Lower Putah Creek Watershed Management Action Plan
Phase I – Resource Assessments

Text and Appendices

Prepared for:

Lower Putah Creek Coordinating Committee

Contact:

Rich Marovich
Putah Creek Streamkeeper

December 2005

EDAW

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P 1T136.02

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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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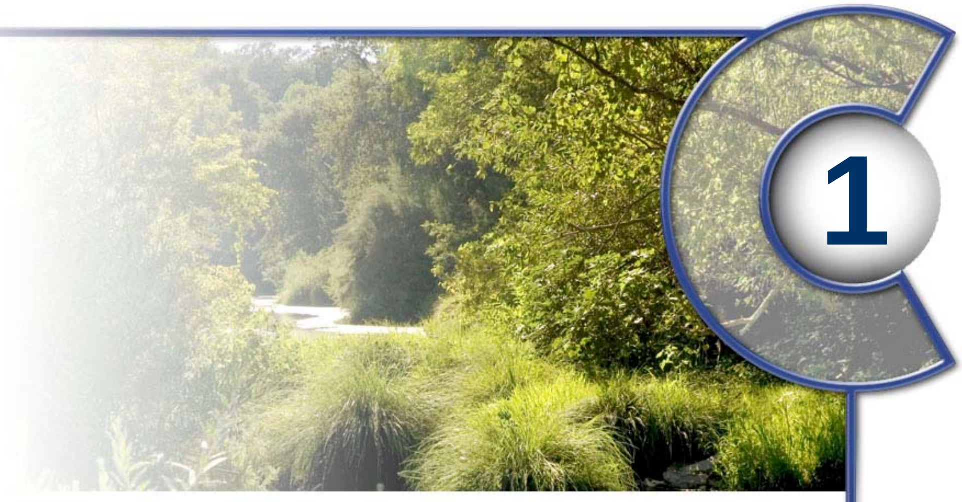
ACRONYMS AND ABBREVIATIONS

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."

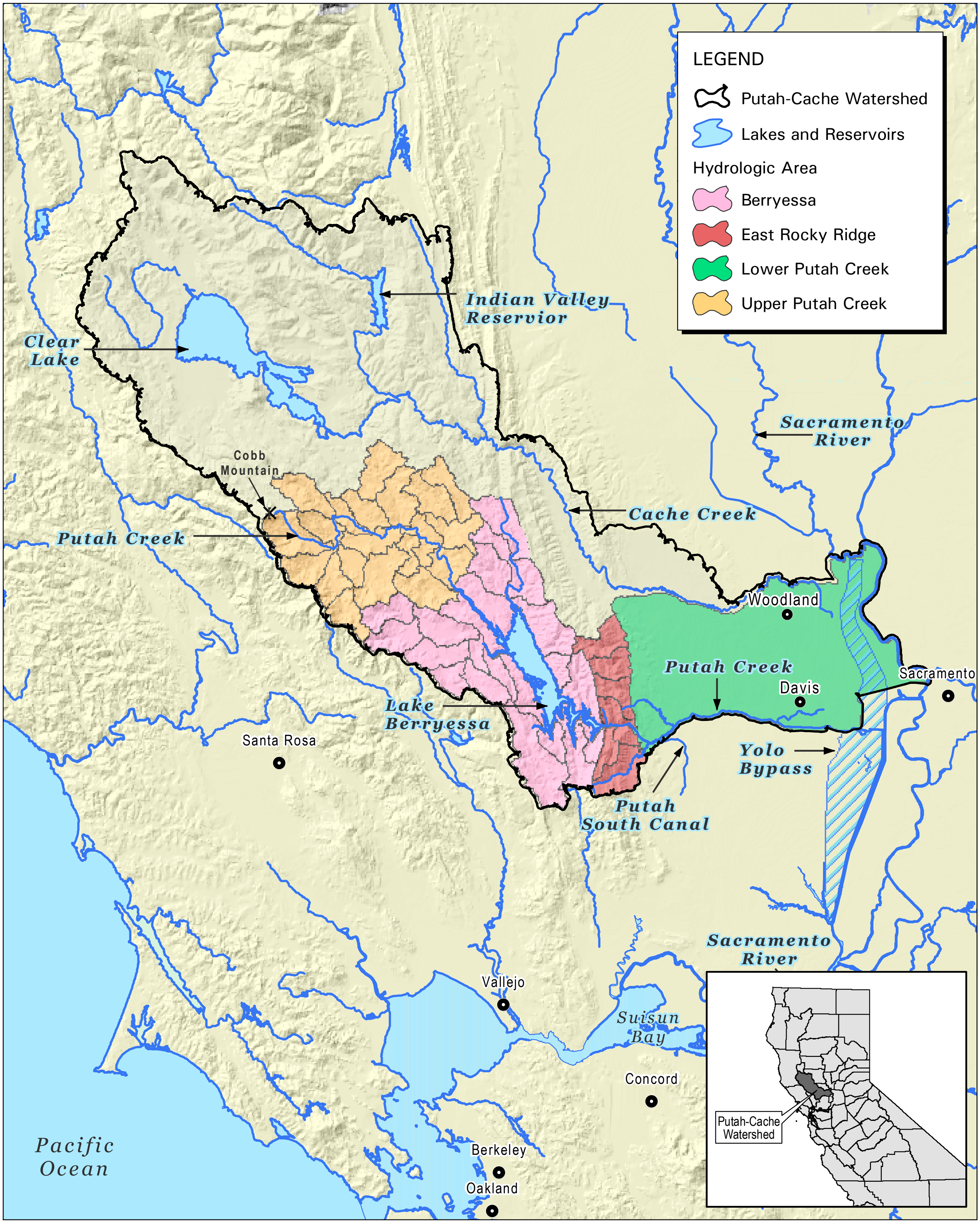
-Rob Thayer on Putah Creek, October 15, 1996

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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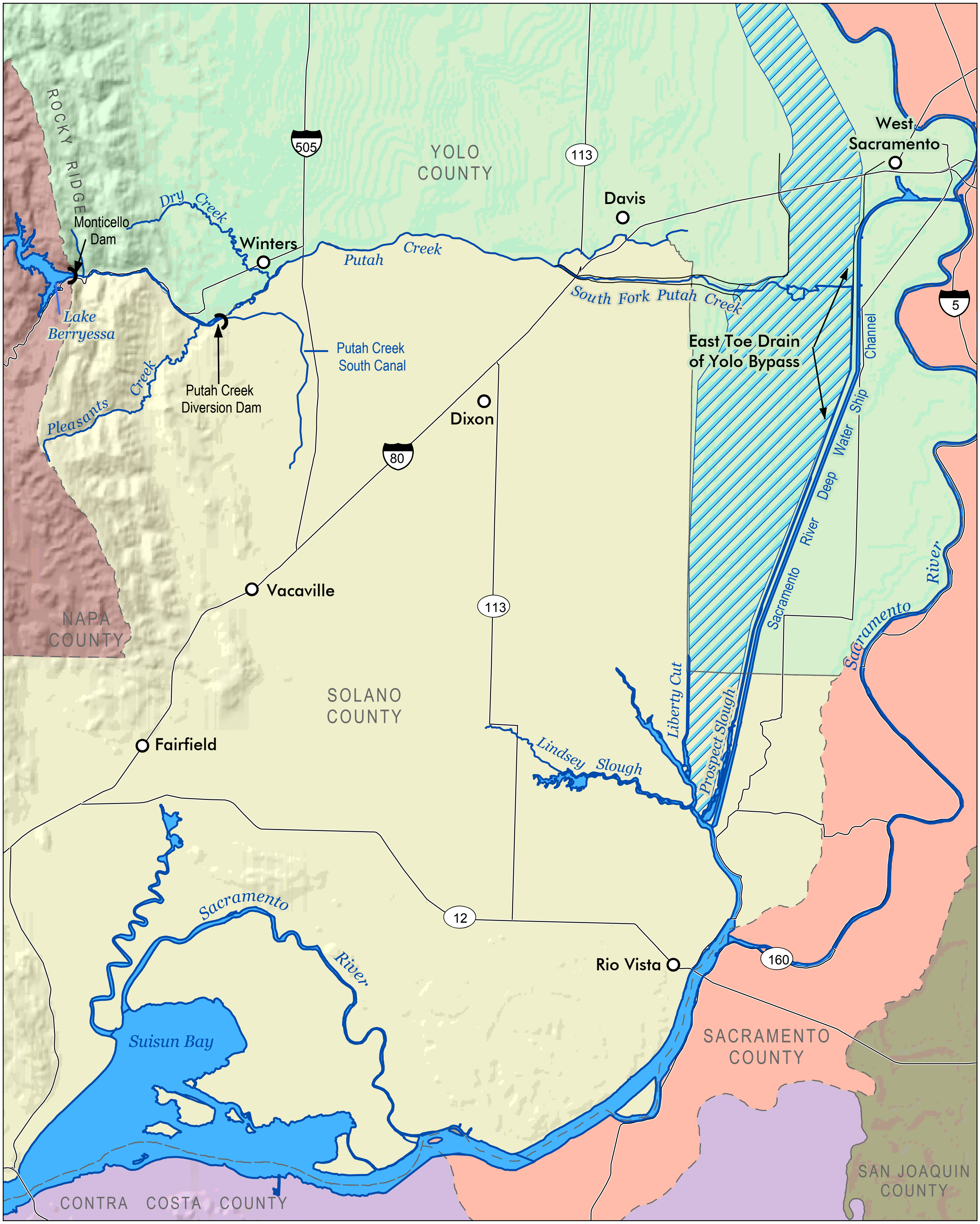

Source: Teale GIS Solutions Group 1999, U.S. Census Bureau 2002, U.S.G.S 1993

Lower Putah Creek Regional Area

EXHIBIT 1-2

Lower Putah Creek Watershed Management Action Plan

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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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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

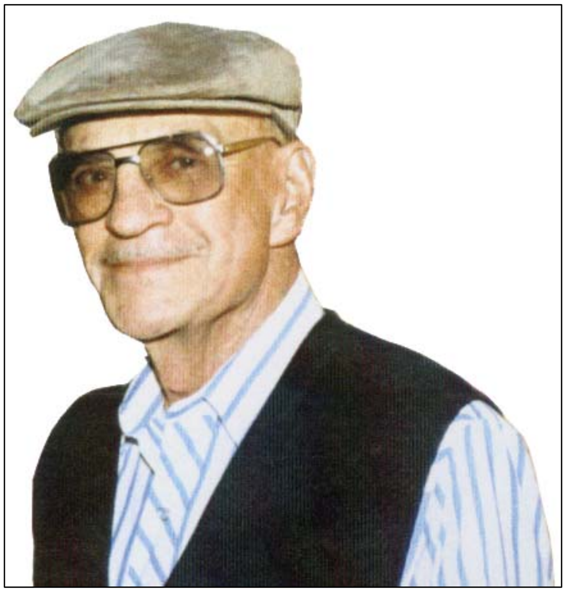
CLIMATE

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.

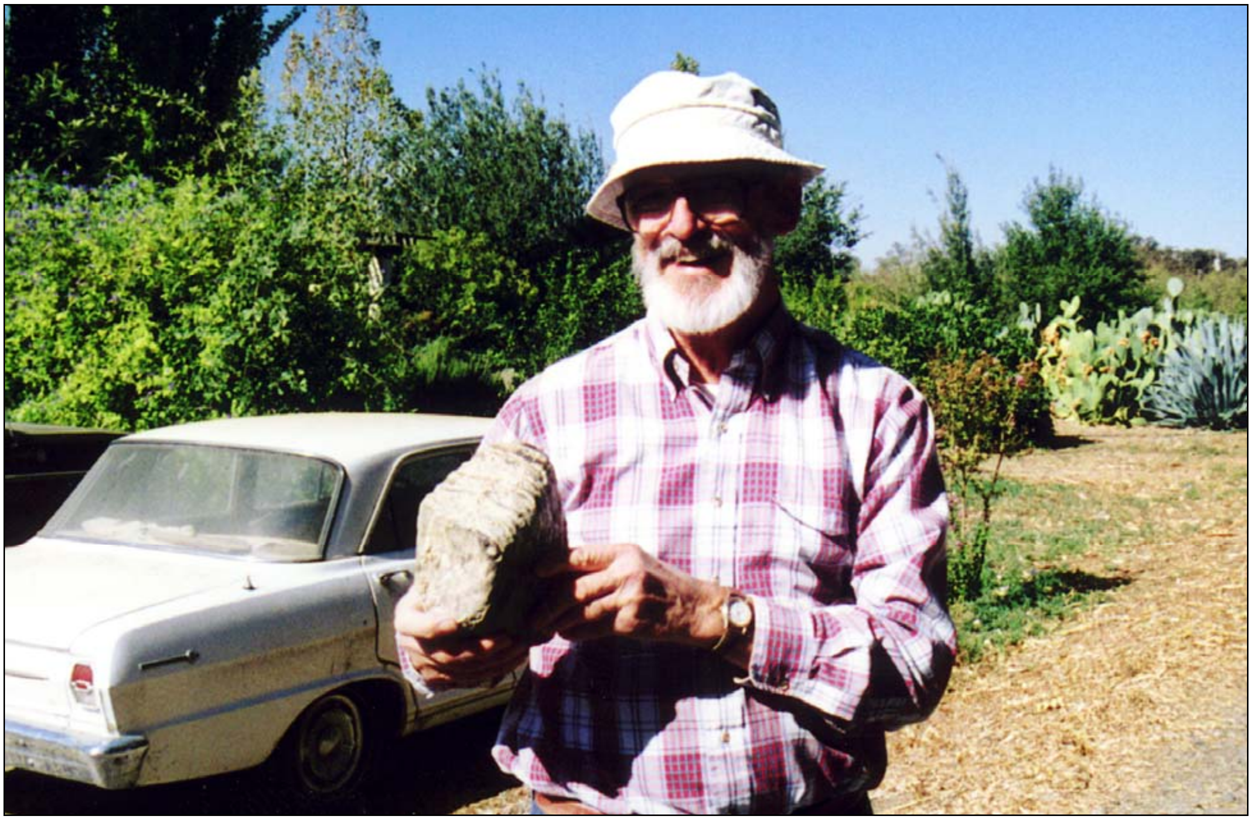
Raptors that nest adjacent to Putah Creek include white-tailed kite, red-shouldered hawk, red-tailed hawk, Swainson's hawk, and great-horned owl. The diverse array of mammals along Putah Creek and the nearby fields and hills include weasels, minks, skunks, opossums, beavers, river otters, rabbits, deer, 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.

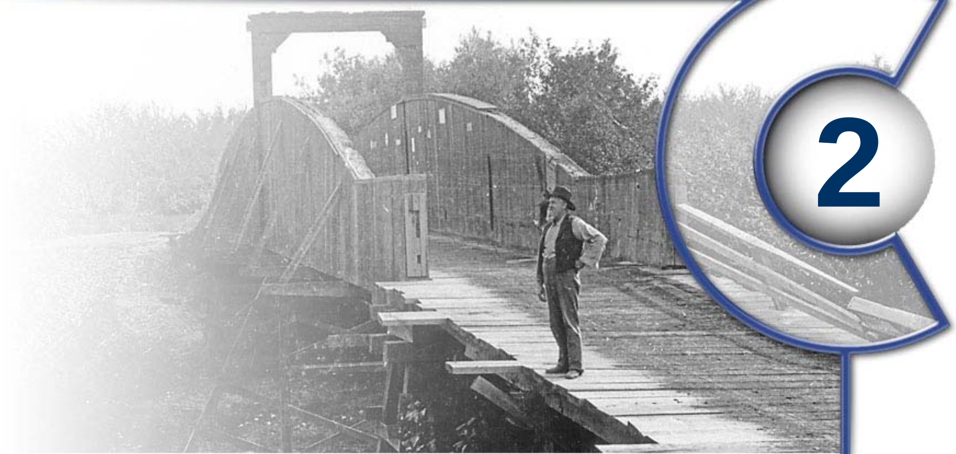
Putah Creek was first named by early native peoples who lived along its banks. Jack Forbes, professor emeritus of Native American Studies at UC Davis says that the ancient village of Poo-tah-toi appears to have been located on the north bank of what used to be called "the river of the Poo-tah-tos," near 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

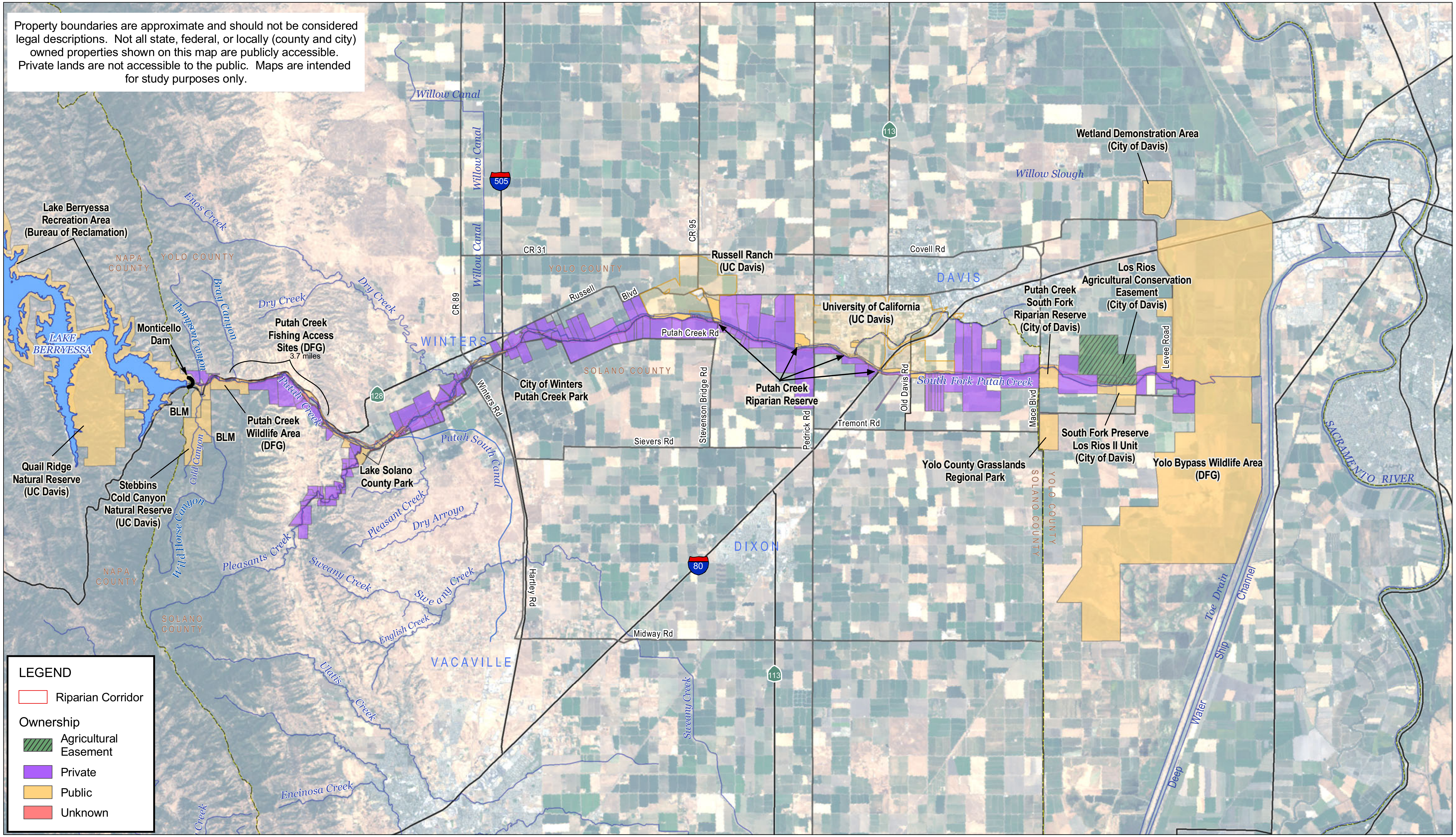
There are over 100 different private landowners that own property in and adjacent to the lower Putah Creek and Pleasants Creek riparian corridors. Private lands within and adjacent to the riparian corridors account for 10,824 acres, or 78% of the creek and creek-side parcels. A number of local and regional 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

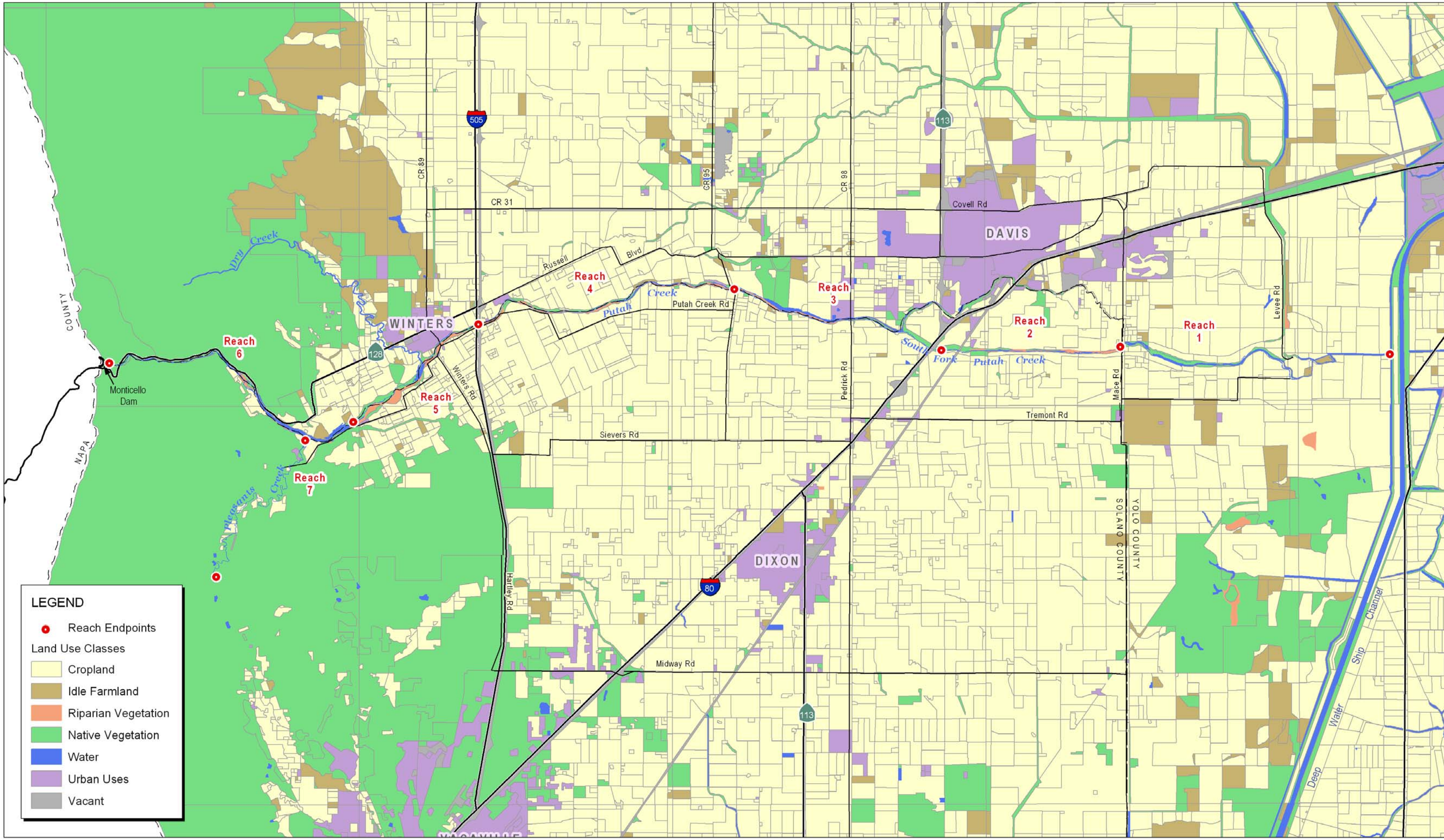
Currently, urban development in the vicinity of the lower Putah Creek riparian corridor is concentrated within the cities of Davis and Winters. Urban development accounts for approximately 4% of the land adjacent to the riparian corridors and consists primarily of low-density residential development, 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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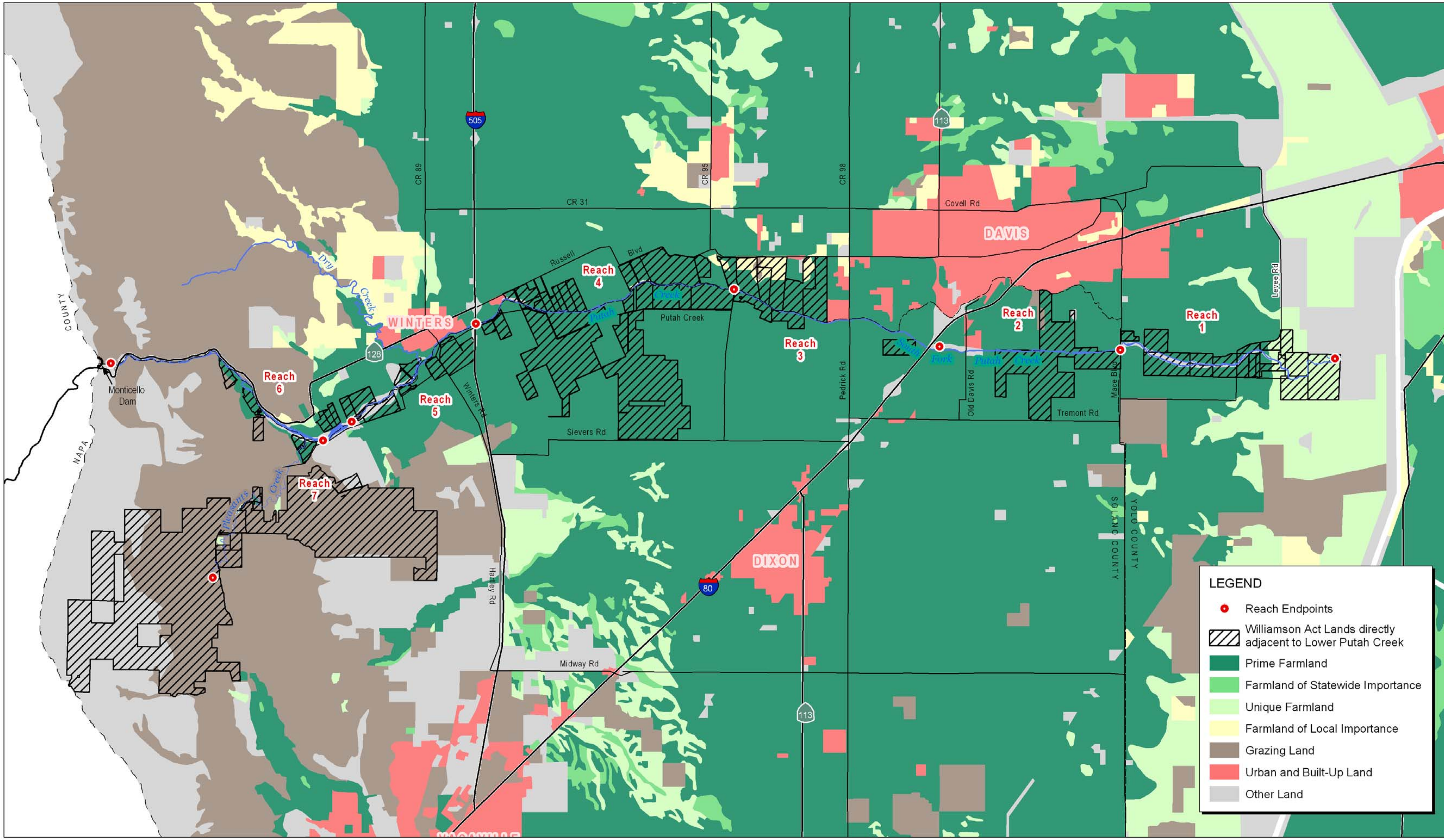

Source: Department of Conservation (DLRP) 2002, DLRP 2000, EDAW 2003.

Williamson Act Lands and Important Farmland Map

Lower Putah Creek Watershed Management Action Plan

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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.

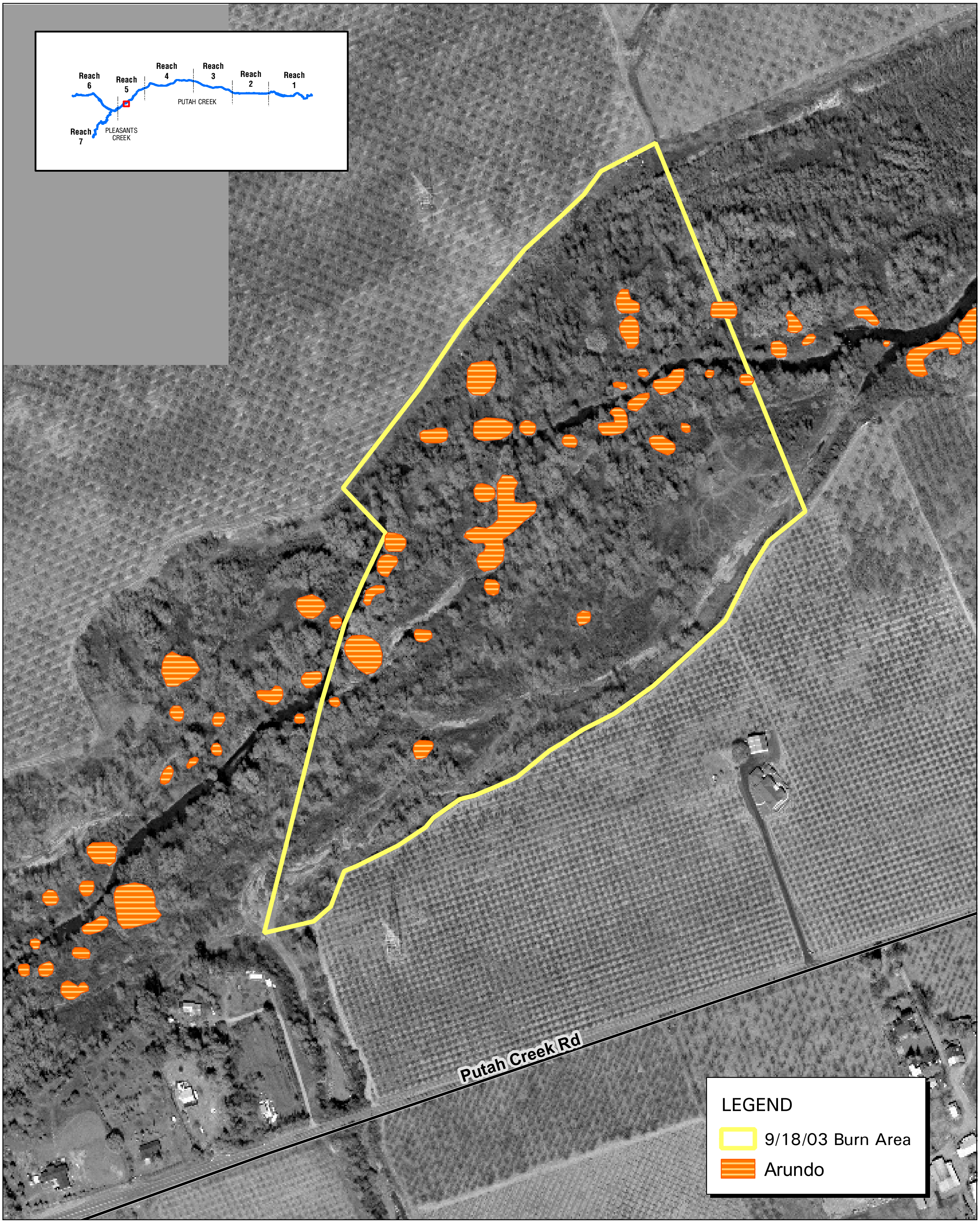
The following is a summary of the fire and fuel load vegetation management programs and techniques used by various landowners and managers within the Putah Creek riparian corridor.

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

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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.

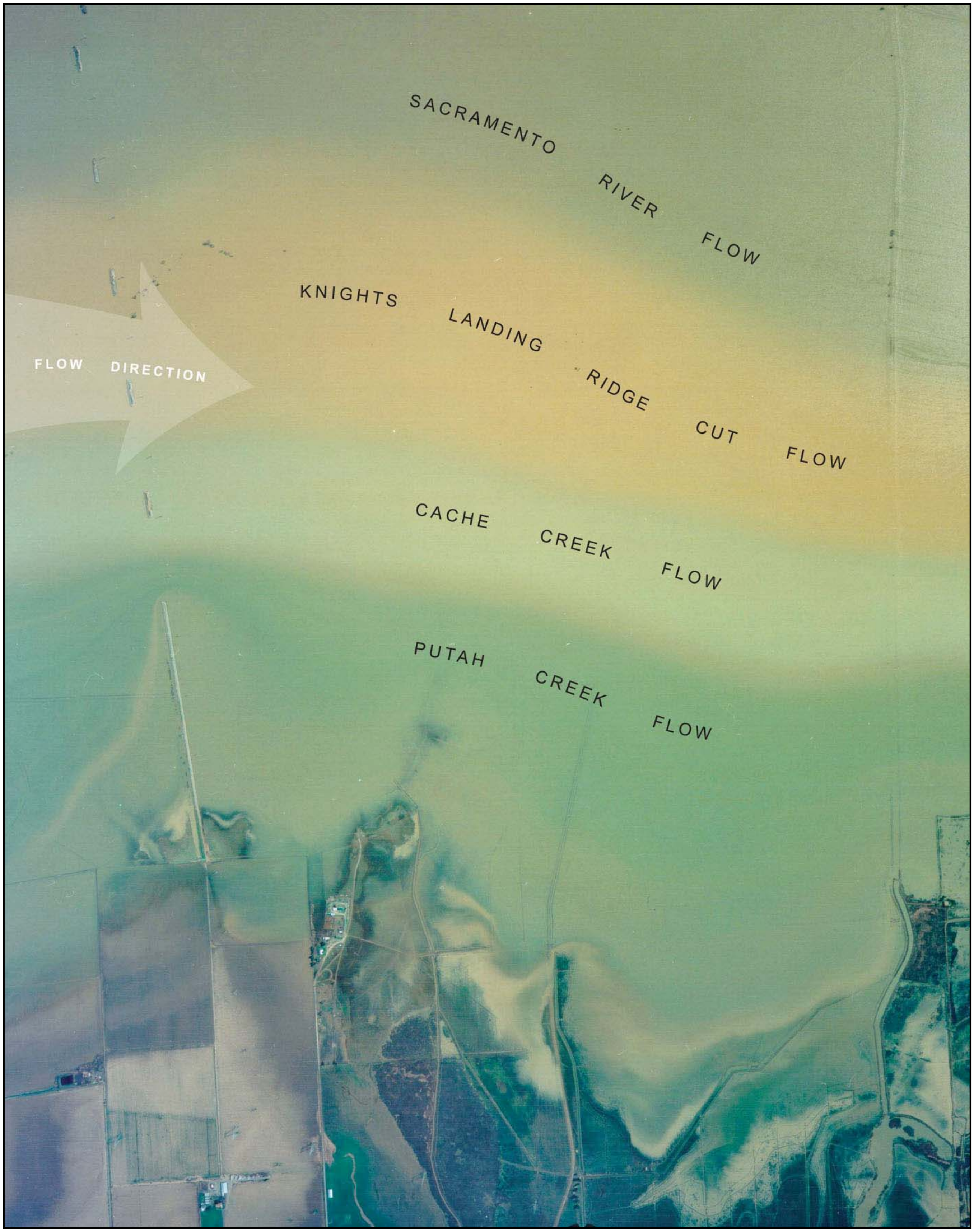
Notable tributaries to lower Putah Creek include Thompson Creek, which enters along the north side of Putah Creek just downstream of Monticello Dam, and Cold Creek, which enters slightly farther downstream on the south side. Pleasants Creek enters from the south just upstream of Lake Solano. Dry Creek 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
P 01110136.02 12/05

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).

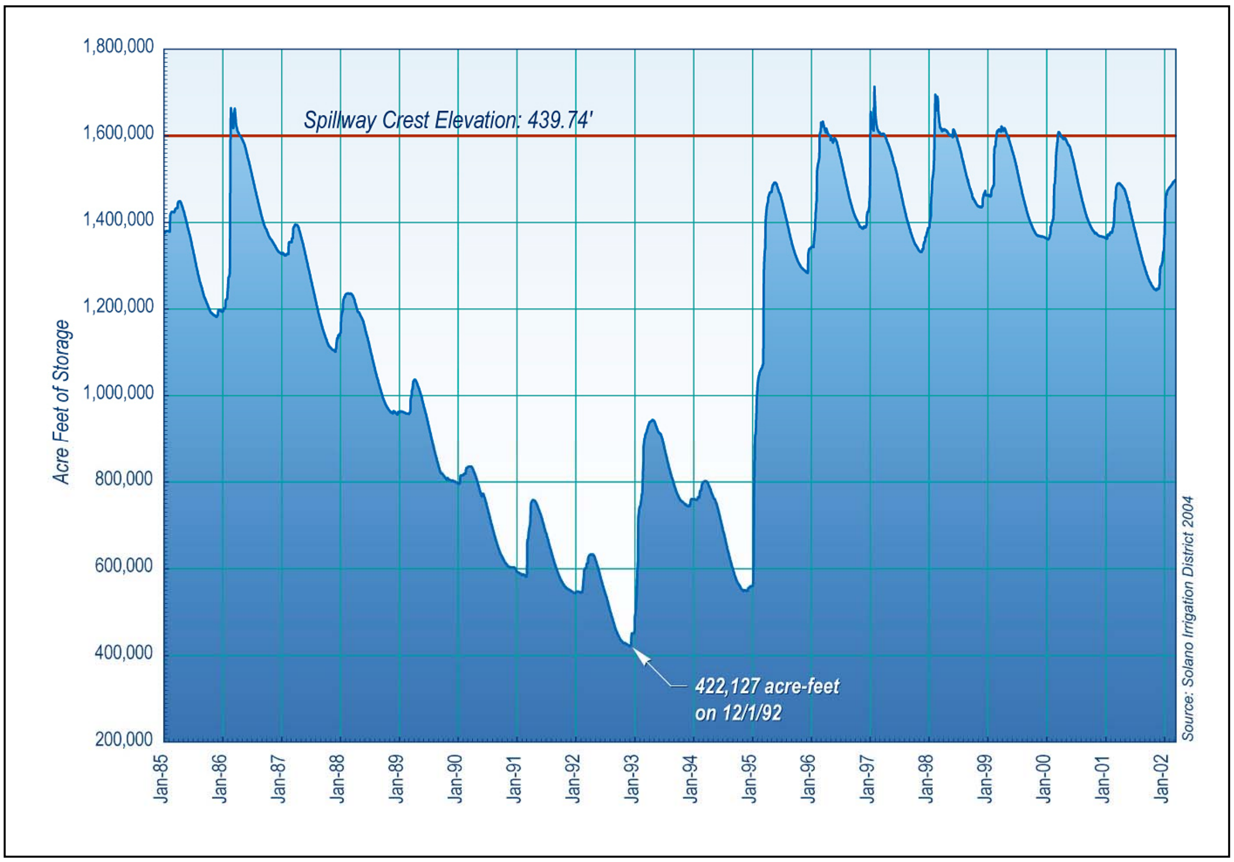
Solano Irrigation District (SID) diversions to Putah South Canal average about 207,350 acre-feet annually from Lake Solano, equivalent to about 55 percent of the total water yield in the upper subbasin. Consequently, the Solano Project has also dramatically reduced the natural fluctuations and peaks 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.

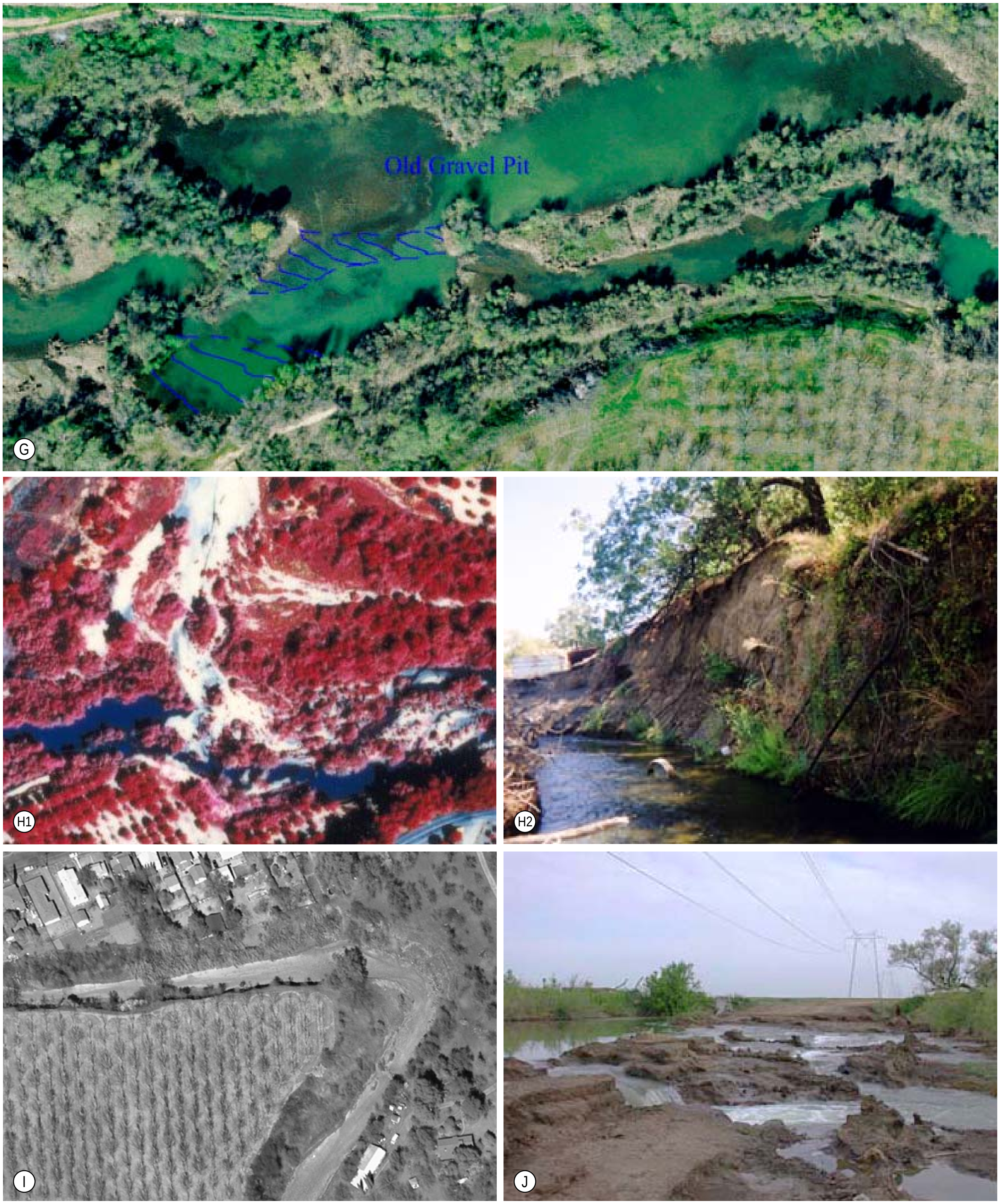
Pleasants Valley Road was constructed in the bottom of the valley alongside the creek and numerous bridges and their abutment structures within the channel create streamflow energy concentration zones with associated changes in erosion and deposition. Solano County has repeatedly installed riprap revetment 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

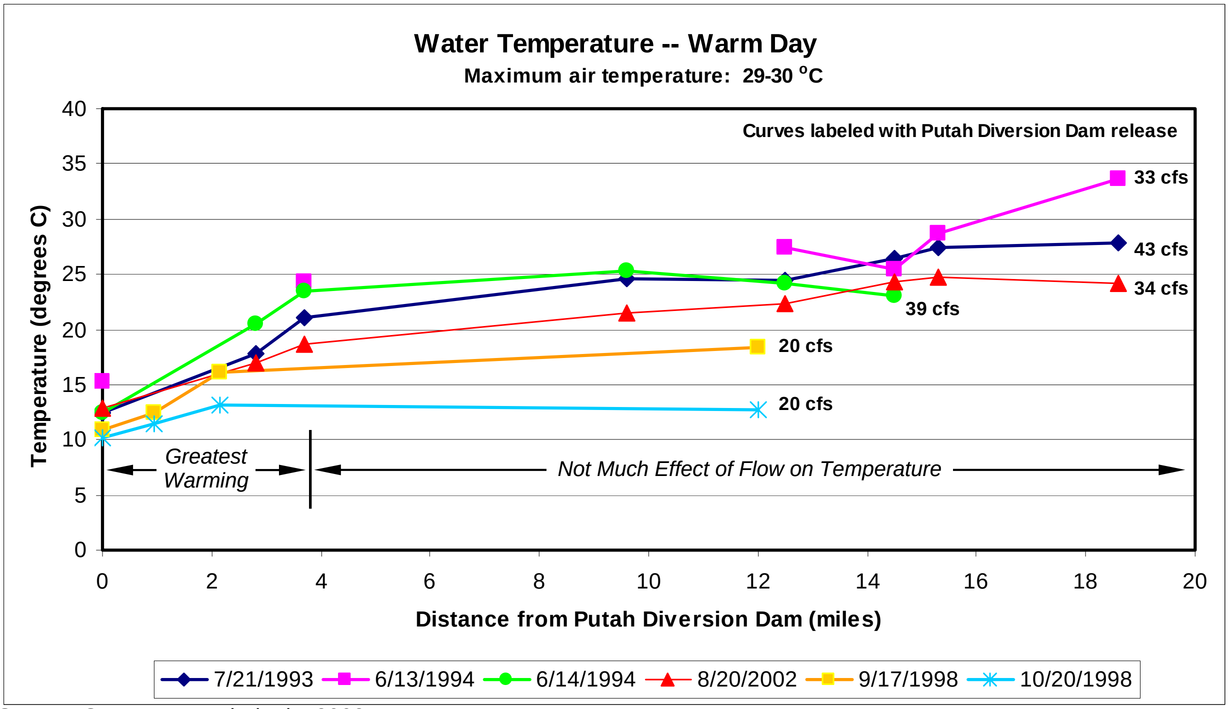
This section assesses of the initial set of water quality factors or issues identified as important to resources in the lower Putah Creek watershed. The factors or issues evaluated include those for which there is some data or information to begin to formulate conclusions such as determining seasonal 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.

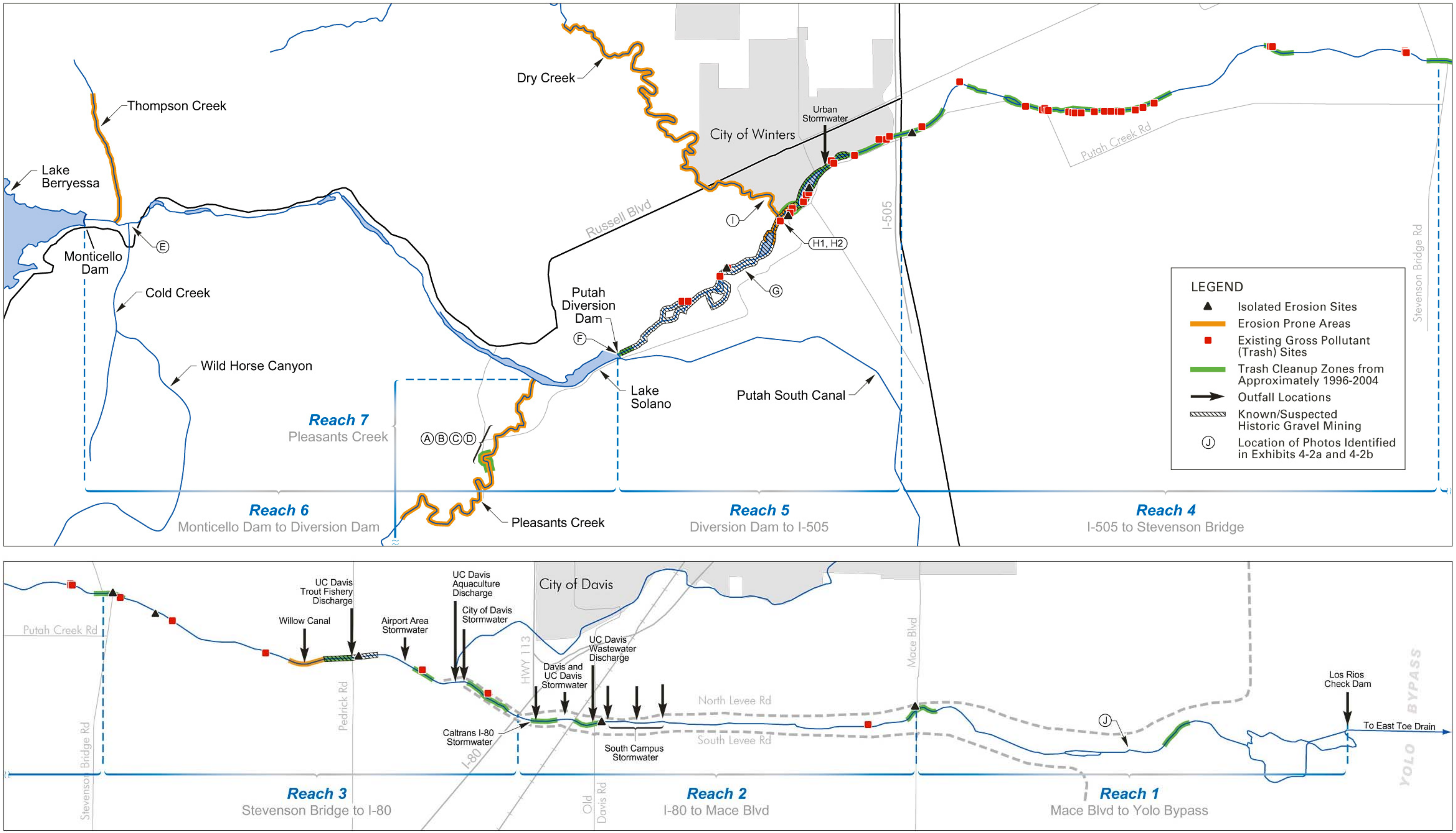
In 2001, the Winters Putah Creek Committee in cooperation with Solano County Department of Environmental Management installed a vehicle barrier at the I-505 bridge crossing over Putah Creek to restrict vehicle access and reduce illegal dumping. The LPCCC is seeking to install a farm gate at the southwest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

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.