predators.

- Suitable substrate for nesting (e.g., vegetation near the nest position for concealment, snags, or trees with existing or potential nesting cavities).

6.1.3 WESTERN POND TURTLE

One of the most common native species of reptiles to occur in the lower Putah Creek drainage is the western pond turtle (*Emys marmorata*). Although western pond turtles are relatively common in Putah Creek, western pond turtle populations are declining throughout their range. Western pond turtle is considered a federal and California species of special concern because of habitat loss and alteration, loss of breeding areas and low population recruitment, and increased predation by introduced aquatic species (Jennings and Hayes 1994). By assessing habitat quality for western pond turtle in Putah Creek, more insight into the restoration needs can be obtained.

Habitat Attributes:

- < Slack or slow moving water.
- < Aerial basking areas, such as logs, rocks, and exposed bank.
- < Dense submergent vegetation (e.g., pondweed, ditch grass) for basking and feeding; and/or short emergent vegetation for hatchlings.
- < Upland nesting sites (up to 1,300 feet from aquatic habitat) with high clay or silt fraction substrate on an unshaded, often south-facing slope of usually less than 25% gradient.

6.1.4 SHADED RIVERINE AQUATIC COVER HABITAT

SRA habitat is the interface of riparian vegetation and aquatic habitat. Overhead SRA cover, such as riparian trees and shrubs, provides shade over aquatic areas, maintains cool water temperatures, and deposits fallen leaves, branches, and insects into the nutrient cycle of the aquatic system. Instream SRA cover, such as undercut banks, vegetation, roots, low-hanging branches, and vegetative debris, provides a variety of micro-habitats characterized by various flows, depths, cover, and food production. Instream cover also provides a food source, shelter, and spawning substrate for a variety of fish and other aquatic organisms.

Habitat Attributes:

- < Riparian shrubs and trees that overhang and shade the creek.
- < Herbaceous and low-growing plants (e.g., sedges) that overhang and shade the creek.
- < Natural banks that support riparian vegetation rather than concrete levees or rip-rap.
- < Instream vegetation and debris such as logs, branches, and leaves.
- < Under-cut banks and exposed tree roots that create cover.

6.1.5 WILDLIFE MOVEMENT CORRIDOR

A wildlife movement corridor describes a linear habitat whose primary wildlife function is to connect two or more significant habitat areas. The following attributes facilitate movement for a variety of wildlife species, including large and mid-sized mammals.

Habitat Attributes:

- < Vegetative cover for concealment.

- Connectivity. Areas of suitable habitat should be connected without major (greater than 150 feet) gaps in vegetation or obstacles to travel along the corridor.
- Low amount of disturbance in the area.

6.2 HISTORICAL CONDITIONS

Historically, the complex vegetation mosaic created by dynamic, meandering river systems in the Central Valley and surrounding foothills provided resources necessary to support an abundance of resident and migrant wildlife species. This dynamic system created a variety of habitats, including oxbow lake edges, openings and gravel bars, shrubby early-successional vegetation, and mature forest stands. Riparian forests were structurally and floristically diverse, characterized by species such as box elder (*Acer negundo*), Oregon ash (*Fraxinus latifolia*), white alder (*Alnus rhombifolia*), Goodding's and red willow (*Salix gooddingii*, *S. laevigata*), button willow (*Cephalanthus occidentalis*), mulefat (*Baccharis salicifolia*), California nettle (*Urtica dioica*), wild grape (*Vitis californica*), California blackberry (*Rubus ursinus*), Fremont cottonwood (*Populus fremontii*), valley oak (*Quercus lobata*), and California sycamore (*Platanus racemosa*) (Jones & Stokes Associates 1992, Sutter and Dawson 1986). Adjacent uplands were irregularly flooded and supported extensive valley oak woodlands (Russell and Coil 1940).

Prior to settlement of the area through land grants, the vegetation along Putah Creek consisted of a wide riparian forest that extended from the Coast Ranges to the Putah Creek sinks (HortScience 1997). Estimates of the area of riparian vegetation that existed along lower Putah Creek between Winters and the Putah Creek sinks prior to development range from 22,000 to 65,000 acres (Katibah 1984, Kuchler 1977). Calculations using the lower of these estimates suggest that the historical riparian corridor averaged 1.5 miles wide between Lake Solano and the Yolo Bypass (USFWS 1993).

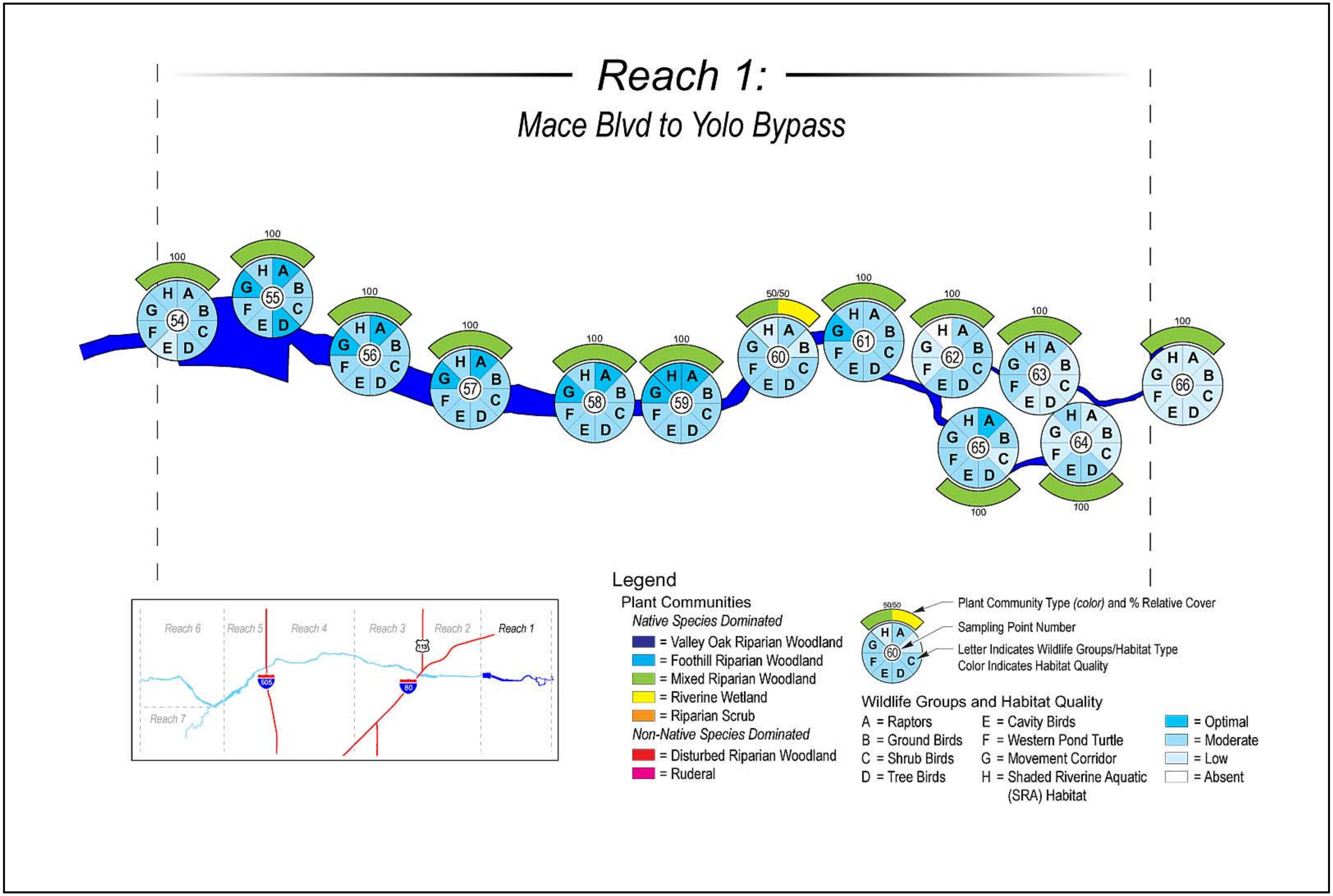
Despite the importance of riparian and wetland habitats, California has lost approximately 90–95% of these habitats over the past 150 years due to reservoir construction, levee and channelization projects, livestock grazing, timber harvest, water pollution, introduction of nonnative invasive plant species, gravel and gold mining, and clearing for agricultural, residential, and industrial uses (Barbour et al. 1993, RHJV 2000). Similarly, Putah Creek has experienced several large-scale changes which have affected natural resources over the last 100 years (HortScience 1997). The riparian vegetation along much of Putah Creek was cleared in the late 1800s as settlements were established and large tracts of land were converted to agricultural uses. In addition, the south fork of Putah Creek was constructed in the late 1800s and completed in the 1940s (USFWS 1993, Larkey 1969). By the 1940s, most of the bank-to-bank riparian vegetation was removed from Winters to the Yolo Bypass (HortScience 1997). Vegetation clearing by the USACE continued into the 1970s. Although trees and other riparian vegetation have re-grown along the creek and are fairly mature in some areas, the riparian corridor is constrained by adjacent land uses, including agriculture, residential and urban development, and roadways. Continuing periodic stream maintenance activities for fire suppression or flood protection also affect riparian woodland structure, SRA habitat, and plant and wildlife species composition.

Presently, we estimate that approximately 2,000 acres of riparian habitat remains along Putah Creek, with a riparian corridor width of 71 to 807 feet. A discussion of the historical changes along lower Putah Creek and Pleasants Creek is provided in Chapter 2, "Cultural Resources." A discussion of the extent of different existing land use types along lower Putah Creek and Pleasants Creek, including the riparian corridor, is provided in Chapter 3, "Land Ownership, Land Uses, and Resource Management Programs." Exhibit 3-2 shows the extent of the current lower Putah Creek and Pleasants Creek riparian corridors relative to other land uses in Solano and Yolo counties.

6.3 EXISTING PLANT COMMUNITIES

This section describes the plant communities observed during surveys conducted in the lower Putah Creek and Pleasants Creek riparian corridor in 2002. Appendix D contains a list of plants observed or known to occur in the lower Putah Creek riparian corridor. The plant communities are characterized by dominant plant species, as well as structural characteristics (e.g., mature trees versus shrubs). Plant communities are typically dependent on a range of conditions (e.g., soil moisture during the growing season, flood frequency, and soil type) that support the plants in those communities. The plant communities described in this section are generally consistent with those described by Holland (1986). It is important to note that plant communities are dynamic, changing in species composition and structural characteristics over time as a result of perturbations such as fires, floods, disease, human activities (e.g., habitat conversion, stream maintenance, and species introductions), and over a longer timeframe, climate change. As a result of varying conditions and perturbations, plant communities intergrade with one another in the landscape. The degree and manner in which they change or remain static, and the degree to which the landscape is homogeneous (i.e., single community) or heterogeneous (i.e., many communities) affects both the type and abundance of wildlife that use the riparian corridor.

The lower Putah Creek riparian corridor is characterized by a mixture of plant communities, including mixed riparian forest, valley oak riparian forest, foothill riparian woodland, riparian scrub, riverine wetland, open water, disturbed riparian woodland, and ruderal (i.e., disturbed or dominated by herbaceous weeds) areas. Agricultural land and developed areas are the dominant land cover types adjacent to the riparian corridor. The dominant native community types throughout the watershed are mixed riparian forest and valley oak riparian forest, representing approximately 60% and 12% of the area surveyed at the 75 sampling locations in the riparian corridor, respectively. About 15% of the area surveyed at the sampling locations consisted of disturbed riparian woodland. Exhibits 6-1a through 6-1g show the relative cover of the plant communities at each sampling location.



Source: EDAW 2004

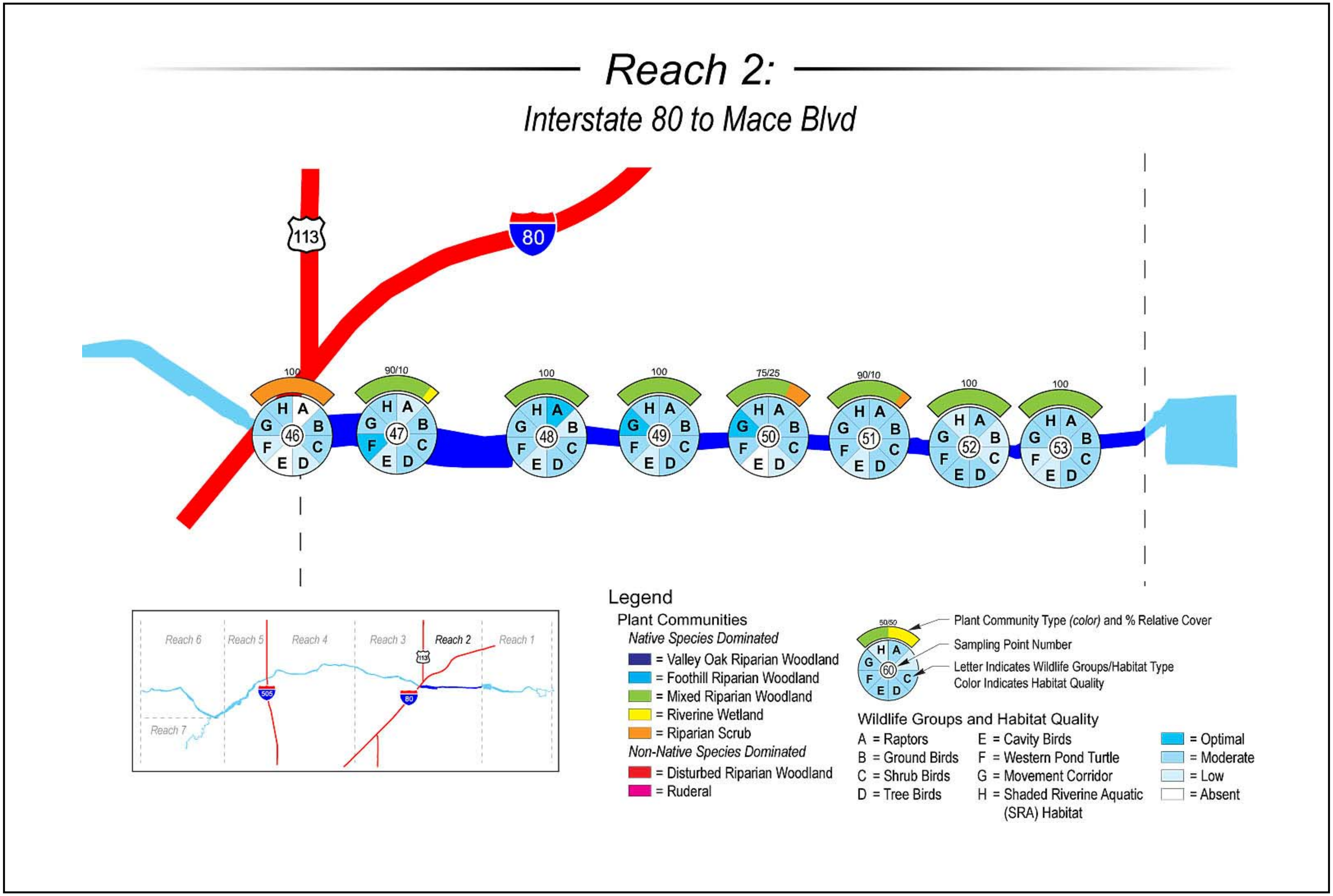
Plant Communities and Wildlife Habitat Quality

EXHIBIT 6-1a

Lower Putah Creek Watershed Management Action Plan

P 1T136.02 12/03

EDAW

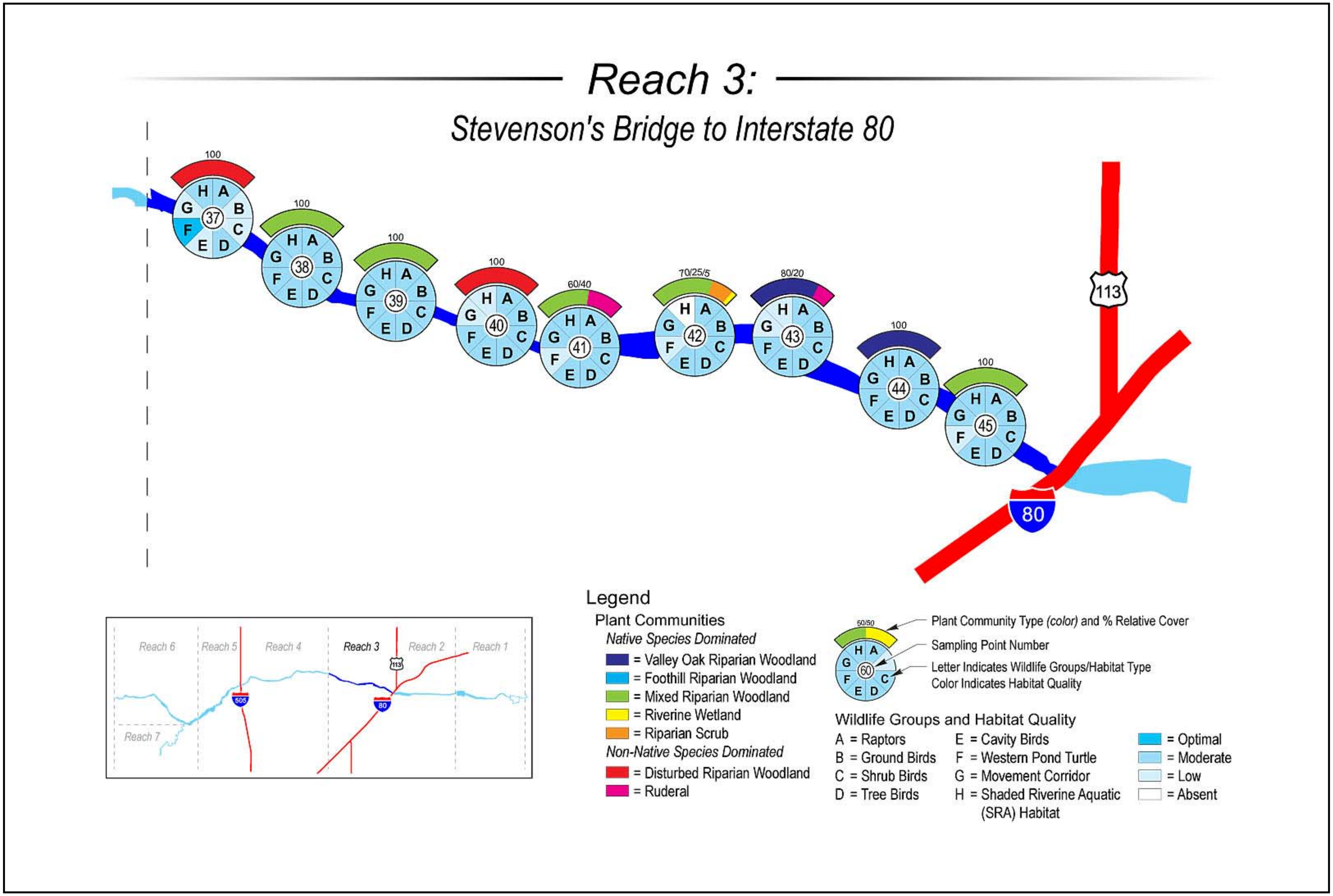


Source: EDAW 2004

Plant Communities and Wildlife Habitat Quality

EXHIBIT 6-1b

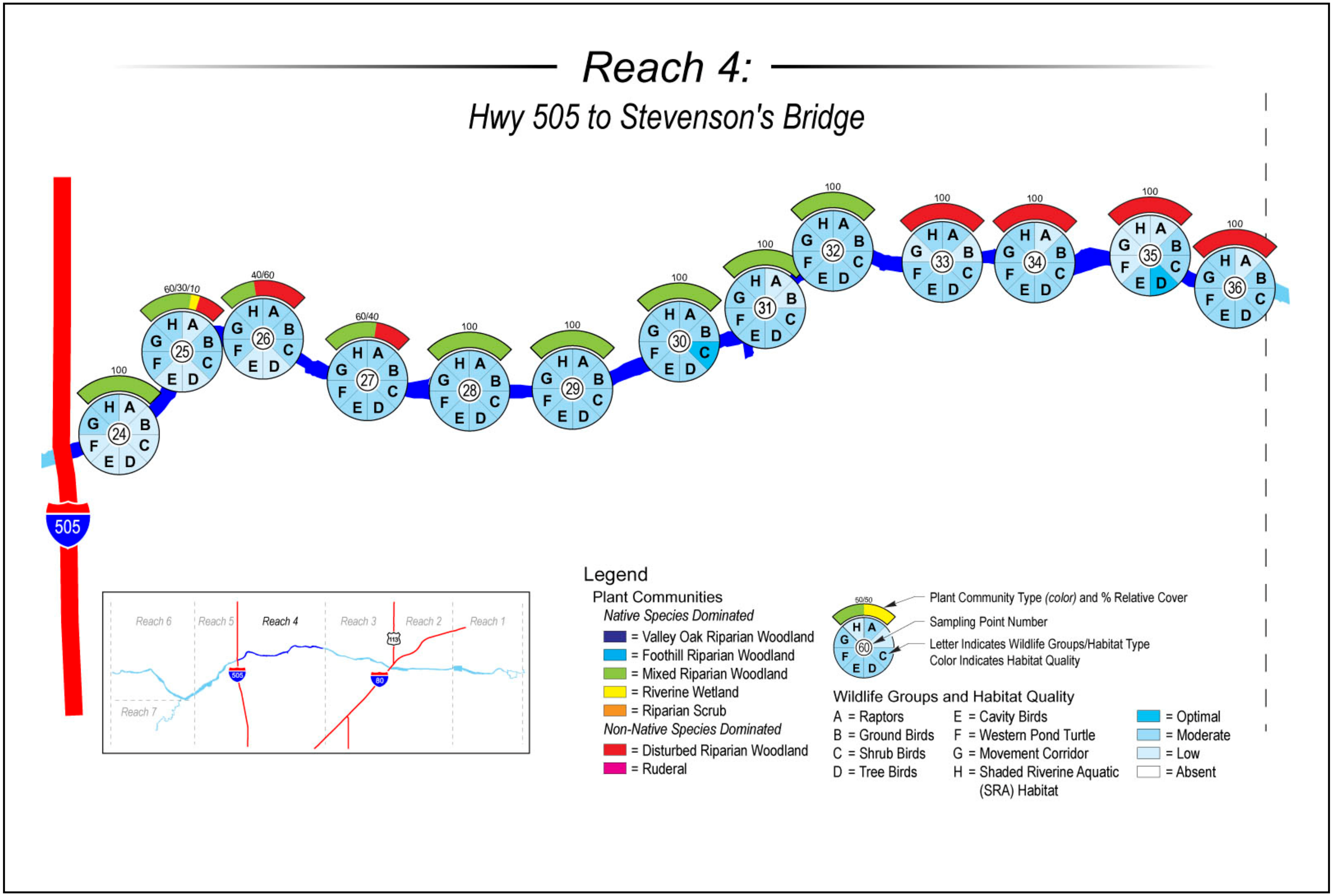
EDAW



Source: EDAW 2004

Plant Communities and Wildlife Habitat Quality

EXHIBIT 6-1c



Source: EDAW 2004

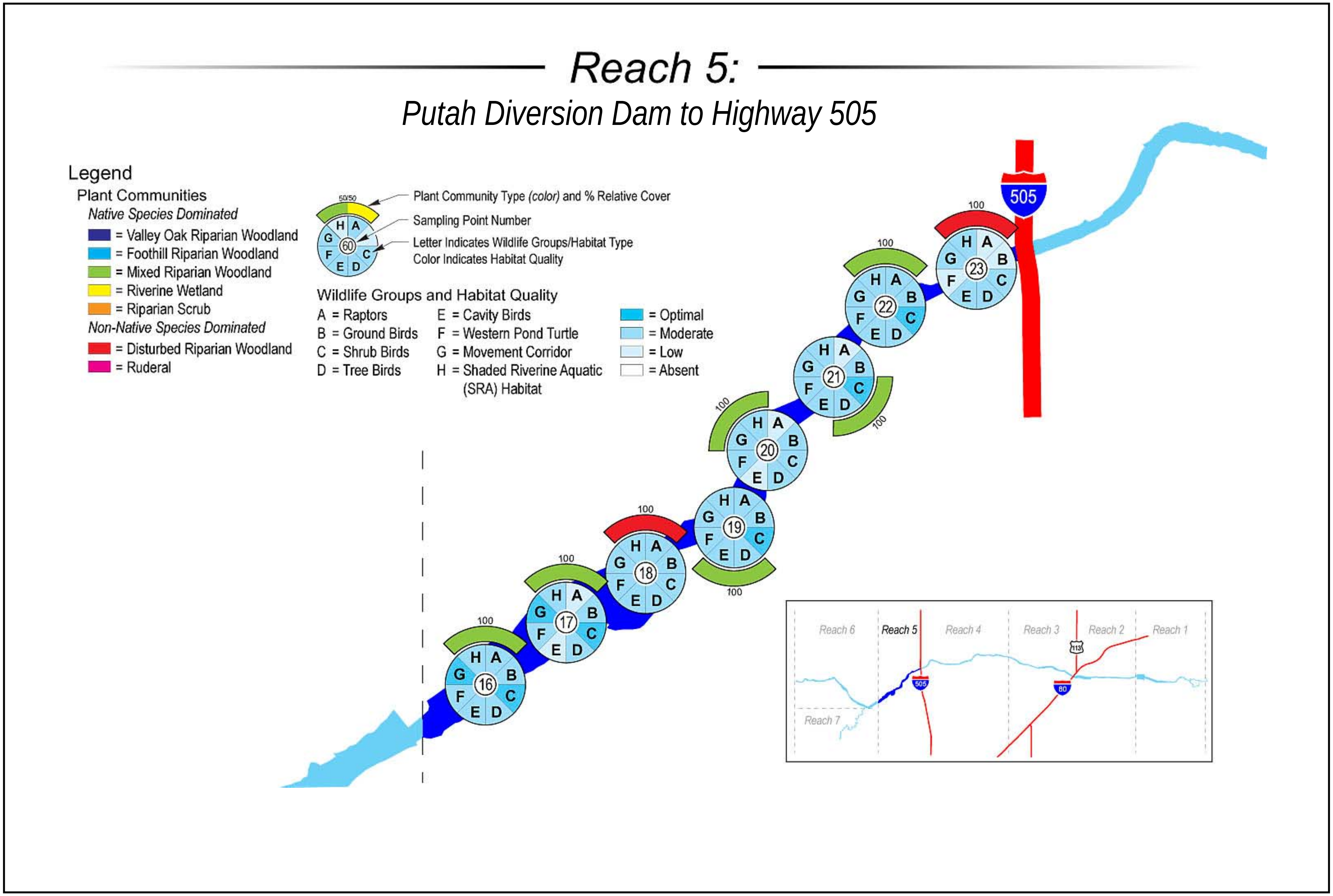
Plant Communities and Wildlife Habitat Quality

EXHIBIT 6-1d

Lower Putah Creek Watershed Management Action Plan

P 1T136.02 08/03

EDAW



Source: EDAW 2004

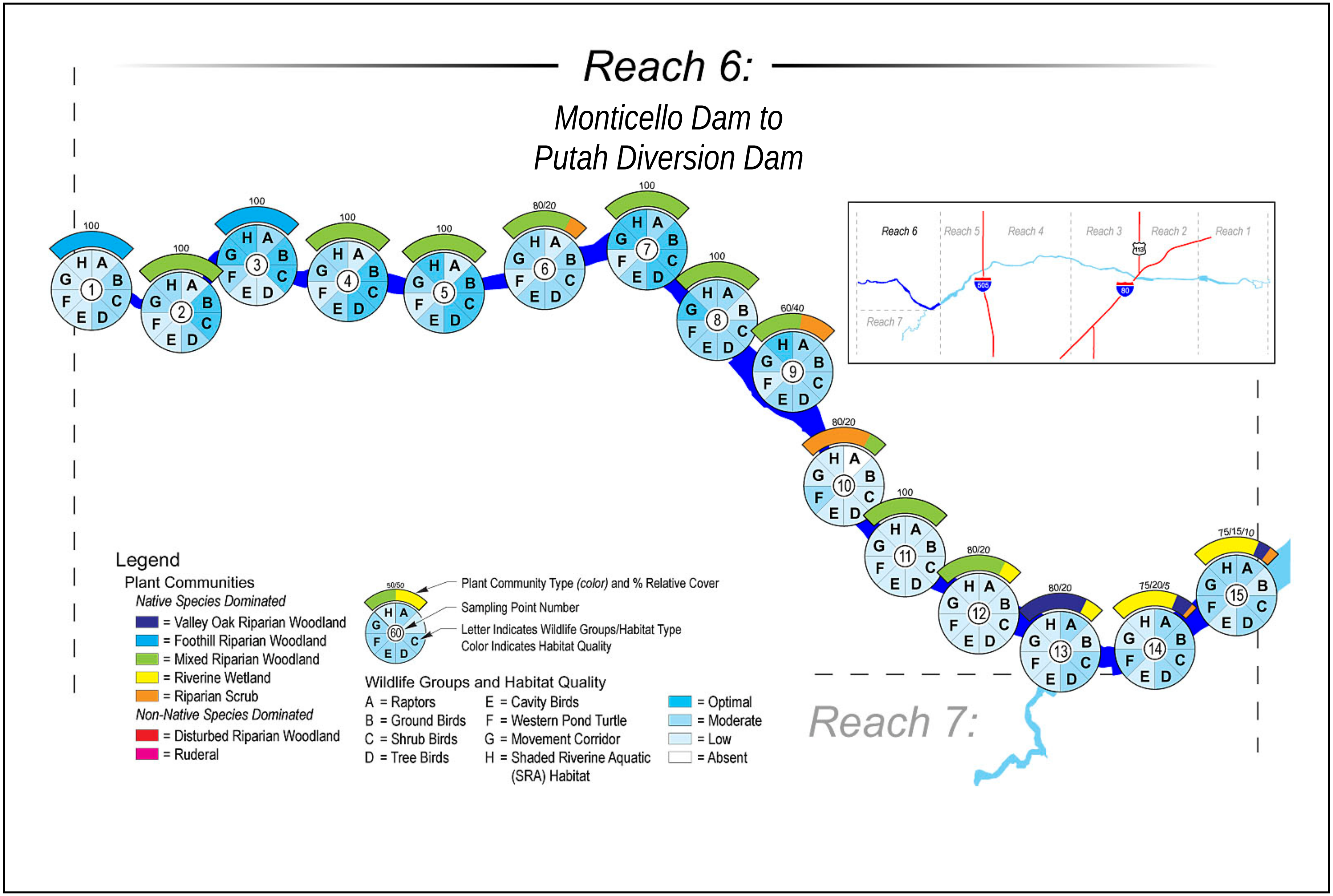
Plant Communities and Wildlife Habitat Quality

EXHIBIT 6-1e

Lower Putah Creek Watershed Management Action Plan

P 1T136.02 08/03

EDAW



Source: EDAW 2004

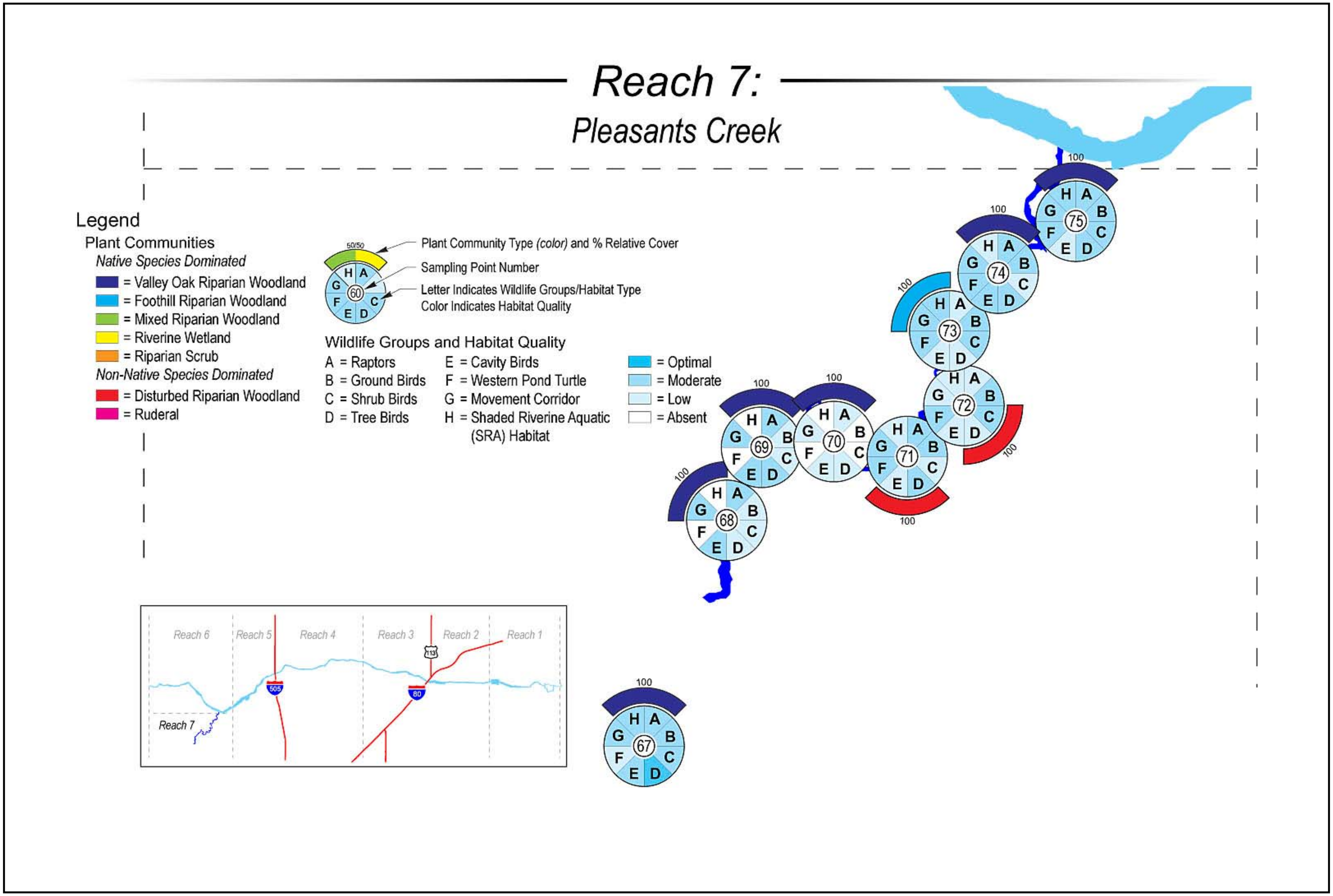
Plant Communities and Wildlife Habitat Quality

EXHIBIT 6-1f

Lower Putah Creek Watershed Management Action Plan

P 1T136.02 08/03

EDAW



Source: EDAW 2004

Plant Communities and Wildlife Habitat Quality

EXHIBIT 6-1g

Lower Putah Creek Watershed Management Action Plan

P 1T136.02 08/03

EDAW

Much of lower Putah Creek can be characterized as having varying amounts of mixed riparian forest and valley oak riparian forest, riparian scrub, and other plant community types. However, there are some shifts in community type, primarily in the upper reaches. The interdam reach (Reach 6) is dominated by mixed riparian woodland, and Pleasants Creek (Reach 7) is dominated by valley oak riparian woodland. Several reaches have major infestations of nonnative invasive weeds, forming woodland communities dominated by nonnative species, especially in Reach 4, upstream of Stevensons Bridge.

Most of the invasive weeds documented during surveys occur in more than one plant community. Some of the primary invasive weed species in lower Putah Creek are eucalyptus (*Eucalyptus* spp.) and tree-of-heaven (*Ailanthus altissima*) in the tree layer; Himalayan blackberry (*Rubus discolor*), tamarisk (*Tamarix* spp.), and arundo (aka: giant reed) (*Arundo donax*) in the shrub layer; perennial pepperweed (*Lepidium latifolium*) and yellow star-thistle (*Centaurea solstitialis*) in the herb layer; and water milfoil (*Myriophyllum* sp.) in the creek channel.

The characteristics and distribution of invasive weeds along lower Putah Creek and Pleasants Creek are provided in detail in Chapter 7, "Invasive Weeds."

6.3.1 Mixed Riparian Forest

The most common plant community in the lower Putah Creek and Pleasants Creek riparian corridor is mixed riparian forest (See Exhibit 6-2 for a representative photo). The width and complexity of mixed riparian forest varies and is characterized by one or more well-developed canopy layers. When present, the highest canopy layer is generally open and dominated by tall Fremont cottonwood trees. The next canopy layer, frequently the uppermost, is typically moderately dense and composed of tree species such as valley oak, Oregon ash, Goodding's willow, and box elder. In some areas of the creek, there is a subcanopy layer of dense riparian scrub dominated by willow species including Arroyo willow (*Salix lasiolepis*) and sandbar willow (*S. exigua*). A discontinuous shrub layer is generally present within the mixed riparian forest including species such as blue elderberry (*Sambucus mexicana*), button bush (*Cephalanthus occidentalis*), Himalayan blackberry (*Rubus discolor*), wild rose (*Rosa californica*), poison oak (*Toxicodendron diversilobum*), and wild grape (*Vitis californica*). A sparse to densely vegetated ground layer, when present, typically includes grasses such as creeping wildrye (*Leymus triticoides*) and forbs such as mugwort (*Artemisia douglasiana*). Seedlings of many of the tree species mentioned above could also be found in the understory.

Many invasive weeds have colonized the mixed riparian forest, including tamarisk, arundo, and tree-of-heaven in the subcanopy and shrub layers, and Northern California black walnut (*Juglans californica* var. *hindsii*) hybrids in the upper canopy. The characteristics and distribution of these invasive weeds are provided in detail in Chapter 7, "Invasive Weeds."

6.3.2 Valley Oak Riparian Forest

Valley oak riparian forest occurs most commonly on the upland terraces and high floodplains of the creek adjacent to mixed riparian forest, with which it often intergrades. Valley oak

Mixed riparian forest

Riparian scrub along banks and valley oak riparian forest at top of bank

Source: EDAW 2003

Riparian Communities

EXHIBIT 6-2

EDAW

riparian forest typically grows in locations above the active creek channel that are less subject to physical disturbance (e.g., scour) from flooding but still receive annual inputs of silty alluvium and subsurface irrigation (Holland 1986). Along Putah Creek, valley oak riparian forest is characterized by a single, moderately-tall canopy layer that is relatively open and dominated by valley oak with some interior live oak (*Quercus wislizenii*) occasionally present. The Valley oak riparian forest canopy sometimes has other tree species present which are often associated with mixed riparian forest, including box elder, Oregon ash, and invasive Northern California black walnut hybrids. The shrub layer is generally sparse and includes poison oak, blue elderberry, wild rose, wild grape, and California pipevine (*Aristolochia californica*). The understory typically has young valley oak and walnut seedlings. The ground layer, when present, has a range of species, from those found in mixed riparian forest to species found in drier conditions.

6.3.3 Disturbed Riparian Woodland

Disturbed riparian woodland is dominated by invasive tree species such as *Eucalyptus* and tree-of-heaven (Exhibit 6-3). *Eucalyptus* tends to exclude other species. Its leaves and roots alter the soil chemistry and inhibit the germination and growth of other species. However, disturbed riparian woodland can also include native tree, shrub, and herbaceous species.

Invasive weeds can quickly proliferate and displace native plant populations and contribute to a loss of habitat to native wildlife dependent on those plants. Invasive weeds can also affect the balance of natural processes such as the frequency and extent of fires, flooding, sediment transport, erosion and channel formation, and nutrient cycling. Such alterations can contribute to further habitat loss and damage human infrastructure and land uses causing economic hardship and safety concerns.

6.3.4 Riparian Scrub

Riparian scrub occurs adjacent to the creek channel. In general, it consists of an open to dense shrubby thicket dominated by a mixture of sandbar willow, arroyo willow, and red willow (Exhibits 6-1a through 6-1g and Exhibit 6-2). This plant community sometimes forms a subcanopy in mixed riparian forest. Dense stands of riparian scrub typically lack an understory, while more open stands sometimes support an understory of Himalayan blackberry, wild rose, wild grape, and nonnative grasses. In addition, areas supporting early seral (i.e., pioneer or young) stage stands of mixed riparian forest are considered riparian scrub because of the shrub-like stature of the trees.

6.3.5 Foothill Riparian Woodland

This plant community is transitional in nature and includes elements of both foothill woodland and mixed riparian forest. Foothill riparian woodland occurs along Putah Creek near the Monticello Dam. The canyons surrounding the creek in this area are relatively steep and support foothill woodland vegetation, characteristic of the east slope of the coastal foothills. This area appears to be much less disturbed than other areas along the creek, as evidenced by the scarcity of invasive weed infestations. Foothill woodland has a tall, open canopy dominated

Invasive arundo-covered streambank

Disturbed bank, rocks and invasive tree-of-heaven intermixed with native vegetation

Source: EDAW 2003

Disturbed Riparian Communities

EXHIBIT 6-3

by foothill pine (*Pinus sabiniana*) and interior live oak, along with lesser amounts of canyon live oak (*Quercus chrysolepis*). The taller trees are interspersed with a subcanopy consisting of scattered shrubs and small trees, including toyon (*Heteromeles arbutifolia*), redbud (*Cercis occidentalis*), sticky monkeyflower (*Mimulus aurantiacus*), and California fuchsia (*Epilobium canum*). The ground layer consists of valley grassland species and woodland herbs. Fremont cottonwood and foothill pine dominates the creek edge, interspersed with an understory of scattered willows, foothill woodland shrubs, and a ground layer consisting of grasses and forbs such as mugwort.

6.3.6 RIVERINE WETLAND

Riverine wetland along Putah Creek includes seasonal and perennial wetlands along the creek channel and lower bank, instream wetlands that formed on sand or gravel bars, and patches of emergent freshwater marsh (Exhibit 6-4). Riverine wetlands are dynamic, herb-dominated plant communities that are influenced by frequent flooding, scour, and creek water level fluctuations that occur on a seasonal and annual basis. Species common to this plant community include wetland plants such as smartweed (*Polygonum* spp.), umbrella sedge (*Cyperus eragrostis*), sedges (*Carex* spp.), common rush (*Juncus effusus*), mugwort, cocklebur (*Xanthium strumarium*), rice cutgrass (*Leersia oryzoides*), canarygrass (*Phalaris* spp.), field mint (*Mentha arvensis*), and western goldenrod (*Euthamia occidentalis*), as well as large emergent perennials such as cattails (*Typha angustifolia*) and tule (*Scirpus acutus*). Invasive weeds, including *Arundo* and tamarisk, also occur on sand or gravel bars in the creek.

6.3.7 OPEN WATER

Open water habitat includes the creek channel, side-channel ponds, and habitats around Lake Solano. The density of vegetation in open water areas varies considerably. For instance, portions of the channel just below Lake Berryessa lack vegetation altogether, but many downstream areas are characterized by high aquatic plant cover. Common floating plant species in lower Putah Creek included water milfoil (*Myriophyllum* sp.), floating water-primrose (*Ludwigia peploides*), waterweed (*Elodea* sp.), and curly pondweed (*Potamogeton crispus*). The character of the open water aquatic plant community also varies from season to season and year to year, depending on the flow and flooding pattern, temperature, and availability of propagules. That is, in some years invasive weeds such as water hyacinth (*Eichhornia crassipes*) may dominate, while in other years, such as during the sampling period, weeds such as water milfoil may dominate. In addition, the amount of agricultural runoff, which can contain concentrated nutrients such as nitrogen and phosphorus, varies seasonally and may influence the aquatic plant community.

6.3.8 RUDERAL AREAS

Ruderal areas consist of disturbed areas that have been stripped of their natural vegetative cover. These areas are either covered by gravel or dirt or dominated by nonnative herbs such as yellow star-thistle (*Centaurea solstitialis*), milk thistle (*Silybum marianum*), Italian thistle (*Carduus pycnocephalus*), prickly lettuce (*Lactuca serriola*), mustard species (*Brassica nigra, Hirschfeldia incana*), soft chess (*Bromus hordeaceus*), ripgut brome (*Bromus diandrus*), and wild oat

Riparian corridor, riverine wetland, and open water

Riparian corridor in the background and freshwater marsh in the foreground

Source: EDAW 2003

Riverine Wetland

EXHIBIT 6-4

EDAW

(*Avena fatua*). Ruderal vegetation typically occurs on the upland periphery of the riparian corridor where the natural vegetation has been disturbed by adjacent land uses.

6.3.9 Agricultural Land

Throughout most of lower Putah Creek, including its tributaries, there is considerable agricultural land adjacent to the riparian corridor. Typical agricultural uses include walnut and almond orchards, row crops such as tomatoes, and fallow fields. A discussion of the agricultural land and other land uses along lower Putah Creek and Pleasants Creek is found in Chapter 3, "Land Ownership, Land Use, and Resource Management Programs."

6.3.10 Developed Areas

Developed areas along lower Putah Creek and Pleasants Creek include residential houses and yards, a landscaping business storage yard, roads, bridges, fishing access facilities, parking areas, developed parks, dams (excluding reservoir areas), and other developed plots within the riparian corridor. Most developed land along lower Putah Creek and its tributaries lies outside but often near the riparian corridor. Developed areas are typically lacking in vegetation cover. Where vegetation exists, it ranges from a sparse cover of native vegetation to horticultural plantings, including both invasive (e.g., *Catalpa*, black locust, and *Eucalyptus*) and non-invasive species (e.g., *Toyon* and western redbud).

6.4 Existing Wildlife Habitats

This section discusses the importance of Putah Creek's riparian habitat to wildlife, including an analysis of riparian corridor size, potential for wildlife movement, SRA cover, and an assessment of existing wildlife habitat quality for the western pond turtle, raptors, and other nesting birds. These assessments are based on field evaluations conducted at 75 sampling points as described under Section 6.1 "Methods," above. A list of bird species observed along lower Putah Creek during the breeding season (approximately February through August) is provided in Appendix E.

6.4.1 General Riparian Habitat Value

Riparian habitats support the most diverse wildlife communities of any habitat type in California (Mayer and Laudenslayer 1988, RHJV 2000). Over 225 species of birds, mammals, reptiles, and amphibians depend on riparian habitats for nesting, foraging, dispersal corridors, and migration stop-over sites. Riparian vegetation is also critical to the quality of instream aquatic life. It provides shade, food, and nutrients that form the basis of the food chain (RHJV 2000). Riparian vegetation also supplies instream habitat when high flows dislodge trees and patches of willows, creating pools where the creek bed and bank vegetation is scoured. The downed trees also form logjams important for fish, semi-aquatic reptiles and amphibians, and aquatic insects. Riparian habitats may also be the most important habitat for bird species in California (Gaines 1977, RHJV 2000).

6.4.2 RIPARIAN CORRIDOR AREA ANALYSIS

The width of the riparian corridor is an important characteristic for assessing wildlife and fish habitat quality. It is used as a criterion in the evaluation of riparian nesting bird habitat and wildlife movement corridor function. For this WMAP, we define the riparian corridor as the area extending from each creek bank to its adjacent upland area, agricultural lands in most cases. The average width of the riparian corridor in 1-mile intervals along lower Putah Creek and Pleasants Creek is indicated in Table 5-8 in Chapter 5, "Fisheries."

The riparian corridor along lower Putah Creek is generally narrow. Its current extent of less than 2,000 acres for the entire watershed, with an average width of less than 334 feet, is greatly reduced from its pre-development estimated size of between 22,000 and 65,000 acres and 1.5 miles average width for the area between Winters and the Putah Creek sinks (Katibah 1984, Kuchler 1977, USFWS 1993).

Riparian corridor width currently ranges from 71 feet to 807 feet per river mile, divided between both sides of the creek. This equates to acreage values ranging from 10 to 100 acres per river mile. Throughout most of the watershed, however, the corridor varies from about 250 to 400 feet wide, divided between both sides of the creek. The most extensive moderately-wide (448 – 807 feet) stretch of riparian corridor area is located within Reach 6, downstream of the PDD. The longest continuous stretch of very narrow corridor area is located along Pleasants Creek, where the corridor varies from 102 to 148 feet wide.

6.4.3 SPECIFIC RIPARIAN HABITAT ASSESSMENTS

Overall, habitat quality for all wildlife groups is moderate. Exhibits 6-1a through 6-1g show the results of the vegetation classification and wildlife habitat quality assessments at sampling locations by reach. Table 6-1 shows the percent of sampling sites assigned to each habitat quality level for each wildlife group considered. The groups are discussed in more detail in the following sections.

Table 6-1
Percent of Sampling Sites Comprising Each Wildlife Group Habitat Quality Level

	Optimal	Moderate	Low	Absent
Raptors	9	53	35	3
Ground-nesting birds	7	59	33	1
Shrub-nesting birds	15	63	21	1
Tree-nesting birds	8	68	24	0
Cavity-nesting birds	0	55	41	4
Western Pond Turtle	3	64	29	4
Wildlife Movement Corridor	17	62	21	0
SRA Cover	7	66	20	7

Source: EDAW 2003

Table 6-2 shows the locations of high- and low-quality habitats by functional groups. Detail on each functional group follows.

Table 6-2
Comparison of Locations of High- and Low-Quality Habitats by Functional Groups

Functional Group	High-Quality Habitat	Low-Quality Habitat
Raptors	East of I-80 (Reaches 1 & 2)	Near Hwy 505 (Reach 4 and 5) at I-80 (Reach 2)
Tree-Nesting Birds	Upstream of Stevensons Bridge (Reach 4); Upstream portion of Reach 6	Lake Solano (Reach 6) Downstream of I-505 (Reach 4)
Shrub-Nesting Birds	Downstream of Monticello Dam (Reach 6) Downstream of PDD (Reach 5)	Los Rios Check Dam
Ground Nesting Birds	Upstream portion of Reach 6	Pedrick Rd. to SR 113 Lake Solano (Reach 6)
Cavity-Nesting Birds	None, but many areas of moderate habitat	I-80 to Mace Blvd. (Reach 2) Downstream of Hwy 505 (Reach 4) Lake Solano (Reach 6)
Western Pond Turtles	Downstream of Stevensons Bridge (Reach 3); Downstream of I-80 (Reach 2)	Pleasants Creek (Reach 7)
Corridor Width	Upstream of confluence between Putah Creek and Bypass (Reach 1); Reach 5	Yolo Bypass (Reach 1)
Shaded Riverine Aquatic	Upstream from Lake Solano (Reach 6)	Lake Solano (Reach 6) Pleasants Creek (Reach 7) Yolo Bypass (Reach 1)
Movement Corridor	Middle of Reach 2; Downstream of Putah Creek Diversion Dam (Reach 5)	Lake Solano (Reach 6)
Native Riparian Woodland	Reach 1; Middle of Reach 4; Reach 6	Upstream of Stevensons Bridge (Reach 4)

Source: Truan 2005.

RAPTORS

Habitat quality for raptors along lower Putah Creek and Pleasants Creek is considered to be moderate (53% of all sampled locations) to low (35% of sampled locations), with only 9% of sampled locations considered to be optimal habitat. The area east of I-80 (Reaches 1 and 2) has the highest quality habitat, with almost all sampling points in these reaches classified as moderate or optimal (Exhibits 6-1a and 6-1b). These areas have large trees that could support nests, have suitable foraging habitat near potential nesting locations, and have relatively low disturbance from adjacent land uses, such as residential or commercial development or major roadways. The presence of alfalfa and certain other crops adjacent to the riparian corridor within the levees provides high-quality foraging habitat for raptors because these crops incidentally support higher concentrations of rodents than native vegetation. Areas classified as moderate or low tend to have fewer suitable nest trees, adjacent foraging areas may be limited, or nearby land uses may be a potential disturbance. Habitat was considered absent, because of the lack of any potential nest trees and low-quality foraging habitat, at two sampling locations upstream from Winters in Reach 6 and at I-80 in Reach 2 (Exhibit 6-1f).

OTHER NESTING BIRDS

For ground-nesting birds, most (59%) of the sampling locations showed moderate habitat quality. These areas have adequate nesting substrate, a relatively wide area of riparian vegetation along the creek corridor, good vegetative structural complexity, and relatively low apparent density of predators/disturbance or attractants for predators (e.g., see Exhibit 6-2). Optimal habitat for ground-nesters occurs upstream, in Reach 6 (Exhibit 6-1f). Areas of low-quality habitat occur in scattered locations along the creek, mainly from Pedrick Road to Highway 113 (Reach 3) and near Lake Solano in Reach 6. These areas were considered to provide low-quality habitat because of fair to poor availability of suitable nesting substrate in the ground layer of vegetation, residential or other development encroachment along the riparian corridor, and a lack of structural complexity in the understory layer (Exhibit 6-1c).

A similar trend was observed for shrub-nesting birds, with most of the creek classified as moderate habitat quality (63% of sampling locations) (Exhibit 6-2). The criteria used to evaluate habitat quality were similar for ground-, shrub-, tree-, and cavity-nesting birds, except that the nesting substrate locations were different. Optimal habitat for shrub-nesting birds includes an adequate nesting substrate (e.g., blackberry, California rose, mugwort, wild grape, and tree saplings in the shrub layer), a complex vegetation structure, a relatively wide riparian corridor, and a low density of predators with few disturbances. Optimal habitat occurs downstream of Monticello Dam in Reach 6, and a few areas downstream of the PDD in Reach 5 (Exhibit 6-1f). Scattered areas of low-quality habitat exist along the entire study area. However, more areas are considered optimal (15% of sampling locations) and fewer considered low-quality, for shrub-nesters than for ground-nesters. The largest stretch of low-quality habitat for shrub-nesters is located near the Los Rios Check Dam in the Yolo Bypass area, where the shrub layer is underdeveloped or lacking (Exhibit 6-1a).

Habitat for tree-nesting birds is also mostly considered moderate (68% of sampling locations). Habitats of moderate quality are often interspersed with some areas of optimal (Exhibit 6-3) or low-quality habitat. Optimal habitat for tree-nesting birds is similar to that for shrub-nesting birds. Tree-nesting birds nest in willow, cottonwood, box elder, and black walnut trees. Areas of low-quality habitat for tree-nesting birds occur near Lake Solano in Reach 6 (Exhibit 6-1f) and downstream of I-505 in Reach 4 (Exhibit 6-1d). In general, these areas have poor availability of suitable trees for cup-nesters, the structural complexity of the riparian vegetation and the riparian corridor width is poor to fair, and the apparent density of predators/ disturbance or attractants for predators is high.

Habitat for cavity-nesting birds along Putah Creek is of moderate to low quality, with no areas of optimal habitat recorded. In a few locations, habitat for cavity-nesters was absent. Cavity-nesting birds nest in trees with holes, areas with rotten or broken limbs, and snags. Otherwise, optimal habitat for cavity nesters is similar to that discussed for other nesting birds. The areas near Lake Solano (Reach 6), the confluence of Pleasants Creek with Putah Creek (Reach 7), downstream of I-505 (Reach 4), and downstream of I-80 (Reach 2) had consistently low-quality habitat at the sampling locations, because of the lack of snags or trees with cavities (Exhibits 6-1f, 6-1g, 6-1d, and 6-1b). Areas of moderate habitat were located in Reaches 1, 3, and 5 (Exhibits 6-1a, 6-1c, and 6-1e).

WESTERN POND TURTLE

The Western Pond Turtle is a relatively common semi-aquatic reptile species along Putah Creek; therefore, habitat quality for pond turtles was included in the assessment. Other reptile and amphibian species may require different habitat attributes and the classification for pond turtles may not accurately portray the habitat quality for these species. A good overview of reptiles and amphibians that occur within the Putah Creek watershed can be found in the *Putah Creek News* article, "Meet the amphibians and reptiles of the lower Putah Creek watershed" (Barry 2000).

Most sampling locations are classified as moderate or low quality for western pond turtles. Many areas of Putah Creek have slack or slow-moving water, with aerial basking areas such as logs, rocks, and exposed banks. Areas of moderate-quality habitat also have dense submergent vegetation (e.g., pondweed and ditch grass) for basking and feeding. However, most sampling sites lack suitable upland nesting sites (i.e., open grassy areas up to 1,300 feet from aquatic habitat). A lack of suitable habitat was also observed for portions of Pleasants Creek, where all aquatic habitat had dried up by late summer (Exhibit 6-1g).

SHADED RIVERINE AQUATIC COVER

SRA cover habitat is classified as moderate quality for most of the study area (Exhibit 6-1a through 6-1f). In general, these areas had good to fair amounts of high (e.g., trees and shrubs) and low (e.g., sedges) vegetation that overhang the water, instream vegetative debris (e.g., leaves, branches, and logs), and naturally eroding banks with undercuts (Exhibit 6-3). The largest areas of low-quality SRA cover habitats were located along Lake Solano in Reach 6 and along Pleasants Creek in Reach 7 (Exhibit 6-1f and 6-1g). For more details, see the discussion of SRA cover in Chapter 5, "Fisheries."

WILDLIFE MOVEMENT CORRIDOR

A wildlife movement corridor is a linear habitat whose primary wildlife function is to connect two or more areas of suitable habitat. As such, connectivity of riparian woodland is a critically important characteristic. Putah Creek is one of the few drainages that connect the Coast Range to open-space preserves (i.e., Yolo Bypass Wildlife Area) on the Central Valley floor. Riparian connectivity provides cover that enables dispersal or exploratory movement by mammals through a landscape dominated by agricultural and urban land uses. (Exhibits 3-1 and 3-2 in Chapter 3, "Land Ownership, Land Use, & Resource Management Programs," depict selected wildlife areas and reserves, and existing land uses in the region). Although wildlife may move through adjacent agricultural fields and orchards, they risk greater potential predation or harassment from dogs, cats, and people.

Putah Creek provides movement for small and medium-size mammals, such as beaver and river otter, and large mammals such as deer. On two known occasions during the 1980s, mountain lions were sighted on the UC Davis campus and a black bear was reported along Putah Creek at Pedrick Road in 1998 (Boyer et al. 2001). Presumably, these animals originated from Putah Creek's headwaters in the coastal mountain forests. Although these species have been incidentally observed using the riparian corridor, it is not expected that they would regularly occur because the habitat is not considered suitable to support large predators. However, movement of smaller mammals, such as skunks, opossums, and raccoons, likely occurs regularly and may be important in maintaining local populations. Scattered obstacles to movement occur along the creek, primarily near residential settlements, bridges, or freeways that have sparse vegetative cover and a narrow riparian corridor. An area of particularly low-quality habitat for dispersal occurs along Lake Solano. Campsites and parking lots within the riparian corridor likely restrict wildlife movement along the south bank, while on the north bank Highway 128 runs along the edge of the creek and confines the narrow fringe of riparian vegetation to the south side of the roadway.

6.5 SENSITIVE BIOLOGICAL RESOURCES

Sensitive biological resources are afforded special protection through the California Environmental Quality Act (CEQA), California Fish and Game Code, federal and state Endangered Species Acts, and the Clean Water Act (CWA). A summary of these regulations is provided in Appendix H. Special-status species include plants and animals that are legally protected or considered sensitive by federal, state, or local resource conservation agencies and organizations. These include species that are state and/or federally listed as Rare, Threatened, or Endangered, those considered as candidates or proposed for listing, species identified by DFG and/or USFWS as species of concern, and plants considered by the California Native Plant Society (CNPS) to be Rare, Threatened, or Endangered. Sensitive natural communities include those that are especially diverse, regionally uncommon, or of special concern to local, state, and federal agencies.

A list of special-status species that have the potential to occur in the project area was developed by reviewing DFG's California Natural Diversity Data Base (DFG CNDDB 2003a) and CNPS Electronic Inventory of Rare and Endangered Plants (CNPS 2002) for the Monticello Dam, Mt. Vaca, Winters, Merritt, Davis, and West Sacramento 7.5 minute geographic quadrangles, and consultation with local experts and agency personnel. There are 10 special-status wildlife species and one special-status plant species with potential to occur in the study area. Table 6-3 provides information on special-status wildlife species that may occur in the watershed study area, though the occurrence of some of these would be highly unlikely. Special-status wildlife species that might realistically be expected to occur in the study area today include: valley elderberry longhorn beetle (VELB), foothill-yellow legged frog, western pond turtle, giant garter snake, tricolored blackbird, burrowing owl, Swainson's hawk, white-tailed kite, yellow-breasted chat, and Modesto song sparrow. Each of these species is discussed briefly below. The only special-status plant species with potentially suitable habitat in the study area is rose-mallow (*Hibiscus lasiocarpus*), described briefly following the special-status wildlife species. Although not a special-status plant species, blue elderberry is protected because of its function as habitat for VELB. Special-status fish species are described in Chapter 5, "Fisheries."

Table 6-3
Special-Status Wildlife Species with Potential to Occur in the Lower Putah Creek Watershed

Species	Habitat	Potential for Occurrence	DFG	USFWS
INVERTEBRATES				
VALLEY ELDERBERRY LONGHORN BEETLE *Desmocerus californicus dimorphus*	elderberry shrubs	Known to occur in study area; elderberry shrubs are present.	---	FT
AMPHIBIANS				
CALIFORNIA TIGER SALAMANDER *Ambystoma californiense*	vernal pools and permanent waters in grasslands	Not expected to occur. No suitable breeding habitat in study area; however, known to occur in west Davis area.	CSC	FT
CALIFORNIA RED-LEGGED FROG *Rana aurora draytonii*	deep water ponds with overhanging vegetation	Not expected to occur in the study area. Presumed extirpated from the area; however, known to occur in several locations near Cordelia and Fairfield in Solano County.	CSC	FT
FOOTHILL YELLOW-LEGGED FROG *Rana boylii*	Partly shaded, shallow streams and riffles with cobble-sized substrate.	Could occur in the study area. Known to occur in Cold Canyon Creek and could potentially occur in the inter-dam section of lower Putah Creek.	CSC	FSC
REPTILES				
WESTERN POND TURTLE *Emys marmorata*	ponds, marshes, streams, and irrigation ditches	Known to occur in the study area.	CSC	FSC
GIANT GARTER SNAKE *Thamnophis gigas*	Freshwater marsh and low gradient streams. Also irrigation ditches and canals. Needs upland habitats for winter dormancy	Could potentially occur in lower portion of study area. Known to occur in Willow Slough and the Yolo Bypass area (DFG 2003a).	CT	FT

Table 6-3
Special-Status Wildlife Species with Potential to Occur in the Lower Putah Creek Watershed

Species	Habitat	Potential for Occurrence	DFG	USFWS
BIRDS				
TRICOLORED BLACKBIRD *Agelaius tricolor*	freshwater marsh, blackberry thickets, and nonnative thistle	Known to occur near Winters and elsewhere in Yolo and Solano counties; some potential to occur adjacent to riparian corridor of lower Putah Creek.	CSC	FSC
BURROWING OWL *Athene cunicularia*	grasslands and agricultural areas	Known to nest and winter adjacent to Putah Creek. Suitable nesting habitat present at edges of agricultural fields bordering the creek.	CSC	FSC
SWAINSON'S HAWK *Buteo swainsoni*	grasslands, riparian woodlands, and agricultural fields	Known to nest in mature trees in the study area.	CT	---
WHITE-TAILED KITE *Elanus leucurus*	grasslands, open woodlands	Known to nest in trees in the study area.	CSC	---
YELLOW-BREASTED CHAT *Icteria virens*	Riparian thickets of willow, blackberry, wild grape, and other brushy tangles near watercourses	Reported to occur during breeding season near Pleasants Creek in 1987 (DFG 2003a). May also occur in study area during migration.	CSC	---
MODESTO SONG SPARROW *Melospiza melodia mailliardi*	Moderately dense riparian vegetation, near water source, with patches of open ground for foraging	Known to nest in the study area. May also occur year-round in the study area.	PSC	---

U.S. Fish and Wildlife Service (USFWS) Federal Listing Categories:

FSC Federal Species of Concern - Species of concern to the Sacramento Fish and Wildlife Office (no formal protection)
FT Federal Threatened

California Department of Fish and Game (DFG) State Listing Categories:

CT California Threatened
CSC California Species of Concern
PSC Proposed Species of Concern

6.5.1 SPECIAL-STATUS WILDLIFE

VALLEY ELDERBERRY LONGHORN BEETLE

The valley elderberry longhorn beetle (VELB) is federally-listed as Threatened. This beetle requires blue elderberry shrubs (*Sambucus mexicana*) for reproduction and survival. Blue elderberry shrubs are common in the riparian vegetation along Putah Creek. Valley elderberry longhorn beetles are rarely seen because they spend most of their life cycle as larvae within the stems of elderberry shrubs. Often the only evidence of the beetles' presence are exit holes created by the larvae just prior to the pupal stage. Adult emergence is from late March through June. During this period, adults mate, lay eggs, and die.

DFG's CNDDB (DFG 2003a) includes a recent sighting of an adult VELB at the PGT-Pacific Gas & Electric gas line crossing site near the City of Winters (occurrence #131), as well as older collections along the creek above Lake Solano in 1975 and 1985 (occurrence #3), and in Cold Canyon in 1982 (occurrence #12). In addition to these sightings of adults, exit holes have been observed at many locations along the creek, including from the Monticello Dam to the PDD, east of I-505, and on Pleasants Creek near the Pleasants Valley Road bridge (EDAW 2002, DFG 2003a). Researchers at UC Davis are currently conducting VELB surveys on some properties along Putah Creek.

Two areas in Sacramento County along the Sacramento and American rivers have been identified as critical habitat because they harbor the densest known populations of beetles in the region (USFWS 1980). Putah Creek was considered for designation as critical habitat, but was withdrawn because of lack of information on the population in that area. However, essential habitat was identified in the recovery plan for VELB in Reach 6 between the Monticello Dam and Lake Solano (USGS 7.5 minute Monticello Dam quadrangle, Township 8 North, Range 2 West, Sections 25, 26, 35 and 36) (USWFS 1984).

FOOTHILL YELLOW-LEGGED FROG

The foothill yellow-legged frog is a federal and California Species of Special Concern. Foothill yellow-legged frogs are characteristically found close to water in association with perennial streams and ephemeral creeks that retain perennial pools through the end of summer. They require shallow, flowing streams with some cobble-sized substrate on which they deposit large masses of eggs. In coastal areas, egg masses are often laid along stream margins in sunny, open areas of shallow (usually less than 3 feet) water. Egg-laying normally follows the period of high-flow discharge associated with winter rainfall, usually between late March and early June. Eggs hatch in about 15 to 30 days depending on water temperature, and tadpoles metamorphose into juvenile frogs in 3 to 4 months. Populations of foothill yellow-legged frogs are threatened by loss of habitat and introduced aquatic predators.

The distribution of foothill yellow-legged frogs in the lower Putah Creek watershed is not known, as comprehensive surveys have not been conducted. Competition with introduced species, especially bullfrogs (*Rana catesbeiana*), likely occurs, but its effects are unknown.

Yellow-legged frogs are known to occur in the Cold Canyon tributary, however, and may stray into areas of suitable habitat in the inter-dam area of Putah Creek (DFG 2003a, Barry 2000).

GIANT GARTER SNAKE

The giant garter snake is federally and state listed as a Threatened species. Giant garter snakes inhabit a variety of aquatic habitats, such as agricultural canals, marshes, sloughs, and ponds. They also require adjacent upland habitat for basking and rodent burrows for overwintering that provide sufficient cover and are at high enough elevations to function as refuges from flood waters during the snakes' inactive season. Giant garter snakes are typically absent from larger rivers and from wetlands with sand, gravel, or rock substrates. Riparian woodlands do not typically provide suitable habitat because of excessive shade, lack of basking sites, and absence of prey populations (USFWS 1999). Essential habitat components for giant garter snake consist of the following:

< sufficient water during the snake's active season (early spring through mid-fall) to provide adequate permanent water to maintain dense populations of food organisms;

< emergent, herbaceous wetland vegetation, such as cattails and bulrushes, for escape cover and foraging habitat during the active season;

< upland habitat with grassy banks and openings in waterside vegetation for basking; and

< higher elevation upland habitats for cover and refuge from flood waters during the snake's inactive season.

Although these four components comprise the optimal habitat for the complete life cycle of the giant garter snake, the species may use areas with only one of these components on a temporary or seasonal basis.

Giant garter snakes are not expected to occur in much of Putah Creek where there are well-developed riparian woodlands. They are more likely to occur in areas where the creek is slow-moving and slough-like and where vegetation is ruderal or scant. They were reported to occur in 1976 on the South Fork of Putah Creek at Old Davis Road, but were not seen during surveys in 1986–1987 (DFG 2003a). Giant garter snakes have more recently been reported in vegetated irrigation ditches near rice fields north of Davis on the Conaway Ranch in 1990, 7 miles south-southeast of Woodland in 1987, and in the Willow Slough Bypass approximately 4.5 miles northeast of Putah Creek and I-80 in 1990 (DFG 2003a). Two populations of giant garter snakes are known to occur in rice production areas along the western edge of the Yolo Bypass in Yolo and Solano counties: one in Willow Slough in the northern area of the Bypass and the other in the Liberty Farms area (USFWS 1999). Because the water in Putah Creek in the Yolo Bypass is slow moving and the riparian vegetation is not well developed, there is potential for individuals from the Willow Slough population to be found in the Bypass area of lower Putah Creek also.

WESTERN POND TURTLE

The western pond turtle is a federal Species of Concern and a California Species of Special Concern. Pond turtles generally occur in streams, ponds, freshwater marshes, and lakes. They require still or slow moving water with instream emergent woody debris, rocks, or other similar features for basking sites. Nests are typically located on unshaded upland slopes in dry substrates with clay or silt soils.

Western pond turtles are frequently observed in many locations along Putah Creek, especially along the North Fork on the UC Davis campus arboretum. The CNDDB also reports pond turtles on Putah Creek downstream from Winters (DFG 2003a).

The Central Valley once may have been the area of greatest western pond turtle density within their range. However, extensive draining of wetlands and habitat alteration in the past century have left few aquatic areas that are suitable for this species. Several researchers have noted that several Central Valley populations may be at risk of serious decline because they were composed of non-reproducing old adults and no small turtles had been observed during visual surveys (USFWS 1992, Jennings and Hayes 1994). However, a recent study conducted throughout the Central Valley revealed that at several sites where turtles were abundant, the population included young, but large individuals (Germano and Bury 2001). Although the authors concluded that current pond turtle abundance falls at a small fraction of historical levels, recruitment does appear to be occurring.

TRICOLORED BLACKBIRD

The tricolored blackbird is a federal Species of Concern and a California Species of Special Concern. Tricolored blackbirds nest colonially and have three basic requirements for selecting their breeding colony: (1) open accessible water, (2) a protected nesting substrate that is usually either flooded or characterized by thorny or spiny vegetation, and (3) a suitable foraging area providing adequate insect prey near the nesting colony, such as agricultural fields and grasslands (Beedy and Hamilton 1997). Studies conducted in the early 1900s documented that almost all nests were located in freshwater marshes dominated by tules and cattails, with remaining nests in willows, blackberries, thistles (*Cirsium* and *Centaurea* spp.), or nettles (*Urtica* spp.) (Beedy and Hamilton 1997). However, more recent research has documented an increasing trend for colonies to nest in Himalayan blackberry, and other plants used for silage (i.e., crops that are harvested when green and stored and allowed to ferment for use as animal feed) and grain fields. Table 6-4 summarizes this change in use of nesting substrate (Cook and Toft 2005). A recent study on nesting success has shown that colonies in Himalayan blackberries have much greater reproductive success than colonies using other substrates, including freshwater marsh (Cook and Toft 2005). The Riparian Bird Conservation Plan (RHJV 2000) recommends that any management efforts to remove blackberry from riparian areas (i.e., invasive weed removal programs) should first assess any detrimental effects the removal may have on local breeding bird populations.

Tricolored blackbirds are known to forage in agricultural fields adjacent to Putah Creek, but no nesting colonies are known to occur in the riparian corridor along the creek. There are no DFG 2003a records of past colonies along lower Putah Creek. There are approximately 16 historical and current colonies reported in Yolo and Solano counties (DFG 2003a). The locations of the colonies are considered sensitive by DFG because of their vulnerability to disturbance. Although tricolored blackbirds are not known to nest along Putah Creek, they are known to occur in the area and nesting in the lower Putah Creek watershed could also occur if suitable habitat were present.

Table 6-4
Proportion of Individuals and Colonies of Tricolored Blackbirds by Nesting Substrate from the 1930s to 2000

Nesting Substrate	1932–1934 [1]		1968–1972 [2]		1994–2000 [3]	
	% of colonies	% of total birds	% of colonies	% of total birds	% of colonies	% of total birds
Emergent marsh	94.8	92.7	69.7	n/a	52.3	41.0
Himalayan blackberry	1.3	0.1	16.1	n/a	25.1	14.8
Silage	0.0	0.0	0.0	n/a	4.9	29.6
Other flooded plants	1.3	0.2	5.8	n/a	6.9	5.5
Other protecting plants	2.6	7.0	9.0	n/a	10.7	8.9
Total native plants	96.7	93.0	75.5	n/a	64.7	46.4
Total nonnative plants	3.3	7.0	24.5	n/a	35.2	53.6

[1] Data from Neff (1937) from the Sacramento Valley and northern San Joaquin Valley.
[2] Statewide data from DeHaven et al. (1975).
[3] Statewide data from Cook and Toft 2005).
Source: Cook and Toft 2005)

BURROWING OWL

The burrowing owl is a federal Species of Concern and a California Species of Special Concern. This species is also protected under §3503.5 of the California Fish and Game Code, which prohibits the destruction of raptors and their nests. Burrowing owls prefer dry grasslands and other dry, open habitats. They typically nest and roost in burrow systems created by medium-sized mammals (e.g., ground squirrels), artificial sites (e.g., drain pipes and culverts), or self-dug burrows where soil conditions are appropriate.

Approximately 600 pairs of burrowing owls are known to nest in the middle Central Valley, encompassing all of Yolo and Sacramento counties, most of Solano County, and other surrounding counties to the east and west, representing about 7% of the state breeding population (Center for Biological Diversity [CBD] et al. 2003). The pairs are associated largely with agricultural lands. Recent observations in Yolo County suggest that the population has declined by approximately 50% since 1985 to 30 or 40 pairs in 2000 (CBD et al. 2003). As of 2001, owls were known to occupy sites at UC Davis, the Yolo airport, and Mace Ranch Park (CBD et al. 2003). In Solano County, there have been numerous recent observations of breeding owls between the Yolo Bypass and Dixon, in the vicinity of Vacaville and Fairfield, and along the Delta (CBD et al. 2003). No nesting pairs are known to occur within the lower Putah Creek riparian corridor, but they could occur along edges of agricultural fields adjacent to lower Putah Creek. UC Davis is currently restoring habitat for burrowing owls at its Russell Ranch.

SWAINSON'S HAWK

Swainson's hawk is state listed as a Threatened species. This species prefers to nest in scattered tall riparian or woodland trees adjacent to grasslands and/or agricultural fields that provide suitable foraging habitat. Preferred foraging habitat includes agricultural fields planted with alfalfa, beet, tomato, or other low-growing row or field crops, fallow fields, dry-land and irrigated pasture, rice land (when not flooded), and cereal grain crops (including corn after harvest) (DFG 1994).

In 1989, it was estimated that approximately 80% of the total statewide population of 550 pairs was found in the Central Valley (DFG 1993). The dependence of Swainson's hawk on agriculture poses a continuing threat to a large percentage of the remaining population since current trends point toward cultivation of incompatible crop types such as vineyards, and conversion of agricultural lands to residential and commercial land uses (DFG 1993).

Swainson's hawks are known to nest along almost the entire length of lower Putah Creek, where there are suitable nest trees and foraging habitats (DFG 2003a). Based on long-term studies conducted within the 215 square mile area bounded on the south by the South Fork of Putah Creek, on the north by County Road 12 near Zamora, on the west by County Road 95, and on the east by the Yolo Bypass, there are an estimated 250 Swainson's hawk territories, of which about 130 are active in any given year (Estep 2003, unpublished data).

WHITE-TAILED KITE

The white-tailed kite is fully protected under §3511 of the California Fish and Game Code. Fully protected birds may not be "taken" or possessed at any time. "Take" is defined as hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill. White-tailed kites are also protected under §3503.5 of the California Fish and Game Code, which prohibits the destruction of raptors and their nests. White-tailed kites prefer scattered trees for breeding and open grasslands and marshes for foraging. White-tailed kites typically nest in trees that are between 15 and 60 feet tall. Native tree species often used include oaks, cottonwood, and willows, but nonnative species such as eucalyptus and black walnut are also frequently used.

White-tailed kites nest along Putah Creek. Nests have been documented along lower Putah Creek near the UC Davis campus and in the Davis vicinity in strips of riparian and nonnative vegetation near agricultural fields (DFG 2003a).

YELLOW WARBLER

The yellow warbler is a California Species of Special Concern. Yellow warblers typically nest in willow thickets. Historically, yellow warblers were common nesters along the Sacramento River and tributaries throughout the Central Valley. By 1973, they were considered uncommon in this region, and recent studies have not detected yellow warblers breeding in riparian habitats on the valley floor, including locations where suitable habitat remains, such as the Cosumnes River Preserve in Sacramento County, Bobelaine Audubon Reserve in Sutter County, or in the Sacramento River National Wildlife Refuge (Heath 2001). Brood parasitism by the Brown-headed cowbird is believed to be largely responsible for nest failures of this species in riparian areas bounded by agricultural land uses.

Although yellow warblers are known to use the riparian woodlands along Putah Creek during migration, nesting has not been confirmed. However, a single male was observed singing from the confluence at Dry Creek into early July in 2003 and 2004 (Engilis, pers. comm. 2004). MAPS (Monitoring Avian Productivity and Survivorship) surveys initiated in 2005 will help establish the breeding status of this species on the creek.

YELLOW-BREASTED CHAT

Yellow-breasted chat is a California Species of Special Concern. Yellow-breasted chats typically nest in riparian habitats with a dense shrub layer. They tend to prefer willow, wild grape, and blackberry thickets (Ricketts et al. 2000). Historically, chats bred in suitable riparian habitat throughout the state, exclusive of higher mountains and coastal islands (Ricketts et al. 2000). By 1973, singing males were common on the Upper Sacramento River in northern Colusa County, but uncommon on the Feather River (Ricketts et al. 2000).

Recent surveys have detected chats breeding in very few locations in the Sacramento Valley, such as Clear Creek in Shasta County, Bidwell Park and Oroville Wildlife Area in Butte County and along Little Stony Creek in Colusa County (Ricketts et al. 2000). A few chats have been recently observed singing in the thick riparian growth on Putah Creek downstream from Monticello Dam (Kemper 2001) and near Pleasants Valley Road and Highway 128 (DFG 2003a).

Chats have been reported to use the introduced Himalayan blackberry in at least one area of California (Zack et al. 1997), and most likely use it throughout the state because of its dense thicket-forming properties (Ricketts et al. 2000). The Riparian Bird Conservation Plan recommends that any management efforts to remove this plant from riparian areas (i.e., invasive removal programs) should first assess any detrimental effects the removal may have on local breeding chats (Ricketts et al. 2000).

MODESTO SONG SPARROW

The Modesto song sparrow is being considered as an addition to the list of California Species of Special Concern. Several subspecies of song sparrows are known to breed in California.

Modesto song sparrows are year-round residents in the central lower basin of the Central Valley, from Colusa south to Stanislaus County and east of the Suisun marshes (Humple and Geupel 2000). The ecological requirements of the Modesto song sparrow are largely undescribed. What is known comes mainly from studies performed at the Cosumnes River Preserve in southern Sacramento County (Humple and Geupel 2004). Song sparrows prefer freshwater marshes and riparian willow thickets, especially areas with small clearings and early successional riparian vegetation (Grinnell and Miller 1944). Song sparrows also nest in riparian forests of valley oak (*Quercus lobata*) with a sufficient understory of blackberry (*Rubus* spp.), along vegetated irrigation canals and levees, and in recently planted valley oak restoration sites (DiGaudio and Geupel 1998, PRBO unpublished data).

Along the lower reaches of the Sacramento River, the Modesto song sparrow is notably absent from almost all riparian areas, based on recent breeding surveys (Humple and Geupel 2000). They are most numerous in the Delta and Butte Sink areas (Gardali 2001). In the northern San Joaquin Valley, they are locally numerous in several riparian corridors, such as the Cosumnes, Mokelumne, and Stanislaus rivers, and sparse along vegetated irrigation canals and levees (Gardali 2001).

Song sparrows were observed during resource assessment surveys in several locations along lower Putah Creek. In the foothill region, song sparrows are likely to be the Marin subspecies (*M. m. gouldii*), which ranges from the coast inland to western Yolo and Solano counties (Humple and Geupel 2000). Farther downstream toward the valley floor, it is likely that the song sparrows present are the Modesto subspecies. Modesto song sparrows are expected to nest in suitable habitat along the lower portions of Putah Creek.

6.5.2 SPECIAL-STATUS PLANTS

ROSE-MALLOW

Rose-mallow (*Hibiscus lasiocarpus*) is an emergent perennial herb in the mallow family (Malvaceae) that produces large white or pink flowers. This CNPS List 2 species blooms from June to September. CNPS List 2 plants are those that are considered rare, threatened, or endangered in California but are more common elsewhere (CNPS 2002). Suitable habitat consists of freshwater marshes and swamps. Rose-mallow could occur within patches of riverine wetland located in the creek channel, but it was not observed during summer 2002 surveys.

6.5.3 PROTECTION MEASURES

The USFWS, NMFS, and DFG have concurred that an initial set of restoration activities proposed as part of the Watershed Management Action Plan is unlikely to have an adverse affect on special-status species, so long as certain protection measures are implemented during restoration activities to ensure that impacts to these species are avoided or minimized. Protection measures required in conjunction with all proposed restoration activities are provided in Appendix I.

7

Invasive Weeds

7 INVASIVE WEEDS

This chapter provides an overview of invasive weeds issues, briefly describes invasive weeds present in the lower Putah Creek watershed, and describes the current distribution of invasive weed infestations in the lower Putah Creek riparian corridor from field surveys conducted in 2002. Introduced invasive fish and aquatic invertebrates are discussed in Chapter 5, "Fisheries," Section 5.2, "Introduced and Invasive Species."

The assessment will help to determine strategies to efficiently remove invasive weeds and provide maximum benefit to watershed resources. It also serves as a baseline from which to assess rates and patterns of weed growth and spread, and to determine the effectiveness of weed abatement projects over time. A Weed Abatement Plan (WAP) will be developed to provide guidance for the identification and control of invasive weeds in the watershed. The WAP will contain detailed information describing the ecology of each weed species, control and monitoring methods, and management practices.

7.1 DEFINITION AND OVERVIEW OF INVASIVE WEEDS

An invasive weed is a plant that has been introduced into a region where it is not native and has the potential to cause environmental or economic harm. Terms such as nonnative, non-indigenous, exotics, pest plants, and alien species are commonly used as synonyms for invasive weeds. Invasive weeds often have no natural enemies or competitors in their new environment, and they frequently have characteristics that allow them to out-compete other plants and grow and spread rapidly. Accordingly, invasive weeds can quickly proliferate and displace native plant populations and contribute to a loss of habitat to native wildlife dependent on those plants. Invasive weeds can also affect the balance of natural processes such as the frequency and extent of fires, flooding, sediment transport and deposition, erosion and channel formation, and nutrient cycling. Such alterations can contribute to further habitat loss and damage human infrastructure and land uses, causing economic hardship and safety concerns.

Disturbance is often a main trigger for the introduction and spread of invasive weeds. Undisturbed landscapes with established native vegetation are generally considered more resistant to weed invasion than disturbed landscapes. Invasive weed species are often able to colonize after some type of natural or manmade disturbance (e.g., fire, flood, gravel mining, and vegetation clearing) opens up areas and creates an opportunity for invasive weeds to establish. Human activities, including road building and maintenance, construction projects, heavy grazing, and the planting of exotic ornamental plants around buildings and parks, have all contributed to the widespread introduction of invasive weeds. Once introduced, invasive weeds can, and often do, spread into relatively pristine, or undisturbed, natural communities.

Many plants have been introduced to California and to the Central Valley region. Most are not considered invasive. Plants in the lower Putah Creek riparian corridor are considered invasive if they exhibit one or more of the following characteristics:

- *Invasive and habitat transforming* – Invasive and habitat-transforming species typically possess characteristics that allow them to out-compete other species and quickly dominate and transform a landscape. Often, weedy species have reproductive adaptations that allow them to rapidly spread and develop, or produce compounds that are released into the soil that inhibit the growth and survival of other species. They have typically developed these characteristics in their native habitat to compete with the species with which they have co-evolved. However, freed of the predation and competition from their native associates, they often have a competitive advantage over species in the environment in which they are introduced. Some examples of invasive and habitat-transforming species in the lower Putah Creek riparian corridor are Himalayan blackberry, perennial pepperweed, and arundo.

- *Threat to native species biodiversity* – Plants and animals have generally co-evolved over the millennia in association with other species native to their region, often resulting in highly interdependent biological networks. Many flora and fauna rely solely on a very small number of species for their survival. Invasive weed species are able to capitalize on the lack of predation in their new environments, free of biological predators that exist in their native environment. As a result of these and other characteristics that make them successful, they often out-compete native species and alter the composition and abundance of native plant species in the invaded plant community. This alteration of plant communities often results in the loss of habitat (food and shelter) for native wildlife dependent on native plants, leading to a decline in native wildlife species. The rapid extinction of species worldwide today is considered by many ecologists to be a result of habitat conversion, both direct (e.g., land use changes) and indirect (e.g., global warming), and the introduction of invasive weeds. Some examples of invasive species in the lower Putah Creek riparian corridor that alter plant communities and threaten native species biodiversity include eucalyptus and tree-of-heaven.

- *Threat to infrastructure* – Several invasive weed species pose a hazard to infrastructure features such as homes, roads, and bridges by increasing the frequency, intensity, and damage from natural processes. The timing or intensity of natural disturbance regimes such as fires, floods, and erosion can be altered by the presence of certain weed species resulting in costly losses of structures and increased maintenance to prevent those losses. Some examples of invasive species that threaten infrastructure in the lower Putah Creek riparian corridor include tamarisk, eucalyptus, and arundo.

- *Not naturalized* – Species that are not naturalized are still considered controllable. In contrast to these, several introduced species are now considered naturalized in California or a particular region within California, meaning they have largely colonized and/or transformed most areas in which they could grow. They are generally widely distributed, abundant, and stable in the landscape and are no longer considered containable. However, species that are not naturalized are still transforming the landscape and negatively affecting ecosystems. They have not yet reached the levels of abundance and distribution at which they are considered beyond control. All of the invasive species discussed in this chapter are generally considered controllable, either locally or regionally.

Following are examples of some of the concerns regarding invasive weeds in the lower Putah Creek watershed:

< *Biodiversity* – Tree of heaven, arundo (Exhibit 7-1a and 7-1b), eucalyptus, and perennial pepperweed are species that form large monocultures that exclude most other vegetation. They spread both by seed (except arundo) and vegetatively. The change in plant species composition and structure as a result of these invasive weeds reduces usage by most native wildlife.

< *Agriculture* – Yellow starthistle is a plant with a deep, vigorous tap root that rapidly depletes soil moisture following the end of the rainy season, providing it with a competitive advantage. It invades and dominates grassland, rangeland, and crop fields, creating a large problem for the agricultural community.

< *Fire* – Riparian areas dominated by native plants often act as a buffer or green line that hinders the spread of fires. However, arundo, tamarisk, eucalyptus and other fire-adapted invasive plants create an enormous biomass of volatile, oily, or dry fuel. A recent fire in the riparian corridor near the City of Winters destroyed over a mile of riparian forest (Exhibits 3-4 and 7-1b). According to the local fire captain, Scotty Dozier, in a letter to Team Arundo del Norte, arundo was primarily responsible for spreading the recent fire from the north bank across 100 feet of open water to ignite dry grass on the south bank where it burned an additional half-mile of riparian habitat before the blaze could be controlled. Arundo acts as a combustive agent during a wildfire, following which it regenerates and spreads quickly. Although invasive weeds like eucalyptus, arundo, and tamarisk quickly resprout after fires, many native riparian plants are killed (Exhibit 7-1b) or regrow more slowly than the invasive weeds. As an example, about 5 days after a recent fire, arundo was observed to have sprouted from among smoldering logs and had already grown 5 inches tall. Further observations 3 months later documented the presence of native species that were only beginning to grow while the arundo that had burned to the ground had already grown 8–10 feet tall. Repeated fires (five fires over the past 10 years) east of the PDD have helped transform the native riparian woodland community to a large monoculture of arundo. The conversion of native riparian woodland to an invasive weed-dominated, fire-prone plant community frequently displaces native wildlife habitat.

< *Fish Habitat* – In-channel colonization by arundo and tamarisk is causing sediment bars to stabilize rather than disperse, restricting the extent of salmonid and lamprey spawning habitat. Introductions of nonnative fish and aquatic organisms also affect native fish habitat, and are discussed in Chapter 5, "Fisheries."

Arundo (top left), tamarisk (top right) and eucalyptus (bottom) form monotypic stands that crowd out native riparian plants and degrade native wildlife and fish habitat quality. These invasive weeds produce massive amounts of dry or oily tinder that fuels wildfires. Tamarisk and arundo alter the stream sedimentation pattern and create flooding and erosion problems in many locations.

Source: EDAW 2003

Invasive Weed Issues

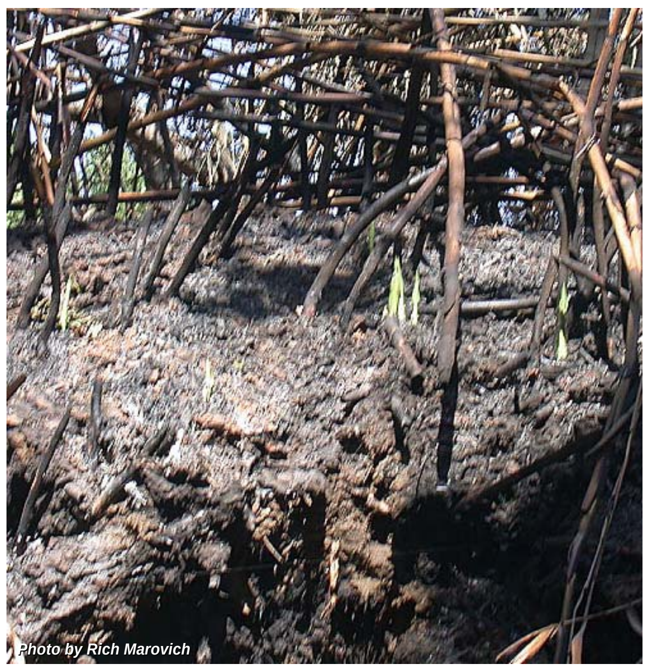
EXHIBIT 7-1a

EDAW

Equipment used to remove arundo along Pleasants Creek and Putah Creek. Arundo is ground to mulch and dried in place. The mulched stems can suppress weeds and reduce erosion in the transition period in which native plants are restored.

Pleasants Creek channel in 2002 following removal of arundo. Bank failure was thought to be caused, in large measure, by water forced into banks due to the arundo. Project funded by USFWS Partners for Wildlife grant.

A Winters area fire burned 1 mile of the riparian corridor in 2003, aided by dry arundo canes.



Arundo canes resprouting 5 days after the 2003 Winters area wildfire. Tinder was still smoldering.

Source: Rich Marovich, Jenny Drewitz, EDAW 2003

Invasive Weed Issues

EXHIBIT 7-1b

< *Erosion and Bank Failure* – Heavy infestations of arundo have choked the channel along much of Pleasants Creek and Putah Creek (see Exhibits 4-2a and 7-1a/b), impeding flood flows. In Pleasants Creek and portions of Putah Creek, this has resulted in lateral erosion and failure of streambanks at the rate of 3 or more feet per year (Marovich pers. comm.), threatening structures and adjacent farmland and contributing to the failure of Pleasants Creek bridges. The sediment load from Pleasants Creek then moves downstream and accumulates in Lake Solano. Arundo and tamarisk also trap sediments during high flows, raising the elevation of gravel bars. The higher elevation cuts off floodplain access and constricts the channel. The constricted channel, in turn, causes higher flow velocities that can lead to accelerated erosion. Higher velocities can also lead to avulsion (sudden channel shifts) during high-flow events. For instance, at the confluence of Dry Creek and Putah Creek, a delta has formed from sediment transported primarily from Dry Creek. The deltaic gravel bar was colonized with Arundo that trapped sediment and stabilized the bar. As the gravel bar grew, it forced Putah Creek to avulse (i.e., jump out of its main channel) southward causing bank failure that may eventually destabilize Putah Creek Road.

7.2 METHODS

Invasive species were mapped and quantified through site surveys conducted during summer 2002 throughout the lower Putah Creek riparian corridor. Invasive weed surveys took place in two phases. The first phase was conducted in May and June 2002 as part of the biological resources assessment of four properties identified by the LPCCC for potential wildlife habitat enhancement and restoration activities (EDAW 2003). The second phase was conducted throughout the entire study area during summer 2002 in conjunction with plant and wildlife resource surveys described in Chapter 6, "Vegetation and Wildlife," Section 6.1, "Methods." Surveys were conducted from public roads and waterways, and from lands where access was granted by the landowners. Methods included walking the riparian corridor along one or both sides of the creek and surveying sections of the creek in a canoe. Each infestation (i.e., discrete patch [occurrence] of a particular weed) encountered along the survey route was mapped onto a laminated aerial photograph. Additional data were collected on infestations observed at 57 sampling locations as described in Chapter 6, "Vegetation and Wildlife," Section 6.1, "Methods." A copy of the data form is provided as Appendix C. Data collected included estimates of the size of infestations, quantity and sizes of invasive trees, percent cover of the weed in its canopy layer, position of the weed within the creek profile, erosion problems caused by the weed (if any), and quantity of recruits (e.g., seedlings) of the weed and other native and nonnative species in the infested area. All survey data and mapped infestations were entered into a GIS database. Some areas along Putah Creek and Pleasants Creek were inaccessible and infestations could only be mapped for one side of the creek. In addition, the view of portions of the riparian corridor was frequently obstructed by vegetation or topography. As a result, the true size and extent of some infestations are likely to be underestimated. For example, in one especially wide part of the channel where the only permissible access was from canoe, an infestation of Himalayan blackberry was estimated to be 0.25 acre. When land surveys were subsequently allowed by a new landowner, the same infestation turned out to be 16 acres of nearly solid thicket.

7.3 EXISTING CONDITIONS

A total of 21 plant species was identified as invasive weeds in the lower Putah Creek riparian corridor. These species are listed in Table 7-1, along with their status as a state-listed noxious weed, status as invasive by the California Invasive Plant Council (CalIPC), and their current or historic uses. About 75% of the invasive weeds in the lower Putah Creek watershed riparian corridor are of horticultural origin. All but one of the identified invasive weed species were mapped and assessed during surveys. Water hyacinth (*Eichhornia crassipes*) is an aquatic plant that was not found during the 2002 surveys, although it has previously infested Putah Creek. It likely died back during winter(s) and/or was displaced by high channel flows.

Table 7-1
Lower Putah Creek Watershed Invasive Weeds Status and Current or Historic Uses

Invasive Weed	State Noxious Weed (CDFA) [1]	CalIPC List (1999) [2]	General Habitats	Horticultural	Agricultural	Erosion Control	Wind Breaks	Other
Almond *Prunus dulcis (P. americana)*	--	--	streambanks, riparian forests		X			
Arundo *Arundo donax*	L	A-1	waterway edges, riparian communities	X		X	X	X
Black locust *Robinia pseudoacacia*	--	B	forests/woodland, fallow fields, roadsides, meadow edges, oak savannas, streambanks and ravines	X				
Catalpa *Catalpa bignonioides*	--	--	drainages, roadsides, riparian forests	X				
Edible fig *Ficus carica*	--	A-2	stream banks, levees, agricultural ditches, channel bottoms, riparian forests	X	X			
English ivy *Hedera helix*	--	B	forests/woodlands, forest edges, fallow fields, wetland edges, roadside and riparian corridors	X				
Eucalyptus, river red gum *Eucalyptus camaldulensis*	--	A-2	roadways, wind screens/shelterbelts, riparian forests, floodplains	X	X		X	
Eurasian watermilfoil; Parrot feather *Myriophyllum spicatum; Myriophyllum aquaticum*	--	B; A-1	Slow-moving water including streams, ditches, marshes, lakes, ponds, canals	X				X

Table 7-1 Lower Putah Creek Watershed Invasive Weeds Status and Current or Historic Uses								
Invasive Weed	State Noxious Weed (CDFA) [1]	CalIPC List (1999) [2]	General Habitats	Horticultural	Agricultural	Erosion Control	Wind Breaks	Other
Fennel *Foeniculum vulgare*	--	A-1	waste places, pastures, abandoned lots, wetland and stream edges, plowed or grazed areas		X			X
Himalayan blackberry *Rubus discolor*	--	A-1	disturbed landscapes, fallow fields, roadsides, pastures, forest plantations, right-of-ways	X	X			X
Jubata grass, pampas grass *Cortaderia jubata, C. selloana*	L	A-1	roadsides, cut banks, dunes, coastal bluffs, landslides, logged lands, stream corridors and open landscapes	X		X		
Milk thistle *Silybum marinum*	--	--	roadsides, pastures, waste places, river flats, areas with high soil nitrogen levels, ditches, other high disturbance areas					X
Pepper tree *Schinus molle*	--	B	washes, fallow fields, steep canyon slopes, streambanks, and roadsides	X				
Perennial pepperweed *Lepidium latifolium*	B	A-1	grassland, roadsides, disturbed sites, riparian areas, wetland and stream edges	X				X
Tamarisk, salt cedar *Tamarix ramosissima, T. parviflora*	L	A-1	riparian forests, floodplains, lake and stream edges, irrigation ditches	X			X	
Tree of heaven *Ailanthus altissima*	L	A-2	roadsides, riparian corridors	X				X
Tree tobacco *Nicotiana glauca*	--	NMI	waste places, open and disturbed sites	X				
Vinca, periwinkle *Vinca major*	--	B	moist sites in shaded places, especially along streams, commonly escapes landscape plantings, roadsides and waste places	X				

Table 7-1
Lower Putah Creek Watershed Invasive Weeds Status and Current or Historic Uses

Invasive Weed	State Noxious Weed (CDFA) [1]	CalIPC List (1999) [2]	General Habitats	Horticultural	Agricultural	Erosion Control	Wind Breaks	Other
Virginia creeper *Parthenocissus quinquefolia*	--	--	forest edges and openings, along fence rows and streambanks	X				
Water hyacinth *Eichhornia crassipes*	--	A-2	Slow-moving water including streams, ditches, marshes, lakes, ponds, canals	X				X
Yellow starthistle *Centaurea solstitialis*	C	A-1	roadsides, foothill savannah, fallow fields, pastures, disturbed woodland					X
Total (21 weeds)				16	2	3	3	8

[1] CalIPC List Definitions:
[from California Invasive Plant Council's (CalIPC) Exotic Pest Plants of Greatest Ecological Concern in California (CalEPPC 1999)]

List A: Most Invasive Wildland Pest Plants; documented as aggressive invaders that displace native species and disrupt natural habitats. Includes two sub-lists:

List A-1: Widespread pests that are invasive in more than three Jepson regions (Regions listed in the Jepson Manual of Higher Plants of California, Hickman Edition)

List A-2: Regional pests invasive in three or fewer Jepson regions.

List B: Wildland Pest Plants of Lesser Invasiveness; invasive pest plants that spread less rapidly and cause a lesser degree of habitat disruption; may be wide-spread or regional.

NMI = Need More Information

NL = Evaluated, Not Listed.

-- = no status indicated

[2] CDFA Designations:
[California Department of Food and Agriculture]

B - Eradication, containment, control, or other holding action at the discretion of the commissioner.

C - State-endorsed holding action and eradication only when found in a nursery; action to retard spread outside of nurseries at the discretion of the commissioner; reject only when found in a crop seed for planting or at the discretion of the commissioner

L - Listed 2003, C designation anticipated

-- = no status indicated

A description of invasive weed laws and regulations are provided in Chapter 11, "Recommendations."

7.3.1 Invasive Weed Species Descriptions

The section provides a brief description of the invasive weeds mapped in the lower Putah Creek watershed riparian corridor. Table 7-2 presents the distribution and abundance of the most common invasive weeds.

Domestic Almond

Almond trees are a major agricultural species grown throughout California. The trees are native to the Middle East and were subsequently spread throughout the Mediterranean regions in northern Africa and southern Europe by Egyptians, Greeks, and Romans. The almond was introduced to California in the 1700s by the Spanish missionaries who settled the Mission at Santa Barbara. It was not until the mid-1800s that the tree was grown in larger quantities (Marks Fruit Crops 2002). Ground squirrels likely hasten the spread of domestic almond on Putah Creek.

Arundo

Arundo (aka, giant reed), is an herbaceous perennial plant resembling bamboo. It is believed that arundo is native to eastern Asia, but has been widely cultivated around the world. The date of its introduction to California is unknown. By the 1820s, however, abundant populations were harvested in southern California for roof thatching and feed (Bossard et al. 2000). Arundo is commonly cultivated to produce reeds for wind instruments, for misguided use as an erosion control agent, and as an ornamental. The plant reproduces through creeping rootstocks and rooting stem fragments. Arundo's aggressive nature allows it to thrive in all types of soils and under a broad range of ecological conditions. Dense forests of arundo, which out-compete native vegetation and eliminate wildlife habitat, can create fire hazards and threaten infrastructure during flood events (Bell 1998, Team Arundo del Norte 1995).

Black Locust

Black locust is a short-lived deciduous tree from the Appalachian Mountains and other localized regions of the eastern United States. It is believed that settlers may have introduced this species to California during the gold rush era, but no documentation has been found to support the assertion (Bossard et al. 2000). The species is known for its robust sprouting and root suckers, which lead to the formation of dense colonies (Plant Conservation Alliance 1998). Young trees have extremely rapid growth rates and can be distinguished from other species by pairs of thick thorns along stems. The tree is extremely shade intolerant and spreads outward from the center of the infestation. Even though trees produce numerous seeds, rarely are any seedlings produced (Conservation Commission of Missouri 2003). With its rapid spread and growth abilities, black locust poses a threat to native plant communities and biodiversity. The tree populations expand rapidly, shade out most native plants, and have little growth under their dense canopies (Plant Conservation Alliance 1998).

CATALPA

Calalpa (aka southern catalpa) is a fast-growing deciduous tree native to the southeastern United States. This hardy species has large, heart-shaped leaves whorled around the stem. The leaves may emit an unusual odor when crushed. The seed pods are one of its most recognizable features. From summer through early fall, the tree bears long, bean-like pods (Brenzel 1995, NRCS 2002). Southern catalpa can often be spotted growing in drainages, along roadsides and within riparian forests. The plant produces large amounts of seeds that can be distributed by water. The tree can resprout from its trunk when cut or injured, but does not have the ability to reproduce by vegetative means (NRCS 2002). The rapid growth and tendency to outcompete native riparian species can result in the loss of biodiversity and a reduction of wildlife habitat value.

EDIBLE FIG

Edible figs are small deciduous trees or shrubs commonly cultivated for their fruit. Records can be found from Mesopotamia (currently Iraq) going back 4,900 years. There are numerous cultivars of edible fig. Trees that bear only female flowers produce edible fruits, while another variety that bears both male and female flowers, called caprifigs, produces unpalatable fruits. Spanish missionaries introduced the fig tree to California in 1769, where it was dubbed the 'mission' fig (Bossard et al. 2000). The primary method of reproduction for figs is through the production of seeds but, like many riparian species, it can grow from stem fragments. Birds and other mammals often eat the fruits and disperse the seeds intact through their waste. Seed dispersal also occurs when streams and rainwater carry and break apart the fruit (Bossard et al. 2000). The species exhibits some invasive characteristics, such as crowding out native riparian species, but is typically less invasive than many of the other species mapped within the lower Putah Creek riparian corridor. Along portions of the San Joaquin River and other riparian environments, figs have produced large clonal stands, excluding all other vegetation.

ENGLISH IVY

English ivy is a common woody vine that is a highly valued ornamental. Settlers arriving from Europe introduced English ivy during early colonial times and its native range includes Europe, northern Africa, and western Asia (Plant Conservation Alliance 2000). The long-lived plants typically escape into natural settings from nearby urban settings. The plant can reproduce by rooting stems as well as by the production of berries that attract wildlife. Dispersal and germination of viable seed is often attributed to birds. Digestion of seed by bird species removes the seed's tough coat and is then eliminated and dispersed into new areas (Bossard et al. 2000). English ivy is capable of out-competing native species for light, moisture, and nutrients. It suppresses the growth of trees it covers, and adds weight to the limbs of trees, making them more susceptible to breakage during storms (Okerman 2000). English ivy provides ideal habitat for Norway rats in waterways. However, the large homogeneous stands formed by the plant are not considered to provide much native wildlife habitat value. The plant is also considered slightly toxic to humans and animals.

EUCALYPTUS

The majority of eucalyptus trees in the lower Putah Creek riparian corridor are river red gum (*Eucalyptus camaldulensis*). River red gum is a fast-growing tree that commonly grows to between 80 and 120 feet. It is an evergreen, hardwood tree that is native to Australia, primarily along river channels (Chippendale 1988). The bark exfoliates leaving stems and trunks that are mottled and multicolored (tan, white, or grayish). The bark is generally smooth except near the base of the trunk where it is often rough. Its blue-gray leaves are up to 10 inches long, lance-shaped, and straight or curved. Its flowers are creamy white or yellow, and its fruit is a pea-like capsule containing tiny (pepper grain sized) seeds. Red gum is often found growing in large monoculture stands with little or no understory vegetation. The tree propagates easily from seeds, and the roots are considered invasive (Arizona Board of Regents 2004). The leaves of red gum, like other Eucalyptus species, likely have toxic compounds that are released into the soil litter layer, inhibiting the growth of other species. Eucalyptus stands are typically extremely flammable and pose a great fire risk. Recent analyses of cut stumps on Putah Creek have shown that eucalyptus can grow up to 1.53 inches in diameter in a single year. Removal costs increase exponentially with size. Young trees up to 12 inches in diameter can be removed without specialized equipment. Removal of larger trees is a job for specialists. Removal of very large trees (e.g., over 36 inches in diameter) can cost thousands of dollars per tree. Due to self seeding, rapid growth rates, and exponential cost increase with size, eucalyptus control has the greatest time value of any weed on Putah Creek.

EURASIAN WATERMILFOIL, PARROTS FEATHER

Eurasian watermilfoil and parrots feather are invasive aquatic weeds. The native species, Siberian watermilfoil (*Myriophyllum sibericum*), closely resembles the nonnative Eurasian watermilfoil (*M. spicatum*). To distinguish the two species, DNA analysis or pigmentation tests are sometimes conducted. Based on their growth form and floristic characteristics, the plants found in lower Putah Creek appear to be Eurasian watermilfoil, not Siberian watermilfoil. Eurasian watermilfoil, as well as parrot's feather, are both submerged aquatic plants that form dense mats of vegetation within waterways. These aquatic plants often become established in waterways via the dumping of aquariums or escaping home water gardens. Eurasian watermilfoil is native in parts of Europe, Asia, North Africa, and Greenland. Research done by the Washington Department of Ecology found that the species may have been introduced into Chesapeake Bay by ship ballast waters during the 1880s. Parrot's feather is indigenous to the Amazon region of South America and was imported to the United States in the late 1800s for use in aquariums and water gardens (Bossard et al. 2000). Both Eurasian watermilfoil and parrot's feather rely upon vegetative reproduction for spreading and dispersal. While the Eurasian watermilfoil does produce viable seed, it is not thought that sexual reproduction is a major factor in the spread of this species (Washington Water Quality Program 2002). These two species choke out waterways, shade out native aquatic species, reduce wildlife habitat values, interfere with recreational opportunities (i.e., boating, fishing, and swimming), create stagnant water favorable to mosquito reproduction, and increase water temperatures (Washington Water Quality Program 2002, Bossard et al. 2000). Threats to infrastructure include increased flooding problems and obstruction of irrigation pumps and water intakes

(Bossard et al. 2000). Eurasian watermilfoil was the predominant aquatic invasive weed in lower Putah Creek during surveys, with parrot's feather observed only in the Yolo Bypass portion of the creek.

FENNEL

Fennel has been cultivated for centuries and is widely naturalized in temperate climates (Bean and Russo 1988). The perennial plant has fine, feathery leaves and its crushed stems and leaves emit a strong licorice scent (Bossard et al. 2000). Native to southern Europe and the Mediterranean region, fennel has been used as a common medicinal and culinary ingredient since Roman times. There is little information on the initial establishment of fennel in California, but it has been around for at least 120 years (Bossard et al. 2000). Reproduction occurs through seed production, crown sprouting, and root fragmentation. Dispersal of seed by water is a main source of new infestations, but other common means of dispersal include seed attachment to vehicles, machinery, animal fur, clothing, and agricultural produce (Bean and Russo 1988). Once established, fennel is a difficult weed to eradicate. In native plant communities, the plant may potentially alter community structure and species composition. Fennel tends to out-compete native plant species because of its rapid growth and aggressive reproductive abilities and may release compounds that inhibit the growth of other plants. If left unchecked, fennel is likely to develop impenetrable, homogeneous stands (Bossard et al. 2000).

HIMALAYAN BLACKBERRY

Himalayan blackberry is a robust, sprawling vine that has become naturalized in moist areas throughout the west. This species, which originates from Europe, was imported for cultivation in the late 1800s by Luther Burbank, who dubbed the species the Himalayan giant, assuming it originated on the Asian continent (Bossard et al. 2000). The majority of Himalayan blackberry reproduction is vegetative. The plant forms shoots along its root system and stems typically root where they touch the ground. Cut stems and fragmented roots can also form new plants that can reproduce and re-sprout vigorously. The rambling blackberry canes grow quickly and send out roots when in contact with the soil. Himalayan blackberry has been observed to be both beneficial and detrimental to wildlife. Birds and mammals feed on the delectable fruit and disperse the seeds. The fast-spreading dense thickets provide valuable nesting and foraging habitat for many songbird species (RHJV 2000). This may be especially valuable in areas that lack protection from predators, such as narrowed riparian corridors, or riparian habitat lacking thickets formed by native species such as California rose or native blackberry. However, Himalayan blackberry bramble also harbors rats that prey on riparian birds (Truan pers. comm.). Its rapid spread also leads to competition with native riparian plants on which wildlife depend. The impenetrable thickets of blackberry impede passage of larger mammals through the riparian corridor and restrict their access to water (U.S. Department of Agriculture 2002a). Himalayan blackberry is the dominant understory vegetation in many locations. It retains its leaves in the winter in contrast with most of the riparian forest. While the native deciduous forest offers little resistance to flood flows when dormant in the winter, Himalayan blackberry remains a dense thicket throughout the year (Exhibit 7-2). While native trees mostly tower over flood stage elevations and offer little resistance to flows, Himalayan blackberry grows at the same elevation as flood flows. Wherever Himalayan blackberry grows on the floor of the channel, it impedes drainage. Thick deposits of sediment can be found in Himalayan blackberry thickets where the velocity of flood flows was reduced to the point that flows could no longer transport sediment. In many reaches of Putah Creek, Himalayan blackberry constricts the low-flow channel with levees that are formed by sediment deposits. In the Putah Creek channel, Himalayan blackberry is second only to arundo in causing bank erosion by deflecting flood flows (Marovich, pers. comm.).

MILK THISTLE

Milk thistle is a biennial or annual herb with distinctive white mottling along the veins of its dark green leaves. The plant's thistle-like flowers, usually purple to pinkish in color, produce tufted seeds that are dispersed long distances by wind. A typical milk thistle plant can produce up to 5,000 seeds during its life cycle (Bean 1985, Hickman 1993, Washington State Noxious Weed Control Board 2002). The weed usually establishes in tall, thick patches that exclude the growth of other plant species either by shading or competition. Seeds do not tend to germinate in areas with a thick litter layer such as well-covered perennial grassland. Disturbances such as over-grazing and fire also drive the proliferation of milk thistle in large areas. The plant is also considered toxic to some livestock (Bean 1985). In Putah Creek, milk thistle occurs mostly on the upper edge of the riparian forest or on upper terraces in full sun.

JUBATA GRASS/PAMPAS GRASS

These two large ornamental grasses are perennial species with long, sharp leaves that arise from a dense tufted base. Jubata grass is generally shorter and wider than the more erect, cascading tufts of pampas grass. Both are native to South America; pampas grass comes from Argentina, Brazil, and Uruguay (Bossard et al. 2000). It is believed that jubata grass was introduced to California from cultivated specimens in France and Ireland and was recognized as a weed beginning in the 1960s when it was found invading logged lands in Humboldt County (Bossard et al. 2000). Pampas grass was first introduced to California from European sources by a nursery in Santa Barbara. The plant was sold as an ornamental for hedges or landscape plantings, and the Natural Resource Conservation Service formerly planted the species to supply forage on rangeland and prevent erosion (Bossard et al. 2000). Both species reproduce by wind dispersed seeds, as well as vegetatively by root fragments that can be dispersed by water (Bossard et al. 2000). In addition to crowding out native species, pampas grass increases the potential for wildfires because each year it develops a thick layer of dry leaves and flowering stalks (Bossard et al. 2000).

Eucalyptus stand by Yolo Housing site and annual growth ring (inset). Eucalyptus is extremely flammable, posing a great fire risk. Removal costs can be thousands of dollars per tree (e.g., over 36” diameter). With rapid growth rates of up to 3 inches in diameter per year and high, size-dependent costs for removal, rapid control of eucalyptus is a high priority.

Himalayan blackberry smothers the banks of Putah Creek. The dense vines and year-round leaves trap sediment and impede flows. Recruitment of new native vegetation is hindered, resulting in loss of high quality wildlife habitat.

Source: Marovich 2005

Invasive Weeds: Eucalyptus and Himalayan Blackberry

EXHIBIT 7-2

PEPPER TREE

Pepper tree (aka California pepper tree) is a small to medium-sized shrubby evergreen tree native to the Andes region of Peru. The tree is willowy in appearance with long drooping upper branches. During the fall, reddish, peppercorn-like berries become apparent (Hickman 1993, Brenzel 1995). The seeds are often eaten and dispersed by birds (Brenzel 1995). Spanish missionaries most likely introduced the tree in 1830, but it has been used medicinally for centuries in South and Central America (Davidson 1936, Jōker et al. 2002). Pepper tree is an escaped ornamental weed and the resilient characteristics of this tree (i.e., its drought tolerance and rapid growth pattern) that make it a desired ornamental allow it to out-compete native vegetation. The tree is reported to cause hay fever, asthma, and dermatitis (De Ruff 2002). Pepper tree on Putah Creek currently occurs as widely dispersed solitary trees.

PERENNIAL PEPPERWEED

Perennial pepperweed is a very invasive weed of moist agricultural and wildland areas. It originates from southeastern Europe and southwestern Asia. The herbaceous perennial plant produces dense white flower heads and has alternately arranged leaves that clasp the stem. It is thought that perennial pepperweed was introduced to the United States in contaminated sugar beet seed, but the assertion may be undocumented. The first confirmed record of the plant was collected in 1936 on a ranch in Stanislaus County (Bossard et al. 2000). The primary methods of reproduction are from creeping roots and root fragments that produce new shoots and from numerous small seeds. The small seeds are commonly dispersed by water, wind, waterfowl (Bossard et al. 2000), and large equipment used for farming, ranching, and road maintenance (CDFA 2002). Perennial pepperweed's aggressive spreading capability typically leads to the formation of large, dense homogenous colonies over time. With the exclusion of native plant species, especially in wetland and riparian areas, wildlife habitat may be compromised. The sparsely branched root system, which readily fragments, tends to increase the erosion potential for streambanks during large flow events. Additionally, perennial pepperweed absorbs salt deep within the soil profile and transports it into its leaves where it is eventually deposited onto the soil surface. This alteration of soil chemistry may lead to the displacement of native plant species (Renz 2000).

TAMARISK

Tamarisk (aka salt cedar) is a deciduous shrub from southern Europe and Asia (Carpenter 1988). The origin of introduction for this plant has not been clearly determined, although many infestations are believed to have begun as intentional plantings for erosion control. Tamarisk disperses both by seed and vegetatively. Its numerous flowers can each produce thousands of tiny, tufted seeds dispersed by wind and water (Plant Conservation Alliance 1997). Vegetative reproduction occurs through submerged and rooting stems (Plant Conservation Alliance 1997). Tamarisk transforms the landscape and alters riparian systems in many ways. It draws salts from deeper soil layers and deposits them on the soil surface as it grows. The altered soil chemistry hinders the germination of native salt-intolerant riparian plants. Tamarisk colonizes and transforms floodplains and sediment bars by trapping sediment and altering the channel profile.

The species is highly adapted to fire and flooding and resprouts vigorously after these events. Eventually, tamarisk transforms the riparian landscape such that tamarisk-dominated areas have higher frequencies and intensities of fire and floods (Plant Conservation Alliance 1997). It also results in reduced wildlife habitat value to species dependent on the native trees and shrubs that tamarisk displaces. Tamarisk, like arundo and Himalayan blackberry, impedes flood flows as evidenced by a build up of sediment around the base of individual plants, occasionally causing bank erosion when it occurs in dense thickets.

TREE-OF-HEAVEN

Tree-of-heaven is a medium-sized deciduous tree with long divided (i.e., compound) leaves similar to black walnut, for which it is often mistaken. However, unlike black walnut, tree-of-heaven leaves omit a characteristically unpleasant odor when crushed. Tree-of-heaven is native to eastern China and was planted as a street tree throughout Europe and the United States during the 1800s by Chinese laborers as symbols for good luck (Bossard et al. 2000).
In California, it was widely planted until the late 1800s. The tree produces copious wind-dispersed seeds in late summer to early fall that resemble the winged seeds of maple. It spreads both by seeds and vegetatively from root sprouts and is common in disturbed urban or developed areas, as well as riparian areas. It is no longer popular as an ornamental because of its unpleasant odor and prolific root sprouting, which causes damage to pavement and structures in urban areas. Over time, dense thickets of young tree-of-heaven trees form, often around older established trees, creating monoculture stands that diminish wildlife habitat value.

TREE TOBACCO

Tree tobacco is a widely cultivated ornamental deciduous shrub from South America. It has bluish green leaves and shiny reddish brown fruits that appear in late fall and winter (Brenzel 1995, Hickman 1993, Wilken and Hannah 1998). Tree tobacco commonly infests waste places and open, disturbed sites. It has also been found to colonize freshly burned areas in southern California chaparral (Wilken and Hannah 1998). Tree tobacco can reproduce both sexually and asexually: its flowers are capable of self-fertilizing, but they are also pollinated by birds in naturalized habitats. The seeds germinate rapidly after dispersal, especially in open sites free from competition (Wilken and Hannah 1998). Tree tobacco appears to be increasing rapidly on Putah Creek, especially at burned sites. Its successful invasion of disturbed stream banks may be an impediment to the natural restoration of some stream bank areas by native riparian species.

VINCA

Vinca (aka periwinkle) is a sprawling mat-like vine native to southern Europe and northern Africa. It was introduced to many continents as a medicinal herb and later as an ornamental ground cover. Vinca creates dense vegetative carpets that preclude the growth of native species and, once established, are rather stable in natural environments (Bean and Russo 1988). It has been noted that the plant can affect hydrology within streams by inhibiting natural erosional processes and initiating channel incision (Bossard et al. 2000). Vinca often disperses from established plantings around residences (Bean and Russo 1988). The plant spreads mainly by vegetative growth, and it is not known to reproduce sexually in California. The arching stems that grow laterally can root at the stem tips, helping to create a thick mat. For long distance dispersal, water sometimes transports stem fragments within riparian zones that resprout and spread rapidly (Bossard et al. 2000).

VIRGINIA CREEPER

Virginia creeper is an ornamental woody vine known for its magnificent fall foliage that turns fiery orange to scarlet. The species is widely cultivated and native to the eastern and central United States. This fast-growing perennial attaches itself to upright surfaces by adhesive disks. Ripened bluish black berries, which are savored by many birds and mammals, are produced from August through October (Brenzel 1995, U.S. Department of Agriculture 2002b). The vine can also sprout from above ground, laterally growing stems as well as from the root crown (U.S. Department of Agriculture 2002b). Virginia creeper has the tendency to move out of landscaped areas to potentially smother and displace native vegetation.

WATER HYACINTH

Water hyacinth is a free-floating aquatic plant from the Amazon River basin and Pantanal region of western Brazil. Its thick, waxy green leaves are held upright above the water surface on bulbous, air-filled stalks. In early spring, the plants begin to vegetatively produce daughter plants by runners that grow horizontally and can produce new plants every 6 to 18 days (Western Aquatic Plant Management Society 2002). It is thought that the initial introduction to the United States occurred in 1884 when a visitor to the 1884–1885 World's Industrial and Cotton Centennial Exposition carried the plant to Florida where it spread to the St. John's River (Western Aquatic Plant Management Society 2002). By 1904, it had appeared in California (Bossard et al. 2000). It is a popular nursery item for home water gardens and ponds because of its showy flowers and ability to take up excess nutrients. Water hyacinth is considered one of the most productive plants on earth. By clogging waterways and displacing native aquatic species, the weed disrupts many natural settings and causes serious economic hardships. Many infestations are the result of deliberate introduction or the disposal of excess plants from someone's water garden (Bossard et al. 2000).

YELLOW STARTHISTLE

Yellow starthistle is an annual, sometimes biennial, herb that thrives in open, disturbed landscapes. Originating from southern Europe, the plant has spread to most temperate areas around the globe. It was probably first introduced to California during the Gold Rush as a seed contaminant in Chilean-grown alfalfa seed (Gerlach et al. 1998), and in the early 1900s as a seed contaminant in alfalfa seed from Europe. It has rapidly spread throughout California as an unintentional byproduct of alfalfa farming, feed, ranching, suburban development, and road building (Gerlach 1997a, 1997b; Maddox and Mayfield 1985; DiTomaso 2001). It is now estimated to infest 15–20 million acres in California and an additional couple of million acres in other western states (DiTomaso 2001). The plant spreads by seed, and its high germination rate and deep, vigorous tap root, which rapidly depletes soil moisture following the end of the rainy season, provide the competitive edge for yellow starthistle to displace native plants.

Yellow starthistle is also poisonous to horses, causing a nerve disorder called "chewing disease" (*nigropallidal encephalomalacia*), which is fatal once symptoms develop (DiTomaso et al. 2003). The loss of native vegetation and infestations within crop and grazing lands caused by this weed create a large problem for the conservation and agricultural communities. Creeping wild rye and Santa Barbara sedge, two perennial grasses that are native to Putah Creek, compete well with yellow star thistle and other herbaceous weeds.

7.3.2 INVASIVE WEED DISTRIBUTION AND EXTENT

This section summarizes weed distribution in the lower Putah Creek riparian corridor, followed by subsections discussing the distributions by reach and by individual weed species. There is also a comparison of the current distribution of weeds with the distribution of four invasive weeds indicated in the 1992 resource assessment maps produced by the USFWS (1993), to determine if and how those four invasive weeds may be spreading.

Invasive weed infestations cover over 127 acres, or about 6% of the lower Putah Creek riparian corridor. The invasive weeds vary greatly in their distributions; however, one or more invasive weeds are found throughout most of the approximately 1,900-acre riparian corridor. The distribution and extent of invasive weeds in the lower Putah Creek riparian corridor are summarized in Table 7-2 and Exhibits 7-3 and 7-4a–g. The most abundant weed species within the riparian corridor are arundo, eucalyptus, Himalayan blackberry, Eurasian watermilfoil, perennial pepperweed, tamarisk, tree-of-heaven, and yellow starthistle. These weed species each infests between 5 and 25 acres. Eucalyptus is the most extensive, with 302 infestations covering a total of 24 acres. Arundo exhibits the largest number of total infestations, with 406 infestations covering a total of 21 acres. Twelve of the weeds have total infestations amounting to less than 1 acre each. They include almond, black locust, catalpa, edible fig, English ivy, fennel, milk thistle, jubata or Pampas grass, pepper tree, tree tobacco, vinca, and Virginia creeper. They may be recent introductions to the watershed that have not yet dispersed extensively, or they may be contained to relatively few small areas thus far.

REACH DISTRIBUTION ANALYSIS

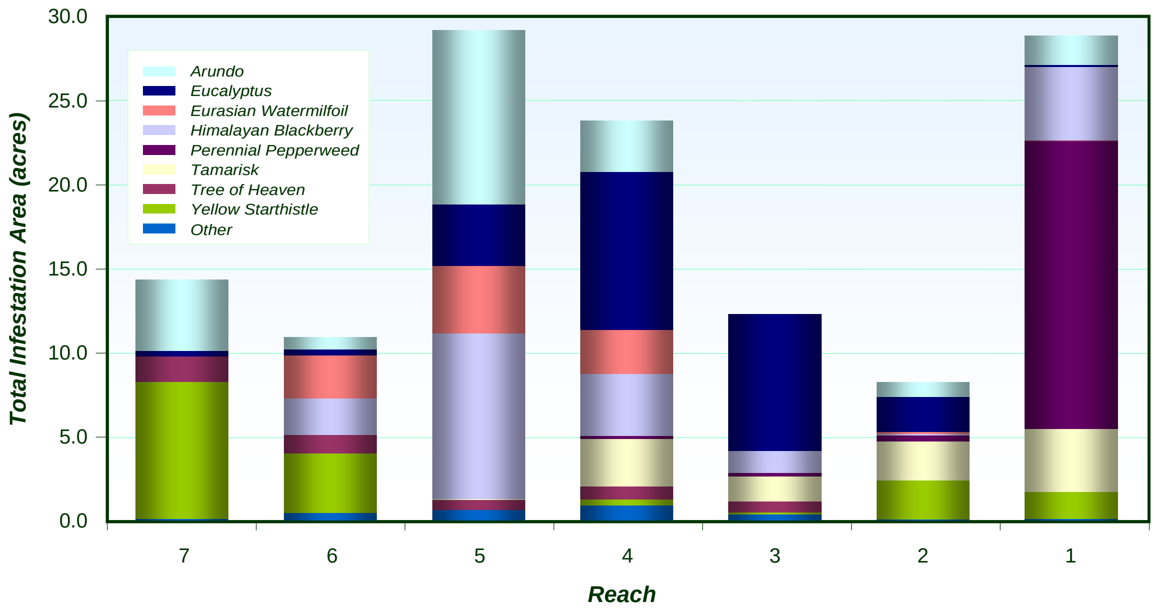
Beginning with the upstream reaches, seven weed species were mapped along Pleasants Creek (Reach 7), totaling over 14 acres in infestations (Exhibit 7-4a). Yellow starthistle and arundo are substantially more extensive in acreage than any other weeds in that reach. Tree-of-heaven is also moderately extensive and widely distributed. Based on the survey, the remaining four weeds, black locust, fig, eucalyptus, and pepper tree, together have infestations that amount to less than 0.5 acre.

In Reach 6, the interdam reach, thirteen invasive weeds were mapped, with infestations totaling over 11 acres (Exhibit 7-4b). The most abundant invasive weeds are yellow starthistle, Eurasian watermilfoil, Himalayan blackberry, tree-of-heaven, and arundo. The remaining eight weeds have infestations that total less than 1 acre together. They include black locust, fig, eucalyptus, fennel, jubata or Pampas grass, perennial pepperweed, tree tobacco, and vinca.

Table 7-2
Distribution of Invasive Weeds by Reach

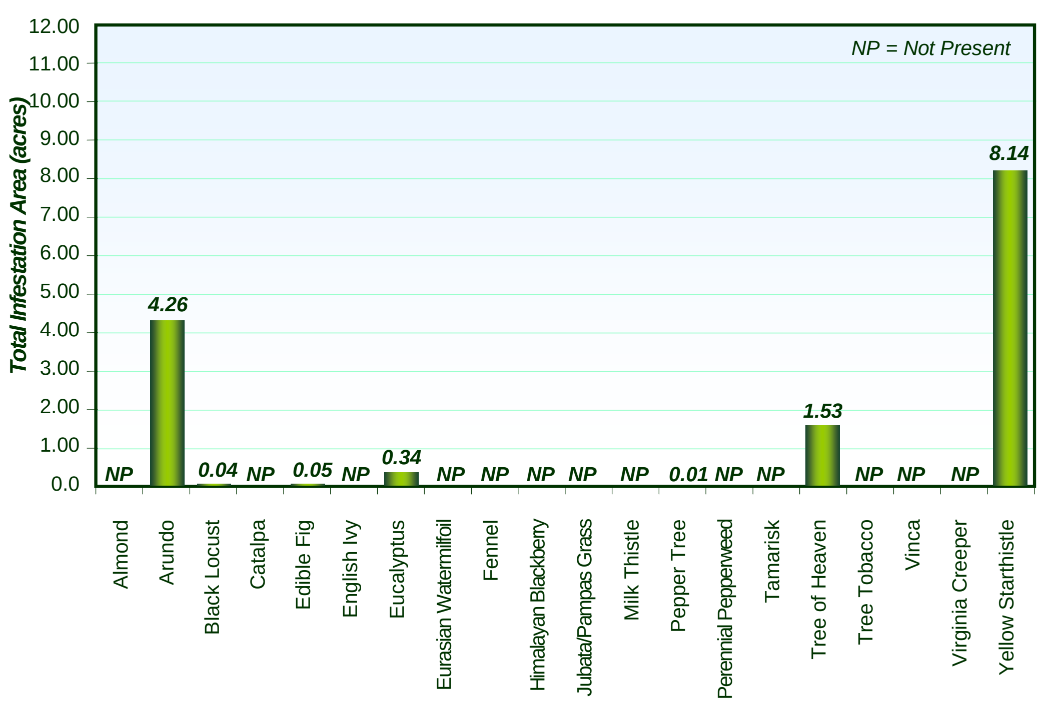
Weed	Reach 1 (Mace Blvd to Yolo Bypass)		Reach 2 (I-80 to Mace Blvd)		Reach 3 (Stevensons to I-80)		Reach 4 (I-505 to Stevensons)		Reach 5 (PDD* to I-505)		Reach 6 (Monticello to PDD*)		Reach 7 (Pleasants Creek)		Total Inf [1]	Total Acres	Avg. Inf Size (acres)
	Inf [1]	Acres	Inf [1]	Acres	Inf [1]	Acres	Inf [1]	Acres	Inf [1]	Acres	Inf [1]	Acres	Inf [1]	Acres			
Almond	--	--	--	--	--	--	5	0.12	21	0.23	--	--	--	--	26	0.3	0.01
Arundo	25	1.77	19	0.88	3	0.05	99	3.09	178	10.4	19	0.76	63	4.26	406	21	0.05
Black locust	--	--	--	--	4	0.32	2	0.07	5	0.07	2	0.04	3	0.04	16	0.5	0.03
Catalpa	--	--	--	--	--	--	5	0.01	1	0.01	--	--	--	--	6	0.02	0.003
Edible fig	--	--	1	0.01	3	0.02	9	0.05	22	0.18	15	0.17	5	0.05	55	0.5	0.01
English ivy	--	--	--	--	--	--	--	--	1	0.004	--	--	--	--	1	0.004	0.004
Eucalyptus	3	0.11	80	2.09	90	8.18	106	9.45	17	3.66	4	0.41	2	0.34	302	24	0.1
Eurasian watermilfoil; parrot's feather[2]	12	0.012	1	0.11	--	--	15	2.60	16	4.00	6	2.55	--	--	39	9	0.2
Fennel	--	--	--	--	--	--	--	--	--	--	9	0.09	--	--	9	0.09	0.01
Himalayan blackberry	36	4.36	3	0.09	34	1.30	51	3.72	89	9.96	28	2.21	--	--	241	22	0.1
Jubata grass; Pampas grass	--	--	--	--	--	--	--	--	--	--	1	0.04	--	--	1	0.04	0.04
Milk thistle	2	0.08	--	--	--	--	6	0.66	--	--	--	--	--	--	8	0.7	0.1
Pepper tree	--	--	--	--	--	--	--	--	8	0.09	--	--	2	0.01	10	0.1	0.01
Perennial pepperweed	104	17.22	14	0.36	10	0.22	14	0.20	--	--	1	0.01	--	--	143	18	0.1
Tamarisk	109	3.75	88	2.35	72	1.48	118	2.84	6	0.06	--	--	--	--	393	10	0.03
Tree-of-heaven	3	0.04	2	0.01	8	0.65	22	0.76	27	0.58	17	1.13	44	1.53	123	5	0.04
Tree tobacco	--	--	6	0.04	3	0.02	--	--	1	0.01	21	0.10	--	--	31	0.2	0.01
Vinca	--	--	--	--	--	--	--	--	--	--	1	0.004	--	--	1	0.004	0.004
Virginia creeper	--	--	1	0.03	--	--	--	--	3	0.03	--	--	--	--	4	0.06	0.02
Yellow starthistle	2	1.61	4	2.27	3	0.10	4	0.34	--	--	7	3.51	8	8.14	28	16	0.6
Total	285	28.95	219	8.24	230	12.34	456	23.91	395	29.25	131	11.02	127	14.37	1843	127.52	

Notes:
[1] Inf = Number of infestations
[2] Parrot's feather was found only in Reach 1
"--" = no infestations observed
*PDD = Putah Diversion Dam



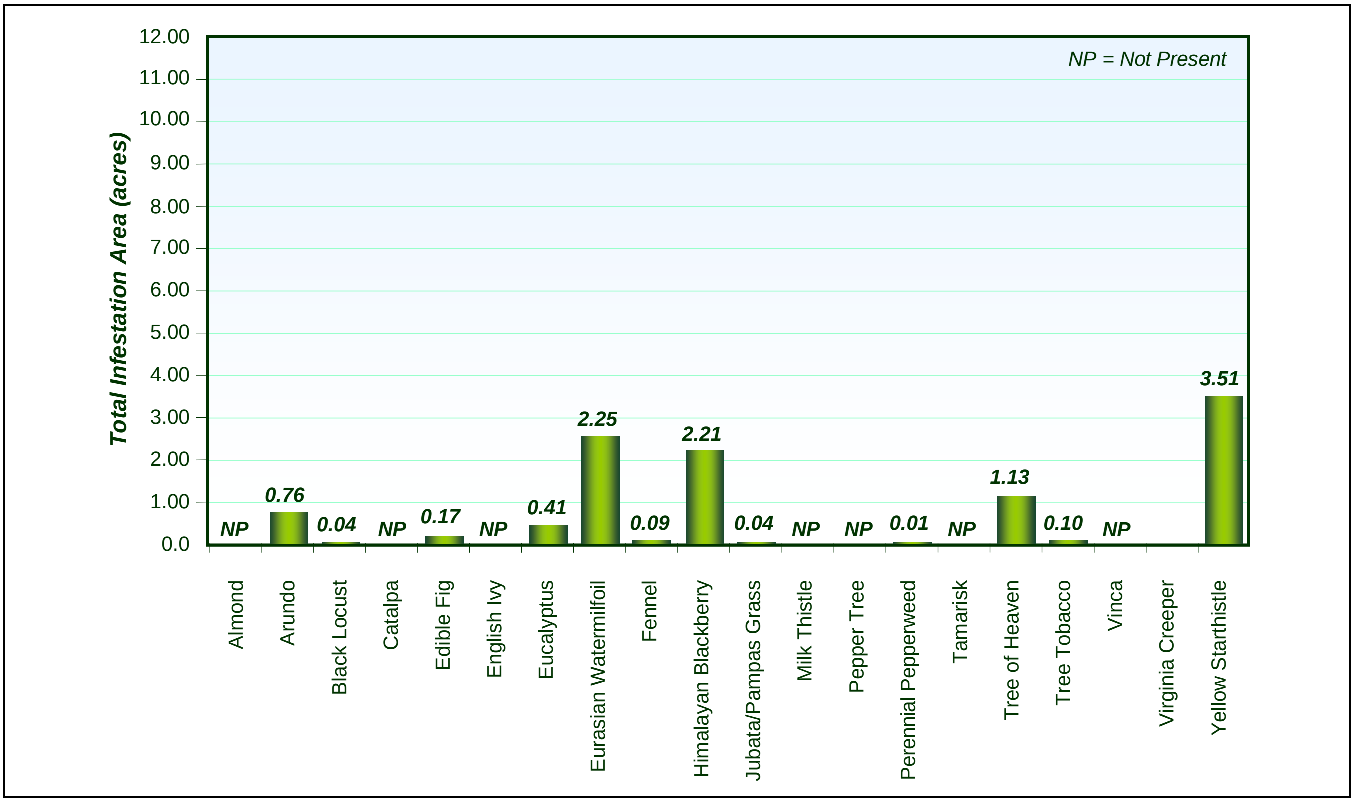
Distribution of Invasive Weeds by Reach

EXHIBIT 7-3



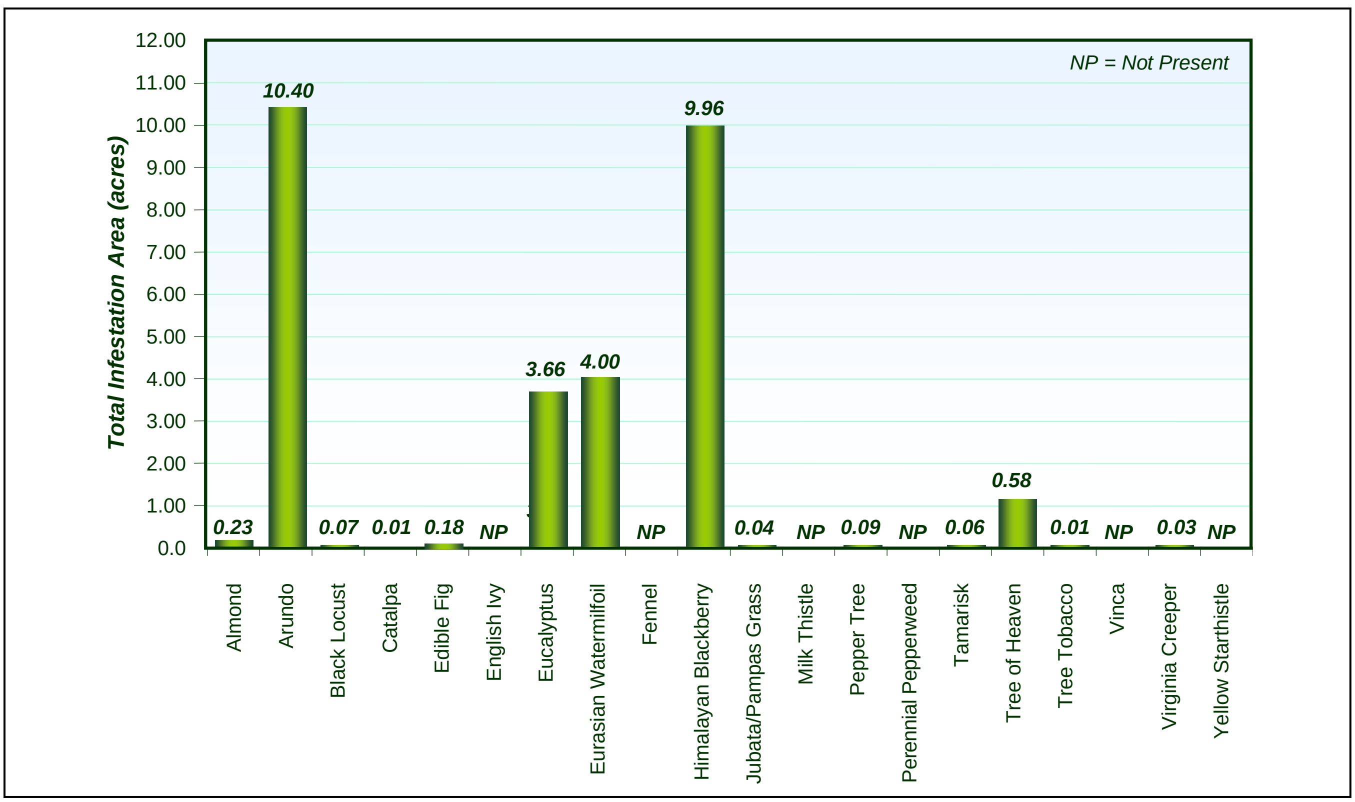
Distribution of Invasive Weeds by Reach 7, Pleasants Creek

EXHIBIT 7-4a



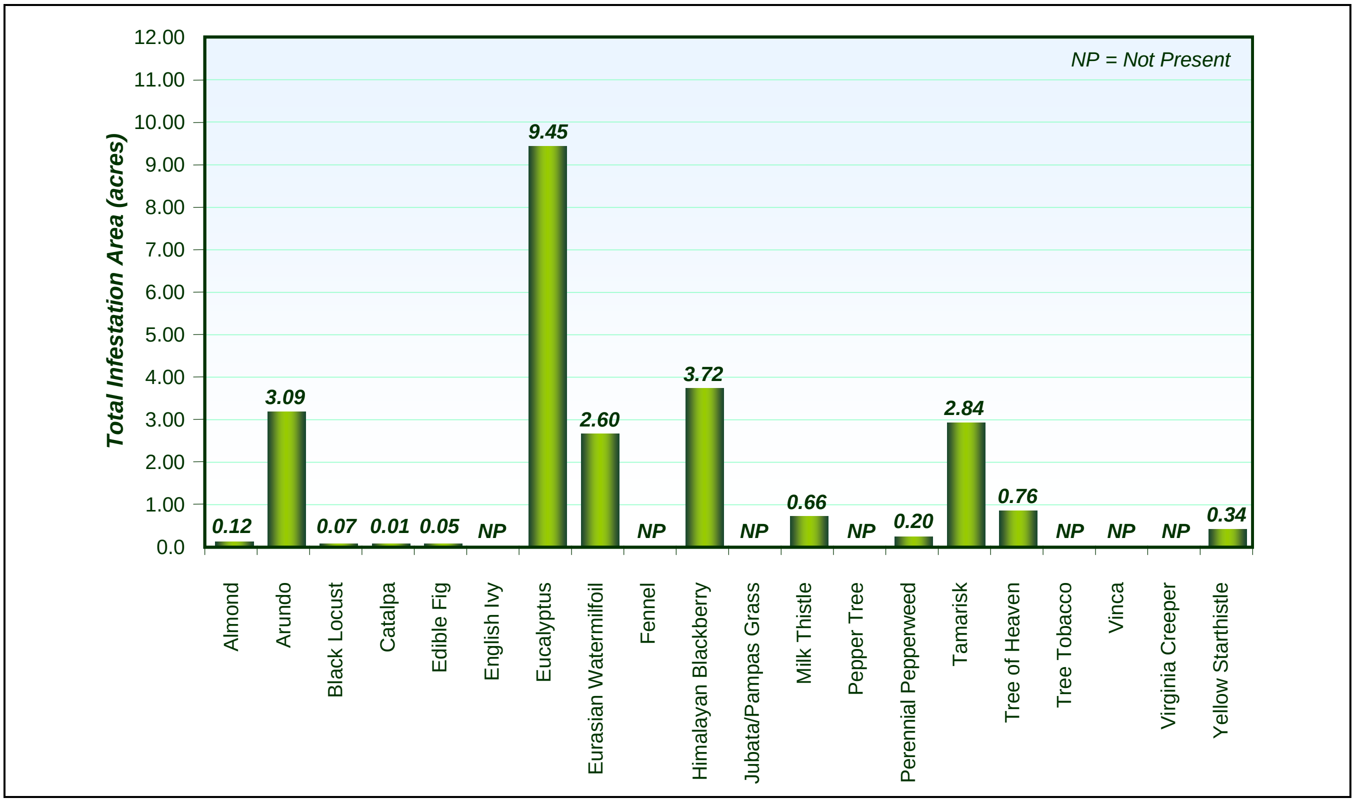
Distribution of Invasive Weeds in Reach 6,
Monticello Dam to Putah Diversion Dam

EXHIBIT 7-4b



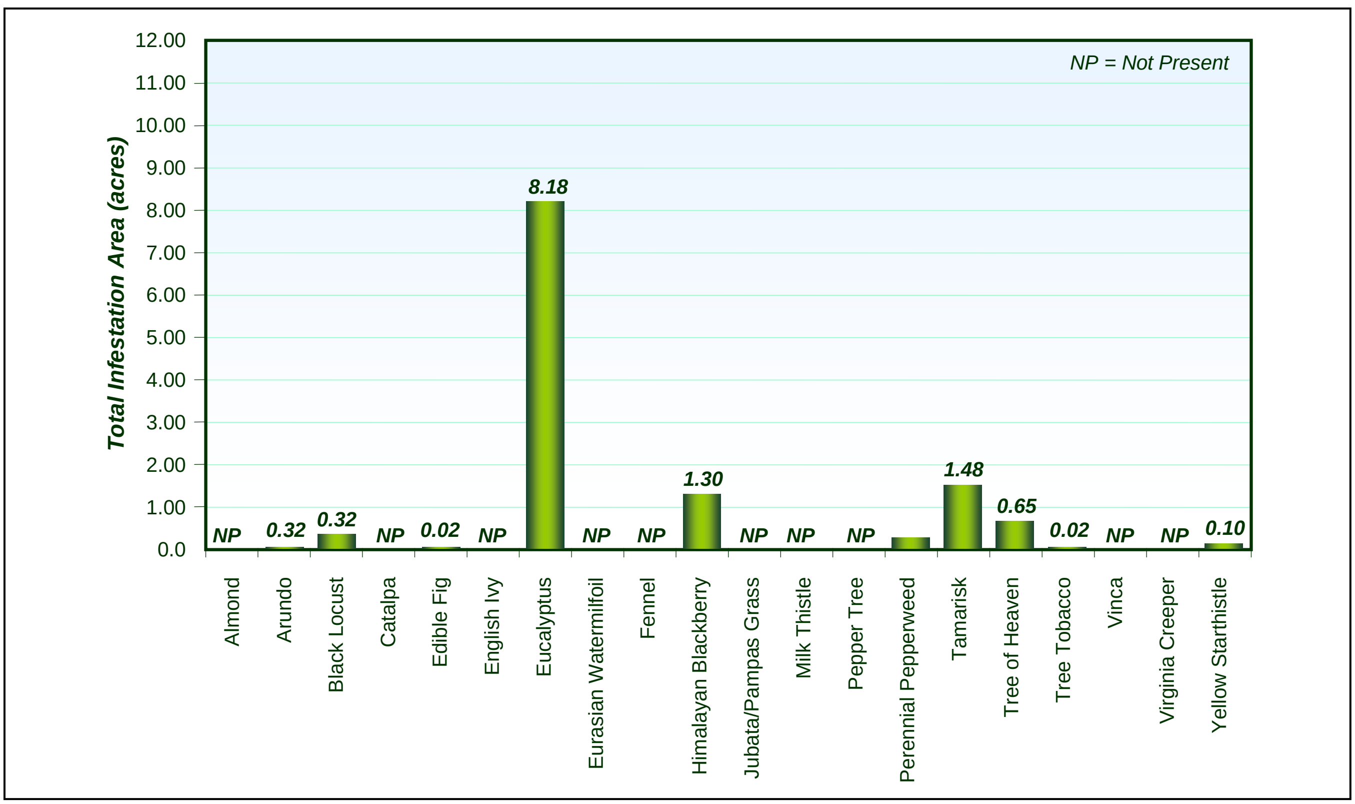
Distribution of Invasive Weeds in Reach 5,
Putah Diversion Dam to I-505

EXHIBIT 7-4c



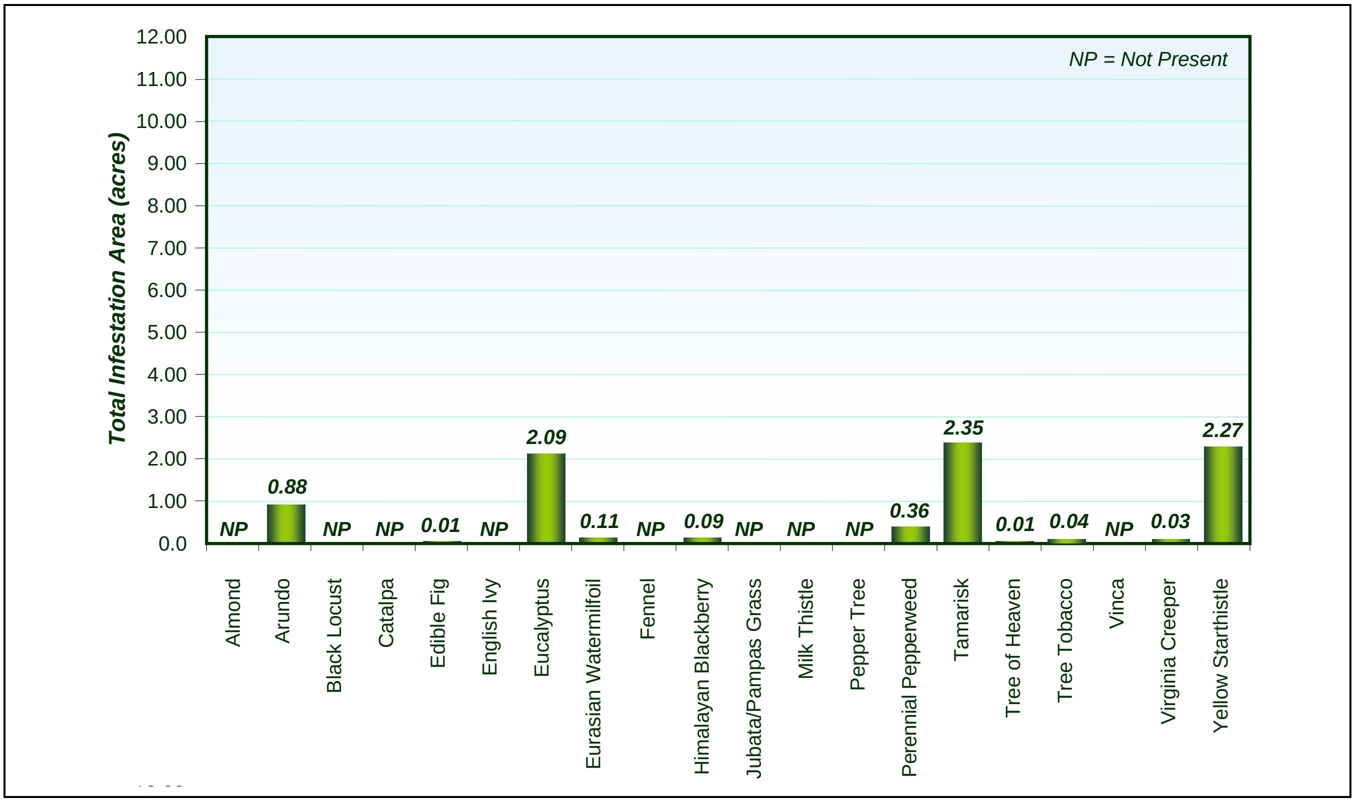
Distribution of Invasive Weeds in Reach 4,
I-505 to Stevensons Bridge

EXHIBIT 7-4d



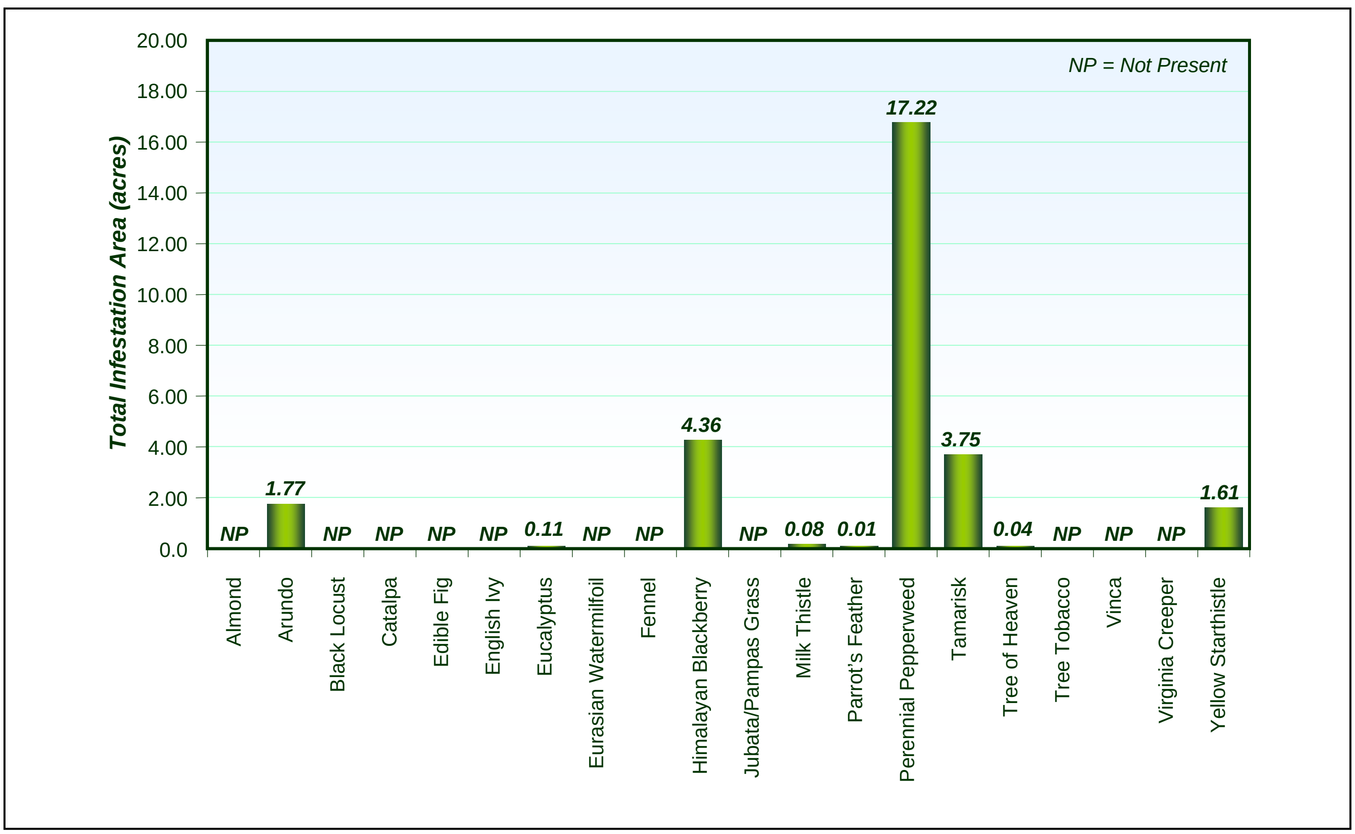
Distribution of Invasive Weeds in Reach 3
Stevensons Bridge to I-80

EXHIBIT 7-4e



Distribution of Invasive Weeds in Reach 2,
I-80 to Mace Blvd.

EXHIBIT 7-4f



Distribution of Invasive Weeds in Reach 1,
Mace Blvd to Yolo Bypass

EXHIBIT 7-4g

In Reach 5, the area from the PDD to I-505 near Winters, fourteen invasive weed species were mapped, more than in any other reach (Exhibit 7-4c). The infestations of those weeds total over 29 acres, which is more extensive than in any other reach, except Reach 1, which has nearly the same total infestation area. However, unlike Reach 1, there are several weeds in Reach 5 that account for the infestations. Only Reach 4 has more infestations than Reach 5. Arundo and Himalayan blackberry infestations in Reach 5 are substantially larger in total acreage than in any other reaches in the study area, with each of those weeds totaling about 10 acres. That represents about half of the total infestation areas along lower Putah Creek for those two weeds. Eurasian watermilfoil, at 4 acres, is also much more extensive in Reach 5 than in any other reach. Eucalyptus begins to become a dominant species in the landscape in Reach 5, increasing in number of infestations and total acres in Reaches 4 and 3 before tapering off in Reach 2. A total of 10 additional invasive weeds occur in Reach 5, amounting to just over 1 acre of infestations together. These include almond, black locust, catalpa, fig, English ivy, pepper tree, tamarisk, tree-of-heaven, tree tobacco, and Virginia creeper. The high number of horticultural weeds found in this reach may be associated with landscaping around residences and commercial developments or parks near or in the City of Winters.

In Reach 4, from I-505 at Winters to Stevensons Bridge midway between Winters and UC Davis, thirteen weed species were documented, with infestations from these weeds totaling nearly 24 acres (Exhibit 7-4d). Eucalyptus is more extensive in this reach than in any other reach in the study area. Tamarisk is also abundant in this reach, unlike any reaches upstream of this point in the study area, suggesting that the source populations may have begun in this reach. Arundo, Himalayan blackberry, and Eurasian watermilfoil are all extensive in this reach, although not as abundant as they are in Reach 5. Due to the high number of infestations of arundo, eucalyptus, Himalayan blackberry, and tamarisk, Reach 4 has the highest number of infestations along lower Putah Creek. The remaining eight weeds occurring in this reach total just over 2 acres, with most of that acreage accounted for by infestations of tree-of-heaven and milk thistle. The remaining six weeds include almond, black locust, catalpa, edible fig, perennial pepperweed, and yellow starthistle.

In Reach 3, from Stevensons Bridge to I-80 near the UC Davis Putah Creek Riparian Reserve, 10 invasive weed species were mapped with a total infestation area of just over 12 acres (Exhibit 7-4e). Eucalyptus, at over 8 total acres, is by far the most dominant weed in this reach. Tamarisk and Himalayan blackberry are also somewhat extensive, with each totaling over an acre. However, they are not as abundant as they are in Reach 4, immediately upstream. The remaining seven weeds account for about 1.3 acres, primarily because of tree-of-heaven infestations. The remaining weeds include arundo, black locust, edible fig, perennial pepperweed, tree-of-heaven, tree tobacco, and yellow starthistle.

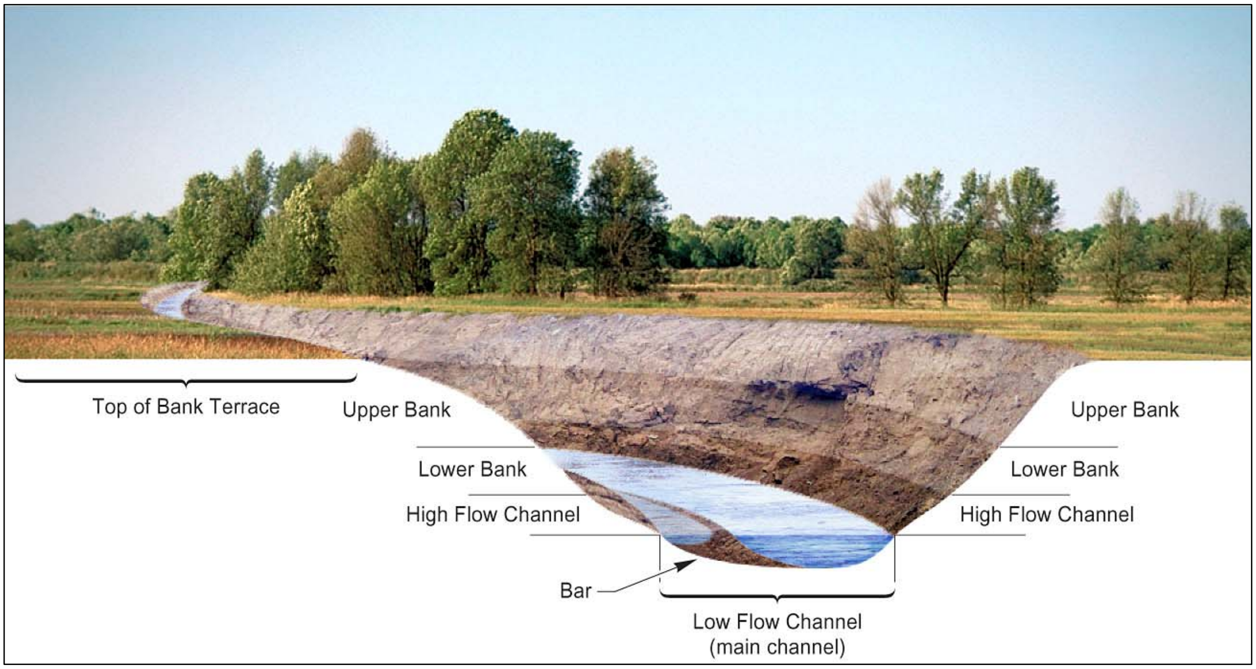
In Reach 2, from I-80 to Mace Boulevard south of Davis, eleven weed species were mapped, with infestations totaling about 8 acres (Exhibit 7-4f). Reach 2 is one of the least infested reaches in the study area. However, there is a moderate infestation of yellow starthistle, and the extent of tamarisk in this reach is second only to Reach 1, downstream. The eucalyptus infestation area is still substantial in this reach, but much less than it is in the next three reaches upstream. Arundo accounts for about an acre. The remaining seven weeds in this reach account for less than an acre of infestations. They include edible fig, Himalayan blackberry, Eurasian watermilfoil, perennial pepperweed, tree-of-heaven, tree tobacco, and Virginia creeper.

In Reach 1, from Mace Boulevard to Putah Creek's confluence with the Yolo Bypass, nine invasive weed species were mapped, accounting for nearly 29 acres of infestations (Exhibit 7-4g). Reach 1 and Reach 5 have the largest total infested area by reach. In Reach 1, the infestations are primarily due to an abundance of perennial pepperweed. Perennial pepperweed, at over 17 acres, is by far the most dominant weed in this reach, and it accounts for almost all of the pepperweed found along lower Putah Creek. The tamarisk population is also larger in this reach than in any other. Additional weeds with sizable populations include Himalayan blackberry, arundo, and yellow starthistle. Only four other weeds were mapped in Reach 1, and they account for only about 0.2 acre of infestations. The four weeds are eucalyptus, milk thistle, Eurasian watermilfoil, and tree-of-heaven.

Individual Species Distribution Analysis

The following discussion characterizes the distribution of individual invasive weed species growing in the lower Putah Creek riparian corridor. The discussion describes the general location where the weed grows within the stream channel profile, shown in Exhibit 7-5, and a designation as one of three distribution profiles. The channel was partitioned into the low-flow channel, sediment bars within the low-flow channel, the high-flow channel, lower and upper banks, and the top of bank terrace for purposes of weed data collection. Invasive weeds in the riparian corridor are assigned to one of three distribution profiles that characterize the extensiveness of each weed in the watershed. The distribution profiles are described in Table 7-3. The distribution profiles are defined based on relative differences in the number of infestations and the average size of each infestation. They will help determine priorities for future abatement actions. The types range from weeds presumed to have recently invaded and/or which have not yet spread throughout the corridor to those which are now ubiquitous in the corridor. The acreage and infestation frequency values provided to define differences between groups are based on approximate ranges of values in which the invasive weeds appear scarce, widespread, or ubiquitous in the lower Putah Creek riparian corridor. The distribution characteristics of each invasive weed species are summarized, along with the distribution profile designation, in Table 7-4.

There are twelve invasive weeds in the lower Putah Creek riparian corridor that can be considered incipient. They have characteristically small and relatively confined infestations that have not yet spread extensively throughout the corridor. They are indicated in Table 7-4. Together, infestations of the twelve incipient weeds currently account for only 2.5 acres, or 2% of all mapped infestations in the riparian corridor. Three weeds, including arundo, tamarisk, and tree-of-heaven, are considered widespread with numerous small infestations throughout much of the riparian corridor. These weeds have characteristics of having recently spread and colonized in much of the corridor, but the infestations have not yet grown to a large size. Unabated, they are likely to quickly become more extensive in size. The three widespread



Creek Channel Profile

EXHIBIT 7-5

Table 7-3
Distribution Profile Characteristics of Lower Putah Creek Riparian Corridor Invasive Weeds

Distribution Profile	Average Size of Each Infestation 1 (acres)	Total Number of Infestations	Total Infestation Area 2	Comments
Incipient – Few Small Infestations (I)	Small – less than 0.1 acre	Less than 100	Small – less than 1 acre	Presumed to be very recent introductions or those relatively contained thus far
Widespread – Many Small Infestations (WS)	Small – less than 0.1 acre	Over 100	Varies – greater than 1 acre	Weeds that have spread rapidly and are now beginning to increase in infestation size
Ubiquitous – Few to Many Large or Continuous Infestations (U)	Large – greater than 0.1 acre	Varies	Large – greater than 5 acres	Weeds that have already spread and grown considerably in infestation size

[1] An infestation is defined here as the patch of a particular weed species mapped during surveys. It is generally close to 100% cover by the invasive weed.
[2] Total infestation area is the total area of mapped infestations.
Source: EDAW 2004

Table 7-4 Distribution Profiles for Invasive Weeds in the Lower Putah Creek Riparian Corridor				
Weed	Avg. Infestation Size (acres)	Number of Infestations	Total Acres	Profile Type
Almond	0.01	26	0.3	I
Arundo	0.05	406	21	WS
Black locust	0.03	16	0.5	I
Catalpa	0.003	6	0.02	I
Edible fig	0.01	55	0.5	I
English ivy	0.004	1	0.004	I
Eucalyptus	0.1	302	24	U
Eurasian watermilfoil, parrot's feather	0.2	39	9	U
Fennel	0.01	9	0.09	I
Himalayan blackberry	0.1	241	22	U
Jubata grass; Pampas grass	0.04	1	0.04	I
Milk thistle	0.1	8	0.7	I
Pepper tree	0.01	10	0.1	I
Perennial pepperweed	0.1	143	18	U
Tamarisk	0.03	393	10	WS
Tree-of-heaven	0.04	123	5	WS
Tree tobacco	0.01	31	0.2	I
Vinca	0.004	1	0.004	I
Virginia creeper	0.02	4	0.06	I
Yellow starthistle	0.6	28	16	U
Total		1843	127.52	
Source: EDAW 2004				

weeds account for about 36 acres, or 28% of all invasive weed infestations in the riparian corridor. The five remaining mapped invasive weeds, including eucalyptus, Himalayan blackberry, Eurasian watermilfoil, perennial pepperweed, and yellow starthistle, are all considered ubiquitous with extensive infestations throughout much of the riparian corridor. These five weeds together account for 89 acres, or 70%, of all invasive weed infestations in the riparian corridor.

Almond

Almond is a weed characterized as an incipient population that has spread into the corridor from old orchards. Almond is growing mostly on the upper banks and top of bank terraces within the creek profile. It was mapped at 26 locations totaling 0.3 acre. It was found in

Reaches 4 and 5 adjacent to orchards or agricultural fields. While there were more patches mapped in Reach 5, Reach 4 had the largest patch totaling 0.11 acre. In Reach 5, the almond trees occur below Winters Road bridge and are scattered along the creek from the Yolo Housing Authority property to the I-505 crossing. In Reach 4, the trees are found in one main infestation across from an orchard.

Arundo

Arundo is a weed that is characterized as widespread, with numerous small infestations that have spread throughout the creek. Arundo was mapped at 406 locations throughout all seven reaches for a total of 21 acres. It grows mainly in the high-flow channel, on gravel bars, and along the lower bank of the creek. Most infestations are thick stands that preclude the growth of any other plants. The largest contiguous infestation mapped was approximately 0.8 acre. Reach 5 has the greatest amount of arundo, with 178 infestations mapped, totaling 10 acres. Large-sized (e.g., greater than 0.05 acre) infestations of arundo begin just downstream of the PDD and continue to the confluence of Putah Creek with Dry Creek. Reaches 4 and 7 also have major infestations. Reach 7 (Pleasants Creek) likely has more infestations than were mapped because large stretches of the creek were inaccessible. Pleasants Creek may be contributing to the large infestations found downstream in Reaches 4 and 5. Reaches 1, 2, 3, and 6 are less infested by arundo than the other reaches and Reach 3 has the fewest infestations, with only three small populations mapped.

Many infestations of arundo have been removed subsequently to the 2002 surveys. In 2002 and 2003, several acres of infestations immediately below the PDD and at the confluence of Putah Creek and Dry Creek were removed through a grant provided by the CALFED Bay-Delta Authority to Team Arundo del Norte and under contract with the LPCCC. The City of Davis and Los Rios Farms removed arundo on property near the Yolo Bypass in 2003. Additional infestations were removed prior to the surveys. Substantial infestations were removed along Pleasants Creek in 2001 by California Department of Forestry crews with funding by a USFWS Partners for Wildlife grant and private landowner funds. The work was conducted to stabilize creek banks that were eroding away quickly, aided by arundo that clogged the channels. Substantial infestations were removed by volunteers with the Putah Creek Committee at Winters Putah Creek Park in conjunction with habitat restoration in the late 1990s. Substantial infestations were also removed below Mace Boulevard in the late 1990s by volunteers with the Putah Creek Council and by the City of Davis.

Black Locust

Black locust is characterized as an incipient population. Black locust was documented in 16 locations totaling 0.5 acre. It grows from the high-flow channel all the way up to the top of bank terrace. Small infestations occur in Reaches 3, 4, 5, 6, and 7, but not in Reaches 1 and 2. It is evenly scattered across Reaches 3 through 6, while Reach 7 has small groupings of trees in one main area. The largest patch of black locust mapped is in Reach 3 and is a total of 0.15 acre.

Catalpa

Catalpa is characterized as an incipient population. Catalpa was mapped at six locations along the creek for a total of 0.02 acre. The trees typically are found growing on both the lower and upper banks of the creek. Most mapped infestations are individual trees, five of which are found in Reach 4. In Reach 4, the scattered individuals are concentrated in one area near the beginning of Reach 5. Only one tree was found in Reach 5. Catalpa trees are most likely escaped ornamentals from nearby landscaped areas or, in some cases, may have been planted.

Edible Fig

Edible fig is characterized as an incipient population in the lower Putah Creek riparian corridor. Edible fig was mapped at 55 locations and totals 0.5 acre. Fig trees are found growing mainly in the high-flow channel and along the lower banks, areas which satisfy its moisture requirements.

Most infestations mapped are individual trees. The reaches with the highest number of fig trees are Reaches 5 and 6, with decreasing amounts upstream and downstream. No individuals were found in Reach 1.

English Ivy

English ivy is an incipient population, with only one infestation of this weed found during the surveys. It is in Reach 5 and is approximately 0.004 acre. It is likely a garden escape.

Eucalyptus

Eucalyptus is characterized as a ubiquitous weed growing throughout most of the lower Putah Creek riparian corridor. The majority of eucalyptus trees are growing on the upper banks and top of bank terraces, but a large proportion is also growing on the lower banks. The majority of eucalyptus trees in the lower Putah Creek riparian corridor are red gum. They comprise a total of 302 locations and 24 acres of infestations. Reaches 3 and 4 are the most infested, although Reaches 2 and 5 also have extensive areas of eucalyptus stands. The largest stand mapped is in Reach 5, totaling 1.2 acres. Small, satellite infestations exist in Reaches 1, 6, and 7. In some cases, these smaller patches are intentional plantings in landscaped settings.

Eurasian Watermilfoil, Parrots Feather

The majority of infestations mapped along Putah Creek were Eurasian watermilfoil. It is considered ubiquitous and was found in nearly continuous infestations throughout major portions of the creek open-water channel. Eurasian watermilfoil typically grows in the low-flow channel, but one infestation was found growing on the lower bank along the creek. The population of this weed can vary considerably from year to year in response to changes in flows, temperature, and other conditions. Only one infestation was identified as parrot's feather. It was found in the Yolo Bypass near the Putah Creek sinks in Reach 1 (0.01 acre). The remaining 38 infestations were Eurasian watermilfoil, which totaled approximately 9 acres. The major infestations of Eurasian watermilfoil were located in Reaches 4 through 6, with smaller amounts in Reaches 1 and 2. Watermilfoil was not located in either Reach 3 or 7 during surveys. However, the plant could have been submerged and obscured by the turbid water in Reach 3 during surveys. Reach 7, Pleasants Creek, has only seasonal water and limited water was present at the time of the survey. The lack of perennial water likely prevents establishment of the weed there.

Fennel

Fennel is characterized as an incipient weed population currently restricted to nine mapped locations in Reach 6 totaling 0.09 acre and some unmapped terrace locations in Reach 1. It grows in the high-flow channel up to the top of bank terrace. Most infestations are small (0.01 acre) and scattered, but the largest infestation is approximately 0.04 acre.

Himalayan Blackberry

Himalayan blackberry is characterized as a ubiquitous weed growing throughout much of the riparian corridor. The species usually grows in the high-flow channel and along the lower banks of the creek, but at times is found up to the top of the bank terrace. It was mapped at 241 locations totaling 22 acres of infestations located in the entire lower Putah Creek watershed riparian corridor, with the exception of Pleasants Creek (Reach 7). Reach 5 has the largest infestation area, with 89 occurrences totaling nearly 10 acres. Reaches 1, 3, 4, and 6 have smaller amounts, although those reaches generally have large, scattered patches distributed throughout half or more of each reach. The largest infestation mapped was 0.8 acre found in Reach 1. Reach 2 appears to be the least infested area along lower Putah Creek, with only a few small patches that were mapped. However, it is likely that Himalayan blackberry is more extensive than what was mapped because it was often obscured by taller vegetation during surveys.

Jubata Grass/Pampas Grass

Jubatagrass or Pampas grass is an incipient population that was found at one location along the creek. It was approximately 0.04 acre in size and growing in the high-flow channel in Reach 6. The specimen could not be identified to species, however, because it was observed from a distance and not accessible to surveyors. It may have propagated from other plantings located at the mouth of Pleasants Creek.

Milk Thistle

Milk thistle is an incipient weed population found at eight locations and totaling 0.7 acre. It is an annual plant, so the population extent may vary considerably from year to year. Most of the infestations were located on the upper banks or top of bank terrace along the creek. It was found in six locations within Reach 4 interspersed within yellow starthistle. The remaining two small infestations were found in Reach 1. The largest infestation was in Reach 3 and totaled 0.28 acre.

Pepper Tree

Pepper tree is characterized as an incipient population in the riparian corridor. It is found growing on the upper bank and top of bank terraces within the creek profile. It is currently found at only 10 sites totaling 0.1 acre in Reaches 5 and 7. The largest number of occurrences (five), as well as the largest infestation (0.09 acre), are located in Reach 5. Most of the infestations are small, scattered patches around the Winters Road bridge. In Reach 7, two infestations were found close together.

Perennial Pepperweed

Perennial pepperweed is characterized as ubiquitous in lower Putah Creek, although it is largely restricted to Reach 1. Perennial pepperweed grows mainly on the upper banks and top of bank terrace in areas subject to flooding. It is also occasionally found on lower banks and in the high-flow channel. The population occurs in 143 locations totaling 18 acres. The largest infestations are found in Reach 1 in an area adjacent to agricultural fields in a levee bounded floodplain. The infestations mapped in Reaches 2, 3, and 4 were primarily small, scattered patches and perennial pepperweed were not found during surveys in Reaches 5 and 7. Only one patch was located in Reach 6. The largest infestation covers approximately 2.4 acres in Reach 2.

Tamarisk

Tamarisk is characterized as widespread in the riparian corridor, with numerous small infestations found in all but Reaches 6 and 7. Tamarisk typically grows in the high-flow channel and along the creek's lower banks. However, some infestations are located on the upper bank and top of bank terrace. There are 393 mapped infestations totaling 10 acres. The heaviest infestations are in Reaches 1 and 4, though it is also prevalent in Reaches 2 and 3. Only a small amount of tamarisk was found in Reach 5 near the Winters Road bridge. The most extensive patch was mapped in Reach 1 and covered 0.27 acre. Additional patches of tamarisk were removed along Putah Creek in the late 1990s prior to the survey. A few were removed by volunteers with the Putah Creek Council on or near the UC Davis Putah Creek Riparian Reserve, and some were removed just downstream of Mace Boulevard by the City of Davis.

Tree-of-Heaven

Tree-of-heaven is characterized as widespread with numerous small populations found throughout the riparian corridor. It was mapped in 123 locations totaling 5 acres of infestations. Tree-of-heaven grows mainly on the upper banks and terrace, but occasionally is found in the channel and on lower banks. Tree-of-heaven occurs in every reach. Reach 7 is the most infested reach and Reaches 1 and 2 are the least infested. The largest infestation is approximately 0.38 acre.

Tree Tobacco

Tree tobacco is considered an incipient population. It was mapped at 31 locations totaling 0.2 acre. Tree tobacco is found on the top of bank terrace, usually in open areas or along road cuts. Infestations are most extensive in Reach 6, with 21 small infestations that total 0.1 acre. Patches occurring in Reaches 2, 3, and 5 are currently few in number and small in size. No infestations were found in Reaches 1, 4, or 7.

Vinca

Vinca is an incipient weed that was found growing only as a single small patch that is 0.0004 acre or 174 square feet. It grows along the top of the bank terrace.

Virginia Creeper

Virginia creeper was mapped at four locations totaling 0.06 acre. This species appears to be colonizing small areas within Reaches 2 and 5. Three of the four infestations were found in Reach 5, but both reaches had very similar maximum acreage for an infestation; Reach 2 was 0.025 acre and Reach 5 was 0.032 acre. These infestations were found growing on trees on the top of bank terrace.

Water Hyacinth

Water hyacinth has previously been found in lower Putah Creek. However, no infestations were found during the 2002 surveys. It is likely that this weed will appear again because aquatic weed lifecycle patterns change from year to year in response to variations in flood-flow regimes, available propagules, and other factors.

Yellow Starthistle

Yellow starthistle is considered a ubiquitous weed in the watershed. It was mapped at 28 locations in all reaches except for Reach 5. Yellow starthistle occurs predominantly on the top of bank terrace, but occasionally is found along the banks of the creek. The total infested area mapped was 16 acres. The largest infestations occurred in Reach 7, where large fields used for grazing are found adjacent to the creek. Heavy infestations also were found in Reaches 2 and 6, with only a few infestations found in Reaches 1, 3, and 4. The largest infestation mapped occupied approximately 5.6 acres.

COMPARISON OF CURRENT DISTRIBUTION WITH USFWS INVASIVE SPECIES MAP

In 1993, the USFWS published its results on resource inventories conducted for the Report to Congress – Reconnaissance Planning Report – Fish and Wildlife Resource Management Options for Lower Putah Creek, California (USFWS 1993). The mapped inventory covered the mainstem Putah Creek riparian corridor between Monticello Dam and the Yolo Bypass. As part of the resource inventories, land use and habitat cover types within the planning area were assessed including invasive weeds mapping. The invasive weeds mapped during the

USFWS project included eucalyptus, tree-of-heaven, tamarisk, and arundo. The populations of those four species were mapped using aerial photographs, as well as field mapping during canoe, car, and foot surveys. The USFWS maps were compared to the maps created during the WMAP surveys to assess any major differences in the distribution of the four weeds that may be indicative of the rate and extent of their spreading to new areas of the riparian corridor. While it is likely that there are some information gaps in both the USFWS and current WMAP studies, the following comparison provides some insight into the changes that have occurred over the 10-year period between the studies.

Arundo

Arundo appears to have spread downstream substantially during the 10-year period between studies. Arundo first appears on the USFWS maps immediately downstream of the PDD, with no infestations recorded in the interdam reach. On the USFWS maps, a substantial number of stands were mapped in the vicinity of the PDD and downstream near the confluence of Putah Creek and Dry Creek. In contrast, in 2002, arundo was mapped at 19 locations in the interdam reach, with the majority of those infestations located around the confluence of Pleasants Creek and Putah Creek. It is possible that populations of arundo existed near the confluence with Pleasants Creek in 1991, but were not recorded during the surveys. Below the PDD, in Reach 5, arundo appears to have spread downstream, including new infestations on the south side of the creek, downstream of the Winters Road bridge, and near the Yolo Housing Authority property below the Winters Road bridge. New infestations are now present in Reach 2 approximately 1 mile south of I-80, and in Reach 1 near the Yolo Bypass.

Some infestations, which have since been removed, were present during or subsequent to the 1991 surveys. Infestations were removed during the mid to late 1990s in Winters Putah Creek Park and downstream of Mace Boulevard in the upper portion of Reach 1. Those populations were removed by volunteers with the Winters Putah Creek Committee, Putah Creek Council, and the City of Davis.

Eucalyptus

By the early 1990s, eucalyptus was already widespread throughout the riparian corridor below I-505. On the USFWS maps, it was first shown to occur just upstream of the I-505 bridge. Based on the 2002 survey, eucalyptus stands now occur farther upstream, just below the Winters Road bridge in Reach 5, possibly indicating a population expansion adjacent to residences. Eucalyptus infestations also appear to have spread and expanded in portions of Reach 5 and continuing into Reach 4, including upstream and downstream of Stevensons Bridge on the creek's northern bank, the northern bank adjacent to the UC Davis Aquaculture Facility, and within the UC Davis Riparian Reserve from I-80 to Old Davis Road. In Reach 2, infestations appear to be more extensive on the north bank between river mile 5 and 6.

Tamarisk

The distribution of tamarisk is similar between the USFWS maps and the 2002 maps. However, there are indications of population expansions. It appears that the quantity of infestations upstream of Stevenson's Road may be greater now than it was in 1991. There also appears to be a substantial number of new infestations on the south side of Putah Creek in Reach 2, approximately 2.5 miles south of Mace Boulevard.

Tree-of-Heaven

The USFWS map includes only a single stand of tree-of-heaven in between Monticello Dam and PDD in Reach 6, along State Route 128. During the 2002 surveys, 17 infestations were mapped in that reach. Many of the recently recorded infestations occur along Lake Solano and at the confluence with Pleasants Creek and Putah Creek Road, although there are additional patches scattered throughout Reach 6. There also appears to have been a substantial increase in the distribution and size of new infestations in Reach 5 upstream and downstream of Winters Road bridge, as well as scattered new infestations continuing downstream into Reach 4.

Tree-of heaven tends to grow in widely separated patches near the tops of the stream banks. It is not distinguishable in aerial photographs nor is it visible from canoes on the creek channel, the two primary methods used by USFWS to conduct the surveys. It is likely that the extent of tree-of-heaven was underestimated during prior surveys, and that the plant continues to grow and spread.

7.3.3 PRIORITIZATION OF WEED SPECIES FOR MANAGEMENT EFFORTS

Implementing any weed management program depends on landowner participation and funding availability (and often, volunteer labor). Nonetheless, within these constraints, weed control efforts will be most effective when guided by a comprehensive strategy for maximizing their benefits. Such strategies prioritize species and sites for removal efforts to maximize available resources.

Prioritization of species should consider their distribution (i.e., acreage infested and size of infestations), invasiveness, removal costs, and how they affect physical processes, biological communities, and human uses. These attributes indicate the effort required to control a species, the benefits of that control, and the impacts that will likely occur in the absence of any control effort.

Prioritization of individual sites (i.e., infestations) should consider the human uses, structures, and sensitive biological or other (e.g., cultural) resources affected by the infestation (or that could be affected by its removal), the potential for the infestation to expand or to serve as the source of propagules establishing additional infestations, and the effort required to eradicate the infestation. These attributes indicate where the greatest benefits can be attained and further invasion prevented.

As a step towards such a strategy, Table 7-5 provides a preliminary prioritization of the invasive weed species found along lower Putah Creek. Though all of these species are considered invasive species that are important to control in the lower Putah Creek riparian corridor, available resources are not sufficient to remove all of them simultaneously. Therefore, further prioritization is necessary.

Table 7-5
Attributes and Abatement Priority of Invasive Weeds in the Lower Putah Creek Riparian Corridor

Weed	Effects Physical-Biotic-Human[1]	Invasiveness[2]	Control Cost (per unit area)[3]	Total Acres	Profile Type
Level 1 Species[4]					
Arundo, giant reed *Arundo donax* (perennial grass)	H-H-H	M	H	21	WS
Tamarisk *Tamarix* spp. (evergreen shrub)	H-H-H	H	H	10	WS
Edible fig *Ficus carica* (deciduous tree)	L-H-L	H	L	0.5	I
English ivy *Hedera helix* (perennial vine)	M-H-L	H	L	< 0.1	I
Eucalyptus[5] *Eucalyptus* spp. (evergreen tree)	M-H-H	H	H	24	U
Fennel *Foeniculum vulgare* (perennial herb)	L-H-L	H	H	< 0.1	I
Himalayan blackberry[5] *Rubus discolor* (evergreen shrub)	M-H-M	H	H	22	U
Parrots feather *Myriophyllum aquaticum* (aquatic)	H-H-H	H	H	< 0.1	I
Pepper tree *Schinus molle* (deciduous tree)	M-H-L	M	H	0.1	I
Tree-of-heaven *Ailanthus altissima* (deciduous tree)	L-H-M	M	H	5	WS
Vinca, periwinkle *Vinca major* (perennial groundcover)	M-H-L	M	H	< 0.1	I
Level 2 Species[4]					
Eurasian watermilfoil *Myriophyllum* spp. (aquatic - submergent)	H-H-H	H	H	9	U

Table 7-5
Attributes and Abatement Priority of Invasive Weeds in the Lower Putah Creek Riparian Corridor

Weed	Effects Physical-Biotic-Human[1]	Invasiveness[2]	Control Cost (per unit area)[3]	Total Acres	Profile Type
Jubata grass, Pampas grass *Cortaderia jubata. C. selloana* (perennial grass)	M-M-M	M	L	< 0.1	I
Perennial pepperweed *Lepidium latifolium*	H-H-L	H	H	18	U
Tree tobacco *Nicotiana glauca* (deciduous shrub)	L-M-L	M	L	0.2	I
Virginia creeper *Parthenocissus quinquefolia* (deciduous vine)	L-M-L	L	L	0.06	I
Yellow starthistle *Centaurea solstitialis* (annual herb)	H-H-L	M	L	16	U
Level 3 Species[4]					
Almond *Prunus dulcis (P. americana)* (deciduous tree)	L-M-L	L	L	0.3	I
Black locust *Robinia pseudoacacia* (deciduous tree)	L-L-L	M	H	0.5	I
Catalpa *Catalpa bignonioides* (deciduous tree)	L-L-L	M	L	< 0.1	I
Milk thistle *Silybum marinum* (annual/biennial herb)	L-L-L	L	L	0.7	I

Notes:

1 – Physical process effects are based on Criterion 1.1 and biotic effects are based on Criteria 1.2-1.4 of the California Invasive Plant Council (CalIPC) plant assessment form (PAF) (CalIPC 2003), and if available, on existing CalIPC ratings; human effects are detrimental effects on infrastructure, buildings, agriculture, recreation, or other human uses based on professional judgment of EDAW ecologists.

2 – Based on CalIPC criteria and scoring methodology for invasiveness (CalIPC 2003), and if available, existing CalIPC ratings.

3 – Ratings are based on costs per treatment and the likely number of treatments required for control; species with persistent soil seed banks or spreading via below-ground stems were rated "High," as were species requiring large amounts of biomass removal. Data sources included available literature (particularly the reviews in Bossard et al. 2000), data collected for the lower Putah Creek WMAP, and professional judgment of EDAW ecologists.

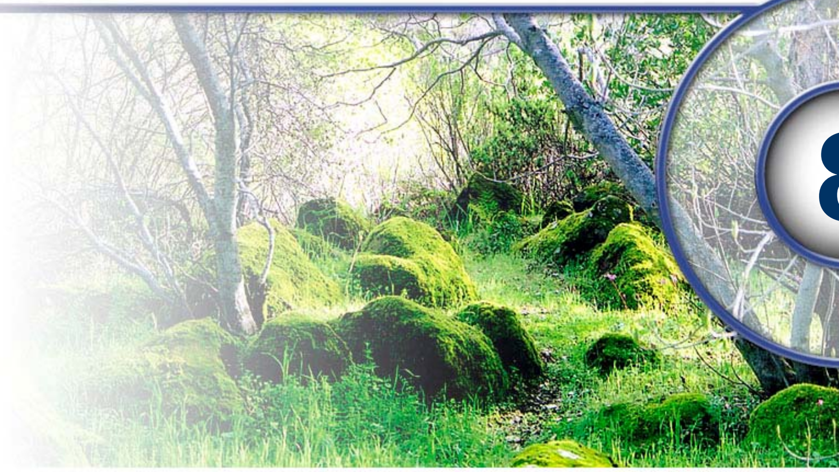
4 – Priority classification is: Level 1 species – I or WS species with either high invasiveness or a high rating for at least one effect type; Level 2 species – species not satisfying criteria for high priority but with at least moderate invasiveness and at least one effect type rated moderate; and Level 3 species – species with either all effects rated low or low invasiveness.

5 – Eucalyptus and Himalayan blackberry, though ubiquitous, were placed in the Level 1 category rather than in Level 2. Eucalyptus grows fast and high removal costs rise sharply as it grows, based on tree mass, elevating the importance of removing trees as soon as possible; Himalayan blackberry causes substantial adverse geomorphic effects (traps sediment, slows flows, and cuts off floodplain access); also, recent progress has been made on Putah Creek in developing cost-effective Himalayan blackberry abatement strategies, making it feasible to restore infested areas.

Source: EDAW 2004

The invasive weeds have been grouped into three priority levels based on the differences in their attributes. Those species placed in Level 1 have incipient or widespread distribution patterns and are either highly invasive in general or known to cause substantial impacts. Arundo, fennel, and vinca are examples of such species. In the absence of control measures, these are species whose effects are expected to increase the most in the near future. Species that are already ubiquitous, or that are less invasive and whose infestations cause lesser impacts, were placed in the moderate priority category (Level 2). Those species both with a relatively low level of invasiveness and causing relatively low levels of effects (in all effect categories) were placed in the lowest priority category (Level 3).

Because removal costs have not been well documented for many species, this attribute was not uniformly used to assign species to a priority category. However, as species removal costs become better known, species priority levels should be reassessed if their removal costs are substantially higher or lower than most other species. For instance, eucalyptus was raised to priority Level 1 due to its high cost of removal, which also increases rapidly as eucalyptus grows.



8

Stakeholder Planning

8 STAKEHOLDER PLANNING

8.1 STAKEHOLDERS

A stakeholder is an individual, group, or agency with an interest in Putah Creek. Landowners are the essential stakeholders for any action pertaining to Putah Creek since no actions may occur on private or public land without the consent of the landowner or land manager. Many groups have formed to represent Putah Creek landowners over issues including water rights, resource protection, and management of public lands. Other groups have formed that include landowners and non-landowners to advance public interests through creek cleanups and restoration projects with willing landowners. Several public agencies provide funding for creek enhancement projects because the public has an interest in issues such as weed abatement, flood protection, fish and wildlife conservation, water quality, and solid waste abatement. For purposes of the Putah Creek Watershed Management Action Plan (WMAP), stakeholders are divided into three broad groups: landowners, local organizations, and funding agencies. This section describes the roles and activities of each.

8.1.1 LANDOWNERS

There are over 200 private and public landowners and 275 parcels in the lower Putah Creek watershed, including those portions of Pleasants Creek below Miller Creek and Dry Creek below Highway 128, that are influenced by flows in Putah Creek. Approximately 78% of the land along Putah Creek is privately-owned, primarily in crop and orchard production but also with a growing number of private rural residences. The balance, in public ownership, is held by Yolo and Solano counties, the cities of Davis and Winters, the University of California, Davis (UC Davis), the California Department of Fish and Game, and the U.S. Bureau of Reclamation.

Riparian landowners (i.e., those whose property adjoins and/or includes the creek) own land to the centerline of creek. Riparian parcels cover nearly 14,000 acres with a total riparian corridor of about 1,700 acres. Landowner holdings range in size from 0.13 acre to 640 acres, with an average size of 61 acres. As landowners do not always live on the land they own, it is helpful to understand the different types of landownership that is found along Putah Creek:

< rural residential with private residence and no farm,
< rural residential with a farmer living and working on the land,
< non-residential with the landowner living elsewhere but possibly working the property himself, and
< farmed land with an absentee landowner who may have a lessee working the land.

Lessee interests and authorities may or may not include Putah Creek issues.

8.1.2 LOCAL ORGANIZATIONS

Several local organizations focused on Putah Creek and tributaries have formed in recent years. The following is a brief history of these organizations and why they formed.

PUTAH CREEK COUNCIL

The Putah Creek Council (PCC) is a public interest non-profit organization. PCC was formed in 1988 to increase appreciation for the natural resources of Putah Creek. Early PCC activities included nature walks and the production of a newsletter. In 1990, the effects of the 1987 – 1994 drought began to dramatically affect the aquatic and riparian habitat of the creek, at times resulting in over 20 miles of dry creek bed for extended summer periods. At this point, the PCC began to advocate for more flows in the creek to support the creek's unique collection of native fish, wildlife, and California fauna. In 1991, PCC began legal proceedings to ensure adequate environmental flows. In 1993, the City of Davis and UC Davis joined the litigation, which resulted in a 1996 ruling of the Sacramento Superior Court significantly increasing flows to Putah Creek. The judgment was appealed by Solano County water interests and that began negotiations that led to an historic May 2000 settlement agreement – the Putah Creek Accord. The Accord provides up to 50 percent more water, guarantees minimum flows to downstream compliance points, includes flow pulses to attract historic salmon back up Putah Creek, and also recognizes the need for shared water supply and instream flow reductions during periods of low water storage behind Monticello Dam.

The PCC currently organizes community volunteers in creek enhancement projects including trash cleanup days, invasive weed removal, and native fish and wildlife habitat projects, and provides seminars to the public on creek-related natural resource topics. The PCC's mission is to protect and enhance Putah Creek and its tributaries through advocacy, education, and community-based stewardship. The PCC plans and implements projects on lands of willing landowners in a manner that respects and advances landowner interests, rights, and concerns.

PUTAH CREEK LANDOWNERS ASSOCIATION

The Putah Creek Landowners Association, consisting of 30 riparian landowners, was formed to oppose an attempted adjudication of riparian water rights by Solano County Water Agency. The adjudication was eventually dropped and riparian water allocation has been resolved via individual negotiations in rare instances when riparian water supplies have been overdrawn.

DRY CREEK HOMEOWNERS ASSOCIATION

The Dry Creek Homeowners Association (DCHA) was formed by Valerie Whitworth to address eroding streambanks on Dry Creek on the west side of the City of Winters. The DCHA received two grants from the California Department of Water Resources' (DWR's) Urban Streams Restoration Program and completed several pilot projects on Dry Creek near the confluence with Putah Creek.

LOWER PUTAH CREEK COORDINATING COMMITTEE

The Putah Creek Accord established a new forum, the Lower Putah Creek Coordinating Committee (LPCCC), to oversee implementation of the settlement, hire and supervise the Streamkeeper, and coordinate creek studies and enhancement efforts. The LPCCC is composed of five Yolo and five Solano County-appointed members representing environmental and water interests, including the cities of Davis, Fairfield, Suisun, Vacaville, Vallejo, and Winters; PCC, UC Davis; a representative of riparian landowners; Solano Irrigation District (SID), Solano County Water Agency (SCWA), and Maine Prairie Water District. The LPCCC administers an annual budget of $160,000 indexed to inflation for fish and wildlife monitoring, vegetation management, and Streamkeeper salary, as well as administering additional funds from grants to protect the resources of Putah Creek. The LPCCC holds its public meetings six times per year, alternating between Davis and Winters, to discuss issues affecting Putah Creek and to provide a forum for resolving disputes within the framework of the Putah Creek Accord.

WINTERS PUTAH CREEK COUNCIL

The Winters PCC was formed as a volunteer organization to guide decisions on Winters Putah Creek Park and help with its planting and maintenance. Activities include cleanups, planting of riparian vegetation, and a forum for discussing issues affecting the park.

PUTAH-CACHE BIOREGION PROJECT

The Putah-Cache Bioregion Project (PCBR) was formed by UC Davis to promote conservation of the Putah Creek and Cache Creek watersheds. Activities include educational events.

PUTAH CREEK DISCOVERY CORRIDOR

This effort was formed by UC Davis to organize public landowners in the Interdam Reach from Monticello Dam to PDD to provide coordinated educational opportunities. Activities include development of a master plan, leading field trips for school-age children, and other related educational opportunities.

YOLO LAND TRUST

The Yolo Land Trust is a land conservation organization founded in 1988 to protect the agricultural and open space lands in Yolo County. The Yolo Land Trust primarily works with individual landowners to purchase and establish conservation easements on private property and may have a role in holding conservation easements along Putah Creek.

SOLANO LAND TRUST

The Solano Land Trust is another land conservation organization formed to conserve agricultural, environmentally sensitive, and open space land in Solano County. The Solano Land Trust has purchased conservation easements along Putah Creek and Pleasants Creek.

FISHING ORGANIZATIONS

Various fishing organizations have participated in the conservation of lower Putah Creek as a blue ribbon trout fishery. They sponsor annual cleanup events and spawning gravel augmentation, and promote measures to stop the spread of New Zealand Mud Snail.

CALIFORNIA AUDUBON

California Audubon promotes conservation and enhancement of bird habitat. The Winters office has organized planting and cleanup events on lower Putah Creek and the Dry Creek watershed.

SOLANO COUNTY RESOURCE CONSERVATION DISTRICT

The Solano County Resource Conservation District has organized landowners on Pleasants Creek to control arundo, an invasive exotic plant, and has managed major cleanup projects to-date, removing eight cars and 1,200 tons of concrete from the banks of Putah Creek and Pleasants Creek tributary.

8.1.3 KEY FUNDING AGENCIES

This section discusses agencies that by virtue of their decisions to fund Putah Creek projects are shaping the future of the Putah Creek watershed. Stakeholders in this category fall into a more regional framework; while they may fund or do work along Putah Creek, their missions and mandates are much broader.

SOLANO COUNTY WATER AGENCY

SCWA administers water from the Solano Project and is fiscal agent of the LPCCC. SCWA serves 300,000 municipal water users and irrigation water for 70,000 acres of agricultural land. Its responsibilities are to ensure water availability for agricultural, municipal, commercial, industrial, and all other beneficial uses; control flood and storm waters using a combination of reservoir storage, diversion, or release for groundwater recharge; promote water conservation; protect life and property from floods; install recreational facilities or landscaping; and generate power for wholesale or agency use.

SOLANO IRRIGATION DISTRICT

SID is an independent special district, a local governmental agency, formed in 1948. SID has entitlements for 151,000 acre feet of agricultural and domestic water for service to many areas in Solano County each year. The District also is the operator of the Solano Project, which delivers Lake Berryessa water to the cities of Fairfield, Suisun City, Vacaville, and Vallejo; Maine Prairie Water District; and the SID agricultural customers. The District owns and operates the hydroelectric power plant at the base of Monticello Dam. SID is a member of the LPCCC and independently funds water conservation programs.

CALFED/CALIFORNIA BAY-DELTA AUTHORITY

The California Bay-Delta Authority (CBDA) oversees the implementation of the CALFED Bay-Delta Program for state and federal agencies working cooperatively to improve the quality and reliability of California's water supplies while restoring the Bay-Delta ecosystem. The CALFED Bay-Delta Program is responsible for developing and implementing a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses of the Bay-Delta System. CALFED Ecosystem Restoration and Watershed Programs have funded physical and biological assessments, community outreach, stewardship planning, and educational programs in the Lower Putah Creek watershed.

U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service (USFWS) is the federal agency responsible for conservation and enhancement of nonanadromous fish and wildlife resources. The USFWS conducted a reconnaissance study of Putah Creek in 1993 and has provided project grants to landowners in the Putah Creek watershed through the Partners for Wildlife Program.

State Water Resources Control Board

State Water Resources Control Board (SWRCB) issues water rights and protects water quality throughout the state. The SWRCB currently funds stewardship planning on Putah Creek as a continuation of a 2001 Proposition 204 project.

Central Valley Regional Water Quality Control Board

The Central Valley Regional Water Quality Control Board (RWQCB) is the local implementing agency for protecting water quality in the state. The RWQCB administers the CBDA and Proposition 13 projects in the Putah Creek watershed.

Wildlife Conservation Board

Wildlife Conservation Board (WCB) promotes wildlife conservation throughout the state and currently funds invasive weed control and riparian restoration projects throughout the lower Putah Creek watershed.

Integrated Waste Management Board

Integrated Waste Management Board (WMB) implements solid waste management programs, including trash disposal and recycling, throughout the state. The IWMB Farm and Ranch Cleanup Program provides funding for removal of solid waste on agricultural lands, including several sites in the lower Putah Creek watershed.

8.2 Stakeholder Involvement

8.2.1 Methods

Stakeholders have been involved in Putah Creek stewardship on several occasions since 1992 when the Dry Creek Homeowners Association led by a local landowner, Valerie Whitworth, began implementing bank stabilization projects on the Dry Creek tributary.

Subsequent public comment opportunities arose during the review of the USFWS Putah Creek Reconnaissance Planning Report in 1993. Primary issues identified then were invasive weed control (particularly arundo, eucalyptus, tamarisk, and tree-of-heaven), water conservation methods (prior to the settlement agreement), scarification of gravel bars, and infilling riparian vegetation to maintain a continuous wildlife migration corridor. Shortly thereafter, the Putah Creek water litigation prompted landowners to organize in opposition to adjudication of riparian water rights.

In 2000, the Solano County Department of Environmental Management received a Proposition 204 grant to organize a Lower Putah Creek Watershed Stewardship Group. Several meetings were held with affected stakeholders, chiefly riparian landowners. This was the first public forum on Putah Creek since the attempted adjudication of water rights by the SCWA. Although water rights were not part of the Stewardship Group's mission, the initial meetings were consumed by discussions of water rights. Eventually, in an attempt to bring closure to that issue, an entire meeting was devoted to the subject with experts from the SWRCB explaining that adjudication was among few mechanisms for resolving water rights disputes. To further shape stakeholder discussion, the facilitator conducted a survey to determine the breadth of issues of concern to stakeholders. Out of this survey, three subcommittees were formed to address landowner issues, remediation and prevention of illegal dumping, and weed control. These were highly productive discussions. Unfortunately, the term of the grant expired before additional meetings could be held and the notes were not compiled into a plan.

The LPCCC continued stakeholder discussions with individual landowners arising out of common interest in solid waste removal, weed control, bank stabilization, and establishment of native vegetation. The LPCCC surveyed landowners informally to determine interests in solid waste removal and weed control, especially control of arundo, for which funds were available. As a result, the LPCCC published a newsletter, "The Flow," to cover news on Putah Creek and opportunities for restoration. The LPCCC toured eroding streambanks on Pleasants Creek with drinking water treatment plant managers to illustrate the cause of source water turbidity.

During this time, the PCC began conducting seminars on a wide range of topics to further inform stakeholders about Putah Creek resources and hosted events for volunteers to engage in cleanup and restoration projects.

The Solano Resource Conservation District contacted landowners individually and held special field days to promote arundo control and bank stabilization in the Pleasants Creek tributary. Most landowners along Pleasants Creek are now working cooperatively to address these issues.

8.2.2 FINDINGS

STAKEHOLDER MEETINGS

1. Public landowners and private riparian landowners engage most productively on common interests such as in the subcommittees (landowner issues, remediation, prevention of illegal dumping, and weed control) that formed under the initial Proposition 204 project.

2. Private landowners reserve the right to determine what is done on their land, but also enjoy meeting other landowners and learning about similarities and differences of issues on different reaches of the creek.

3. It takes time to build trust and familiarity among stakeholders. Early meetings were attended by many people who did not know each other and who began to build trust and familiarity over the course of several meetings.

4. While landowners are generally wary of non-landowners participating in a plan affecting private land management, the public participates in planning for public lands.

5. Only a landowner can agree to take action on their land; no one else can make that decision or take an action for them.

6. The value of working with landowners as a group is to ensure that information is disseminated broadly and evenly first-hand.

7. Landowner views and issues are diverse.

8. Local communities provide input to local government offices that are responsible for managing public lands.

9. The goal of the WMAP should be to present issues (questions) requiring further discussion and to describe opportunities for progress on stakeholder defined issues.

Stakeholder Interests and Concerns

Respect for Private Property

Landowners are concerned with issues of liability, trespass, and privacy. Watershed enhancement projects along Putah Creek must respect these landowner concerns and incorporate measures to minimize problems.

Liability

Landowners are concerned about liability for injury. The terrain is often rugged and there are rattlesnakes, wasps, poison oak, gopher holes, and other hazards. Liability waivers are essential for volunteer projects. The SCWA covers volunteers with workers compensation and holds landowners harmless for LPCCC-sponsored projects for the duration of the project.

Trespass

Landowners are concerned about trespass due to problems with theft, illegal dumping, and property damage. Signage helps to reduce trespass by clearly marking boundaries that are not otherwise apparent.

Privacy

Some landowners have residences on their properties and find uninvited persons to be an invasion upon their privacy.

Illegal Dumping

Illegal dumping includes legacy dump sites and ongoing dumping from rural roads. Laws prohibiting illegal dumping are difficult to enforce in rural areas due the low probability of witnesses. Removal of legacy dumpsites and prevention of illegal dumping can improve water quality and reduce blight. This improves the appearance and value of private property while enhancing the appearance of public viewscapes. Trash reduction also may discourage future dumping, since the existence of trash piles attracts more illegal dumping.

Legacy Dumps

Many legacy dump sites on Putah Creek have yet to be cleaned up. Much progress has been made under the IWMB Farm and Ranch Cleanup Program that provides funding for removal of solid wastes on agricultural lands.

Ongoing Dumping

Cleanup events sponsored by the PCC, Winters Putah Creek Committee, IWMB Farm and Ranch Cleanup Program, and others have cleaned up over a thousand tons of trash. However, some sites continue to experience illegal dumping, especially near Stevensons Bridge and other locations where a public road (especially Putah Creek Road) runs along the top of the bank providing ready access to vehicles.

Deterrence

Signage to deter dumping has proven to be ineffective. Fences and gates are also ineffective barriers except for heavy vehicle barrier gates.

Enforcement

Resources for enforcement of laws prohibiting dumping have been limited because it is difficult to prove who was responsible even if there are articles such as discarded mail that provide names and addresses.

Vegetative Barriers

Illegal dumping is most common in areas where there are gaps in the riparian vegetation suggesting that infilling of vegetation along the top of the bank could provide an effective barrier to dumping. Vegetation provides a three-dimensional, self-repairing barrier that is superior to fences. The IWMB and the LPCCC have funded infilling of vegetation along roads to deter dumping. Vehicle barriers have been effective in preventing dumping from farm roads. Vegetative barriers offer the best hope of preventing dumping in areas where public roads are adjacent to the top of the bank.

Bank Erosion and Bank Failure

Bank erosion and bank failure are threatening farms, residences, bridges, structures, and riparian woodland in a number of locations along lower Putah Creek and its tributaries.

Pleasants Creek

Bank erosion and bank failure along Pleasants Creek below the Miller Creek confluence has damaged to property and structures along Pleasants Creek, including roads, bridges, and residential property. The bank erosion and failure has accelerated since the construction of Monticello Dam because reduced flows on mainstem Putah Creek have led to steeper water surface gradients on the tributary creeks during high-flow events, therefore resulting in higher velocity flows and more erosion. Rock vanes at Hoskins Ranch deflect flows away from the banks and reduce downstream velocities. Similar rock structures throughout Pleasants Creek could provide a long-term solution to eroding banks. Pleasants Creek is the primary source of sediments in Lake Solano and the main source of turbidity for the Solano Project. Source water protection grants may be available to help stabilize the banks of Pleasants Creek.

Dry Creek

Bank erosion on Dry Creek below Highway 128 has also accelerated since Monticello Dam was built, threatening banks of farms and residences along Dry Creek. Two Urban Streams Restoration Program grants from the DWR have stabilized the banks of Dry Creek behind Russell Blvd in Winters, and a third proposal is under review.

Mainstem Putah Creek

Bank erosion on mainstem Putah Creek is less pronounced than on the tributaries, in part because the channel of mainstem Putah Creek was formed by much higher flows prior to Monticello Dam, leading to excess channel capacity and reduced erosion pressure on the banks. However there are isolated locations of severe erosion, including just downstream of the Dry Creek confluence and just below Road 92F in Yolo County. The LPCCC submitted a proposal to the DWR's Urban Streams Restoration Program to rebuild the banks of Putah Creek and restore the channel to a remnant course that did not threaten to erode the banks and adjacent Putah Creek Road. Funding from the Wildlife Conservation Board to control weeds can also take pressure off of the banks by opening up flows in the center of the channel.

Impediment of Flood Flows

Excess Vegetation

Since the late 1970s when the U.S. Army Corps of Engineers (USACE) ceased to manage vegetation in the Putah Creek channel, vegetation has grown unchecked, increasing water surface elevations for a given volume of flow (i.e., reducing channel capacity) and raising concern among many landowners that more needs to be done to control excess vegetation in the creek channel, primarily invasive weeds.

Invasive Weeds

Invasive weeds in the riparian corridor increase fire risk, degrade wildlife habitat value, and increase flood risk. Most native riparian vegetation lays flat in high flows or consists of single stem trees that go dormant in the winter, dropping leaves, and offering little resistance to flood flows. Certain invasive weeds, however, especially Himalayan blackberry, arundo, and tamarisk do not lay flat or drop their leaves in most winters and therefore impede flows to a much greater degree than native vegetation. They also slow flow velocities to such a great extent that sediment drops out and builds mounds around arundo clumps and blackberries, further reducing channel capacity and deflecting flows toward streambanks, resulting in increased lateral erosion. A grant from the Wildlife Conservation Board for weed control in the channel offers opportunities to increase wildlife habitat value, increase channel capacity, and reduce fire and flood risk.

Watershed Management Action Planning and Funding

Ongoing stewardship planning and grant awards will provide a way for landowners to learn about funding opportunities and participate in future projects. Current grants awarded to the LPCCC for enhancement of resources along lower Putah Creek include:

< State Wildlife Conservation Board grant for invasive weed control, and fish and wildlife habitat enhancement;

< DWR Urban Streams Restoration Program grant under consideration to rebuild the banks of Putah Creek and restore the channel to reduce streambank erosion and damage to residential property and Putah Creek Road;

< SWRCB stewardship grant to conduct stakeholder meetings to ascertain watershed resource issues and concerns.

< Proposition 13 grant through the RWQCB, SWRCB, and CALFED Bay-Delta Program to provide an update to the lower Putah Creek WMAP, including presentations to stakeholders on findings determined in this WMAP version, and exploration of opportunities for improving watershed resources, based on resource needs and landowner interests, while addressing landowner concerns.

< Integrated Waste Management Board Farm and Ranch Cleanup Grants and Directed Actions provide funding for cleanup of solid wastes dumped by persons other than the landowner or landowner's family. At the request of the landowner, the Streamkeeper documents the dump site with maps and photographs and solicits bids for the cleanup

work. The county resource conservation districts incorporate this information into grant applications and oversee resulting cleanup projects.

9

Key Findings and Watershed Management Questions

9 KEY FINDINGS AND WATERSHED MANAGEMENT QUESTIONS

Chapters 1 through 8 of the Putah Creek WMAP evaluate the historic and present resources of the watershed. This chapter highlights the key findings in those chapters to present an array of possibilities for actions and decisions on Putah Creek in the future. Each section below is arranged to highlight the main resource areas followed by a summary of the primary challenges inherent to the resource. The result is a series of key questions that could be addressed in the course of WMAP updates. Resource-specific questions conclude each resource section. Key questions that highlight the interrelated and complex relationship between resource areas conclude the chapter.

9.1 CULTURAL RESOURCES

Though small in scale relative to the major watersheds of California, Putah Creek has an exceptionally rich cultural history. From the earliest Native Americans who inhabited the watershed for thousands of years to those farming and residing there today, the creek and its tributaries have influenced quality of life for centuries. Traces of historic activities can be found throughout the watershed and range from village sites to homesteads, farms, and bridges.

VALUES AND BENEFITS

As a perennial watercourse, Putah Creek attracted Native and European/American peoples who may have left materials and features on the landscape.

< *Recorded sites*. Numerous archaeological and historical research projects have been conducted within the vicinity of Putah Creek and have recorded Native American and Euro-American sites, features, and artifacts in areas that could be affected by activities associated with habitat restoration activities. Some of these resources have been found to be eligible or potentially eligible for listing on the California Register of Historical Resources (CRHR) and the National Register of Historical Places (NRHP). Sites known to exist along Putah Creek include those listed below.

- ethnographic Native American site of Ku'ndihi,
- prehistoric artifact scatters,
- Native American occupation sites,
- Chambers Farmstead (c. 1860–1945),
- the Yolo-Solano Bridge (1907), and
- Stevensons Bridge (1923).

PROBLEMS AND LIMITATIONS

In addition to protecting recorded sites, as required by law, there may be undiscovered cultural remains in the watershed that could be impacted by future restoration activities.

< *Incomplete knowledge*. It is unknown where other similar prehistoric and historic-era sites, features, and artifacts are located in the area.

< *Effects on projects*. Cultural resource survey data are important to ensure the protection of cultural resources along Putah Creek.

KEY NEEDS AND QUESTIONS

< What are the key goals and objectives for cultural resources along Putah Creek?

< To what extent should additional efforts be made to identify and protect significant cultural resources?

9.2 LAND OWNERSHIP, LAND USE, AND RESOURCE MANAGEMENT PROGRAMS

Land use patterns in the Central Valley over the past 200 years began with the establishment of homesteads, and farming and grazing enterprises that converted native habitats to developed rural uses. More recent urban development has constrained historic rural uses and resulted in additional losses of native habitats, including riparian habitat along creeks and rivers. Moreover, water storage in Lake Berryessa has reduced the scale of riparian vegetation that is supportable compared to historic conditions when flooding was frequent. This regional trend is reflected in changes in land uses along lower Putah Creek, Pleasants Creek, and Dry Creek.

VALUES AND BENEFITS

The following list characterizes current land ownership, land use, and resource management conditions along Putah Creek:

< *Riparian habitat*. Less than 2,000 acres of riparian corridor presently exists along lower Putah Creek and Pleasants Creek, representing less than 0.2% of the total acreage (1,182,336 acres) of Solano and Yolo counties.

< *Adjacent agricultural and native vegetation lands*. The vast majority, about 70%, of lands adjacent to (i.e., bordering) the riparian corridors of lower Putah, Pleasants, and Dry creeks are agricultural lands, nearly all of which are designated as Prime Farmland, Farmland of Statewide Importance, or Farmland of Local Importance. Reaches 1–5 have the highest proportion of adjacent farmland (80–96%) and lowest percentage of adjacent native vegetation (0.4–9%). Reach 6 (the interdam reach) and Reach 7 (Pleasants Creek) have the highest percentages of adjacent native vegetation (71–74%) and the least farmland (23–26%).

< *Urban development*. Urban development accounts for approximately 4% of the land adjacent to the riparian corridors and consists primarily of low-density residential development, commercial, and light industrial uses. The majority of developed land occurs on the north

side of Putah Creek, in Yolo County. The majority of urban development adjacent to the riparian corridor occurs in Winters (in Reach 5 and along Dry Creek).

< *Private and public ownership*. GIS analysis shows that most (78%) of the land within and adjacent to the lower Putah Creek and Pleasants Creek riparian corridors is privately owned (see Table 3-1, Exhibit 3-1). Public lands account for about 21.2% of the corridor and adjacent parcels. Ownership of the remaining 0.8% of land is unknown at this time.

< *Public interest*. The degree of public interest in the various resources present in the lower Putah Creek watershed highlights the need for comprehensive management programs. Interests that may seem divergent can be addressed in plans and programs that recognize and allow for varied uses and objectives within the watershed.

< *Public access*. Public access is available on publicly-owned lands in and near lower Putah Creek and Pleasants Creek. These include (from west to east):

- Bureau of Land Management property,
- Stebbins Cold Canyon Reserve,
- Putah Creek Wildlife Area,
- DFG fishing access sites,
- Lake Solano County Park,
- Winters Putah Creek Park,
- Stevensons Bridge,
- UC Davis Putah Creek Riparian Reserve,
- Davis South Fork Preserve, and
- Yolo Bypass Wildlife Area/Putah Creek Sinks.

PROBLEMS AND LIMITATIONS

< *Complex land use patterns*. The lower Putah Creek watershed has developed complex land use patterns that would benefit from a comprehensive management plan, such as this WMAP, to:

- recognize and incorporate public and private interests in watershed resources;

- present a balanced approach to conserving and enhancing natural resources and functions within the watershed; and

- optimize compatibility of adjacent land uses.

< *Need to protect and restore remaining riparian habitat*. Native riparian communities in the Central Valley provide among the most important habitat for wildlife, including many species that have become rare as natural habitat areas were converted to other uses. As natural habitat continues to dwindle in size regionally, riparian communities require ever more protection and enhancement efforts.

< *Balancing agriculture, urban, and habitat management requirements*. Agricultural and urban uses would benefit from management of resources to reduce risks related to flooding, wildfires, erosion, invasive weeds, and other issues. A functioning watershed management plan integrates resource management requirements of developed uses, including agricultural and urban uses, and continued efforts to protect and enhance important natural habitat.

KEY NEEDS AND QUESTIONS

< What are the key goals and objectives for land use and resource management along Putah Creek?

< There is a need for greater planning and discussion among interested stakeholders to address and accomplish long-term and collaborative maintenance requirements.

< What proportion of the riparian corridor should be restored to native riparian communities, overall and/or by reach?

< What management actions would be beneficial to both the riparian corridor resources and land uses on lands adjacent to the riparian corridor? If/when/where would it be most (or least) beneficial to enhance or restore resources on adjacent lands?

< Agricultural land uses are often incompatible with public access, for example during re-entry intervals after applications of pesticides, or because of problems with pilferage of crops. How can the security of agricultural lands and private property in general be protected or enhanced?

< What method of notifying creekside landowners would be good to use if/when there are pending land use proposals that could affect them?

< How will Williamson Act contracts and non-renewed contracts affect land use planning and conservation in the lower Putah Creek watershed?

9.3 GEOMORPHOLOGY, HYDROLOGY, AND WATER QUALITY

The geomorphology, hydrology, and water quality of Putah Creek reflects the sum of the physical, chemical, and biological properties of the stream and its tributaries and can have direct and dramatic effects on the vitality of aquatic organisms, water-dependent aquatic habitat, human health, recreation, agriculture, and other beneficial uses of the water. The relationships are typically complex, can vary spatially and temporally, and there is a level of uncertainty regarding how different characteristics interrelate.

VALUES AND BENEFITS

While the lower Putah Creek watershed currently enjoys good water quality in general, protecting the beneficial uses of the creek is dependent on ongoing active management of stream flows, regulatory compliance among permitted dischargers, and developing/

maintaining a riparian buffer to protect the creek from nonpoint runoff from adjacent land uses. Lower Putah Creek water is characterized by the following:

< *Flood protection.* The hydrology and geomorphology of the lower Putah Creek watershed has been manipulated and altered to provide flood protection for residents, communities, and agricultural lands in the watershed.

< *Water project development and management.* Development and operation of the Solano Project (Monticello Dam and Lake Berryessa, PDD, Putah South Canal, and the necessary waterways, laterals, and drainage works) meets the water demands of agriculture and municipalities as well as recreation.

< *Geomorphic and hydrologic interrelated processes.* Geomorphic and hydrologic processes influence the form and function of Putah Creek and play a large role in shaping the characteristics, functions, and values of other resources in and adjacent to the riparian corridor including water quality, fisheries, vegetation and wildlife, land uses, and cultural resources.

< *Good water quality*. Putah Creek water quality is generally classified as good and the waterway supports a wide variety of existing and potential designated beneficial uses, including:

- municipal and domestic water supply,
- agricultural water supply,
- primary contact (i.e., swimming) and secondary contact (e.g., canoeing) recreation,
- warm freshwater habitat,
- warmwater fish habitat, for spawning
- wildlife habitat, and
- cold, freshwater habitat for spawning (although not designated an "existing" beneficial use of Putah Creek, lower Putah Creek is associated with a blue-ribbon trout fishery.)

PROBLEMS AND LIMITATIONS

Geomorphology, hydrology, and water quality have been affected over time by the changes in water management, flood control, and land uses throughout the watershed. Flood protection activities and water project development and management have altered natural processes and changed the ecosystem. Historic mining activity in the upper watershed continues to present a lingering water quality problem for the lower watershed. Without additional effort, protecting the beneficial uses of the creeks in the lower Putah Creek watershed will be constrained by the following:

- *Channel process alterations*. Water management measures and other channel modifications in the early 20th century discussed above caused significant changes in natural channel processes. Completion of Monticello Dam and the PDD caused major changes in the lower reaches of Putah Creek including reduction in backwater effects at tributaries (USACE 1995) and reduction natural sediment transport. These changes have resulted in dramatic alterations in natural processes and have led to problems that include erosion and channel incision, especially to tributaries.

- *Limited data*. Routine water quality monitoring data are limited to samples taken by Reclamation in the Putah South Canal terminal reservoir and by UC Davis, upstream and downstream of the university wastewater treatment plant.

- *Remnant mercury mining contamination*. Lower Putah Creek is on the 303(d) list of impaired water bodies for mercury contamination. Studies confirmed the mercury levels in the creek are consistent with remnant mining-derived mercury, together with some level of ongoing movement through Lake Berryessa, constituting the primary source of contamination in lower Putah Creek.

- *Nonpoint sources of polluants*. Nonpoint source loadings that may contribute potential contaminants include mercury discharge sources from the upper watershed, agricultural activities along the lower reaches below PDD, illegal dumping in various locations, and identifiable stormwater discharge outfalls near municipal centers of Winters and Davis.

- *Not all pollutant sources are identifiable*. Identifying a pollutant does not imply that an effective control can be found and/or implemented.

KEY NEEDS AND QUESTIONS

Past channelization of Putah Creek for flood protection and gravel extraction have left large reaches of over-widened channel that cause excessive warming due to exposure of the water surface and low-flow velocities that create long residence time of water in what are now long pools. Future management actions might address funding sources and methods to help restore the natural form and function of these reaches.

- What are the key goals for the hydrology, geomorphology, and water quality of Putah Creek?

- Geomorphic assessments of the Putah Creek system are needed to better understand the effects of past and present actions and fluvial processes on creek resources and to determine beneficial, feasible, and affordable solutions (e.g., rock vanes, biological revetment) to address priority issues of concern, such as erosion and bank instability, as well as to determine opportunities for feasible resource enhancements such as restoration of fisheries, floodplain, and other habitats.

< Many legacy dumpsites remain on Putah Creek causing blight and degradation of water quality through the presence of solid wastes (gross pollutants) in the creek channel. What resources exist for cleaning up these wastes and deterring future dumping?

< The relative effects on water quality from point sources and nonpoint sources can be better quantified with regular monitoring of conventional pollutants at more points along the creek. What are the opportunities to coordinate with landowners in different parts of the watershed to develop a volunteer water quality monitoring program?

9.4 FISHERIES

Fisheries in the lower Putah Creek watershed are comprised of different assemblages and have changed from the period prior to Euro-American settlement to the present. The different fish assemblages are based primarily on the distinctly different aquatic habitats found in mountains, foothills, and valley floors within the watershed. The history of fisheries in Putah Creek from the period prior to Euro-American settlement to the present can be divided into four sections that are based on periods of different human modifications to the creek. Conditions from four periods are described as: (1) prehistoric (prior to mid-1800s: historical distribution of native fishes), (2) Euro-American settlement (late 1800s through 1950s: nonnative fish introductions and alterations to habitat), (3) Solano Project (1960s to Putah Creek Accord (2000): large-scale alterations in natural processes and habitat), and (4) Putah Creek Accord (provisions to manage instream flows to assist in enhancing native fish populations).

VALUES AND BENEFITS

Primary fisheries resource values and benefits of the lower Putah Creek watershed include the presence of special-status and other native and recreationally important nonnative fish species. Additionally, the native fisheries response to the Accord water release schedules has been positive.

< *Diverse historic native fishery*. Historically, a diverse population of native resident and anadromous fish species utilized aquatic habitat in the lower Putah Creek watershed.

< *Special-status fish species*. A total of seven special-status anadromous and resident freshwater fish species occur or have the potential to occur in lower Putah Creek. Special-status anadromous fish species include Central Valley steelhead Evolutionarily Significant Unit (ESU) (*Oncoryhnchus mykiss*), Central Valley fall-/late fall-run chinook salmon ESU (*Oncoryhnchus tshawytscha*), and Pacific lamprey (*Lampetra tridentada*). Special-status freshwater fish species include Sacramento splittail (*Pogonichthys macrolepidotus*), Sacramento-San Joaquin roach (*Lavinia symmetricus* sp. *symmetricus*), hardhead (*Mylopharodon conocephalus*), and Sacramento perch (*Archoplites interruptus*).

< *Present recreational fishery*. Lower Putah Creek supports a recreationally important fishery that is comprised of cold- and warm-water, native and nonnative fish species. The Putah

Creek interdam reach between Monticello Dam and the PDD at Lake Solano is especially well known for quality trout fishing.

< *Fisheries response to Accord water release schedules*. Based on limited initial data and other observations, it appears that the distribution and abundance of native fish in lower Putah Creek may be benefiting by the Accord flow release schedule. Moreover, small chinook salmon spawning runs have returned to the creek.

PROBLEMS AND LIMITATIONS

Problems and limitations affecting fisheries resources associated with the current state of the watershed include habitat modifications, nonnative fish species, invasive aquatic invertebrates, lack of suitable spawning habitat, high water temperatures, and fish passage impediments.

< *Habitat modifications and nonnative species*. Putah Creek is an example of a creek modified by human activities and characterized by a greater diversity and quantity of introduced species than native species (Moyle et al. 2003). General declines in native fishes in Putah Creek reflect a changing ecosystem.

< *Invasive aquatic invertebrates*. Three invasive aquatic invertebrates that may affect or are affecting lower Putah Creek are the Chinese mitten crab (*Eriocheir sinensis*), Asian clam (*Corbicula fluminea*), and New Zealand mud snail (*Potamopyrgus antipodarum*). Invasive aquatic invertebrates are introduced invertebrates that can drastically alter the ecology of a body of water such as a lake, stream, estuary, or entire watershed, and as a result, alter, reduce, or eliminate both native and introduced aquatic flora and fauna. Invasive invertebrates can have negative effects on an ecosystem by modifying the food chain and competition, creating habitat interference, and introducing new diseases.

< *Lack of suitable spawning habitat*. The lack of suitable spawning habitat is a constraint for most native fish species, including salmon. Recent observations of salmon at the concrete pool below the PDD indicated that most or all spawning locations downstream had likely been utilized by the migrating salmon.

< *High water temperatures limiting habitat*. High water temperatures resulting from loss of SRA habitat, flow modifications and geomorphic alterations, and standing water are important limiting factors to native fish production in lower Putah Creek.

< *Fish passage issues*. Chinook salmon, steelhead, and lamprey are all anadromous species that migrate up lower Putah Creek to spawn, and later return to sea. Two structures, the PDD and Monticello Dam, completely block migration into historic spawning and rearing areas in the interdam reach and as far upstream as Berryessa Valley. Several other natural and human-made migration barriers may also impede fish passage including beaver dams, weirs, culverts, and small dams.

KEY NEEDS AND QUESTIONS

< What are the key goals and objectives for the fisheries of Putah Creek?

< Should efforts be made to attempt to restore the native aquatic ecosystem? What are the implications on recreationally important nonnative species?

< Recent changes to flow releases from the PDD have been favorable to native species. What are additional measures that can be designed to restore and enhance native fish in Putah Creek could help improve the larger ecosystem, benefiting both native and introduced game species? Aquatic habitat restoration and enhancement measures designed to benefit native and valued nonnative fish species may include:

- Continued management of flow releases to queue fish migration and spawning; provide adequate passage conditions; protect spawning, egg incubation, and rearing habitat; and manage (i.e., reduce) water temperatures. Should beaver dams be monitored and seasonally breached to facilitate passage and migration of salmon and other anadromous fish?

- Enhancement of spawning habitat through spawning gravel augmentation. What locations in the watershed are most appropriate for effective gravel augmentation projects?

- Improvement of aquatic habitat through the design and implementation of instream (e.g., boulder and rootwad structure) and riparian SRA habitat restoration and enhancement projects. What locations in the watershed would benefit the most from instream and/or riparian habitat restoration and enhancement? What types of specific habitat restoration and enhancement projects (e.g., directed towards specific species and/or life stages) would be most effective and/or are deemed most important?

9.5 VEGETATION AND WILDLIFE

California's existing riparian forests comprise only 5-10% of their original acreage. Yet, these habitats support a disproportionately large percentage of California's flora and fauna. Thus, measures to protect and enhance these ecosystems will have far-reaching benefits to the vegetation and wildlife of the region while helping to safeguard important natural resources and ecosystem services.

VALUES AND BENEFITS

< *Plant Communities.* The dominant plant community types along the lower Putah Creek corridor are mixed riparian forest (60%), disturbed riparian woodland (15%), and valley oak riparian forest (12%). Other community types are riparian scrub, foothill riparian woodland, riverine wetland, open water, ruderal associations, and agricultural crops. Several reaches have major infestations of nonnative invasive weeds, especially Reach 4 upstream of Stevensons Bridge.

< *Corridor Width*. The width of the riparian corridor (including the open water creek channel) ranges from approximately 110 feet to 840 feet, equating to an average acreage of 16 to 108 acres per river mile. By river mile, Reach 1 contains the smallest amount of riparian acreage (in the Yolo Bypass) while the largest is in Reach 5, particularly in the first mile downstream of the PDD. Pleasants Creek and Reach 1 contain the longest continuous stretches of very narrow corridor.

< *Habitat Quality*. Table 9-1 below summarizes the habitat quality data for all wildlife groups. In general, habitat is of moderate quality for most of the wildlife groups analyzed, lending support to continued and expanded conservation and habitat restoration efforts along Putah Creek. While habitats are clearly in need of enhancement, they are not so highly degraded that conservation and/or restoration efforts would be ecologically or economically infeasible.

Table 9-1
Comparison of Habitat Quality between Functional Groups

Functional Group	High Quality Habitat	Low Quality Habitat
Raptors	East of I-80 (Reaches 1 & 2)	Near I-505 (Reach 4 and 5), At I-80 (Reach 2)
Tree Nesting Birds	Upstream of Stevensons Bridge (Reach 4), Upstream portion of Reach 6	Lake Solano (Reach 6), Downstream of I-505 (Reach 4)
Shrub Nesting Birds	Downstream of Monticello Dam (Reach 6), Downstream of Putah Diversion Dam (Reach 5)	Los Rios Check Dam
Ground Nesting Birds	Upstream portion of Reach 6	Pedrick Road to SR 113 Lake Solano (Reach 6)
Cavity Nesting Birds	None, but many areas of moderate habitat	I-80 to Mace Boulevard (Reach 2), Downstream of Hwy 505 (Reach 4), Lake Solano (Reach 6)
Western Pond Turtles	Downstream of Stevensons Bridge (Reach 3), Downstream of I-80 (Reach 2)	Pleasants Creek (Reach 7)
Corridor Width	Upstream of confluence between Putah Creek and Bypass (Reach 1), Reach 5	Yolo Bypass (Reach 1)
Shaded Riverine Aquatic	Upstream from Lake Solano (Reach 6)	Lake Solano (Reach 6), Pleasants Creek (Reach 7), Yolo Bypass (Reach 1)
Movement Corridor	Middle of Reach 2, Downstream of Putah Diversion Dam (Reach 5)	Lake Solano (Reach 6)
Native Riparian Woodland	Reach 1 (portions); Middle of Reach 4, Reach 6	Upstream of Stevensons Bridge (Reach 4)

< *Sources of colonists*. Restoration would be facilitated by the fact that Putah Creek still supports adequate source wildlife populations that would serve as sources of colonists to restored habitats.

< *Reference sites*. Table 9-1 suggests that certain sites and/or reaches along the creek could be targeted for conservation, management, and/or restoration actions. For example, certain areas of Reaches 5 and 6 have higher-quality habitat than other reaches, especially for shrub- and ground-nesting birds. These areas could be targeted for conservation and habitat enhancement, and used as reference sites to guide restoration actions elsewhere on the creek.

PROBLEMS AND LIMITATIONS

< *Areas of low-quality habitat*. Lake Solano, Pleasants Creek, downstream of I-505, Pedrick Road to Highway 113, and the Yolo Bypass are notable for their low-quality habitat. These areas represent the greatest challenges for maintaining wildlife populations and should be targeted for protection and habitat restoration.

< *Landowner support.* Implementing the recommendations for improving the habitat and wildlife along Putah Creek, such as widening the riparian corridor or manipulating floodplain topography, would be complex, involve dedication of land, and require significant landowner coordination and support.

KEY NEEDS AND QUESTIONS

< What are the key goals and objectives for vegetation and wildlife along Putah Creek?

< What are the key restoration and enhancement measures for plant communities and wildlife habitat. Measures designed to restore and enhance vegetation and wildlife along Putah Creek would help improve the larger ecosystem functions and values? Habitat restoration and enhancement measures designed to benefit plant communities and wildlife may include:

- *Widening the riparian corridor* where it is currently narrow and creating upland woodland buffer strips would create more habitat for upland species like the burrowing owl and Swainson's hawk and insulate the riparian corridor from predators, songbird brood parasites (e.g., brown-headed cowbirds), and physical disturbances, such as wind and pesticide overspray.

- *Increasing habitat heterogeneity and microsite topography* within the floodplain to create more diverse habitats and hydrologic complexity that will support a greater abundance and diversity of organisms. Sensitive biological resources expected to benefit from this measure include song sparrow, western pond turtle, foothill yellow-legged frog, as well as many fish species.

- *Reducing channelization and recontouring streambanks* to increase the floodplain and reduce channel incision. This would raise the water table for riparian plants and promote a wider riparian corridor.

- *Creating instream wetlands* to slow the flow of water, create opportunities for groundwater recharge, and provide habitat for western pond turtle, tricolored blackbird, yellow-breasted chat, and other wetland-associated species.

- *Maintaining instream and bankside woody debris* to provide habitat for juvenile fish and aquatic insects, and basking sites for western pond turtles.

- *Increasing the amount of cobble-sized and smaller instream sediments* to provide habitat for fish and foothill yellow-legged frogs.

- *Increasing vegetative structural complexity and density* of native understory plant species to provide cover and nesting substrates for ground- and shrub-nesting birds, such as song sparrow.

- *Retaining large decadent trees and snags* where safe to do so to provide perching sites for raptors and nesting sites for primary and secondary cavity nesting birds, such as woodpeckers and western bluebirds.

- *Improving connectivity* along the riparian corridor to facilitate wildlife movement, especially near bridges, freeways, and residential development.

- *Reducing the ability of predators, brood parasites, and humans to disturb the riparian corridor* and minimize attractants for predators, such as trash piles and picnic areas.

- *Developing habitat enhancement and restoration actions to benefit sensitive wildlife species* that occur in the Putah Creek corridor.

- *Conducting long-term biological studies* such as bird surveys currently being conducted by the UC Davis Museum of Wildlife and Fish Biology. Also under the auspices of the Museum, surveys for selected terrestrial invertebrates and comprehensive vegetation surveys of the entire lower watershed have commenced in July 2005. Longer-term surveys and monitoring will help verify whether the habitat quality assessment characterizations are borne out in terms of species distribution and abundance.

- *Developing standardized methods for vegetation mapping* of the entire riparian corridor that mesh well with existing assessments would enhance understanding of wildlife habitat. A LiDAR (airborne laser imaging technology) study will provide a surface model of vegetation, as well as ground points by January 2006.

- *Identifying lesser-known invasive weed threats* to the creek. The widespread and ubiquitous invasive weeds have been readily identified. However, some invasive weeds, such as Italian thistle (*Carduus pycnocephalus*), have been overlooked as threats to the Putah Creek ecosystem, although this species has increased its presence over a number of years. Identifying lesser-known threats along the creek could help define actions that can be taken by landowners before the threat becomes a problem.

- *Determining additional research needs for Valley Elderberry Longhorn Beetle (VELB).* Putah Creek was considered for designation as critical habitat for VELB, but was withdrawn because of lack of information on the population in the area. Emphasis should be placed on obtaining the results from UC Davis surveys for this species led by Marcel Holyoak and Teresa Talley, and determining whether additional research or studies are needed to address outstanding issues.

- *Conducting surveys for foothill yellow-legged frog in lower Putah Creek.* Yellow-legged frogs are known to occur in the Cold Canyon tributary, and may stray into areas of suitable habitat in the interdam area of Putah Creek (DFG 2003a, Barry 2000). However, comprehensive surveys to assess the distribution of foothill yellow-legged frogs in the lower Putah Creek watershed have not been conducted. While there may be competition with introduced species, especially bullfrogs (*Rana catesbeiana*), its effects are unknown.

- *Conducting surveys for giant garter snake.* The water in the Putah Creek portion of the Yolo Bypass is slow moving and the riparian vegetation is not well developed, creating potential for giant garter snakes from the Willow Slough population to be found in the Bypass area of lower Putah Creek. Surveys should be undertaken to address this issue.

- *Identifying future vegetation management strategies.* The U.S. Army Corps of Engineers once controlled vegetation in Putah Creek channel with mechanical clearing and burning of vegetation but that program ended in 1977 and there has been no comprehensive plan for vegetation management since that time. How will vegetation be managed in the future?

9.6 INVASIVE WEEDS

KEY FINDINGS

< *Invasive weeds are widely distributed throughout the riparian corridor of lower Putah Creek.* The 20 inventoried species have established over 1,800 infestations that occupy about 128 acres, or 6% of lower Putah Creek's riparian corridor. These infestations are along all reaches and across all geomorphic surfaces (e.g., Arundo at creek bottom to yellow starthistle on the top of bank and terrace) of the channel. Each reach has about 125 to 450 infestations that occupy 8 to 30 acres.

< *Invasive weed infestations alter ecosystem functions along lower Putah Creek.* Invasive weeds alter riparian ecosystem functions including conveyance of floodwaters, transport and storage of sediment, geomorphic processes that sustain channel and floodplain landforms, nutrient cycling and provision of wildlife habitat, and other functions. As invasive weeds displace native vegetation, some important effects include the following.

- **Altered conveyance of floodwaters and sediment.** Establishment of invasive weeds (e.g., Arundo and tamarisk) on or along the channel bed increases roughness and reduces the channel's ability to convey flood flows. Dense stands of invasive weeds also trap sediments and divert flows against channel banks, decreasing bank stability and sediment transport.

- **Alteration of wildlife habitats.** Many invasive weeds (e.g., Arundo, tree-of-heaven, tamarisk) form dense monocultures that provide less wildlife habitat than the native riparian vegetation they displace. Invasive weeds in the channel also detrimentally affect native fish habitat (e.g., by trapping gravels and other sediment).

- **Altered fire regime.** Native riparian vegetation often hinders the spread of fires. However, invasive weeds, such as eucalyptus, Arundo, and tamarisk, produce volatile oily or dry fuel that increases the frequency, extent, and damage caused by fires.

< *Species differ substantially in the size and number of their infestations*. For the 20 inventoried species, the number of infestations ranged from one to several hundred, and the area infested ranged from fractions of an acre to about 24 acres. However, species can be grouped into three categories.

- **Ubiquitous Weeds.** Five species have established numerous infestations occupying large contiguous areas. They include Eucalyptus (302 infestations occupying 24 acres), Eurasian milfoil (39 infestations occupying 9 acres), Himalayan blackberry (241 infestations occupying 22 acres), perennial pepperweed (143 infestations occupying 18 acres) and yellow starthistle (28 infestations occupying 16 acres). Together, these five species account for half (50%) of the total mapped infestations and 70% of the total area occupied by the infestations.

- **Widespread Weeds.** Three species have established a large number of smaller infestations. They include Arundo (406 infestations occupying 21 acres), tamarisk (393 infestations occupying 10 acres), and tree-of-heaven (123 infestations occupying 5 acres). Together, these species account for 41% of the mapped infestations and 28% of the total area occupied by infestations. Because of their numerous infestations, these species have considerable potential to rapidly expand the area they occupy.

- **Incipient Weeds.** The remaining 12 species are less abundant than both the ubiquitous and widespread species. Together, incipient species currently account for just 9% of infestations and just 2% of the total area occupied by infestations. Several of these species (e.g., fennel) may be in the early stages of a much more extensive invasion of natural vegetation along lower Putah Creek.

< The implementation of any weed management program depends on landowner participation and the availability of funding (and often of volunteer labor).

< Prioritization of weeds and sites for removal efforts is intended to make the best use of limited resources and to maximize environmental benefits. While all invasive species included in the WMAP are considered invasive and important to remove, species were

grouped into three priority levels for control. Prioritization of species in the WMAP considered weed distribution, invasiveness, removal costs, and effects on physical processes, biological communities, and human uses. Level 1 species include those which have incipient or widespread distribution patterns and are either highly invasive in general or known to cause substantial impacts. They include species such as arundo, tamarisk, eucalyptus, fennel, English ivy, and fig. Level 2 species are already ubiquitous (regardless of invasiveness and effects) or are less invasive and cause lesser impacts. Level 2 includes species such as Himalayan blackberry and perennial pepperweed, both ubiquitous and very invasive, as well as tree tobacco and Virginia creeper, which are incipient, but less invasive. Level 3 species are considered to be least invasive and cause relatively low levels of effects. These include species such as almond and catalpa. Regardless of priority level, other factors may warrant control of one or more infestation(s) of weeds even before all Level 1 species are controlled. Examples include infestations that are part of a comprehensive site restoration effort, important infestation damages to address at a particular location, etc.

- *Invasive weeds may still be controlled along lower Putah Creek, and removal efforts could even eradicate some species from the riparian corridor.* Removing the roughly 128 acres of invasive weeds from the riparian corridor, though requiring a large-scale effort, is feasible. Furthermore, the 12 incipient weeds occupy less than 3 acres combined, making it feasible to eradicate these species from lower Putah Creek's riparian corridor.

PROBLEMS AND LIMITATIONS

- *The cost and problems associated with invasive weeds are likely to be considerable if they are not controlled.* While invasive weed infestations may still be controlled along lower Putah Creek, in the absence of removal efforts, the area infested by invasive weeds may increase considerably and the costs of control efforts will increase accordingly.

- *Landowner cooperation.* Many invasive weeds send propagules downstream leading to infestation throughout the creek. Gaining cooperation from landowners and coordinating removal efforts is a key challenge to success.

KEY NEEDS AND QUESTIONS

- *What are the key goals and objectives for invasive weed abatement along lower Putah Creek?*

- *What species and locations of infestations can/should be prioritized?* While invasive weed species have been preliminarily grouped into three priority levels, removal costs have not been well documented for many species; therefore, this attribute was not uniformly used to assign species to priority categories. As species removal costs become better known, species priority levels should be reassessed if those costs are substantially higher or lower than for most other species. For instance, eucalyptus was raised to priority Level 1 due to its high cost of removal, which also increases rapidly as eucalyptus grow. Regardless of priority level, factors such as location of sensitive resources and the pattern and distribution of infestations need to be considered when prioritizing individual infestations for control.

- *What locations offer the greatest potential habitat quality benefit through invasive weed removal combined with other efforts to enhance and restore ecosystems along lower Putah Creek?* Invasive weed removal and other riparian restoration projects should be closely coordinated. Restoration may be necessary after some removal projects to ensure recovery of native riparian vegetation. Conversely, restoration projects may be hindered by competition from invasive weeds, unless invasive weeds are removed prior to restoration. Recommendations from fish, wildlife, and vegetation habitat analyses along with knowledge of the hydrology and geomorphology of the creek should be combined to prioritize locations to remove weeds and restore habitat, when feasible.

- *What are the most cost-effective removal techniques?* While removal techniques exist for many invasive weeds, new and more effective approaches are continually being discovered. Some uncertainties or concerns may exist with regard to different treatment types, such as some herbicides. Also, different techniques are more or less viable or effective in different conditions and based on available resources. Learning from various treatments used will increase efficiencies in removing the weeds and successfully restoring native species habitat.

- *What monitoring and adaptive management protocols will best serve to continually improve treatment approaches, prioritization of species and infestation locations to control, and combinations of habitat restoration to include?* Monitoring of invasive weed distributions and the results of weed removal and restoration projects are integral to a successful program. An adaptive management approach of monitoring, evaluating, and refining approaches, if needed, would enable continual improvements and gains in efficiency in achieving invasive weed abatement and habitat restoration goals and objectives.

- *What can be done to control eucalyptus and how can the trees be disposed of with minimum disturbance or enhancement of the creek channel? Eucalyptus is a significant invasive species on Putah Creek that grows rapidly and is extremely costly to remove, especially as trees reach mature size.*

9.7 STAKEHOLDER PLANNING

A stakeholder is an individual, group, or agency with an interest in Putah Creek. For purposes of the WMAP, stakeholders are divided into three broad groups: landowners, local organizations, and funding agencies. There are over 200 private and public landowners and 264 parcels in the lower Putah Creek watershed, including those portions of Pleasants Creek below Miller Creek and Dry Creek below Highway 128, that are influenced by flows in Putah Creek. Since the early 1990s, many groups have formed to represent Putah Creek landowners over issues including water rights, bank stabilization, and public land management.

VALUES AND BENEFITS

- Landowners are the essential stakeholders for any action pertaining to Putah Creek since no actions may occur on private or public land without the consent of the landowner or land manager.

< Groups have formed that include landowners and non-landowners to advance public interests through creek cleanups and restoration projects with willing landowners.

< Several agencies provide funding for creek enhancement projects because of public interest in issues such as weed abatement, flood protection, fish and wildlife conservation, water quality, and solid waste abatement.

< Stakeholder meetings can be an effective way to ensure information is disseminated broadly and evenly.

< Landowners engage most productively when there is a common, focused interest.

< A series of stakeholder meetings can serve to build trust and familiarity among stakeholders.

PROBLEMS AND LIMITATIONS

< Although some categorize landowners under one umbrella, their views, interests, and concerns are diverse and cannot be presented unilaterally.

< Public participation is welcome and expected when planning for public lands, but the same public participation can at times be viewed warily when plans are developed affecting private land management.

< Key landowner concerns are respect for private property, liability, trespass, and privacy.

< Resource management-related concerns include: illegal dumping, bank erosion and bank failure, impediments to flood flows, and invasive weeds.

KEY NEEDS AND QUESTIONS

< What are the key goals and objectives for stakeholder planning along Putah Creek?

< Many creek improvement projects (e.g., revegetation) take years to accomplish and some carry risk of failure (e.g., in unexpected high flows). How do landowners know that these projects will be maintained or that maintenance costs will not be passed on to landowners?

< Publicly funded projects often require site visits by representatives of funding agencies some of whom have regulatory authorities. What assurances can be offered to landowners that such visits will not result in increased regulation (i.e., from unrelated issues that exist on the same properties)?

< Landowners have expressed concern that watershed enhancement will lead to unwelcome increases in public use of the waterway. How can creek enhancement proceed without increasing public use, the risk of trespass, and associated liabilities?

- Enhanced fish and wildlife habitat on Putah Creek may increase populations of listed species like Swainson's hawk, steelhead trout, and VELB. How can habitat enhancement proceed with assurances that future property uses will not be compromised?

- Eroding streambanks cause loss or degradation of private property. What remedies exist and how can they be funded?

9.8 OVERARCHING, INTERRELATED, AND INSTITUTIONAL NEEDS AND QUESTIONS

- What is the overall vision for Putah Creek to help develop goals and objectives that will guide specific actions on the creek?

- Historically, human activity intended to provide benefits to the region caused unintended consequences that are now being addressed. This awareness raises questions about the effectiveness or utility of current and future management actions. It is important that we use existing knowledge to help determine when and where to actively fix a problem versus allowing long-term natural processes to work without or with minimal intervention.

- Invasive weed removal, trash cleanup, and bank stabilization projects often temporarily or permanently change landscapes. How can these projects proceed with reasonable assurances that the creek channel and adjacent land uses will not be adversely affected?

- The public occasionally uses Putah Creek for recreational boating, likely without sufficient awareness or regard for resource protection (e.g., spreading New Zealand mud snail or wading on salmon or trout redds), adequate knowledge of potential hazards, and basic precautions such as life jackets. How can recreational uses of Putah Creek be managed to protect natural resources and to protect landowners from liability, invasion of privacy, and trespass?

- Illegal dumping and theft (e.g., walnut burls) is often associated with vehicle access either from public roads or private roads (e.g., farm roads). How can vehicle access to the creek channel be controlled?

- Will actions proposed by the WMAP help address or mitigate the effects of local land use changes, such as urbanization, that may affect water quality? If so, how?

- Enhancing spawning habitat for steelhead trout could lead to a self-sustaining population. Since steelhead trout are protected species, how would this affect fishing in the creek?

- Plantings are needed to provide shade over the water, hold streambanks against erosion, and enhance wildlife habitat. How can restoration plantings proceed without reducing flood flows, increasing fire risk, or contributing to debris jams?

- Some weeds currently provide some stability to streambanks even while causing increased erosive pressure on the opposite bank. How can weed removal proceed without increasing the risk of erosion on banks where they are currently growing?

10

Resource Management Actions and Opportunities

10 RESOURCE MANAGEMENT ACTIONS AND OPPORTUNITIES

This chapter provides an overview of past, present, and proposed future projects and implementation requirements to track project actions over time.

10.1 SUMMARY OF PAST, PRESENT, AND PROPOSED FUTURE PROJECTS

Early actions along Putah Creek were based on both resource needs and opportunities. In the 1990s, funding became available for a variety of resource enhancement projects that have benefited the creek. For example, the Dry Creek Homeowner's Association defined a need for bank stabilization and then acquired funding. By 2002, landowners had identified a need to remediate and prevent illegal dumping and control invasive weeds. With landowner support, multi-year grant funds were acquired from funding partners as indicated in Chapter 8. The funds have thus far enabled development of this WMAP, streamlined regulatory and permitting for watershed enhancement actions, and implemented a variety of resource enhancement projects. These projects have continued to engage the community around Putah Creek. Table 10-1 identifies the range of projects and locations that have been or are being implemented along Putah Creek. Future projects will be developed to reflect and address the key findings, issues, and questions identified in Chapter 9, filtered through ongoing stakeholder involvement and contingent upon continued funding and individual landowners' willingness to take actions.

10.2 PROJECT IMPLEMENTATION REQUIREMENTS

All projects must be implemented in accordance with regulatory requirements. A streamlined regulatory and permitting program has been developed for the lower Putah Creek watershed by the LPCCC. The program enables landowners who wish to participate in grant-funded resource enhancement projects on their property to initiate projects with little or no additional regulatory delays, thus saving time and enabling more funds to be spent on implemention. A detailed overview of future project permitting and regulatory requirements can be found in Appendix H, "Permitting and Regulatory Compliance," and Appendix I, "Restoration and Enhancement Project Requirement Summaries."

Table 10-1
Summary Table of Past, Present, and Proposed Future Projects along Putah Creek

Location	Action Item/Issue	Time Value	Needs/Resources	Funding	Lead/Partners	Timeframe[1]	Results
All	Arundo Removal	High	Permits; Landowner Authorization	CBDA	LPCCC	2002 to 05/2007	60 gross acres cleared to date
All	Solid Waste Removal and Prevention	Med	Permits; Landowner Authorization	IWMB	LPCCC RCDs PCC WPCC	Ongoing	1,500 tons of waste removed to date (1995 to 2005); volunteer cleanups 2–3 times per year
All	Eucalyptus Removal	High	Permits; Landowner Authorization	CBDA WCB City of Winters	LPCCC	2005 to 08/2007	South bank of Winters Putah Creek Park and Yolo Housing cleared to date
All	Tamarisk Removal	Med	Permits; Landowner Authorization	WCB	LPCCC, landowners	2003 to 2007	Control campaign on UCD lands; individual clumps removed by landowners
All	Bank Stabilization	High	Permits; Landowner Authorization; Geomorphic; Assessment	DWR WCB CBDA USFWS	LPCCC Solano RCD	2002 to 08/2007	Hoskins Ranch on Pleasants Creek; Dry Creek – Putah Creek Confluence; Dry Creek
Hasbrook-Kilkenny, YHA, 505	Spawning Habitat Enhancement	Med	Permits; Landowner Authorization; Geomorphic Assessment	CBDA WCB USFWS	LPCCC	2003 to 08/2007; new projects are proposed	200 cubic yards added at Yolo Housing
All	Blackberry Removal	Med	Permits; Landowner Authorization	WCB	LPCCC	2005 to 08/2007	16 acres removed at Wimmer 2 acres removed at YHA 2 acres controlled at Pickerel

Table 10-1
Summary Table of Past, Present, and Proposed Future Projects along Putah Creek

Location	Action Item/Issue	Time Value	Needs/Resources	Funding	Lead/Partners	Timeframe[1]	Results
All	Native Plant Restoration	Med	Landowner Authorization	WCB CBDA	LPCCC RCDs Audubon UCD Cities of Winters, Davis	Ongoing	4 acres at Winters Putah Creek Park Stevenson's Bridge, Hoskins Ranch, Morales, Mertz, McNamara, UCD, Wimmer City of Davis
Dry Creek – Putah Creek Confluence	Channel Realignment	High	Permits; Landowner Authorization	DWR WCB Solano Transportation	LPCCC, Solano Transportation	2005–2007	Design channel completed, flow diverted
Winters Putah Creek Park	Remove Percolation Dam; Construct Lower Trail	Med	Permits	California Resources Agency	LPCCC	2007–2008	
All	Floodplain Restoration	Med	Permits	Unknown	LPCCC	Undetermined	

[1] End dates are based on project grant funding periods and dates may be subject to change.

List of Acronyms:

CBDA = California Bay-Delta Authority
DWR = California Department of Water Resources
IWMB = State Integrated Waste Management Board
LPCCC = Lower Putah Creek Coordinating Committee
PCC = Putah Creek Council
RCD = Resource Conservation District
UCD = University of California, Davis
USFWS = U.S. Fish and Wildlife Service
WCB = State Wildlife Conservation Board
WPCC = Winters Putah Creek Committee

11

Recommendations for Future Plan Development

11 RECOMMENDATIONS FOR FUTURE PLAN DEVELOPMENT

Key elements for future plan development are:

- obtain stakeholder review of Phase 1 WMAP findings and involvement in establishing watershed enhancement goals, objectives, and recommended project actions;
- develop and implement a mechanism for tracking past, present, and future watershed enhancement actions; and
- identify planning, funding, and labor resources that will help facilitate future watershed enhancement actions under consideration.

11.1 STAKEHOLDER INVOLVEMENT AND DEVELOPMENT OF WATERSHED GOALS, OBJECTIVES, AND PROJECT ACTIONS

The success of a watershed plan is dependent on the interests and level of involvement of the stakeholders. Therefore, the next step for the WMAP is to present the data from Phase 1 to the stakeholders to further document their interests and concerns, as well as to define current opportunities and constraints regarding watershed enhancement actions. This will enable LPCCC to blend stakeholder knowledge and needs with the technical information compiled in Phase 1 to create a set of stakeholder-based goals and objectives for the watershed and a list of project ideas that can be implemented over the next 5 years. To assist in watershed planning meetings with stakeholders, an abbreviated version of the WMAP may be prepared to facilitate awareness and discussion of key issues, interests, and concerns. A graphical overview ("mental map") of Putah Creek's history, issues, and solutions may also be helpful in this regard.

Stakeholder meetings should be focused on key topics. Topics may include a review of past efforts and input by previous stakeholder meetings, specific resource areas, and existing watershed enhancement projects and programs underway. The meetings can then focus on developing goals and objectives for watershed enhancement and determining project ideas within each topic. Specific meetings should review invasive weeds and other issues and plan for future collaborative projects with willing landowners. The decision to participate in a project, or not, always remains the choice of each individual landowner, so implementing projects on private lands requires individual landowner approval. However, any goals, objectives, decisions, or actions resulting from meetings would be based on the open discussion of technical knowledge, stakeholder interests, and the funding challenges for these types of projects. As more landowners enroll in particular types of projects (e.g., trash and invasive plant removal), there will be greater benefit to the watershed.

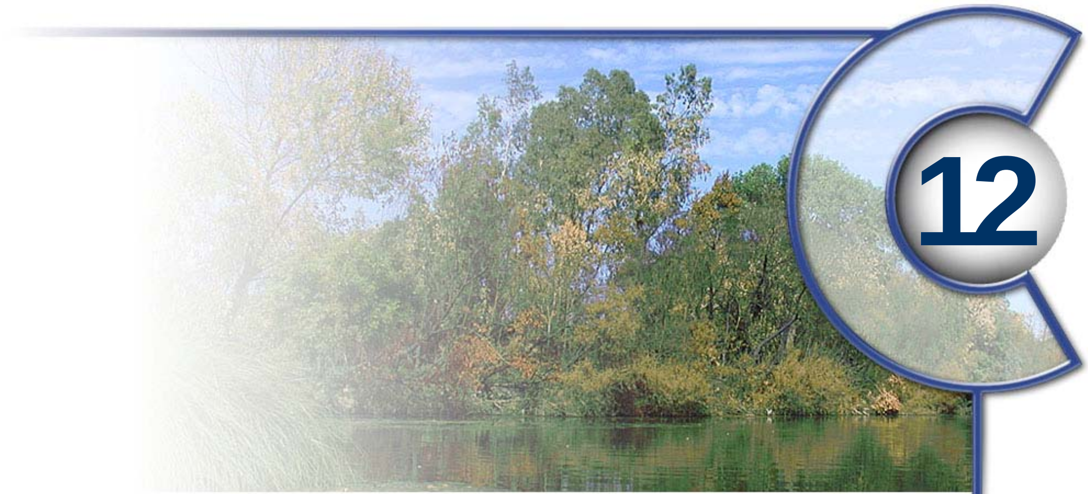
11.2 TRACKING OF PAST, PRESENT, AND PLANNED FUTURE PROJECTS

One of the key functions of the WMAP will be to establish a mechanism for tracking past, present, and planned future projects. Collecting and tracking data over time, and having it easily accessible to stakeholders and agencies, is part of an overall adaptive management strategy for the lower Putah Creek watershed. Chapter 10, "Resource Management Actions and Opportunities," is the first step in this direction. As projects are added and reports collected, the tracked data will facilitate periodic review and refinement of watershed priorities and actions and measure progress against watershed goals and objectives. The LPCCC watershed portal (http://www.watershedportals.org/lpccc) already provides a calendar/journal of events and an open source geographical database is under development. The geographical database could be used to track current and proposed projects.

11.3 WATERSHED ENHANCEMENT RESOURCES

Another need that can be satisfied in Phase II of the WMAP is a collection of resources that will facilitate project implementation and WMAP development over time. Potential resources to include are:

< weed abatement plan for Putah Creek,
< plant palette for Putah Creek restoration and enhancement projects,
< list of plant nurseries that grow and/or stock California native plants,
< list of plants to avoid in landscaping or other projects on or along Putah Creek, and
< funding sources for specific types of actions (e.g., trash abatement).



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Engilis, Andy. Museum Curator, Museum of Wildlife and Fish Biology, Department of Wildlife, Fish, and Conservation Biology, University of California, Davis. Telephone conversation with Linda Leeman of EDAW. September 24, 2004.

Fulks, Andrew. University of California Davis Putah Creek Riparian Reserve. Manager. August 12 and 25, 2003–personal communication with Connie Gallippi at EDAW.

Honer, Karen. City of Winters, Public Works. Director. September 24, 2003–personal communication with Connie Gallippi of EDAW.

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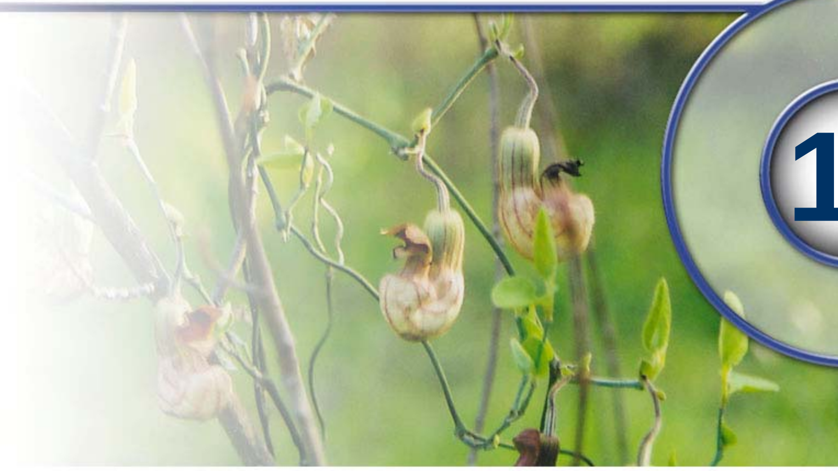

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13 LIST OF PREPARERS

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APPENDIX A

LOCATIONS OF LANDMARKS IN THE LOWER PUTAH CREEK WATERSHED

Appendix A
Locations of Landmarks in the Lower Putah Creek Watershed

Landmark	Feature	Acres	Fish Sampling Site	River Mile	Approx. Miles From PDD	Approx. Km from PDD
Lower Putah Creek						
Monticello Dam	dam forming Lake Berryessa; upper end of study area		--	29.5	-6.6	-11
Highway 128	bridge		--	29.0	-6.1	-10
Stebbins Cold Canyon Reserve/Putah Creek Wildlife Area/BLM	UC Natural Reserve System preserve (576 ac); CDFG Wildlife Area (670 ac); BLM land (365 ac); education, research, public use for nature observation	1,611	--	29.4 to 27.5	-6.5 to -4.6	-10 to -7
Fishing Access Sites	5 sites owned by CDFG, managed by Yolo County Parks Dept.		--	28.5 to 24.7	-5.6 to -1.8	-9 to -3
Pleasants Valley Road	bridge		--	24.4	-1.5	-2
Pleasants Creek	confluence with Putah Creek		--	23.9	-1.0	-2
Lake Solano County Park	public multi-purpose recreation park	60	--	23.9 to 23.6	-1.0 to -0.7	-2 to -1
Lake Solano	reservoir; recreation, irrigation, drinking water			25.4 to 22.9	-2.5 to 0.0	-4 to 0
Putah Diversion Dam (PDD)	dam forming Lake Solano		Site 1	22.9	0.0	0
Dry Creek	confluence with Putah Creek		Site 2	20.5	2.5	4
County Road 89 (Railroad Avenue)	bridges		--	20.0	2.9	5
Winters Putah Creek Park	City of Winters property; public multi-purpose creekside park, fishing access		--	20.0 to 19.0	2.9 to 3.9	5 to 6
Interstate 505 (I-505)	bridge		Site 3	19.1	3.8	6
Yolo Housing Authority	Yolo County property, north side		Site 4	18.2	4.7	8
Hasbrook-Kilkenny	private property		Site 5	17.6	5.4	9
Vickery	private property		Site 6	16.3	6.6	11
Jordan	private property		Site 7	15.3	7.6	12
Russell Ranch	UC Davis property, north side	1,711	Site 8	13.9	9.0	15
Stevensons Bridge	bridge		Site 9	13.0	9.9	16

Appendix A
LOCATIONS OF LANDMARKS IN THE LOWER PUTAH CREEK WATERSHED

Landmark	Feature	Acres	Fish Sampling Site	River Mile	Approx. Miles From PDD	Approx. Km from PDD
Olander	private property		Site 10	12.4	10.6	17
Pedrick Road	bridge		Site 11	10.2	12.7	20
UC Davis Putah Creek Riparian Reserve	UC Davis property; north side; research, education, some public use		--	10.7 to 6.3	12.2 to 16.6	20 to 27
Above Alpha Phi Omega (APO)	1 km upstream of APO picnic area		Site 12	9.8	13.1	21
APO Picnic Area	UC Davis Riparian Reserve fire ring and picnic site		Site 13	9.4	13.5	22
I-80	bridge		--	8.3	14.6	24
S.P. Railroad	railroad bridge		--	7.7	15.2	25
Old Davis Road	bridge		Site 14	7.5	15.5	25
Mace Boulevard	bridge		Site 15	4.2	18.7	30
South Fork Preserve	City of Davis property; north and south side, conservation, public use (north side) for nature observation	110	--	4.0 to 3.5	18.9 to 19.4	30 to 31
Los Rios	City of Davis property and easements; conservation, farming		--	2.8 to 1.4	20.1 to 21.5	32 to 35
Road 106A	earthen seasonal bridge		Site 16	1.2	21.8	35
Yolo Bypass West Levee	north levee bend point adjacent to Putah Creek; river mile (RM) 0.0		--	0.0	22.9	37
Yolo Bypass Wildlife Area/Putah Creek Sinks	California Dept. of Fish and Game Wildlife Area; Yolo Bypass is floodway for Sacramento River	15,830	--	0.6 to -3.2	22.3 to 26.1	36 to 42
Los Rios Check Dam	CDFG managed check dam; lower end of study area		Site 17	-2.0	24.9	40
East Toe Drain of Yolo Bypass	Bypass channel confluence with Toe Drain connecting to Sacramento-San Joaquin Delta		--	-3.2	26.1	42
Pleasants Creek						
Putah Creek confluence	confluence at Lake Solano		--	Pl 0.0	--	--

APPENDIX B

PUTAH CREEK RESOURCE ASSESSMENT
WILDLIFE HABITAT EVALUATION FORM

Instructions to Accompany the Putah Creek Resource Assessment Wildlife Habitat Evaluation Form

Wildlife habitat will be evaluated on Putah Creek by estimating quality based on a checklist of habitat elements (criteria) for groups of species that have similar habitat requirements. Optimal habitat should have all criteria present and classified as good. Moderate quality habitat may have two or three criteria classified as good or fair. Low quality habitat may only have one criterion classified as good or fair. Overall habitat quality determinations will vary depending on the value of the criteria.

A form will be completed at approximately 0.5 mile intervals along lower Putah Creek from the Monticello Dam to the Putah Sinks and for Pleasants Creek. The area encompassed at each sampling point will vary based on access and visibility, but will generally be a zone approximately 300–500 feet long, and at a minimum 100 feet.

<u>Nesting Landbirds</u>

Nesting birds are divided into four categories based on the nest position. The three following criteria can be evaluated once for all groups of landbirds. The fourth criterion, which refers to nest substrate availability, is to be evaluated for each group separately.

Criteria:

- **StrucCom**–Structural complexity (herbaceous, shrub, canopy layers present, resulting in high plant species diversity)
- **RipWidth**–The width of the riparian corridor
- **LowPred**–Lower apparent density of predators/disturbance or attractants for predators, e.g., cats near residential areas; trash piles, picnic areas which may attract rats, raccoons, etc.

<u>Ground/Low Nesters (0–4’):</u>

Includes such species as song sparrow, Lazuli bunting, spotted towhee, and California towhee.

Criteria:

- **NestSub**–Suitable substrate for nesting, i.e., vegetation density relative to the nest position to provide concealment

<u>Shrub Nesters (4–10’)</u>

Includes such species as bushtit and black-headed grosbeak.

Criteria:

- **NestSub**-Suitable substrate for nesting, i.e., vegetation density relative to the nest position to provide concealment.

<u>Tree Nesters (>10’)</u>

Includes such species as western wood-pewee, yellow-billed magpie, and Bullock’s oriole.

Criteria:

- **NestSub**-Suitable substrate for nesting, i.e., vegetation density relative to the nest position to provide concealment.

<u>Cavity Nesters</u>

Includes such species as American kestrel, western bluebird, ash-throated flycatcher, and tree swallow.

Criteria:

- **Snags**-presence of snags in which nesting cavities are present or can be created.

Raptors
Some of the raptors, which nest on Putah Creek, include red-shouldered hawk, red-tailed hawk, Swainson's hawk, and great-horned owl.

Criteria:

- **NestTree**–Tall/mature trees for nests (valley oak, cottonwood, willow, sycamore, walnut preferred by Swainson's hawks).
- **ForageHab**–Open fields or pastures for foraging adjacent to the nesting habitat.
- **LowDistrb**–Low amount of disturbance in the area.

Herpetofauna
The most likely native herpetofauna to occur on Putah Creek is northwestern pond turtle.

Criteria:

- **SlowWat**–Slack or slow moving water.
- **AerialBask**–Aerial basking areas (e.g., logs, rocks, exposed bank).
- **SubVeg**–Dense submergent vegetation (e.g., pondweed, ditch grass) for basking and feeding; and/or short emergent vegetation for hatchlings.
- **UplandNest**–Upland nesting sites (up to 400 meters from aquatic habitat) with high clay or silt fraction substrate on an unshaded slope usually less than 25° and often south-facing.

Shaded Riverine Aquatic
Shaded riverine aquatic (SRA) cover is in the interface of riparian vegetation and riverine habitat. The productive interaction and synergism of terrestrial and aquatic habitat types associated with SRA cover results in a valuable cover for fish and other aquatic organisms, providing a variety of micro-habitats with various flows, depths, cover, and food production. Instream cover such as vegetative debris provides a food source and spawning substrate for a variety of aquatic species.

Criteria:

- **OverVegHi**–Riparian vegetation that overhangs and shades the water in the creek from taller shrubs and trees.
- **OverVegLo**–Riparian vegetation that overhangs and shades the water in the creek from herbaceous or lower-growing plants, e.g., sedges.
- **NatBank**–Banks composed of natural substrates that support riparian vegetation rather than concrete levees or rip-rap.
- **VegDebris**–Presence of vegetative debris such as logs, branches, and leaves.

Wildlife Corridor/Mammal Movement
A wildlife movement corridor is a linear habitat whose primary wildlife function is to connect two or more significant habitat areas. The following criteria are considered to facilitate movement for a variety of mobile species, such as large and mid-sized mammals.

Criteria:

- **Cover**–Vegetative cover.
- **Connectivity**–The reach should connect to other reaches that contain suitable habitat, without major (>50 meters) gaps in vegetation or obstacles to travel along the corridor.
- **LowDistrb**–Low amount of disturbance in the area.

Putah Creek Resource Assessment
Wildlife Habitat Evaluation

Date :______________ **Surveyor Names:________________________________**

Zone Description		
Sample Point Number:		**Aerial Photo #s:**
Zone Length (approx.):	**Location Description** *(Downstream and upstream landmarks, driving instructions)*:	
Channel width (approx. range):		
Riparian corridor width (approx. range):		

Plant Communities	
Plant communities: **(name and % of total area)** *use Sawyer-Keeler-Wolf classification and series, e.g., cottonwood riparian, riparian scrub, valley oak riparian, etc.*	

Vegetation Structure *For each layer, identify dominant species*			
Ground Layer (herbaceous/litter)	**Low (< 5m)**	**Sub-canopy**	**Canopy**
Species	Species	Species	Species

Wildlife Observed *(list all species or sign observed)*				

Habitat Quality for Wildlife Groups

Based on the criteria listed for each group, classify the overall quality of habitat. Optimal habitat should have all criteria present and classified as good. Moderate quality habitat may have two or three criteria classified as good or fair. Low quality habitat may only have one criterion classified as good or fair. Overall habitat quality determinations will vary depending on the value of the criteria. See instruction sheet for more information.

Nesting Landbirds (General)

Criteria:

	Good	Fair	Poor		Good	Fair	Poor
StrucCom	☐	☐	☐	*RipWidth*	☐	☐	☐
LowPred	☐	☐	☐				

Restoration opportunities:____________________________

Notes:____________________________________

Ground/Low Nesting Birds (0–4')

☐ Optimal ☐ Moderate ☐ Low ☐ Absent

Criteria:

	Good	Fair	Poor
NestSub	☐	☐	☐

Restoration opportunities:____________________________

Raptors

☐ Optimal ☐ Moderate ☐ Low ☐ Absent

Criteria:

	Good	Fair	Poor		Good	Fair	Poor
NestTree	☐	☐	☐	*ForageHab*	☐	☐	☐
LowDistrb	☐	☐	☐				

Restoration opportunities:____________________________

Notes:____________________________________

Shrub Nesting Birds (4-10')

☐ Optimal ☐ Moderate ☐ Low ☐ Absent

Criteria:

	Good	Fair	Poor
NestSub	☐	☐	☐

Restoration opportunities:____________________________

Notes:____________________________________

Herpetofauna

☐ Optimal ☐ Moderate ☐ Low ☐ Absent

Criteria:

	Good	Fair	Poor		Good	Fair	Poor
SlowWat	☐	☐	☐	*AerialBask*	☐	☐	☐
SubVeg	☐	☐	☐	*UplandNest*	☐	☐	☐

Restoration opportunities:____________________________

Notes:____________________________________

Tree Nesting Birds (>10')

☐ Optimal ☐ Moderate ☐ Low ☐ Absent

Criteria:

	Good	Fair	Poor
NestSub	☐	☐	☐

Restoration opportunities:____________________________

Notes:____________________________________

Shaded Riverine Aquatic (SRA)

☐ Optimal ☐ Moderate ☐ Low ☐ Absent

Criteria:

	Good	Fair	Poor		Good	Fair	Poor
OverVegHi	☐	☐	☐	*VegDebris*	☐	☐	☐
OverVegLo	☐	☐	☐	*CutBank*	☐	☐	☐
NatBank	☐	☐	☐				

Restoration opportunities:____________________________

Notes:____________________________________

Cavity Nesting Birds

☐ Optimal ☐ Moderate ☐ Low ☐ Absent

Criteria:

	Good	Fair	Poor
Snags	☐	☐	☐

Restoration opportunities:____________________________

Notes:____________________________________

Wildlife Corridor/Mammal Movement

☐ Optimal ☐ Moderate ☐ Low ☐ Absent

Criteria:

	Good	Fair	Poor		Good	Fair	Poor
Cover	☐	☐	☐	*Connectivity*	☐	☐	☐
LowDistrb	☐	☐	☐				

Restoration opportunities:____________________________

Notes:____________________________________

General Notes

APPENDIX **C**

PUTAH CREEK INVASIVE WEED INVENTORY

PUTAH CREEK INVASIVE WEED INVENTORY

Date:					Surveyors:						Location/Reach:							
Map #	Weed ID (e.g., LELA1)	Mapped (Y) / Lat-Long	Size of Poly/Pt (if < 50 ft long/wide)		ARDO form? (Y/N)	Trees			Shrubs		% Weed cover in polygon (within its canopy)	Weed Position*	Describe erosion caused by this infestation, if any	Recruits (this weed) [1]	Recruit Species (use acronym) [1]			Notes
			Length (ft)	Width (ft)		# <6" DBH	# 6–24" DBH	# >24" DBH	#	Avg. Height				(N)one (F)ew (M)any	None	Few	Many	

* Weed Position: LFC =Low flow (main) channel; B=bar; HFC=High flow channel; LB=Lower bank; UB=Upper bank; T=Top of bank terrace

[1] Recruits: Complete this section only for sites with access. Complete within all infestation polygons greater than about 100 square meters (e.g., > 10m x 10m). If infestation observations (points or polygons) are too numerous to record recruitment data for each observation then characterize recruitment throughout the entire site, by specific weed infestation type (use “weed characterization form, by site/reach”).

Weed ID Code	*Scientific Name*	Common Name	Notes
AIAL	*Ailanthus altissima*	Tree of Heaven	
EUC	*Eucalyptus* spp.	Eucalyptus	
ROPS	*Robinia pseudo-acacia*	Black locust	
FICA	*Ficus carica*	Fig	
SCMO	*Schinus molle*	Peruvian peppertree, California peppertree	
ARDO	*Arundo donax*	Giant reed	
TAM*	*Tamarix* spp.	Tamarisk, salt cedar	Also labelled as TARA, but ID not confirmed
LELA	*Lepidium latifolium*	Perennial pepperweed	
CESO	*Centaurea solstitialis*	Yellow starthistle	
PAQU	*Parthenocissus quinquefolia*	Virginia creeper	
HEHE	*Hedera helix*	English ivy	
MYR	*Myriophyllum* sp.	Parrot's feather, watermilfoil	
CAT	*Catalpa* sp.	Catalpa	
RUDI	*Rubus discolor*	Himalayan blackberry	
EICR	*Eichornia crassipes*	Water hyacinth	
SIMA	*Silybum marianum*	milk thistle	
FOVU	*Foeniculum vulgare*	fennel	
NIGL	*Nicotiana glauca*	tree tobacco	

APPENDIX **D**

LOWER PUTAH CREEK PLANT INVENTORY

LOWER PUTAH CREEK PLANT INVENTORY

Scientific Name	Common Name	Family
Acer macrophyllum	Big leaf maple	Aceraceae
Acer negundo	Box elder	Aceraceae
Adenostoma fasciculatum	Chamise	Rosaceae
Achillea millefolium	Yarrow	Asteraceae
Achyrachaena mollis	Blow-wives	Asteraceae
*Aegilops triuncialis**	Barbed goatgrass	Poaceae
Aesculus californica	California buckeye	Hippocastanaceae
*Ailanthus altissima**	Tree-of-Heaven	Simaroubaceae
Alnus rhombifolia	White alder	Betulaceae
*Althea rosea**	Holly hock	Malvaceae
*Amaranthus retroflexus**	Redroot pigweed	Amaranthaceae
Ambrosia psilostachya	Western ragweed	Asteraceae
Ammannia coccinea	Red ammania	Lythraceae
Amsinckia menziesii var. *intermedia*	Common fiddleneck	Boraginaceae
*Anagallis arvensis**	Scarlet pimpernel	Primulaceae
*Anthriscus caucalis**	Bur-chervil	Apiaceae
Apocynum cannabinum	Indian hemp	Apocynaceae
Arctostaphylos manzanita	Common manzanita	Ericaceae
Aristolochia californica	California pipevine	Aristolochiaceae
Artemisia douglasiana	Mugwort	Asteraceae
Artemisia dracunculus	Wild tarragon	Asteraceae
*Arundo donax**	Giant reed	Poaceae
Atriplex patula	Fat-hen	Chenopodiaceae
*Atriplex rosea**	Redscale	Chenopodiaceae
*Avena fatua**	Wild oat	Poaceae
Azolla filiculoides	Mosquito fern	Azollaceae
Baccharis pilularis	Coyote bush	Asteraceae
Baccharis salicifolia	Mulefat	Asteraceae
Bidens frondosa	Stick-tight	Asteraceae
*Brassica nigra**	Black mustard	Brassicaceae
*Bromus catharticus**	Rescuegrass	Poaceae
*Bromus diandrus**	Ripgut brome	Poaceae
*Bromus hordeaceus**	Soft chess	Poaceae
Bromus madritensis ssp. *rubens**	Red brome	Poaceae
Calystegia sp.	Morning-glory	Convolvulaceae
*Cardaria draba**	Hoary cress	Brassicaceae
*Carduus pynocephalus**	Italian thistle	Asteraceae
Carex obnupta	Slough sedge	Cyperaceae
Carex sp.	Sedge	Cyperaceae

* = non-native species

LOWER PUTAH CREEK PLANT INVENTORY

Scientific Name	Common Name	Family
Catalpa sp.*	Catalpa	Bignoniaceae
Ceanothus cuneatus	Buckbrush	Rhamnaceae
*Centaurea solstitalis**	Yellow star-thistle	Asteraceae
Cephalanthus occidentalis	Button bush	Rubiaceae
Cercis occidentalis	Redbud	Fabaceae
*Chamomilla suaveolens**	Pineapple weed	Asteraceae
*Chenopodium album**	White goosefoot	Chenopodiaceae
*Cichorium intybus**	Chicory	Asteraceae
*Cirsium arvense**	Canada thistle	Asteraceae
Clarkia sp.	Clarkia	Onagraceae
Claytonia perfoliata	Miner's lettuce	Portulacaceae
Clematis ligusticifolia	Virgin's bower	Ranunculaceae
*Conium maculatum**	Poison hemlock	Apiaceae
*Convolvulus arvensis**	Field bindweed	Convolvulaceae
*Conyza canadensis**	Canadian horseweed	Asteraceae
Cornus sericea	American dogwood	Cornaceae
*Cortaderia jubata**	Andean pampas grass	Poaceae
Cotula coronopifolia	Brass buttons	Asteraceae
Crassula connata	Pygmy weed	Crassulaceae
*Crypsis schoenoides**	Swampgrass	Poaceae
Cuscuta sp.	Dodder	Cuscutaceae
*Cynodon dactylon**	Bermuda grass	Poaceae
*Cynosurus echinatus**	Dogtail grass	Poaceae
Cyperus eragrostis	Umbrella sedge	Cyperaceae
Cyperus esculentus	Yellow nutsedge	Cyperaceae
Cyperus rotundus	Purple nutsedge	Cyperaceae
*Datura wrightii**	Jimsonweed	Solanaceae
*Daucus carota**	Queen Anne's lace	Apiaceae
Elodea sp. (*or Egeria* sp.)	Waterweed	Hydrocharitaceae
Elymus glaucus	Blue wildrye	Poaceae
Epilobium brachycarpum	Tall annual willow-herb	Onagraceae
Epilobium canum	California fuchsia	Onagraceae
Epilobium ciliatum	Slender willow-herb	Onagraceae
Equisetum arvense	Common horsetail	Equisetaceae
Equisetum sp.	Horsetail	Equisetaceae
Eremocarpus setigerus	Turkey mullein	Euphorbiaceae
Eriodictyon californicum	Yerba Santa	Hydrophyllaceae
*Erodium botrys**	Storkbill filaree	Geraniaceae
*Erodium cicutarium**	Redstem filaree	Geraniaceae

* = non-native species

LOWER PUTAH CREEK PLANT INVENTORY

Scientific Name	Common Name	Family
*Erodium moschatum**	Greenstem filaree	Geraniaceae
Eschscholzia californica	California poppy	Papaveraceae
*Eucalyptus globulus**	Blue gum	Myrtaceae
*Eucalyptus camaldulensis**	Red gum	Myrtaceae
Euphorbia sp.	Spurge	Euphorbiaceae
Euthamnia occidentalis	Western goldenrod	Asteraceae
*Ficus carica**	Edible fig	Moraceae
*Filago gallica**	Narrow-leaved filago	Asteraceae
*Foeniculum vulgare**	Fennel	Apiaceae
Fraxinus latifolia	Oregon ash	Oleaceae
*Galium aparine**	Common bedstraw	Rubiaceae
Glycyrrhiza lepidota	Wild licorice	Fabaceae
Gnaphalium canescens	Everlasting cudweed	Asteraceae
Grindelia sp.	Gum plant	Asteraceae
*Hedera helix**	English ivy	Araliaceae
Helianthus annuus	Common sunflower	Asteraceae
Heliotropium curassavicum	Heliotrope	Boraginaceae
Hemizonia fitchii	Fitch's spikeweed	Asteraceae
Heteromeles arbutifolia	Toyon	Rosaceae
*Hirschfelia incana**	Shortpod mustard	Brassicaceae
Hoita macrostachya	Leather root	Fabaceae
Hordeum murinum ssp. *leporinum**	Foxtail	Poaceae
*Hypochaeris glabra**	Smooth cat's ear	Asteraceae
Juglans californica	California black walnut	Juglandaceae
*Juglans regia**	English walnut	Juglandaceae
Juncus balticus	Baltic rush	Juncaceae
Juncus effuses	Common rush	Juncaceae
*Kickxia elatine**	Sharp-leaved fluellin	Scrophulariaceae
*Lactuca serriola**	Prickly lettuce	Asteraceae
Lathyrus sp.	Sweet pea	Fabaceae
Leersia oryzoides	Rice cutgrass	Poaceae
Lemna sp.	Duckweed	Lemnaceae
*Leontodon taraxacoides**	Lesser hawkbit	Asteraceae
Lepidium latifolium *	Perennial pepperweed	Brassicaceae
*Leucanthemum vulgare**	Ox-eye daisy	Asteraceae
Leymus triticoides	Creeping wildrye	Poaceae
Linaria sp.	Toadflax	Scrophulariaceae
*Liquidambar styraciflua**	Liquidambar, sweet gum	Hamamelidaceae
*Lolium multiflorum**	Italian ryegrass	Poaceae

* = non-native species

LOWER PUTAH CREEK PLANT INVENTORY

Scientific Name	Common Name	Family
*Lotus corniculatus**	Bird's foot trefoil	Fabaceae
Lotus purshianus	Spanish clover	Fabaceae
Lotus sp.	Lotus	Fabaceae
Ludwigia peploides	Floating water-primrose	Onagraceae
Lupinus albifrons	Silver lupine	Fabaceae
Lupinus bicolor	Miniature lupine	Fabaceae
Lupinus microcarpus	Chick lupine	Fabaceae
Lupinus succulentus	Succulent lupine	Fabaceae
Lycopus americanus	Water horehound	Lamiaceae
*Maclura pomifera**	Osage orange	Moraceae
*Malva parviflora**	Cheeseweed	Malvaceae
Malvella leprosa	Alkali mallow	Malvaceae
Marah sp.	Manroot	Cucurbitaceae
*Marrubium vulgare**	Horehound	Lamiaceae
Marsilea vestita	Hairy waterclover	Marsileaceae
*Medicago polymorpha**	California burclover	Fabaceae
*Melia azedarach**	China berry	Meliaceae
*Melilotus alba**	White sweetclover	Fabaceae
*Melilotus indica**	Indian sweetclover	Fabaceae
Mentha arvensis	Field mint	Lamiaceae
Mimulus aurantiacus	Sticky monkeyflower	Scrophulariaceae
Morus sp.*	Mulberry	Moraceae
Myriophyllum sp.	Water milfoil	Haloragaceae
*Nicotiana glauca**	Tree tobacco	Solanaceae
*Olea europaea**	Olive	Oleaceae
Opuntia sp.	Prickly pear	Cactaceae
Panicum capillare	Witchgrass	Poaceae
*Parthenocissus quinquefolia**	Virginia creeper	Vitaceae
*Paspalum dilatatum**	Dalllis grass	Poaceae
*Paspalum distichum**	Knotgrass	Poaceae
*Petrorhagia dubia**	Pinkgrass	Caryophyllaceae
*Phalaris aquatica**	Harding grass	Poaceae
Phalaris arundinacea	Reed canary grass	Poaceae
*Phalaris minor**	Littleseed canary grass	Poaceae
Phoradendron villosum	Oak mistletoe	Viscaceae
Phyla nodiflora	Common lippia	Verbenaceae
Pinus sabiniana	Foothill pine	Pinaceae
*Plantago major**	Common plantain	Plantaginaceae
Platanus racemosa	California sycamore	Platanaceae

* = non-native species

LOWER PUTAH CREEK PLANT INVENTORY

Scientific Name	Common Name	Family
*Poa pratensis**	Kentucky bluegrass	Poaceae
Polygonum arenastrum	Common knotweed	Polygonaceae
Polygonum hydropiperoides	Swamp smartweed	Polygonaceae
Polygonum lapathifolium	Willow weed	Polygonaceae
*Polygonum persicaria**	Lady's thumb	Polygonaceae
Polygonum punctatum	Common water smartweed	Polygonaceae
*Polypogon monspeliensis**	Rabbitfoot grass	Poaceae
Populus fremontii	Fremont cottonwood	Salicaceae
*Potamogeton crispus**	Curly pondweed	Potamogetonaceae
Prunus dulcis (=P. amygdalus)*	Domestic almond	Rosaceae
Prunus sp.	Cherry	Rosaceae
Prunus virginiana var. *demissa*	Western choke cherry	Rosaceae
Psilocarphus brevissimus	Woolly marbles	Asteraceae
Quercus chrysolepis	Canyon live oak	Fagaceae
Quercus douglasii	Blue oak	Fagaceae
Quercus lobata	Valley oak	Fagaceae
Quercus wislizenii	Interior live oak	Fagaceae
*Raphanus sativus**	Wild radish	Brassicaceae
Rhamnus californica	California coffee berry	Rhamnaceae
Rhus trilobata	Skunkbush	Anacardiaceae
*Robinia pseudo-acacia**	Black locust	Fabaceae
Rosa californica	California rose	Rosaceae
*Rubus discolor**	Himalayan blackberry	Rosaceae
Rubus ursinus	California blackberry	Rosaceae
*Rumex crispus**	Curly dock	Polygonaceae
Rumex salicifolius	Willow dock	Polygonaceae
Salix exigua	Sand bar willow	Salicaceae
Salix gooddingii	Goodding's willow	Salicaceae
Salix laevigata	Red willow	Salicaceae
Salix lasiolepis	Arroyo willow	Salicaceae
Sambucus mexicana	Blue elderberry	Caprifoliaceae
Sanicula crassicaulis	Western sanicle	Apiaceae
*Schinus molle**	Peruvian peppertree	Anacardiaceae
Scirpus acutus	Common tule	Cyperaceae
Scrophularia californica	California figwort	Scrophulariaceae
*Senecio vulgaris**	Common groundsel	Asteraceae
*Silybum marianum**	Milk thistle	Asteraceae
Solanum americanum	Common nightshade	Solanaceae
*Solanum elaegnifolium**	Horse-nettle	Solanaceae

* = non-native species

LOWER PUTAH CREEK PLANT INVENTORY

Scientific Name	Common Name	Family
*Sonchus asper**	Prickly sow-thistle	Asteraceae
*Sonchus oleraceus**	Common sow-thistle	Asteraceae
*Sorghum halepense**	Johnson grass	Poaceae
*Spergularia rubra**	Sand spurry	Caryophyllaceae
*Stellaria media**	Chickweed	Caryophyllaceae
Symphoricarpos albus var. *laevigatus*	Upright snowberry	Caprifoliaceae
*Taeniatherum caput-medusae**	Medusahead grass	Poaceae
*Tamarix aphylla**	Athel tamarisk	Tamaricaceae
*Tamarix chinensis**	Five-stamen tamarisk	Tamaricaceae
*Tamarix parviflora**	Four-stamen tamarisk	Tamaricaceae
*Taraxacum officinale**	Common dandelion	Asteraceae
Toxicodendron diversilobum	Poison oak	Anacardiaceae
*Tribulus terrestris**	Puncture vine	Zygophyllaceae
*Trifolium hirtum**	Rose clover	Fabaceae
*Trifolium incarnatum**	Crimson clover	Fabaceae
Typha angustifolia	Narrow-leaf cattail	Typhaceae
Umbellularia californica	California bay laurel	Lauraceae
Urtica dioica	Stinging nettle	Urticaceae
*Verbascum thapsus**	Woolly mullein	Scrophulariaceae
Vicia Americana	American vetch	Fabaceae
*Vicia sativa**	Common vetch	Fabaceae
*Vicia villosa**	Hairy vetch	Fabaceae
*Vinca major**	Periwinkle	Apocynaceae
Vitis californica	California grape	Vitaceae
*Vulpia myuros**	Rattail fescue	Poaceae
Xanthium strumarium	Cocklebur	Asteraceae
*Zelkova serrata**	Sawtooth zelkova	Ulmaceae

* = non-native species

APPENDIX **E**

LOWER PUTAH CREEK AVIAN SPECIES

LOWER PUTAH CREEK AVIAN SPECIES

Sources included Sutter & Dawson 1986, Cole et al. 1990, Truan 2002, compiled by Truan (2003).

COMMON NAME	Scientific name
Pied-billed Grebe	*Podilymbus podiceps*
Double-crested Cormorant	*Palacrocorax auritus*
American Bittern	*Botaurus lentiginosus*
Great Blue Heron	*Ardea herodias*
Great Egret	*Casmerodius albus*
Snowy Egret	*Egretta thula*
Green Heron	*Butorides virescens*
Black-crowned Night Heron	*Nycticorax nycticorax*
Turkey Vulture	*Carthartes aura*
Greater White-fronted Goose	*Anser albifrons*
Canada Goose	*Branta canadensis*
Wood Duck	*Aix sponsa*
Gadwall	*Anas strepera*
American Widgeon	*Anas americana*
Mallard	*Anas platyrhynchos*
Cinnamon Teal	*Anas cyanoptera*
Northern Shoveler	*Anas clypeata*
Northern Pintail	*Anas acuta*
Green-winged Teal	*Anas crecca*
Canvasback	*Aythya valisineria*
Redhead	*Aythya americana*
Ring-necked Duck	*Aythya collaris*
Lesser Scaup	*Aythya affinis*
Bufflehead	*Bucephala albeola*
Common Goldeneye	*Bucephala clangula*
Hooded Merganser	*Lophodytes cucullatus*
Common Merganser	*Mergus merganser*
Ruddy Duck	*Oxyura jamaicensis*
Osprey	*Pandion haliaetus*
White-tailed Kite	*Elanus leucurus*
Bald Eagle	*Haliaeetus leucocephalus*
Northern Harrier	*Circus cyaneus*
Sharp-shinned Hawk	*Accipiter striatus*

LOWER PUTAH CREEK AVIAN SPECIES

COMMON NAME	Scientific name
Cooper's Hawk	*Accipiter cooperii*
Red-shouldered Hawk	*Buteo lineatus*
Swainson's Hawk	*Buteo swainsoni*
Red-tailed Hawk	*Buteo jamaicensis*
Rough-legged Hawk	*Buteo lagopus*
Golden Eagle	*Aquila chrysaetos*
American Kestrel	*Falco sparverius*
Merlin	*Falco columbarius*
Peregrine Falcon	*Falco peregrinus*
Prairie Falcon	*Falco mexicanus*
Red Junglefowl	*Gallus gallus*
Ring-necked Pheasant	*Phasianus colchicus*
Common Peafowl	*Pavo cristatus*
Wild Turkey	*Meleagris gallopavo*
California Quail	*Callipepla californica*
Virginia Rail	*Rallus limicola*
Sora	*Porzana carolina*
Common Moorhen	*Gallinula chloropus*
American Coot	*Fulica americana*
Killdeer	*Charadrius vociferus*
Black-necked Stilt	*Himantopus mexicanus*
American Avocet	*Recurvirostra americana*
Greater Yellowlegs	*Tringa melanoleuca*
Lesser Yellowlegs	*Tringa flavipes*
Spotted Sandpiper	*Actitis macularia*
Whimbrel	*Numenius phaeopus*
Long-billed Curlew	*Numenius americanus*
Western Sandpiper	*Calidris mauri*
Least Sandpiper	*Calidris minutilla*
Ring-billed Gull	*Larus delawarensis*
California Gull	*Larus californicus*
Herring Gull	*Larus argentatus*
Forster's Tern	*Sterna forsteri*
Rock Dove	*Columba livia*
Mourning Dove	*Zenaida macroura*

LOWER PUTAH CREEK AVIAN SPECIES

COMMON NAME	Scientific name
Barn Owl	*Tyto alba*
Western Screech Owl	*Otus kennicottii*
Great Horned Owl	*Bubo virginianus*
Burrowing Owl	*Athene cunicularia*
White-throated Swift	*Aeribaytes saxatalis*
Black-chinned Hummingbird	*Archilochus alexandri*
Anna's Hummingbird	*Calypte anna*
Rufous Hummingbird	*Selasphorus rufus*
Allen's Hummingbird	*Selasphorus sasin*
Belted Kingfisher	*Ceryle alcyon*
Lewis' Woodpecker	*Melanerpes lewis*
Acorn Woodpecker	*Melanerpes formicivorus*
Red-breasted Sapsucker	*Sphyrapicus ruber*
Nuttall's Woodpecker	*Picoides nuttallii*
Downy Woodpecker	*Picoides pubscens*
Hairy Woodpecker	*Picoides villosus*
Northern Flicker	*Colaptes auratus*
Olive-sided Flycatcher	*Contopus cooperi*
Western Wood-Pewee	*Contopus sordidulus*
Willow Flycatcher	*Empidonax traillii*
Hammond's Flycatcher	*Empidonax hammondii*
Dusky Flycatcher	*Empidonax oberholseri*
Pacific-slope Flycatcher	*Empidonax difficilis*
Black Phoebe	*Sayornis nigricans*
Say's Phoebe	*Sayornis saya*
Ash-throated Flycatcher	*Myiarchus cinerascens*
Western Kingbird	*Tyrannus verticalis*
Loggerhead Shrike	*Lanius ludovicianus*
Cassin's Vireo	*Vireo cassinii*
Hutton's Vireo	*Vireo huttoni*
Warbling Vireo	*Vireo gilvus*
Western Scrub-Jay	*Aphelocoma californica*
Yellow-billed Magpie	*Pica nuttalli*
American Crow	*Corvus brachyrhynchos*
Horned Lark	*Eremophilia alpestris*

LOWER PUTAH CREEK AVIAN SPECIES

COMMON NAME	Scientific name
Tree Swallow	*Tachycineta bicolor*
Violet-green Swallow	*Tachycineta thalassina*
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*
Bank Swallow	*Riparia riparia*
Cliff Swallow	*Petrochelidon pyrrhonota*
Barn Swallow	*Hirundo rustica*
Oak Titmouse	*Baeolophus inornatus*
Bushtit	*Psaltriparus minimus*
Red-breasted Nuthatch	*Sitta canadensis*
White-breasted Nuthatch	*Sitta carolinensis*
Brown Creeper	*Certhia americana*
Bewick's Wren	*Thryomanes bewickii*
House Wren	*Troglodytes aedon*
Marsh Wren	*Cistothorus palustris*
Golden-crowned Kinglet	*Regulus satrapa*
Ruby-crowned Kinglet	*Regulus calendula*
Blue-gray Gnatcatcher	*Polioptila caerulea*
Western Bluebird	*Sialia mexicana*
Swainson's Thrush	*Catharus ustulatus*
Hermit Thrush	*Catharus guttatus*
American Robin	*Turdus migratorius*
Varied Thrush	*Ixoreus naevius*
Wrentit	*Chamaea fasciata*
Northern Mockingbird	*Mimus polyglottos*
European Starling	*Sturnus vulgaris*
American Pipit	*Anthus rubescens*
Cedar Waxwing	*Bombycilla cedrorum*
Phainopepla	*Phainopepla nitens*
Orange-crowned Warbler	*Vermivora celata*
Nashville Warbler	*Vermivora ruficapilla*
Yellow Warbler	*Dendroica petechia*
Yellow-rumped Warbler (Audubon's)	*Dendroica coronata*
Black-throated Gray Warbler	*Dendroica nigrescens*
Townsend's Warbler	*Dendroica townsendi*
Hermit Warbler	*Dendroica occidentalis*

LOWER PUTAH CREEK AVIAN SPECIES

COMMON NAME	Scientific name
MacGillivray's Warbler	*Oporonis tolmiei*
Common Yellowthroat	*Geothlypis trichas*
Wilson's Warbler	*Wilsonia pusilla*
Western Tanager	*Piranga ludoviciana*
Spotted Towhee	*Pipilo maculatus*
California Towhee	*Pipilo crissalis*
Chipping Sparrow	*Spizella passerina*
Vesper Sparrow	*Pooecetes gramineus*
Lark Sparrow	*Calamopsiza melanocorys*
Savannah Sparrow	*Passerculus sandwichensis*
Grasshopper Sparrow	*Ammodramus savannarum*
Fox Sparrow	*Passerella iliaca*
Song Sparrow	*Melospiza melodia*
Lincoln's Sparrow	*Melospiza lincolnii*
White-crowned Sparrow	*Zonotrichia leucophyrs*
Golden-crowned Sparrow	*Zonotrichia atricapilla*
Dark-eyed Junco	*Junco hyemalis*
Black-headed Grosbeak	*Pheucticus melanocephalus*
Blue Grosbeak	*Guiraca caeulea*
Lazuli Bunting	*Passerina amoena*
Red-winged Blackbird	*Agelaius phoeniceus*
Western Meadowlark	*Sturnella neglecta*
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*
Brewer's Blackbird	*Euphagus cyanocephalus*
Brown-headed Cowbird	*Molothrus ater*
Hooded Oriole	*Icterus cucullatus*
Bullock's Oriole	*Icterus bullockii*
Purple Finch	*Carpodacus purpureus*
House Finch	*Carpodacus mexicanus*
Pine Siskin	*Carduelis pinus*
Lesser Goldfinch	*Carduelis psaltria*
Lawrence's Goldfinch	*Carduelis lawrencei*
American Goldfinch	*Carduelis tristis*
House Sparrow	*Passer domesticus*

APPENDIX **F**

Lower Putah Creek Fish Species Collected During 1991–2002 Surveys

Lower Putah Creek Fish Species Collected During 1991–2002 Surveys

Common Name	*Scientific Name*	*Abbreviation*	*Origin* Native or Introduced
American shad	*Alosa sapidissima*	AMS	I
bigscale logperch	*Percina macrolepida*	BSL	I
black bullhead	*Ameiurus melas*	BBH	I
black crappie	*Pomoxis nigromaculatus*	BCR	I
bluegill	*Lepomis machrochirus*	BGS	I
brown bullhead	*Ameiurus nebulosus*	BBH	I
brown trout	*Salmo trutta*	BNT	I
California roach	*Lavinia symmetricus*	RCH	N
channel catfish	*Ictalurus punctatus*	CCF	I
chinook salmon	*Oncorhynchus tshawytscha*	CHN	N
common carp	*Cyprinus carpio*	CRP	I
fathead minnow	*Pimephales promelas*	FHM	I
golden shiner	*Notemigonu scrysoleucus*	GSH	I
goldfish	*Carassius auratus*	GLF	I
green sunfish	*Lepomis cyanellus*	GSF	I
green sunfish X bluegill	*Lepomis* spp.	GXB	I
hitch	*Lavinia exilicauda*	HTC	N
inland silverside	*Menidia beryllina*	ISS	I
largemouth bass	*Micropterus salmoides*	LMB	I
Pacific Lamprey	*Lampetra tridentata*	PLR	N
pumpkinseed	*Lepomis gibbosus*	PMK	I
prickly sculpin	*Cottus asper*	PSC	N
rainbow trout	*Oncorhynchus mykiss*	RBT	N
red shiner	*Cyprinella lutrensis*	RSH	I
redear sunfish	*Lepomis microlophus*	RES	I
redear sunfish X bluegill	*Lepomis* spp	RXB	I
riffle sculpin	*Cottus gulosus*	RSC	N
Sacramento blackfish	*Orthodon microlepidotus*	SBF	N
Sacramento perch	*Archoplites interruptus*	SAP	N
Sacramento pikeminnow	*Ptychochelius grandis*	PKM	N
Sacramento sucker	*Catostomus occidentalis*	SKR	N
smallmouth bass	*Micropterus dolomieu*	SMB	I
striped bass	*Morone saxatilis*	STB	I
threadfin shad	*Dorosoma petenense*	TFS	I
threespine stickleback	*Gasterosteus aculeatus*	SBK	N
tule perch	*Hysterocarpus traski*	TUP	N
warmouth	*Lepomis gulosus*	WRM	I
western mosquitofish	*Gambusia affinis*	MSQ	I
white catfish	*Ameiurus catus*	WCF	I
white crappie	*Pomoxis annularis*	WCR	I
yellowfin goby	*Acanthogobius flavimanus*	YFG	I

Source: LPCCC 2003

APPENDIX G

NEW ZEALAND MUD SNAIL

Fishing Alert

The New Zealand Mud Snail, a tiny non-native snail, was recently discovered in Putah Creek. It was probably transported to Putah Creek on fishing or boating equipment used in Montana. In some areas of Montana, the snail population is 700,000 per square yard. Large populations of the snails have reduced mayfly larvae numbers by 50%. That loss of food is expected to eventually have a dramatic impact on trout populations.

Please help protect California trout populations by preventing the spread of this harmful snail to other waterways:

1. **Wash your boots off completely before leaving the creek.**
2. **Inspect your boots, nets, and other equipment for snails.**
3. **Check under the laces and in the tongue folds of your boots.**
4. **Soak your boots and nets in hot water (130°F) until it cools.**
5. **Allow your boots to dry completely.**
6. **Check boats, kayaks, and canoes for snails.**

EVEN BETTER

Use one pair of boots just for Putah Creek and clean as above.

For additional information, links, and answers to your questions go to:

GRANITE BAY Flycasters www.gbflycasters.org

WildlifeFiles.com

CALIFORNIA TROUT KEEPER OF THE STREAMS www.caltrout.org

Source: Granite Bay Flycasters; California Trout, Inc.; Ken Davis 2003

Source: Idaho Dept. of Fish and Game; U.S. Bureau of Reclamation; USFWS; CDFG; Putah Creek Council, 2003

New Zealand Mud Snail Information (side 1)

NEW ZEALAND MUDSNAIL (*Potamopyrgus antipodarum*) in CALIFORNIA

WHAT CAN YOU DO?

Reporting Sightings:

- Report potential sightings to david_bergendorf@fws.gov or sellis@dfg.ca.gov or phone **1-888-321-8913**.
- **Please help the aquatic life in California streams and your fellow fishermen by letting them know about this resource pest and its potential impacts on trout and fish habitat.** Please report any fishing activity in closed areas at Lake Solano Park to Park Rangers at (530) 795-2990 and on Putah Creek to California Fish and Game at 1-888-DFG-CALTIP.
- Immature snails are about 1 mm long and often look like sprinkled black pepper.
- Mature snails have a light to dark brown shell and are still tiny, only growing up to 5 mm long.
- NZMS can tolerate a wide range of habitats including reservoirs, rivers, lakes and estuaries. Found in all substrates including gravel, sand, silt, and vegetation.

Clean Your Gear Before Leaving Site or Moving To Another Site!

- See opposite side for gear cleaning recommendations.

Encourage Friends and Fellow Fishermen to Avoid Closed or Infested Areas, and Keep the Mudsnail from Infesting Other California Streams!

KNOWN LOCATIONS IN CALIFORNIA

- 2000: Owens River (Eastern CA); now found in Hot Creek near the fish hatchery.
- October 2003: Putah Creek (Western Central Valley below Monticello Dam) - Fishing Access #3.
- December 2003: Putah Creek - Found between Fishing Access #2 and #3 and between #3 and #4. **Putah Creek and Lake Solano closed to all fishing in interdam reach between Monticello Dam and diversion dam below Lake Solano Park – Closure began December 26, 2003 for 120 days**
- December 2003: Mokelumne River (Central Valley) - above Woodbridge Dam near Lodi.

HOW THEY SPREAD

- It Only Takes One! The snails reproduce without fertilization, bear 20-120 snails per brood (multiple broods per year), and can spread from just one snail.
- Primarily spread through human activities on angling gear, shoes and boats. Can also spread on clothing and animal fur, so please check your dog or other pets before leaving any infested area.
- Snails can survive passing through the gut of a fish and may be spread that way; may hitchhike on birds.
- Can survive for 25+ days in cool, moist places, like waders, mud, boats, the tread of shoes, and so forth.

FAST FACTS

- First discovered in mid-Snake River, Idaho in the 1980s and is spreading rapidly throughout the west.
- Snail densities as high as 750,000 per square meter have been recorded in some areas.
- At high levels, snails consume most available food leaving little for native snails and aquatic insects to feed on. This leads to a reduction or elimination of the native macroinvertebrates, and therefore a reduction in food available for fish and other members of the native aquatic ecosystem.
- The snails have the ability to close off their shell opening allowing them to live for a long time without being in water (25 days if moist).
- NZMS can travel up to 1 meter per hour and have been found over 40 feet from the water. You can pick them up without being near the water!
- Average life span is over one year.

See Opposite Side For More Information And Websites
Updated 1/22/2004

Source: Idaho Dept. of Fish and Game; U.S. Bureau of Reclamation; USFWS; CDFG; Granite Bay Flycasters; California Trout, Inc., 2003

New Zealand Mud Snail Information (side 2)

Department of Fish and Game

NEWS RELEASE FOR IMMEDIATE RELEASE 04:001 January 13, 2004

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DFG Offers Suggestions to Prevent Spread of New Zealand Mud Snails

The California Department of Fish and Game (DFG) urges anglers throughout California to guard against the unintentional spread of the non-native New Zealand Mud Snails (NZMS). Discovery of NZMS has forced the emergency 120-day closure of Putah Creek in Yolo County to allow studies on the infestation and the best course of action.

In late December 2003, the snails were also discovered in the Mokelumme River, another Central Valley waterway that flows from the Sierra Nevada south of Sacramento. DFG announced the discovery after work crews with the East Bay Municipal Utilities District found the snails on equipment downstream from Camanche Reservoir, east of Lodi. Since 2000, the snails have also been found on the Owens River and Hot Creek in the Eastern Sierra.

"It is important for anyone who fishes in California or works in our waterways to take precautions to not transport the NZMS," said Ed Pert, Chief, DFG Inland Fisheries Division. "A major factor in the spread of the NZMS is a lack of awareness by anglers and others in contact with waters infested with NZMS. These snails can survive out of water on wading and fishing gear for extended periods."

Pert said mud snails can survive up to 25 days if they are in a moist environment, such as inside waders, on muddy wader boots, in live wells or in cooling systems at cool temperatures. DFG suggests that anglers treat their gear with at least one of the following methods to prevent spread of NZMS:

- Spray gear with Clorox Formula 409, and then scrub with stiff-bristled brush to remove all visible snails. Follow the procedure with a careful inspection of waders and gear to ensure the removal of all adults. Finish with a tap water rinse. Snails frequently collect between laces and tongue of wading boots and in the boot's felt soles.

- Freeze waders six to eight hours. It is best to leave them in the freezer overnight to ensure complete mortality.

- Drying in air temperature over 112 degrees (50 degrees Celsius) for 24 hours will eliminate all mud snails. Alternatively, place gear in water maintained at 130 degrees for five minutes. Mortality of snails varies by exposure to heat and humidity at different combinations.

- NZMS are not the only aquatic invasive species spread by anglers and boaters. Live bait and the packaging used for some forms of live bait are known to spread other invaders. In addition, invasive aquatic plants and animals are known to hitchhike on boats, their propellers, live wells, and fishing gear. Cleaning all boating equipment is crucial to reducing the impacts from non-native invasive species.

DFG biologists and field staff members who conduct studies in the infested areas have received similar instructions to guard against the spreading of NZMS, Pert said.

DFG warns that the snails in Putah Creek have been collected on the banks, well away from the water's edge. Outdoor enthusiasts and boaters who travel within the riparian areas should also follow the guidelines.

NZMS is a very small snail with the potential of extraordinary population densities - up to approximately a million snails per square meter. Populations in New Zealand are limited naturally by native parasites and predators. In North America, however, there are no natural predators or parasites of the snail and the populations have flourished where introduced. Currently, no method of eradication has been successfully applied to large, open river systems.

Putah Creek began its 120-day closure on Dec. 26, 2003. The Fish and Game Commission ordered the emergency action, which received support from various fly-fishing clubs, to close the popular winter trout fishery from Monticello Dam downstream to, and including, Lake Solano in Yolo County. There are currently no plans to close the Mokelumne River, which is about 40 miles away from Putah Creek.

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Federation of Fly Fishers
(http://www.fedflyfishers.org/Conserve/mudsnailfactsheet.htm)

New Zealand Mud Snails
New Zealand Mud Snail – Fact Sheet

Scientific Name: *Potamopyrgus antipodarum*

Originally found only in New Zealand the New Zealand Mud Snail (NZMS) was first transported to England in 1859. By 1899 it had reached mainland Europe and the 1920's found it throughout all of England. In 1987 NZMS were discovered in Idaho's Snake River. In 1997 surveys showed the snail had spread to all of the major waters in Yellowstone National Park. In recent years it has been found throughout the Columbia River drainage, in many Montana waters and in several California streams.

NZMS have the capability for clonal asexual reproduction. In this type of reproduction a single snail can reproduce with no mate. Thus, a single snail is all that is required to establish a new population.

NZMS reproduce very rapidly. A single snail produces up to 38 live snails twice a year. Each of these reaches reproductive age very quickly and it is possible that a single individual could be responsible for a population of 3,700,000 in two years.

NZMS impact the environment through sheer numbers. Densities of more than 800,000 per square meter have been recorded in several areas. These huge numbers of snail eat much of the available food in the stream. A recent study from Montana State University showed that NZMS can consume up to 50% of the production in a stream.

The impact of NZMS feeding on available food is seen in several ways. The most immediate impact is on populations of native snails that can quickly be pushed out. In fact, in Pole Cat Creek in Grand Teton National Park a unique native snail found only in the creek is facing extinction because of competition from NZMS.

Many organisms besides snails are impacted by NZMS. Many aquatic insects can be impacted as well. Invertebrate studies show marked declines in midge and mayfly populations.

Loss of native snails and other aquatic invertebrates becomes a loss of food to various fish. NZMS provide little if any nutrition to fish that eat them. In fact, a significant percentage of the snails that are eaten pass through the fish alive.

NZMS have no natural enemies in North America. In New Zealand a tiny parasite controls snail numbers, giving hope that future biological control might be possible.

NZMS invasions can only be controlled by preventing the spread of the snail. Once they are established there is no known way to eradicate them. All of the methods of transport have not been identified but it is almost certain that water recreationists are the primary vector of spread.

New discoveries of NZMS are occurring rapidly as biologists and others become trained in looking for them. They are probably found in far more waters than currently identified.

More information on NZMS can be obtained from the Federation of Fly Fishers at 406/222-9369.

APPENDIX **H**

Permitting and Regulatory Compliance

H PERMITTING AND REGULATORY COMPLIANCE

H.1 REGULATORY BACKGROUND

This section summarizes laws and regulations pertaining to land and resource protection and management within the lower Putah Creek watershed. The section includes an overview California Environmental Quality Act (CEQA), National Environmental Policy Act (NEPA), and other laws and regulations pertaining to the resource areas discussed in this Watershed Management Action Plan (WMAP). However, because of the overlap in laws and regulations, discussions for some resource areas have been combined into the following groups: "water quality, wetlands, and riparian resources," and "fisheries and terrestrial biology." For each resource topic, applicable federal laws are presented first, followed by state laws and, where applicable, local laws and ordinances.

A Categorical Exemption (Cat Ex) under CEQA has been adopted, and several programmatic permits for habitat restoration and watershed enhancement work in the lower Putah Creek watershed have already been obtained. The permits include a programmatic Streambed Alteration Agreement from California Department of Fish and Game (DFG) for work affecting the "bed and bank" of lower Putah Creek and its tributaries, a Nationwide Permit 27 (Restoration) under Section 404 of the Clean Water Act (CWA) from the U.S. Army Corps of Engineers (USACE), and Clean Water Certification pursuant to Section 401 of the CWA from the Central Valley Regional Water Quality Control Board (RWQCB). The Cat Ex and permits are held by the Solano County Water Agency, serving as lead public agency on behalf of the Lower Putah Creek Coordinating Committee (LPCCC). Project and permit requirements specified for the various habitat restoration and watershed enhancement activities have been summarized and are provided as Appendix I of this document.

H.2 CALIFORNIA ENVIRONMENTAL QUALITY ACT

CEQA applies to all discretionary activities that are carried out or approved by California public agencies, including state, regional, county, and local agencies, unless an exemption applies. The main objectives of CEQA are to:

< disclose the decision makers and the public to significant environmental effects of proposed activities,

< identify ways to avoid or reduce environmental damage,

< prevent environmental damage by requiring implementation of feasible alternatives or mitigation measures,

< disclose to the public reasons for agency approval of actions with significant environmental effects,

< foster interagency coordination in the review of projects, and

< enhance public participation in the planning process.

The type of CEQA compliance document prepared for a project depends of the project's potential effect on the environment. A Cat Ex may be prepared if it is determined that the project is exempt from CEQA. If the project will have only minor impacts that can be mitigated to less-than-significant levels, an Initial Study/Mitigated Negative Declaration (IS/ND) is typically adequate. A project resulting in one or more significant effects on the environment typically requires preparation of an Environmental Impact Report (EIR).

H.3 NATIONAL ENVIRONMENTAL POLICY ACT

NEPA requires federal agencies to evaluate the environmental effects of their actions. NEPA applies whenever a federal agency proposes an action, grants a permit, or agrees to fund or otherwise authorize any other entity that could possibly affect environmental resources. Typical NEPA compliance documents include a Cat Ex, Environmental Assessment/Finding of No Significant Impact (EA/FONSI), or Environmental Impact Statement (EIS).

H.4 CULTURAL RESOURCES

H.4.1 FEDERAL LAWS AND REGULATIONS

SECTION 106 OF THE NATIONAL HISTORIC PRESERVATION ACT

Section 106 of the National Historic Preservation Act (NHPA) of 1969 (amended 1970) requires that federal agencies or other public agencies receiving federal support take into account the effects of their actions on properties that may be eligible for or listed on the NRHP, and afford the Advisory Council on Historic Preservation (ACHP) a reasonable opportunity to comment on proposed projects and the findings of cultural resource studies. To determine whether an undertaking could affect NRHP eligible properties, all cultural sites that could be affected must be inventoried and evaluated for inclusion on the NRHP. Section 106 of the NHPA would apply if federal agencies were involved in activities on Putah Creek through various permitting processes or by providing federal funding.

NATIVE AMERICAN GRAVES PROTECTION AND REPATRIATION ACT

Native American human remains are also protected under the Native American Graves Protection and Repatriation Act of 1990 (NAGPRA) (25 United States Code [USC] 3001 et seq.), which requires federal agencies and certain recipients of federal funds to document Native American human remains and cultural items within their collections, notify Native American groups of their holdings, and provide an opportunity for repatriation of these materials. This act also requires plans for dealing with potential future collections of Native American human remains and associated funerary objects, sacred objects, and objects of cultural patrimony that might be uncovered as a result of development projects overseen or funded by the federal government. In 2001, Assembly Bill (AB) 978 enhanced the reach of NAGPRA and established a state commission with statutory powers to assure that federal and state laws regarding the repatriation of Native American human remains and items of patrimony are fully complied with. In addition, AB 978, as opposed to NAGPRA, includes nonfederally recognized tribes for repatriation. Like Section 106 of the NHPA, the Native Graves Protection and Repatriation Act would apply if federal agencies become involved in projects along Putah Creek.

H.4.2 STATE LAWS AND REGULATIONS

CEQA

CEQA has a much broader and far reaching environmental regulatory framework than the NHPA, but it also includes cultural resources as an important component of its oversight and management policies. Before discretionary projects are approved, the potential for significant project impacts on archaeological and historical resources must be considered under CEQA (§§21083.2 and 21084.1) and State CEQA Guidelines (California Code of Regulations [CCR] §15064.5).

Similar to the provisions of Section 106, CEQA requires a consideration of the eligibility of cultural resources for potential listing on the CRHR. To be eligible for listing on the CRHR (and the NRHP), cultural resources must possess at least one of the following features:

1. an association with events that have made a significant contribution to the broad patterns of California (or national) history and cultural heritage;

2. an association with the lives of persons important in our past;

3. distinctive characteristics of a type, period, region, or method of construction or represents the work of an important creative individual or possesses high artistic values; or

4. the ability to yield, or likely yield, information important in prehistory or history.

As a matter of policy, public agencies should avoid causing damaging impacts on historic and archeological resources, particularly those that are NRHP/CRHP eligible. When impacts cannot be avoided, they can be mitigated through the following:

< avoiding the sites during construction,
< incorporating the sites into open space,
< capping the resources with chemically stable fill,
< deeding the site into a permanent conservation easement, or
< recovering data (testing and excavation).

CEQA also provides for the protection of Native American human remains (CCR §15064.5[d]) and for the accidental discovery of cultural resources (CCR §15064.5[e]). These are particularly important provisions in that they take into account the possibility that significant resources not noted as a result of previous research efforts may be present within a project area and need to be treated in a way commensurate with CEQA standards.

H.5 LAND USE

H.5.1 FEDERAL LAWS AND REGULATIONS

FEDERAL FARMLAND PROTECTION POLICY ACT

The Natural Resources Conservation Service (NRCS), a federal agency in the U.S. Department of Agriculture (USDA), is the agency primarily responsible for implementing the federal Farmland Protection Policy Act (FPPA). The purpose of the FPPA is to minimize federal contributions to the conversion of farmland to nonagricultural uses by ensuring that federal programs are administered in a manner compatible with state government, local government, and private programs designed to protect farmland. The FPPA established the Farmland Protection Program (FPP) and the Land Evaluation and Site Assessment (LESA) system, which are discussed below in further detail.

NRCS administers the FPP, which is a voluntary program that provides funds to help purchase development rights to keep productive farmland in agricultural uses. The program provides matching funds to state, local, or tribal government entities and nongovernmental organizations with existing farmland protection programs to purchase conservation easements. Participating landowners agree not to convert the land to nonagricultural use and retain all rights to use the property for agriculture. A minimum of 30 years is required for conservation easements, and priority is given to applications with perpetual easements. NRCS provides up to 50% of the fair market easement value (NRCS 2002).

The LESA system helps state and local officials make sound decisions about land use. The system also accurately ranks lands for suitability and inclusion in the FPP. LESA evaluates several factors, including soil potential for agriculture, location, market access, and adjacent land use. These factors are used to rank land parcels for inclusion in the FPP based on local resource evaluation and site considerations (NRCS 2002).

H.5.2 STATE LAWS AND REGULATIONS

CALIFORNIA LAND CONSERVATION ACT (WILLIAMSON ACT)

The Land Conservation Act, administered by the California Department of Conservation (CDC), was enacted when population growth and rising property taxes were recognized as a threat to the viability of valuable farmland in California. John Williamson authored Assembly Bill 2117 in 1965. The bill proposed the development of a contract between landowners and local governments to voluntarily restrict development on property in exchange for lower tax assessments. The originators of the act conceived a strategy for local governments to protect open space and agricultural lands, while integrating long-term planning and growth patterns.

Under a Williamson Act contract, the property owner is guaranteed that the property would be taxed according to its potential agricultural income, as opposed to the maximum valued use of the property, such as for residential development. The State of California passed Article 13, which allows Williamson Act contracts to be used for recreational, scenic, and natural resource areas, in addition to crop production. Contracts are entered for a 10-year period and can be terminated only by a cancellation or non-renewal.

Cancellation involves an extensive review and approval process, in addition to a payment of fees of up to 12.5% of the property value. Under a non-renewal, a notice is filed by the property owner, after which the 10-year contract expires over time. The non-renewal allows for tax rates to gradually increase over the remainder of the contract, reaching the market value rate by the end of the term (CDC 2001). Subdivision of lands under Williamson Act contracts is limited to a minimum of 10-acre parcels and must incorporate a 200-foot setback from incompatible adjacent uses (CDC 2001).

California Important Farmland Inventory System and Mapping and Monitoring Program

As discussed above, the LESA system under the FPP is used for ranking land for inclusion in the FPP. The LESA system classifies land based on 10 soil and climatic characteristics. The CDC augmented that program in 1980 by initiating a system of inventorying, mapping, and monitoring of farmland acreage in California. The CDC inventory system was designed to document how much agricultural land in California was being converted to nonagricultural land or transferred into Williamson Act contracts. The CDC classifications in the Important Farmland Inventory System are described below:

- Prime Farmland – Land that has the best combination of features for producing agricultural crops,
- Farmland of Statewide Importance – Land other than Prime Farmland that has a good combination of physical and chemical features for producing agricultural crops,
- Unique Farmland – Land of lesser quality soils used for producing the state's leading agricultural cash crops,
- Farmland of Local Importance – Land that is of importance to the local agricultural economy,
- Grazing Land – Existing vegetation that is suitable for grazing,
- Urban and Built-up Lands – Lands occupied by structures in densities of at least one dwelling unit per 1.5 acres,
- Land Committed to Nonagriculture Use – Vacant areas and existing lands that have a permanent commitment to development but have an existing land use of agriculture or grazing lands, and
- Other Lands – lands that do not meet the criteria of remaining categories (CDC 2001).

Farmland, Farmland of Statewide Importance, Unique Farmland, and Farmland of Local Importance are often described together under the term "Important Farmland."

STATE FARMLAND SECURITY ZONES

Farmland Security Zones (FSZs) were established by the CDC with the same intent as Williamson Act contracts. An FSZ must be located in an Agricultural Preserve (area designated as eligible for a Williamson Act contract) and designated as Prime Farmland, Farmland of Statewide Importance, Unique Farmland, or Farmland of Local Importance. Agricultural and open space lands are protected for a minimum of a 20-year term under an FSZ designation and receive an even greater property tax reduction than a Williamson Act valuation. Land protected in an FSZ cannot be annexed by a city or county government or school district (CDC 2001).

An FSZ can be terminated through a non-renewal or cancellation. The non-renewal allows for a rollout process to occur over the remainder of the term of the contract, where the tax rates would gradually rise to the full rate by the end of the 20-year term. A cancellation must be applied for and approved by the director of the CDC, and specific criteria must be met. The cancellation must be in the public interest and consistent with the Williamson Act criteria (CDC 2001). If a cancellation is approved, a payment of fees equal to 25% of the full market value of property must be paid (CDC 2001).

H.6 WATER QUALITY/WETLANDS/RIPARIAN RESOURCES

H.6.1 FEDERAL LAWS AND REGULATIONS

CLEAN WATER ACT SECTION 404

Section 404 of the CWA establishes a requirement to obtain a permit from the USACE prior to initiating any activity that involves any discharge of dredged or fill material into "waters of the United States," including wetlands. Waters of the United States include navigable waters of the United States, interstate waters, all other waters where the use or degradation or destruction of the waters could affect interstate or foreign commerce, tributaries to any of these waters, and wetlands that meet any of these criteria or are adjacent to any of these waters or their tributaries. Wetlands are defined as those areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and which under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Jurisdictional wetlands must exhibit three wetland delineation criteria: hydrophytic vegetation, hydric soils, and wetland hydrology. Many surface waters and wetlands in California meet the criteria for waters of the United States, including intermittent streams and seasonal wetlands.

The USACE permits fall into the following categories:

< Nationwide permits (NWP) for projects that have only minimal impacts on Waters of the United States (thresholds are established for each Nationwide permit),

- Letters of permission (LOP) for projects with larger impacts (i.e., exceed the NWP thresholds) that have undergone thorough environmental review and coordination with other relevant federal and state agencies, and
- Individual Permits (IP) for projects with larger impacts (i.e., exceed the NWP thresholds) on the environment.

NWPs are considered general permits and as a result have undergone past environmental review (i.e., NEPA). LOPs and IPs trigger the need for additional NEPA review of the project and an analysis of alternatives (i.e., Section 404[b][1] analysis) to determine the practicable alternative that is the least damaging to the environment. Mitigation ensuring a no-net-loss of wetland habitat is typically required by USACE permits with a typical minimum replacement ratio of 1:1 (habitat restored or created to habitat lost). A mitigation and monitoring plan would need to be submitted with the permit application.

CLEAN WATER ACT SECTION 402 - NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT PROGRAM

Section 402 of the federal CWA prohibits the discharge of pollutants through a "point source" into "waters of the United States" without a National Pollutant Discharge Elimination System (NPDES) permit. The program is administered by the U.S. Environmental Protection Agency (EPA) in coordination with the RWQCBs. An NPDES permit issued by these agencies establishes effluent limitations, specifies monitoring and reporting requirements, and contains other provisions to ensure that the discharge does not impair water quality of pose a threat to the health of humans. In essence, the permit translates general requirements of the CWA into specific provisions tailored to the operations of each entity discharging pollutants. The two types of NPDES permits are individual and general permits. An individual permit is specifically tailored to a specific facility, while a general permit covers multiple facilities within a certain category.

One type of general permit that typically applies to construction and restoration programs that encompass more that 0.5 acre of soil disturbance is the General Construction Storm Water Permit. A Storm Water Pollution Prevention Plan (SWPPP) specifying Best Management Practices (BMPs) that will prevent construction pollutants from contacting storm water and contain erosion is required for permit application. The SWPPP also contains a plan for inspection and maintenance of erosion control devices. The applicant files a Notice of Intent (NOI) to seek coverage under the General Construction Storm Water Permit, along with an annual fee and the SWPPP, to the State Water Resources Control Board (SWRCB) in order to comply with the NPDES requirements. Coverage ends by filing a Notice of Termination, once the SWRCB has verified that all conditions of the permit have been met.

Recently, the EPA has focused on the goal of integrating the NPDES program further into the concept of watershed planning. This process involves examining the core functions of the NPDES program and assessing how to adapt the program to better promote community-based water resource management rather than permitting on a source-by-source basis. EPA is gaining insight into the best way to refine the NPDES framework to make decisions based on a watershed analysis and to engage local leadership in planning and non-point sources, while maintaining a strong baseline individual and general permitting program.

H.6.2 State Laws and Regulations

Porter-Cologne Water Quality Control Act

The state Porter-Cologne Water Quality Control Act is California's statutory authority for the protection of water quality. Under the Porter-Cologne Act, California must adopt water quality policies, plans, and objectives that ensure the reasonable protection of beneficial uses of the state. The act requires the nine RWQCBs to adopt water quality control plans and establish water quality objectives, and authorizes the SWQCB and RWQCBs to issue and enforce permits containing requirements for the discharge of waste to surface waters and land.

California Fish and Game Code Section 1602

All diversions, obstructions, or changes to the natural flow or bed, channel, or bank of any river, stream, or lake in California that supports fish or wildlife resources is subject to regulation by DFG, pursuant to California Fish and Game Code §§1600–1616. Section 1602 states that it is unlawful for any project to substantially divert or obstruct the natural flow or substantially change the bed, channel, or bank of any river, stream, or lake or use any material from the bed, bank or channel of any river, stream, or lake, or deposit or dispose of debris, wastes, or other material containing crumbled, flaked, or ground pavement where it may pass into any river, stream, or lake without first notifying DFG of such activity by applying for a Streambed Alteration Agreement (SAA). The regulatory definition of a stream is a body of water that flows at least periodically or intermittently through a bed or channel having banks and that supports wildlife, fish, or other aquatic life. This includes watercourses having a surface or subsurface flow that support or have supported riparian vegetation. DFG's jurisdiction within altered or artificial waterways is based upon the value of those waterways to fish and wildlife. Mitigation ensuring a no-net-loss of riparian vegetation and associated habitat values is typically required to obtain a SAA. The permit application also requires a fee. Agreements are typically good for 5 years from date of issuance but an agreement can be issued for a longer period of time if requested.

Reclamation Board Encroachment Permit

The Reclamation Board oversees floodplain management activities for the Sacramento and San Joaquin rivers and their tributaries. Approval of the Reclamation Board is required for projects or uses which encroach into rivers, waterways, and floodways within and adjacent to federal and State authorized flood control projects and within designated floodways adopted by the Board. The Board exercises jurisdiction over the levee section, the waterward area between project levees, a 10-foot-wide strip adjacent to the landward levee toe, an area within 30 feet of the top of the banks on unleveed project channels, and within designated floodways adopted by the Board. Activities outside of these limits that could adversely affect a flood control project are also under Board jurisdiction. Encroachment permits are required for any activities that involve construction or activities within areas regulated by the Board.

H.6.3. LOCAL LAWS AND REGULATIONS

A flood development permit is required by Yolo County through the Department of Planning and Public Works for any work within a 100-year floodplain that involves building, grading, excavation, filling, or other construction. Solano County has a similar floodplain development review and approval process; however, it is limited to building construction within the floodplain.

H.7 FISHERIES AND TERRESTRIAL BIOLOGICAL RESOURCES

H.7.1 FEDERAL LAWS AND REGULATIONS

FEDERAL ENDANGERED SPECIES ACT

Pursuant to the federal ESA, the National Marine Fisheries Service (NMFS) has authority over projects that may result in take of federally listed anadromous fish species. Similarly, the USFWS has authority over projects that may result in take of federally listed wildlife and plant species. Under the ESA, the definition of "take" is to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." USFWS has also interpreted the definition of "harm" to include significant habitat modification that could result in take. If a project has a likelihood that it would result in take of a federally listed species, either an incidental take permit, under Section 10(a) of the ESA, or a federal interagency consultation, under Section 7 of the ESA, is required.

MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

The Magnuson-Stevens Fishery Conservation and Management Act, as amended (16 U.S.C. 1801), requires that Essential Fish Habitat (EFH) be identified and described in federal fishery management plans (FMPSs). Federal action agencies must consult with NMFS on any activity that they fund, permit, or carry out that may adversely affect EFH. The EFH regulations require that federal action agencies obligated to consult on EFH also provide NMFS with a written assessment of the effects of their action on EFH (50 Code of Federal Regulations [CFR] Section 600.920). NMFS is required to provide EFH conservation and enhancement recommendations to the federal action agency. The statute also requires federal action agencies receiving NMFS EFH Conservation Recommendations to provide a detailed written response to NMFS within 30 days upon receipt detailing how they intend to avoid, mitigate, or offset the impact of the activity on EFH. The Central Valley fall-/late fall-run Chinook salmon EFH that occurs in Putah Creek is covered under this Act.

MIGRATORY BIRD TREATY ACT

The Migratory Bird Treaty Act (MBTA), first enacted in 1918, implements domestically a series of treaties between the United States and Great Britain (on behalf of Canada), Mexico, Japan, and the former U.S.S.R., which provide for international migratory bird protection, and authorizes the Secretary of the Interior to regulate the taking of migratory birds. The MBTA provides that it shall be unlawful, except as permitted by regulations, "to pursue, take, or kill … any migratory bird, or any part, nest or egg of any such bird, included in the terms of conventions" with certain other countries (16 USC 703). The current list of species protected by the MBTA essentially includes all native birds. Section 3513 of the Fish and Game Code of California provides for adoption of the MBTA's provisions. Neither the MBTA nor this state code provide a statutory or regulatory mechanism for obtaining an incidental take permit for the loss of non-game, migratory birds.

H.7.2 STATE LAWS AND REGULATIONS

CALIFORNIA ENDANGERED SPECIES ACT

Pursuant to the California Endangered Species Act (CESA) and Section 2081 of the Fish and Game Code, a permit from DFG is required for projects that could result in the take of a state-listed Threatened or Endangered species. Under CESA, "take" is defined as an activity that would directly or indirectly kill an individual of a species, but the definition does not include "harm" or "harass," as the federal act does. As a result, the threshold for a take under the CESA is higher than that under the ESA.

CALIFORNIA FISH AND GAME CODE §3503.5 – PROTECTION OF RAPTORS

Section 3503.5 of the Fish and Game Code states that it is unlawful to take, possess, or destroy any raptors (i.e., species in the orders Falconiformes and Strigiformes), including their nests or eggs. Violations include destruction of active raptor nests from tree removal and disturbance to nesting pairs by nearby human activity, which may cause nest abandonment and reproductive failure.

NATURAL COMMUNITY CONSERVATION PLANNING ACT

Under Section 2800 of the Fish and Game Code, the Natural Community Conservation Planning Act (NCCPA) authorizes and encourages conservation planning on a regional scale in California through preparation of Natural Community Conservation Plans (NCCPs). NCCPs address the conservation of natural communities as well as individual species. The NCCPA's focus on regional conservation rather than individual project mitigation is appropriate for complex and extensive programs. Similar regional planning occurs under federal authority through development of Habitat Conservation Plans (HCPs) to protect listed species under the federal ESA. Both Solano and Yolo counties have initiated development of HCPs/NCCP.

The Solano County HCP/NCCP would establish a county-wide comprehensive program for species and habitat protection on undeveloped and agricultural land in response to existing and projected water delivery service needs. The activities of five cities, two water agencies, and a reclamation district will be addressed in the plan. These include urban development; operation and maintenance of irrigation, flood control, and drainage systems; and certain agricultural and habitat management activities associated with the management of habitat reserves that may be established under the HCP/NCCP. SCWA is the lead agency developing the plan. The report of the independent science advisors was published in fall 2002. A final planning agreement is expected to be available for public review in 2003. The geographic area covered by the draft HCP/NCCP includes a portion of Solano County land along Putah Creek, west of the Putah Diversion Dam (PDD).

Planning efforts are also underway in Yolo County to develop an HCP/NCCP. A grant from USFWS has been awarded to assist in finalizing a county-wide HCP/NCCP. The plan is intended to contribute to balancing well-planned urban development with the preservation of natural and agricultural resources. The funding will also provide additional biological analyses necessary to include western portions of the county, land acquisition planning, the completion of the HCP/NCCP, and environmental review for the county's HCP/NCCP program. Seven listed species are expected to benefit from the plan, including the federally Threatened giant garter snake and valley elderberry longhorn beetle, the federally Endangered palmate-bracted bird's beak, and the State-Threatened Swainson's hawk.

H.7.3 Regional and Local Policies and Ordinances

Sudden Oak Death Syndrome Regulations

The causal pathogen of "sudden oak death" (SOD), *Phytophthora ramorum*, attacks and can kill oaks and other native vegetation in California. Special regulations regarding the pathogen apply in counties in which the occurrence of SOD is confirmed due to the threat of spreading SOD from infected areas to new locations. Occurrence of SOD has been confirmed within Solano County; therefore, special regulations apply. Yolo County is not regulated because the occurrence of SOD has not been confirmed in the County.

Under the Oak Mortality Disease Cooperative Project, a compliance agreement should be obtained from Solano County, prior to project activities involving the removal, transportation, or planting of vegetation material that are potential hosts to SOD. Host species include bigleaf maple (*Acer macrophyllum*), California buckeye (*Aesculus californica*), madrone (*Arbutus menziesii*), tan oak (*Lithocarpus denisflorus*), honeysuckle (*Lonicera hispidula*), coast live oak (*Quercus agrifolia*), black oak (*Quercus kelloggii*), coffeeberry (*Rhamnus californica*), California bay laurel (*Umbellularia californica*), and others.

All people working with regulated vegetation are responsible for knowing if they are working within an infested area. An infested area is an area that is within 1/4 mile of a confirmed SOD occurrence. Putah Creek is currently not known to be an infested area. Host material from within the regulated area (i.e., Solano County) and smaller than 4 inches in diameter should be left on-site (may be chipped or shredded) or disposed of at an approved facility or landfill. If transported, host material smaller than 4 inches diameter should be transported in such a manner that precludes escape of any material (e.g., plastic bags, closed containers) and be accompanied by a copy of the cooperative agreement. Host material larger than 4 inches in diameter may be moved within the regulated area if accompanied by a copy of the cooperative agreement. In addition, all people working in the field should be educated regarding the host, symptoms, and general distribution of SOD.

H.8 INVASIVE SPECIES

H.8.1 FEDERAL INVASIVE SPECIES LAWS AND REGULATIONS

Executive Order 11312 – Invasive Species (February 3, 1999) directs all federal agencies to prevent and control introductions of invasive non-native species (i.e., pest plants, animals, or other organisms) in a cost-effective and environmentally sound manner to minimize their economic, ecological, and human health impacts. Executive Order 11312 established a national Invasive Species Council composed of federal agencies and departments and a supporting Invasive Species Advisory Committee made up of state, local, and private entities. The Invasive Species Council and Advisory Committee oversee and facilitate implementation of the Executive Order, including preparing a National Invasive Species Management Plan.

A number of other federal laws pertain to noxious and invasive weeds, including the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 as amended (16 U.S.C. 4701 et seq.); Lacey Act as amended (18 U.S.C. 42); Federal Plant Pest Act (7 U.S.C. 150aa et seq); Federal Noxious Weed Act of 1974 as amended by the Food, Agriculture, Conservation and Trade Act of 1990 (Section 1453 "Management of Undesirable Plants on Federal Lands;" U.S.C. 2801 et seq); and the Carlson-Fogey Act of 1968 (Public Law 90-583). The U.S. Department of Agriculture and other federal agencies maintain lists of pest plants of economic or ecological concern.

H.8.2 STATE INVASIVE SPECIES LAWS AND REGULATIONS

A number of state laws and regulations pertain to preventing the spread of non-native invasive species (i.e., pest plants, animals, or other organisms). Section 403 of the California Food and Agricultural Code (FAC) directs the California Department of Agriculture (CDFA) to "prevent the introduction and spread of injurious insect or animal pests, plant diseases, and noxious weeds."

FAC Section 5004 defines a noxious weed as follows: "Noxious weed means any species of plant that is, or is liable to be, troublesome, aggressive, intrusive, detrimental, or destructive to agriculture, silviculture, or important native species, and difficult to control or eradicate, which the director, by regulation, designates to be a noxious weed. In determining whether or not a species shall be designated a noxious weed for the purposes of protecting silviculture or important native plant species, the director shall not make that designation if the designation will be detrimental to agriculture." The state-listed noxious weeds are indicated in Section 4500 of the CCR.

CDFA develops and enforces regulations created to protect California from the importation, cultivation, and spread of plant species that are deemed "noxious" by law. Plant species that have been designated as noxious weeds may be subject to various restrictions including the statutory provisions for weed-free areas, California Seed Law, and noxious weed management. Management or control activities taken against noxious weeds may both protect California's agricultural industry and important native species.

CALIFORNIA PEST AND NOXIOUS WEED RATINGS

State-listed pests, including noxious weeds, are rated A, B, C, D, or Q based on CDFA's view of the statewide importance of the pest, the likelihood that eradication or control efforts would be successful, and the present distribution of the pest within the state. The ratings guide CDFA, county agricultural commissioners, and others regarding appropriate actions to take. "A" ranked pests are organisms of known economic importance and are subject to state enforced actions involving eradication, quarantine, containment, rejection, or other holding actions. "B" ranked pests are similar to "A" ranked pests, but actions taken to control them are at the discretion of the individual county agricultural commissioner. "B" ranked pests also include organisms subject to state actions and eradication only when found in a nursery. "C" ranked pests include organisms subject to no state enforced action outside of nurseries except to retard spread. "C" ranked pests are controlled at the discretion of the county agricultural commissioners. "Q" ranked pests are organisms or disorders requiring temporary "A" action pending determination of a permanent rating. The organism is suspected to be of economic importance but its status is uncertain because of incomplete identification or inadequate information. "D" ranked organisms include parasites, predators, and organisms of little or no economic importance that require no action.

Eleven invasive weed species were recently determined by CDFA to present a serious threat and are in the process of being added to the list of noxious weed species. They include the following species located within the lower Putah Creek watershed: *Ailanthus altissima* (tree of heaven); *Arundo donax* (giant reed); *Cortaderia jubata* (jubata grass); and *Tamarisk chinensis*, *T. gallica*, *T. parviflora*, and *T. ramosissima* (salt cedar). Additional invasive weeds within the watershed are already designated as state noxious weeds. The status of invasive weeds within the watershed is provided in the Invasive Weeds section in Chapter 7, "Invasive Weeds."

H.9 REFERENCES

Natural Resources Conservation Service (NRCS). 2002. Available <http://www.info.usda.gov/nrcs/ fpcp/fpp.htm>. Accessed May 2002.

California Department of Conservation (CDC). 2001. Division of Land Resource Protection. Williamson Act Program. Available <http://www.Consrv.ca.gov>. Accessed May 6, 2001.

APPENDIX **I**

RESTORATION AND ENHANCEMENT PROJECT PERMIT REQUIREMENT SUMMARIES

APPENDIX I RESTORATION AND ENHANCEMENT PROJECT PERMIT REQUIREMENT SUMMARIES

These project requirement summaries are intended to be distributed to all personnel or contractors performing any of the lower Putah Creek watershed restoration and enhancement activities listed below under contract or direct written agreement with the Lower Putah Creek Coordinating Committee (LPCCC) and Solano County Water Agency (SCWA), as part of the Lower Putah Creek Restoration and Enhancement project. These summaries were developed as a tool to consolidate information from a variety of sources, including project permits, into easy-to-use guides organized by the type of activity and stream channel zone in which the activity is to take place. Project requirements were specifically summarized from the following documents and permits developed and acquired for this project:

- Protective measures included in the project description in compliance with California Environmental Quality Act (CEQA) and as preparation for the Categorical Exemption (Cat Ex);
- Section 1600 Streambed Alteration Agreement from the California Department of Fish and Game (DFG);
- Clean Water Act Section 404 Nationwide Permit 27 from the U.S. Army Corps of Engineers;
- Clean Water Act Section 401 Clean Water Certification from the Central Valley Regional Water Quality Control Board (RWQCB);
- Informal consultation with the U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS).

Personnel and contractors performing any of the activities described below are responsible for complying with the requirements of the permits and project protective measures. Copies of those documents are available from the LPCCC.

For ANY work on the project, please familiarize yourself with the *General Restoration and Enhancement Project Requirements for All Ground-Disturbing Activities along Lower Putah Creek* first. Those requirements are organized into the following three stream channel zones in which activities may take place: upland, streambank, and in-stream work. Once familiar with the general requirements, please read the specific project activity requirements summary corresponding to the specific work activity that you will perform for this project. Specific project activities summaries are prepared for the following activities:

- Bank Stabilization
- Fish Habitat Enhancement
- Invasive Weed Removal

GENERAL RESTORATION AND ENHANCEMENT PROJECT REQUIREMENTS FOR ALL GROUND-DISTURBING ACTIVITIES ALONG LOWER PUTAH CREEK

General restoration and enhancement activities covered under this summary of project requirements include those activities involving ground disturbance and the use of heavy equipment such as grading, excavations, vegetation clearing, site preparation, and plant installation for vegetation planting, trash cleanup, and the creation of access roads. Any requirements specific to certain activities, such as invasive weed removal, are listed in the requirement summary for the respective activities, provided below. The following summary is organized by activities which will take place in upland, streambank, and in-stream locations. It is important to note that each zone includes the requirements of the preceeding zone. In other words, upland requirements apply to activities on the streambank as well as in-stream locations. Streambank requirements apply, as well, to activities that will take place in-stream.

UPLANDS

For the purposes of this document, the upland zone is considered to be natural habitat areas, grassland, fallow field, and developed, and other areas extending from the streambank to adjacent developed or agricultural areas. Upland areas are typically on a terrace above the streambank, and the distance from the low flow creek channel varies depending on the location along the creek. Requirements for activities in this zone include:

- Soil, silt, other organic material, petroleum products, or other excavated material shall not be placed where they could enter a water course.
- Prevent erosion, wash-out, and sedimentation by implementing protective measures in disturbed areas.
- Avoid and prevent spills of hazardous materials.
- Contractor (through Solano County Water Agency as the permit holder) shall notify the RWQCB and DFG immediately of any spill of petroleum products or other organic material.
- Areas cleared of native vegetation shall be stabilized and allowed to revegetate naturally.
- Use existing access roads wherever possible.
- Stage equipment in previously disturbed areas such as equipment pads or parking areas.
- No equipment shall be fueled within 500 feet of the stream channel, and no equipment will be parked within 50 feet of the stream bank.
- As soon as work is complete and equipment has been removed (and prior to the next rainy season), stabilize using erosion control methods and revegetate where needed.

- Elderberry shrubs shall be avoided. No ground disturbance shall occur within 20 feet of an elderberry shrub, unless approved by USFWS.
- Avoid construction and use of heavy machinery during the breeding season of raptors (February 1–August 31) and other migratory birds (April 1–August 31), if possible.
- If construction or heavy equipment operation is scheduled during the nesting season of raptors or migratory birds (February 1 to August 31), a focused survey for active nests shall be conducted by a qualified biologist within 15 days prior to the beginning of work. Survey results shall be faxed to Dale Watkins with DFG at (916) 358-2842, Notification Number R2020020357.
- If active nests are found during surveys, establish appropriate buffer (0.25 mile for nesting raptors, 50' for nesting migratory birds) or confer with DFG and USFWS regarding appropriate actions to comply with the Migratory Bird Treaty Act and Fish and Game Code.
- Conduct pre-construction surveys for borrowing owls in accordance with DFG protocols if suitable habitat for this species exists on-site. If no occupied burrows are present, no further avoidance measures are necessary. If occupied borrows are found, establish a 250' buffer around the borrow unless a different buffer size is agreed to with DFG.
- Stay out of established exclusion zones for nesting raptors, burrowing owls, and migratory birds.
- Known cultural resources should be flagged and avoided. If ground disturbing activities are scheduled for an area known to be sensitive, an archaeological monitor shall be present.
- If artifacts (including bones, fossils, arrowheads, pottery) are unearthed, work will stop immediately until the area can be inspected by an archaeologist.

STREAMBANKS

For the purpose of this document, the streambank extends from the open-water to the top of bank and terrace, ending where the upland area begins. The following requirements apply to activities in streambank areas in addition to all conditions specified above for upland area activities:

- A copy of the Streambed Alteration Agreement must be obtained by the contractor and must be available on-site during construction activities.
- Notify DFG within 2 working days of beginning work and within 2 working days of the completion of work. Fax notification to 916/358-2842 attention Dale Watkins, DFG, Notification Number R2-2002-357.
- Avoid or minimize clearing of native riparian vegetation when creating access to the streambank for equipment or conducting work within the riparian corridor.

- Minimize grading of the existing stream bank. Grade access point only where necessary to allow safe passage of vehicles.
- Best Management Practices (BMPs) must be used to preclude increased turbidity and to ensure that road construction does not restrict or impede the passage of normal or expected high flows or cause relocation of the water.
- Wetlands shall be flagged and avoided.

IN-STREAM

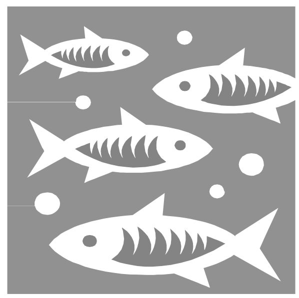
For the purpose of this document, the in-stream zone includes all open water areas. The following requirements apply to activities taking place in-stream, in addition to all requirements specified above for activities in upland and streambank areas:

- Placement of fill in waters of the U.S. shall be avoided whenever possible.
- No litter or construction debris may be left within the stream zone.
- Notify RWQCB in writing (through Solano County Water Agency) of the start of any in-water activity.
- Conduct in-stream work between August 31 and October 31 or whenever Los Rios check dam is removed;
- Time work with awareness of precipitation forecast and likely increases in stream flows;
- Employ BMPs to minimize turbidity and soil erosion during in-stream construction activities. Use materials such as silt fencing to minimize siltation and turbidity.
- Activities should not result in substantial turbidity increases in the watercourse.
- If turbidity increases, monitor per conditions set in CWA Section 401 certification and notify RWQCB if standards stated in the agreement are exceeded.
- Activities should not cause visible oil, grease, or foam in the work area or downstream.
- Discharge of petroleum products or other excavated material to surface waters is prohibited.
- If work in flowing water is unavoidable, divert water around work area and back into stream channel as specified in the Streambed Alteration Agreement.
- Emphasize use of natural materials such as tree trunks, willow cuttings, grass and sedge plugs, and natural gravel from adjacent gravel bars when implementing erosion control measures.

BANK STABILIZATION

Activities included under this category include minor grading and re-sloping, the redistribution of materials on the bed and bank, and the installation of biorevetment such as riparian bush mattress, straw mats, jute mesh, and grass seeding.

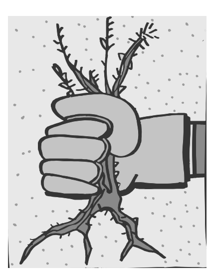
- Before beginning work, make sure appropriate surveys for nesting raptors and migratory birds have been conducted and exclusion zones for active nests, elderberries, wetlands, and known cultural resources have been established, as described above in the general requirements.
- Natural bank stabilization shall be installed immediately following weed abatement or other activities, where necessary to minimize erosion.
- If used, biorevetment materials (ex., mats and seeds) shall be placed by hand or by small equipment.
- Seeding may be done by hand or by using a drill seed attachment to a small tractor or similar equipment.



FISH HABITAT ENHANCEMENT

Activities included under this category include the installation of instream structures such as boulders, tree limbs, and spawning gravels, and the planting of vegetation on the streambanks to enhance Shaded Riverine Aquatic (SRA) habitat.

- Before beginning work, make sure appropriate surveys for nesting raptors and migratory birds have been conducted and exclusion zones for active nests, elderberries, wetlands, and known cultural resources have been established, as described above in the general requirements.
- Material (boulders, tree limbs, and clean gravel) will be placed in the streambed by hand or by using small excavators.
- In-stream work shall be conducted during late summer or fall low-flow periods (August to October), while planting of riparian vegetation may take place at any time.
- Some gravel needed for the streambed may be collected from the immediate vicinity of if the gravel is sifted to remove the silt and sand.



Invasive Weed Abatement

Activities included under this category include the removal of invasive weeks

Methods to be used include:

- Hand methods (i.e., manual cutting with loppers or chainsaws);
- Herbicide application restricted to weed infestation areas, including use of backpack sprayers, hand bottles, hand-held spray wands connected to suitable spray equipment etc.
- Equipment – use of backhoes or excavators to remove continuous stands of Arundo, tamarisk, or similar invasive weeds where hand removal is not feasible.

Weed removal specific details:

- Before beginning work, make sure appropriate surveys for nesting raptors and migratory birds have been conducted and exclusion zones for active nests, elderberries, wetlands, and known cultural resources have been established as described above in the general requirements.
- Use only focused applications of selective low toxicity (to fish and wildlife) herbicides approved by the Cal Environmental Protection Agency for use over or near waterways, in wildland settings, and adjacent to farms.
- No aircraft application of herbicides will occur between March 15 and August 31 to protect nesting migratory birds.
- Minimize grading of the existing stream bank. Grade access point only where necessary to allow safe passage of vehicles.
- As soon as work is complete and equipment has been removed (and prior to the next rainy season), stabilize using erosion control methods and revegetate where needed.
- Use existing access roads wherever possible.
- Minimize removal of native riparian vegetation.
- Any native riparian tree 3-inches diameter breast height (DBH) or larger removed from fully infested weed stands shall be replaced on-site at a 2:1 ratio.
- When stockpiling cut invasive plant materials, place stockpiles in previously disturbed areas more than 50 feet from flowing water where currents cannot disperse them. Prevent live plant material from entering moving water at any time. Dispose of invasive plant stockpiles in the channel within 4 weeks and within upland areas within 3 months of creation by removal to appropriate upland or by burning.
- Material may be burned in place in accordance with state and local permits providing it does not damage sensitive resources (all appropriate state and local permits must be obtained).

- No burning can occur within 1,000 feet of native riparian or wetland habitat between March 15 and September 15 to protect nesting migratory birds.
- All exposed/disturbed areas larger than 5 acres will be seeded with native and non-native grasses and covered with broadcast straw, jute netting, coconut fiber, etc.