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Executive Summary

Goals and objectives

The overall goal of the Stillwater–Churn Creek watershed assessment is to provide an understanding of the ecological processes at work in the Stillwater, Churn, and Clover Creek watersheds, linking past and current human activities and land uses to current landscape conditions, and placing particular emphasis on aquatic resources. Associated specific goals of this watershed assessment are to:

- support the CALFED Bay-Delta Program goal of restoring the ecological health and improving the management of the Bay-Delta system by working with communities in the Sacramento/San Joaquin Basin at a watershed level;
- support the efforts of the Western Shasta Resource Conservation District (WSRCD) in areas of environmental education and stakeholder outreach, and;
- enhance collaboration and coordination between public agencies and non-governmental stakeholders.

Discrete objectives of this watershed assessment report are to:

- characterize the watershed in terms of the dominant physical, biological, and human processes and features;
- compile information using geographic information system (GIS) tools;
- describe the current range, distribution, and condition of ecosystem elements in the watershed;
- describe how these ecosystem elements have changed through time;
- synthesize and interpret the information about current and historical ecosystem elements to establish cause and effect relationships between elements;
- determine if watershed conditions may be limiting beneficial water uses;
- identify areas where additional information is needed; and
- facilitate development of conclusions and suggestions by the public agencies and non-governmental stakeholders.

This watershed assessment treats the existing and potential beneficial uses of surface water defined in the Water Quality Control Plan for the Sacramento River Basin and San Joaquin River Basin as its primary ecological endpoints. The beneficial uses that apply to streams in the Stillwater-Churn Creek watershed are as follows:

- *Municipal and domestic supply:* uses of water for community or individual supply systems, including but not limited to drinking water.
- *Agricultural supply:* uses of water for farming, horticulture, or ranching.
- *Industrial supply:* uses of water for industrial purposes that do not primarily depend on water quality (e.g., mining, fire protection), and uses of water for hydropower generation (in this instance, uses for hydropower that is being generated are outside of the assessment area).
- *Groundwater recharge:* uses of water for natural or artificial recharge of groundwater for purposes of future extraction and maintenance of water quality.
- *Freshwater replenishment:* uses of water for natural or artificial maintenance of surface water quantity and quality.

- *Recreation*: uses of water for contact and non-contact forms of water recreation.
- *Freshwater habitat*: uses of water that support warmwater and coldwater ecosystems and associated habitats.
- *Migration of aquatic organisms*: uses of water that support habitats necessary for migration of aquatic organisms.
- *Spawning, reproduction, or early development*: uses of water that support habitats suitable for spawning, reproduction, or early development of fish.
- *Navigation*: uses of water for shipping, travel, or other transportation.

This watershed assessment identifies how these ecological endpoints are potentially affected by changes in the dominant ecological components and ecosystem processes. It focuses on the existing and historical relationships between ecological components, ecosystem processes, and ecological endpoints, and strives to project, in a qualitative way, how natural or human-induced changes could diminish the ability of the watershed to achieve the desired endpoints.

Funding Sources

This watershed assessment was funded through a grant agreement between the State Water Resources Control Board (SWRCB) and the WSRCD under the Proposition 13 Watershed Grant Program.

Technical Advisory Committee

Following award of the grant, the WSRCD formed a Technical Advisory Committee (TAC) and the Stillwater–Churn Creek Watershed Alliance (Alliance) to foster participation in the watershed assessment by public agencies, Native American tribes, non-governmental entities, and individual stakeholders. The TAC is composed of WSRCD staff and specialists from cooperating agencies. The TAC members provided information, data, and technical review for this assessment.

TAC members include:

Marcia Ames	City of Redding Municipal Utilities
Bob Bailey	Natural Resources Conservation Service
David Braithwaite	City of Redding Development Services
Tricia Bratcher	California Department of Fish and Game
Lynda Burkhalter	California Conservation Corps
Guy Chetelat	Regional Water Quality Control Board
Jim Coats	City of Redding Development Services
Dennis Daily	City of Shasta Lake Public Works
Brad Dupre	Landowner
Eda Eggeman	California Department of Fish and Game
Chris Glover	Western Shasta Resource Conservation District
Margie Graham	California Department of Water Resources
Stuart Gray	Western Shasta Resource Conservation District
Don Groundwater	Bella Vista Water District
Mike Harris	Western Shasta Resource Conservation District
Brenda Haynes	Landowner/California State Assembly Representative
Dennis Heiman	Regional Water Quality Control Board
Scott McDonald	California Department of Forestry and Fire Protection
Karen McGrath	City of Redding Community Services
Bob Nash	Landowner
Julie Nelson	Shasta-Trinity National Forest

Beth Norby	Regional Water Quality Control Board
Jon Oldham	City of Redding Development Services
Brenda Olson	U.S. Fish and Wildlife Service
Gracious Palmer	Landowner/Council-member, City of Shasta Lake
Mary Pfeiffer	Shasta County Department of Agriculture
Dale Pooley	Landowner
Gail Rich	Landowner
Maureen Robison	Landowner
Dan Scollon	Landowner/Shasta College
Brian Sindt	McConnell Foundation
Randall Smith	Rotary Club of Redding
Larry Solberg	Landowner
John Stacher	City of Redding Municipal Utilities
Terri Thesken	City of Redding Development Services
Carla Thompson	City of Shasta Lake Development Services
Richard van Whye	Landowner

Watershed Location

The Stillwater–Churn Creek watershed consists of the lands that receive precipitation that runs off, as surface flow, into Stillwater, Clover, or Churn creeks. Each of these creeks occupies a distinct watershed and is a discrete tributary to the Sacramento River. The assessment area is located at the far northern end of the Central Valley of California, and is bounded on the north and northwest by the southernmost extent of the Klamath Mountains; on the south and southwest by the Sacramento River; and on the east by the nearly level to gently rolling landscape of the Stillwater Plain. This watershed area encompasses approximately 77,735 acres. Portions of the watershed area are located on five U.S. Geological Survey 7.5-minute quadrangle topographic maps, including, "Cottonwood," "Enterprise," "Redding," "Project City," and "Shasta Dam." The general location of the assessment area is shown on Figure ES-1.

The topography of the assessment area is variable. Elevation ranges from 450 feet mean sea level (msl) near the Sacramento River to 2,780 feet msl at Bass Mountain located in the northwest portion of the watershed. Slopes over the large majority of the study area are less than 10 percent. Lands adjacent to and immediately upstream from the Sacramento River are nearly level. East and north of Redding, the topography ranges from nearly level to undulating, with steep slopes occupying the areas immediately adjacent to creeks. Further north, the topography becomes increasingly steep, and the northernmost portions of the study area are dominated by mountainous terrain with slopes steeper than 30 percent.

A diverse assemblage of geologic, geomorphologic, and soil types characterizes the watershed. The steep landscapes in the northernmost sections are underlain by the sedimentary and metamorphic rocks of the Klamath Mountains. Soils in these areas generally are cobbly or gravelly and are less than 5 feet deep. Ancient river terraces north and east of Redding are composed of gravelly and cobbly alluvium and are characterized by high clay content. The nearly level lands adjacent to and immediately upstream from the Sacramento River are composed of gravelly and sandy alluvium deposited in recent time. Soils that develop in these materials generally are deeper than 5 feet and vary in texture from sandy to loamy.

Resources and Land Use

All of the streams in the Stillwater-Churn Creek watershed are classified as intermittent, rain-driven tributaries of the Sacramento River that carry runoff and

shallow groundwater accretions from October through June and are typically dry throughout many reaches during the summer. Because of the transitional geographic location of the assessment area, the area supports diverse vegetation communities and a varied assemblage of wildlife and fish species, including a mixture of species typically found in the Central Valley, foothill, and low- to mid-elevation mountainous regions of northern California. Significant biological resources, including special aquatic sites and special-status species and their habitats, occur within the Stillwater–Churn Creek watershed. Significant biological resources that occur in the assessment area include riparian communities, seasonal wetlands, vernal pools, stream and pond habitats, and the organisms that occupy these habitats. The assessment area falls within the range of more than 100 special-status plant and animal species, including several listed species that depend on vernal pools; cold, freshwater environments; or riparian plant communities to complete crucial life-stages. The watershed area contains habitat designated as critical to the continued existence and recovery of several federally listed species, including spring-run Chinook salmon, winter-run Chinook salmon, steelhead, and vernal-pool fairy shrimp and tadpole shrimp.

Historic land use within the watershed included pre-Columbian Native American seasonal encampments and villages, especially near the principal streams and the Sacramento River, and with European settlement, a number of small towns, mining and construction camps, farms and ranches, railroads, roads, and highways were established through the mid-twentieth century. During this time, small-scale irrigation diversions from watershed streams, aggregate mining of the stream beds, grazing, land conversion, road construction, and introduction of non-native animals and plants (particularly the giant reed, *Arundo donax*) altered the patterns of stream flow, water quality, and the quality of upland and aquatic habitats within the watershed and in downstream portions of the Sacramento River.

Today 96 percent of the land within the watershed is privately owned and 4 percent is administered by three federal agencies (Bureau of Land Management, Forest Service, and Bureau of Reclamation) and local municipalities. City and county general plans have zoned nearly 65 percent of the watershed for urban or suburban residential use, 12 percent for commercial/industrial and public facilities, 10 percent for parks and open space, and about 13 percent for agriculture and mining.

Currently, the watershed is experiencing unprecedented urban and suburban development and 17 percent of the watershed area is now considered urban. While this trend can enhance the economic and cultural vitality of the region, development also carries with it a potential to affect ecological processes and, ultimately, the suitability of the terrestrial and aquatic environments for beneficial uses. For example, wildlife migration corridors are interrupted by roads and property barriers, urban refuse and pollutants in storm runoff contaminate stream habitat, and lands are converted from wildlife habitat for other human uses. Additionally, impervious cover, such as roads, parking lots, and rooftops, can greatly reduce the ability of land to absorb precipitation, altering hydrologic pathways and stream flow patterns, increasing erosion and sedimentation, and expanding the frequency and extent of floods. The current trend toward more intensive land uses also increases the risk of wildfire in the watershed and challenges decision-makers to

balance fuels management with other—potentially competing—ecological objectives.

Stakeholder Concerns

Early in the watershed assessment process, the WSRCD staff met with the TAC and the Alliance to receive input on the analytical focus of the assessment. The participants identified 82 issues for possible consideration. The issues proposed for analysis by these groups, the portions of the watershed to which they are relevant, and the sections of this assessment where they are discussed and analyzed are listed in the following table, Table ES-1, Index to Issues of Stakeholder Concern.

Table ES-1
Index to Issues of Stakeholder Concern

	Stakeholder Assessment Topics				Watershed Assessment Treatment			
Issues	All Three Watersheds	Clover Only	Churn Only	Stillwater Only	Yes	No, Not Relevant	No, No/Limited Data	Chapter/Sub-section
Development and Related Effects								
Developmental pressures	x				x			1.4.5, 2.1.1, 3.7.2, 3.7.3, 3.7.5
Rate of development	x				x			2.1.5, 3.7.2, 3.7.5
Detention responsibilities from development	x							2.1.1, 2.2.2, 3.5.1, 3.5.2, 3.6.1, 4.2, 4.4, 4.7
Development of on-site retention	x							2.2.2, 3.5.1, 4.2, 4.4, 4.7
Developmental setbacks	x				x			3.1.2, 3.7.1, 3.7.5, 4.3, 4.4, 4.6
Trails, parks, and preserves—City, County, McConnell	x				x			Trails: 2.1.1, 2.1.4, 3.2.2, 3.5.1, 3.7.2, 3.7.4, 4.3 Parks: 3.4.3, 3.5.1, Table 3.6-1, 3.7.2, 3.7.4, 4.2, 4.3, 4.6 Preserves: 4.4

Table ES-1
Index to Issues of Stakeholder Concern

	Stakeholder Assessment Topics				Watershed Assessment Treatment			
Issues	All Three Watersheds	Clover Only	Churn Only	Stillwater Only	Yes	No, Not Relevant	No, No/Limited Data	Chapter/Sub-section
Shastina Ranch: 1200 to 1500 new homes (bounded by Knighton, Airport, and Rancho Roads)—identify and review environmental reports		x			x			3.7.5
Developmental Pressures (Auto Mall)			x		x			3.7.5
Oasis Road development iIssues—Deer Creek Manor			x		x			3.7.5
Knauf plant (fiberglass plant)			x		x			3.7.5
Hawley Road development			x				x	
Stillwater Business Park development				x	x			3.7.5
RDD airport development and expansion (vernal pools)				x	x			3.5.3, Table 3.5-2, 3.7.5
Open Space								
Preservation of semi-rural quality	x					x		

Table ES-1
Index to Issues of Stakeholder Concern

	Stakeholder Assessment Topics				Watershed Assessment Treatment			
Issues	All Three Watersheds	Clover Only	Churn Only	Stillwater Only	Yes	No, Not Relevant	No, No/Limited Data	Chapter/Sub-section
Planned existing open space and conservation easement inventory	x				x			2.1.1, 3.5.1, 3.7.2, 3.7.3, 3.7.4
Trails, parks, and preserves	x				x			Trails: 2.1.1, 2.1.4, 3.2.2, 3.5.1, 3.7.2, 3.7.4, 4.3 Parks: 3.4.3, 3.5.1, Table 3.6-1, 3.7.2, 3.7.4, 4.2, 4.6 Preserves: 4.4
Record of open space pressures	x				x			2.1.1
Loss of rural atmosphere	x				x			2.1.1, 3.7.1, 3.7.2, 3.7.3, 3.7.5
Water Quality								
Irrigation run-off from developments and farms	x				x			3.5.1, 3.6.5, 3.10.1, 4.2, 4.4, 4.5, 4.6
Excessive runoff	x				x			3.5.1, 3.6.5, 3.10.1
Water quality and city runoffs	x				x			3.5.1, 3.6.1, 3.6.3, 3.6.4, 3.6.5, 3.6.6
Temperature change	x				x			Table 3.6-2, 3.6.6

Table ES-1
Index to Issues of Stakeholder Concern

	Stakeholder Assessment Topics				Watershed Assessment Treatment			
Issues	All Three Watersheds	Clover Only	Churn Only	Stillwater Only	Yes	No, Not Relevant	No, No/Limited Data	Chapter/Sub-section
Temperature data from water	x				x			Table 3.6-2, 3.6.6
Point and non-point source pollution	x				x			2.2.2, 3.6.1, 3.6.4, 3.6.5, 4.2, 4.5, Table 5-1
Effects of over-fertilization adjacent to residential developments	x				x			2.1.1, 3.6.4, 3.6.5
Sub-standard housing within watershed, related to septics, runoff, etc.	x				x			2.2.2, 3.3.1, 3.7.5, 4.5
Sewage treatment facility			x		x			2.1.5, 2.2.2, 3.3, 3.6.4, Table 3.6-9
Water Quantity								
Historic flows vs. current flows	x				x			2.1.5, 3.4.3, 3.5.1, 3.6, 4.2, 4.4, 4.7, Table 5.1
Low creek levels during summer	x				x			1.4.2, 2.1.3, 2.2.1, 2.3.2, 2.3.3, 3.1.2, 3.4.3, 3.5.1, 3.10.1, 4.2, 4.4
Diversions of flow (identification)	x				x			2.1.3, 3.4.3, 3.5.1, Table 3.5-6, 3.10.1

Table ES-1
Index to Issues of Stakeholder Concern

	Stakeholder Assessment Topics				Watershed Assessment Treatment			
Issues	All Three Watersheds	Clover Only	Churn Only	Stillwater Only	Yes	No, Not Relevant	No, No/Limited Data	Chapter/Sub-section
Water Flooding								
Identification of floodplain and the regulatory body	x				x			2.1.1, 2.2.2, 3.4.3, 3.5.1, 3.7.2, Table 3.7-4, 3.7.3
Vegetation encroachment on channel flows	x				x			2.3.1, 3.4.3, 3.5.1, Table 3.8-3, 3.10.1, Table 5.1
Inventory of culverts conveyances and crossings (public and private)	x				x			Figure 3.4-1, 3.4.3, 3.5.1, 3.10.1, Table 5.1
FEMA boundaries: Montgomery-Watson floodplains (Cities of Redding and Shasta Lake; County of Shasta)	x				x			Flood plain treatment (no FEMA): 2.1.1, 2.2.2, 3.4.3, 3.5.1, 3.7.2
FEMA floodplains and how those floodplains are managed by each jurisdiction	x				x			2.1.1, 2.2.2, 3.4.3, 3.5.1, 3.7.2, Table 3.7-4, 3.7.3
Identify drainage issues (corrugated metal pipe and bridges)	x				x			3.4.3, Figure 3.4-1, 3.5.1, Table 5.1

Table ES-1
Index to Issues of Stakeholder Concern

	Stakeholder Assessment Topics				Watershed Assessment Treatment			
Issues	All Three Watersheds	Clover Only	Churn Only	Stillwater Only	Yes	No, Not Relevant	No, No/Limited Data	Chapter/Sub-section
Water Other								
Water use	x				x			1.4.5, 2.3.3, 3.5.1, 3.6.1, 4.2
Groundwater levels	x				x			1.4.2, 3.5.2, Table 3.6-1, 3.10, 4.2, Table 5.1
ACID canal water in the watershed	x				x			2.1.5
Stream diversions and the amount diverted	x				x			2.1.3, 3.5.1, Table 3.5-6
Churn Creek bottom drainage delineation			x			x		
Wildlife								
Bird habitat (eagles, etc.), native and migratory inventory	x				x			2.3.2, Table 3.6-1, Table 3.9-1
Identification of threatened and endangered species	x				x			Table 3.9-1, Table 3.10-1

Table ES-1
Index to Issues of Stakeholder Concern

	Stakeholder Assessment Topics				Watershed Assessment Treatment			
Issues	All Three Watersheds	Clover Only	Churn Only	Stillwater Only	Yes	No, Not Relevant	No, No/Limited Data	Chapter/Sub-section
Salmon migration	x				x			3.10.1, Table 3.10-1
Lack of natural predators	x					x		
Control of populations of beaver	x					x		
Predators vs. prey relationships	x					x		
Habitat								
Habitat—general	x				x			1.4.4, 1.5, 2.1.1, 2.2.2, 2.3.2, 3.4.3, 3.5.1, 3.5.3, Table 3.6-1, 3.6.1, 3.7.3, Table 3.7-4, Table 3.7-5, 3.8, 3.9, Table 3.9-1, 3.10, Table 3.10-1, 3.11, 4.1, 4.4, 4.5, 4.6, Table 5.1
Vernal pools habitat: connectivity and fragmentation	x				x			1.4.4, 2.1.1, 2.2.2, 3.1.1, 3.3.1, 3.5.1, 3.5.3, 3.7.3, Table 3.7-5, 3.8.1, 3.8.2, Table 3.8-2, Table 3.9-1, 4.4
Wetland mitigation, on-site vs. banked	x				x			3.5.1, 3.6.4, 3.7.3, Table 3.7-5, 3.8.3

Table ES-1
Index to Issues of Stakeholder Concern

	Stakeholder Assessment Topics				Watershed Assessment Treatment			
Issues	All Three Watersheds	Clover Only	Churn Only	Stillwater Only	Yes	No, Not Relevant	No, No/Limited Data	Chapter/Sub-section
Oak woodlands habitat	x				x			3.8.1, 3.11.1, Table 5.1
Changing geomorphology	x				x			3.4.3
Beaver deprivation in Salmon Creek (tributary to Stillwater)	x			x		x		
Environment								
Rainfall in specific basin drainages	x				x			2.2.2, 3.1.2
Rainfall: anecdotal information from landowners	x						x	
Copper smelter effects	x				x			2.1.2, 2.3.1
Historical climate data (use of landowners to fill in gaps)	x						x	
Tree preservation and air quality issues	x					x		
Leachfields near creeks	x				x			3.3.1, 3.6.5, 4.5

Table ES-1
Index to Issues of Stakeholder Concern

	Stakeholder Assessment Topics				Watershed Assessment Treatment			
Issues	All Three Watersheds	Clover Only	Churn Only	Stillwater Only	Yes	No, Not Relevant	No, No/Limited Data	Chapter/Sub-section
Fuels								
Fuels management impacts	x				x			3.11.2, 3.11.3
Fuel loading	x				x			3.11.2, 3.11.3
Fuel reduction in watershed	x				x			2.2.3, 3.11.6
Fuel loading on upper westside Churn Creek			x		x			3.11.2, 3.11.3, 3.11.6
Air Quality								
Effects of smelters (historic)	x				x			2.1.2, 2.3.1
Quality of airshed	x					x		

Table ES-1
Index to Issues of Stakeholder Concern

	Stakeholder Assessment Topics				Watershed Assessment Treatment			
Issues	All Three Watersheds	Clover Only	Churn Only	Stillwater Only	Yes	No, Not Relevant	No, No/Limited Data	Chapter/Sub-section
Vegetation and Invasives								
Invasive and noxious weed encroachment (inventory and education, defining noxious vs. invasive)	x				x			Table 1.2-1, 2.3.1, 3.4.3, 3.5.1, 3.8.3, Table 3.8-3, 3.10.1, 4.4, Table 5.1
Arundo donax (giant reed)	x				x			2.3.1, 3.5.1, Table 3.8-3, 3.10.2, 4.2, 4.4, Table 5.1
Identification of useful plants	x						x	
Hillside vegetation	x						x	
Riparian vegetation change due to development	x				x			3.8.3
Vegetation barriers to migrating fish	x						x	
Native plant identification	x				x			3.8.1, 3.8.2
Vegetation barriers	x					x		

Table ES-1
Index to Issues of Stakeholder Concern

	Stakeholder Assessment Topics				Watershed Assessment Treatment			
Issues	All Three Watersheds	Clover Only	Churn Only	Stillwater Only	Yes	No, Not Relevant	No, No/Limited Data	Chapter/Sub-section
Excessive vegetation	x					x		
Erosion/Soils								
Erosion (Salmon Creek)	x			x			x	
Soils	x				x			1.4.2, 3.3.4, 3.4.2, 3.5.1, 3.5.3, 4.5
Soil surveys					x			3.3.4
Other								
Historic sites registry	x				x			2.1, 2.2
National registry for cultural history	x					x		
Smaller tributary identification	x				x			2.3.3, 3.5.1, Table 3.5-1, Table 3.5-6, 3.7.5, 3.10.1, 3.10.2
Mining activities—Rich Gulch	x		x		x			3.6.5
School boards and Shasta College involvement	x					x		

Key Findings and Key Questions

FINDING 1- WATER SUPPLY

Surface water and groundwater supplies in the assessment area must be supplemented with diversions from the Sacramento River to generally meet existing and projected near-term future uses within the assessment area. However, deficiencies have occurred seasonally and during droughts in the past and are likely to continue to occur as a result of ongoing population growth, regulatory restrictions on use of Sacramento River surface water, and some limitations on groundwater quality and annual yield, especially in northern portions of the assessment area.

Key Questions

[Q 4-1] Where and to what degree are the local water supplies reliant on Sacramento River water? Are there contract limitations on the availability of this water (domestic/agricultural/industrial)? Are there limitations on development/growth in general terms, or in specific areas within the assessment boundary?

[Q 4-2] What are the location, quantity and quality of irrigation runoff water during the dry summer months? How does this runoff affect beneficial uses of water in the watershed? Are there specific land use practices that should be considered in more detail with respect to this question?

[Q 4-3] What are the distribution and use of pumped groundwater in the watershed? What opportunities exist to expand these services? Are there any relationships between groundwater use and surface water?

[Q 4-4] Are detention basins functional in terms of reducing impacts to beneficial and reasonable uses of water? Are there any conflicts between these uses (e.g., retaining water in upslope areas versus recharge of floodplains/stream channels)?

FINDING 2 - WATER QUALITY

The quality of water in the assessment area, with a few exceptions, is generally good to excellent; and, although some stakeholders in the assessment area have reported localized deterioration of surface water quality, monitoring data remain too limited for definitive conclusions.

Key Questions

[Q 4-5] Where and to what degree is poor water quality affecting beneficial and other reasonable uses of water?

[Q 4-6] What are the relative contributions of sediment associated with various land uses and ecological processes? Some type of sediment budget may be used to assess the significance of these uses and processes.

[Q 4-7] Where does Arundo occur in the Churn Creek Watershed? Are there conditions that facilitate expansion of this species within the assessment area (e.g., channel gradient, available substrate, irrigation runoff during the summer)?

[Q 4-8] Are there critical areas where beneficial uses are subject to impacts from fires and/or fuel reduction projects?

[Q 4-9] Where and to what degree is water quality (i.e., nutrients) influencing the beneficial and other reasonable uses of water within the assessment area? Are these influences isolated, or widespread?

[Q 4-10] What is the relationship between irrigation practices and surface waters, particularly in terms of quantity and quality of water?

FINDING 3 - RECREATION

Detailed data describing historic recreational uses in the assessment area are not readily available. Increasing residential and commercial development suggests that dispersed recreational use activities like hunting and fishing may be stable or in decline, and activities like equestrian and off-road vehicle use may be on the increase. While some established dispersed recreational uses, such as for-fee hunting at the Hawes Ranch, will likely continue, informal observations and regional trends suggest that other forms of recreation are increasingly popular, including recreational experiences that are enhanced by proximity to water. Significant opportunities exist to increase water-enhanced recreational use in the forms of walking, biking, wildlife-viewing, and equestrian trails located adjacent to creeks and wetlands.

Key Questions

[Q 4-11] Is there a collective vision among municipalities and other jurisdictions that directs recreational development in the assessment area? Does this vision acknowledge the value of water resources and associated habitats as important elements of the recreational experience?

[Q 4-12] Is there a public perception that surface water quality inhibits recreational experiences within the assessment area? Is there a need to initiate a water quality monitoring program that focuses on key water quality parameters (e.g., odor, nuisance algae, and fecal coliform) that influence the recreational experience?

FINDING 4 - AQUATIC HABITAT

Although available information is limited, it is apparent that the overall quantity and quality of aquatic habitats, including wetlands and streams, has been modified compared to historic conditions. Habitat has been lost or modified in some areas and been created in other portions of the assessment area, although net losses of some habitats (i.e., wetlands) have occurred. The quality (functionality) of many aquatic habitats has and may continue to decline as a result of significant modification of stream channels and fragmentation of wetlands, increased erosion and sedimentation in stream channels, historic gravel extraction, losses of riparian vegetation, introductions of non-native plant and animal species, urban rubbish accumulations in stream channels, and excess nutrients and toxic contamination in surface runoff.

Key Questions

[Q 4-13] Are there specific stream reaches where changes in the hydrologic regime (i.e., stormwater runoff, imported water sources) are evident? What is the nature and extent of the effects of hydrologic changes on stream and riparian habitats? What is the relationship between these changes in habitat and the beneficial and reasonable uses of water?

[Q 4-14] How many constructed impoundments (e.g., ponds, lakes, retention basins) exist within assessment area? What purpose do they serve and how do they influence beneficial and reasonable uses of water?

[Q 4-15] What is the current distribution of Arundo in Churn Creek and Clover Creek? Are there specific circumstances that may result in expanding the range of this species?

[Q 4-16] Are non-native and exotic organisms (e.g., plants, fish, mammals, reptiles) influencing beneficial uses within the assessment area?

[Q 4-17] How well are current Best Management Practices addressing impacts to beneficial uses?

[Q 4-18] Is there a need to prepare a systematic assessment to characterize the cumulative change (loss/conversion/ fragmentation) of seasonal wetlands and riparian corridors in order to prioritize future restoration/enhancement opportunities?

FINDING 5 – WASTEWATER DISCHARGE AND CONVEYANCE

Discharge of treated wastewater effluent from the Shasta Lake Area Wastewater Treatment Plant is highly constrained with no opportunity for increased discharges at current treatment levels. Opportunities for discharge of treated wastewater effluent to Stillwater Creek are similarly limited by seasonal hydrology of the creek, so it is unlikely that point source discharges of this kind will be proposed in the future. Overall, the soils and other characteristics of the assessment area are poorly suited to the discharge of wastes, including discharge of primary treated effluent into conventional septic tank leach fields.

Key Questions

[Q 4-19] What are the number and relative location of developments that rely on individual leach fields? Can the age and relative location of these fields be used to develop a systematic monitoring approach to assess potential impacts to beneficial uses?

FINDING 6 – WATER-DEPENDENT HABITAT

The quantity of water-dependent habitat (i.e., riparian forest, riparian marsh and wetlands) has been altered through time within the assessment area. Similar to the trend for aquatic habitats, these water-dependent habitats have also been lost in some areas and have been created in other portions of the assessment area, although a net loss of riparian forest habitat has generally occurred. The quality of water-dependent habitat has generally declined throughout the assessment area.

Key Questions

[Q 4-20] Where are the critical riparian areas (streams, wetlands) that should be protected, restored, or enhanced with respect to beneficial or reasonable uses? What factors should be considered to evaluate these riparian areas? How functional are they? What stressors exist that are influencing these areas?

[Q 4-21] Are there opportunities to restore specific reaches of Churn Creek in the vicinity of Dana Drive/Highway 44?

FINDING 7 – STORMWATER MANAGEMENT

The capacity of stream channels to convey high flows during storms has been reduced due to encroachment by development into floodplains. At the same time, peak storm runoff has increased, also due to increased urban development. Typically, storm flow detention basins are constructed to mitigate this condition (i.e., increased generation of runoff and decreased conveyance capacity in receiving waters), but data documenting the effectiveness of this approach are lacking.

Key Questions

[Q 4-22] Are there sensitive reaches/habitats that should be considered when siting future stormwater management facilities?

Recommendations

The Technical Advisory Committee reviewed this watershed assessment and jointly, with the Western Shasta Resource Conservation District and North State Resources, Inc. (consultant), developed a series of recommended actions that respond to the principal goals of this assessment (Table ES-2). No ranking or prioritization of these action options is implied by their position on the list. Such prioritization should be made by the watershed coordinator with input from the Technical Advisory Committee and other stakeholders. Specific criteria for prioritizing and funding recommended actions should be developed in a collaborative manner that links desires, interests, needs, and capabilities of as broad a section of the community as possible.

The recommended actions include options for continuation of successful ongoing programs, such as invasive weed control and community-based creek clean-ups, and other stewardship actions that are improving watershed conditions and public awareness of watershed management issues. Other recommended actions include further detailed evaluation of habitat and stream bank and channel erosion conditions that will be needed to verify cause-and-effect relationships within the watershed and to identify specific treatment sites for restoration and enhancement activities.

Table ES-2
Action Options
Stillwater-Churn Creek Watershed Assessment

Action Options	Beneficial Use Category[1,2]
Public Education and Awareness Actions	
1. Continue public awareness and education program through periodic Watershed Alliance meetings that convey information contained in the Stillwater-Churn Creek Watershed Assessment. This program should be designed to offer flexibility that can meet the information and action needs of various stakeholders.	All
2. Engage schools within watershed boundaries in watershed education and management activities through Adopt-a-Watershed or similar program. This program could encourage schools in different areas of the watershed to share information about watershed resources in the areas where their schools are located.	All
3. Continue public awareness campaign and ongoing eradication and control efforts targeting noxious, invasive plants such as giant reed, tree-of-heaven, tamarisk, yellow star-thistle, Scotch/Italian broom, and rattlebush.	3,8,9,10,11,12,B,C,D
4. Build upon the recent tremendously successful Churn Creek Clean-up effort to encourage and promote community volunteerism and public agency and municipality support for local creek protection and rehabilitation actions.	All

Table ES-2
Action Options
Stillwater-Churn Creek Watershed Assessment

Action Options	Beneficial Use Category[1,2]
5. Facilitate public awareness and education on proper erosion and sediment control practices around homes, farms, businesses, and construction sites. This action may be coordinated with municipalities, Shasta Builder's Exchange, Shasta College, home building supply businesses, and regulatory agencies.	1,5,9,10,11,12,B,C
6. Continue to support public education campaign and South Lake Shasta Fire Safe Council projects to reduce catastrophic wildfire hazards. Successful implementation will protect hydrologic function; prevent excessive erosion and sediment delivery; and protect upland, riparian and aquatic habitat values.	1,3,5,9,10,11,12,B,C
Immediate Stewardship Actions	
7. Use the TAC to identify various agency institutional obligations and constraints to facilitate implementation of action options. Assign priorities, identify leadership opportunities, and analyze potential funding to implement programmatic and project level actions. This action should be coordinated with related actions from the Shasta West and Sulphur Creek Watershed Assessments.	All
8. Continue to install signs at waterway road-crossings and label storm drains to promote public awareness of the presence and value of watershed streams.	All
9. Collaborate with the cities of Redding and Shasta Lake to promote and obtain funding for a community-based, volunteer program to monitor water quality (particularly plant nutrients, petroleum-based oils/greases, heavy metals, pesticides, dissolved oxygen, pH, turbidity, total settable solids, and urban refuse) in Churn Creek. This effort may be coordinated with and augment the cities' NPDES Phase II stormwater quality management requirements. Seek assistance of California DWR's Urban Streams Program for grant funding of effort.	3,4,7,9,10,12,B,C
10. Promote adoption of the draft countywide oak woodland management plan to conserve oak woodlands and the ecological communities that they support.	B
11. Identify suitable sites within the watershed for acquisition as well as financial issues, jurisdiction, and socioeconomic considerations to conserve open space, natural resources, and watershed functions and that can be used to mitigate and offset land use impacts that will likely continue to occur throughout the watershed.	1,2,3,7,8,9,10,B,C
12. Investigate opportunities and promote creation of wetlands and widespread use of vegetated swales and buffers for storm water runoff management and water quality improvement.	3,9,10,11,12,D

Table ES-2
Action Options
Stillwater-Churn Creek Watershed Assessment

Action Options	Beneficial Use Category[1,2]
Further Assessment Actions to Support Watershed Management Plan	
13. Map, inventory, and assess condition of stream and riparian habitat along Churn and Stillwater creeks, with Churn Creek as a first priority. Identify opportunities and constraints for habitat protection, rehabilitation, and restoration, particularly those that restore and enhance salmonid use. Approaches that use a combination of aerial imagery, remote sensing data, and field sampling/verification will be most cost-effective.	3,9,10,11,12,B
14. Map and inventory bank erosion sites and establish a baseline characterization of channel geomorphometry on Churn and Stillwater creeks. Identify opportunities and constraints for reducing excessive fine sediment inputs to protect/improve aquatic and riparian habitat, protect property, and protect/improve stream corridor, floodwater storage, and conveyance. Approaches that use a combination of aerial imagery, remote sensing data, and field sampling/verification will be most cost-effective.	3,5,9,10,11,12,B,C
15. Develop a detailed, combined soils and slope map to identify areas of high erosive potential.	1,3,5,9,10,12,B
16. Reactivate or install stream flow gages in Churn and Stillwater creeks to better characterize current hydrologic patterns and monitor long-term trends that may affect aquatic and riparian habitat and flood damage potential. While Clover Creek may not be conducive to a traditional stream gaging, some approach should be developed to understand the relationship between stormwater runoff and flood flows, particularly downstream of Hartnell Avenue, Rancho Road and Knighton Road. Bridges at these locations may be useful in estimating discharge during runoff periods.	1,2,3,4,,9,10,11,12,A,B,C,D
17. Inventory and assess hydraulic and ecologic performance of infrastructure features identified in the watershed assessment that may affect hydrologic and geomorphologic function, water quality, and animal migration in Churn, Stillwater, and Clover creeks. These include, but are not limited to, constructed impoundments, stormwater collection discharges, detention basins and discharges, culverts and road-crossings, utility crossings, and bank protections.	1,3,5,9,10,11,A,B,C,D
18. Expand water quality monitoring efforts (identified in Action Option #9) to include Stillwater and Clover creeks, in coordination with the Churn Creek efforts for cost-efficiency. Use results from this effort and that of Action Option #9 to inform identification of any point source and non-point source pollution problem areas.	3,4,7,9,10,12,B,C

Table ES-2
Action Options
Stillwater-Churn Creek Watershed Assessment

Action Options	Beneficial Use Category[1,2]
19. Use stream and riparian habitat inventory and condition assessment to identify opportunities and constraints to maintain adequate wildlife migration and dispersal corridors within the watershed. Promote conservation and preservation of suitable wildlife habitat, habitat connectivity, open space, and an integrated trail system in community development planning.	7,8,B,C,D
20. Incorporate information and results of the Redding Groundwater Basin Management Plan (development is underway) when completed.	1,2,3
21. Further evaluate existing water rights and uses of surface water within the watershed, including water diverted from the Sacramento River, and opportunities and constraints to increase groundwater recharge and enhance stream flows in Churn and Stillwater creeks for aquatic habitat enhancement purposes.	1,2,3,4,7,8,9,10,11,12,A,B,C,D
22. Enhance opportunities for contact and non-contact water recreational use focusing on better understanding the historic and future uses, particularly as future use may be limited by water quality; determining the adequacy of existing public access; and managing litter and aquatic vegetation to maintain a pleasing environment for recreation.	7,8,9,10,B,D
23. Expand and improve compatible open space and public use recreation, such as increasing and enabling public access for walking, biking, and nature-viewing, at some wildlife set-aside lands (where appropriate) and some portions of the proposed Stillwater Business Park that present significant opportunities for increasing water-enhanced recreation options.	8,D
24. Groundwater and surface water monitoring should be expanded in order to ensure that increasing discharge of septic tank effluent due to increased rural development in unsewered areas does not impair beneficial uses of surface waters and groundwater.	1,7,8,9,10,A,B,D

[1] Beneficial Use Categories

1. Municipal and domestic supply
2. Industrial service supply
3. Groundwater recharge
4. Freshwater replenishment
5. Navigation
6. Hydropower generation
7. Water contact recreation
8. Non-contact water recreation
9. Warm freshwater habitat
10. Cold freshwater habitat
11. Migration of aquatic organisms
12. Spawning, reproduction, and/or early development

[2] Other Reasonable Uses

A. Wastewater Discharge Conveyance
B. Water-Dependent Habitats (such as wetlands and riparian forests and those plant and wildlife resources supported by these habitats, including numerous special-status species and natural communities)
C. Stormwater Management and Conveyance

Chapter 1
Introduction

1.1 Project Goals and Objectives

Watershed assessment is a process, consisting of stakeholder participation, discovery, and analysis, for evaluating how well watersheds function, for identifying ways to make watersheds function better, and for measuring the success of watershed maintenance and enhancement efforts. Watershed assessment is the early part of an ongoing resource-management cycle consisting of data collection and analysis that informs decision-making, and that includes a framework for evaluating the effects of those decisions on natural resources. This watershed assessment provides foundational information that may be considered during later parts of the resource-management cycle to identify priorities, policies, and projects and to anticipate and measure the effects of those policies and projects on watershed health.

The broad goal of the Stillwater–Churn Creek watershed assessment is to provide an understanding of the ecological processes at work in the Stillwater, Churn, and Clover Creek watersheds, linking past and current human activities and land uses to current landscape conditions, and placing particular emphasis on aquatic resources. Narrower goals of the watershed assessment are to:

- support the CALFED Bay-Delta Program goal of restoring the ecological health and improving the management of the Bay-Delta system by working with communities in the Sacramento/San Joaquin Basin at a watershed level;
- support the efforts of the Western Shasta Resource Conservation District (WSRCD) in areas of environmental education and stakeholder outreach, and;
- enhance collaboration and coordination between public agencies and non-governmental stakeholders.

The broad goal of the Stillwater–Churn Creek watershed assessment is to provide an understanding of the ecological processes at work in the Stillwater, Churn, and Clover Creek watersheds, linking past and current human activities and land uses to current landscape conditions, and placing particular emphasis on aquatic resources.

Discrete objectives of this watershed assessment report are to:

- characterize the watershed in terms of the dominant physical, biological, and human processes and features;
- compile information using geographic information system (GIS) tools;
- describe the current range, distribution, and condition of ecosystem elements in the watershed;
- describe how these ecosystem elements have changed through time;
- synthesize and interpret the information about current and historical ecosystem elements to establish cause and effect relationships between elements;
- determine if watershed conditions may be limiting beneficial water uses,
- identify areas where additional information is needed; and
- facilitate development of conclusions and suggestions by the public agencies and non-governmental stakeholders

that will respond to the cause and effect relationships between ecosystem elements.

1.2 Project Participants and Funding Sources

Funding for the Stillwater–Churn Creek watershed assessment was provided through a grant agreement between the State Water Resources Control Board (SWRCB) and the WSRCD under the Proposition 13 Watershed Grant Program. Following award of the grant, the WSRCD formed a Technical Advisory Committee (TAC) and the Stillwater–Churn Creek Watershed Alliance (Alliance) to foster participation in the watershed assessment by public agencies, Native American tribes, non-governmental entities, and individual stakeholders. The Alliance provides a forum for developing a community-based and locally led approach to watershed management, while the TAC provides a vehicle for receiving technical input. Both the TAC and the Alliance met frequently during development of this watershed assessment report to track progress and comment on the scope of the analysis and interim work products. Participants on the TAC, members of the Alliance, and other interested stakeholders provided data in various formats that have been incorporated into this assessment.

Early in the watershed assessment process, the WSRCD staff met with the TAC and members of the Alliance to receive input on the analytical focus of the assessment. The participants in these meetings identified 82 issues for possible consideration in the assessment. The issues proposed for analysis by these groups, and the portions of the assessment area to which they are considered most relevant, are presented in Table 1.2-1, Assessment Topics Matrix.

Table 1.2-1
Assessment Topics Matrix

Issues	All	Clover Only	Churn Only	Stillwater Only
Development and Related Effects				
Developmental pressures	x			
Rate of development	x			
Detention responsibilities from development	x			
Development of on-site retention	x			
Developmental setbacks	x			
Trails and parks and preserves - city, county, McConnell	x			
Shastina Ranch: 1200 to 1500 new homes (bounded by Knighton, Airport, Rancho Roads)—identify and review environmental reports		x		
Developmental pressures (auto mall)			x	

Table 1.2-1
Assessment Topics Matrix

Issues	All	Clover Only	Churn Only	Stillwater Only
Oasis Road development issues - Deer Creek Manor			x	
Knauf plant (fiberglass plant)			x	
Hawley Road development			x	
Stillwater Business Park development				x
RDD airport development and expansion (vernal pools)				x
Open Space				
Preservation of semi-rural quality	x			
Planned existing open space and conservation easement inventory	x			
Trails and parks and preserves	x			
Record of open space pressures	x			
Loss of rural atmosphere	x			
Water Quality				
Irrigation runoff from developments and farms	x			
Excessive runoff	x			
Water quality and city runoffs	x			
Temperature change	x			
Temperature data from water	x			
Point and non-point source pollution	x			
Effects of over fertilization adjacent to residential developments	x			
Sub-standard housing within watershed, related to septics, runoff, etc.	x			
Sewage treatment facility	unid.			

Table 1.2-1
Assessment Topics Matrix

Issues	All	Clover Only	Churn Only	Stillwater Only
Water Quantity				
Historic flows vs. current flows	x			
Low creek levels during summer	x			
Diversions of flow (identification)	x			
Water Flooding				
Identification of floodplain and the regulatory body	x			
Vegetation encroachment on channel flows	x			
Inventory of culverts conveyances and crossings (public and private)	x			
FEMA boundaries: Montgomery-Watson floodplains (cities of Redding and Shasta Lake; County of Shasta)	x			
FEMA floodplains and how those floodplains are managed by each jurisdiction	x			
Identify drainage issues (corrugated metal pipe and bridges)	x			
Water Other				
Water use	x			
Groundwater levels	x			
A.C.I.D. canal water in the watershed	x			
Stream diversions and the amount diverted	x			
Churn Creek Bottom drainage delineation			x	
Wildlife				
Bird habitat (eagles, etc.) native and migratory inventory	x			
Identification of threatened and endangered species	x			
Salmon migration	x			
Lack of natural predators	x			

Table 1.2-1
Assessment Topics Matrix

Issues	All	Clover Only	Churn Only	Stillwater Only
Control of populations of beaver	x			
Predators vs. prey relationships	x			
Habitat				
General habitat	x			
Vernal pools habitat: connectivity and fragmentation	x			
Wetland mitigation on-site vs. banked	x			
Oak woodlands habitat	x			
Changing geomorphology	x			
Beaver deprivation Salmon Creek (tributary to Stillwater)	x			x
Environment				
Rainfall in specific basin drainages	x			
Rainfall: anecdotal information from landowners	x			
Copper smelter effects	x			
Historical climate data (use of landowners to fill in gaps)	x			
Tree preservation and air quality issues	x			
Leach fields near creeks	x			
Fuels				
Fuels management impacts	x			
Fuel loading	x			
Fuel reduction in watershed	x			
Fuel loading on upper west side of Churn Creek drainage (i.e., upstream of Lake Boulevard)			x	

Table 1.2-1
Assessment Topics Matrix

Issues	All	Clover Only	Churn Only	Stillwater Only
Air Quality				
Effects of smelters (historic)	x			
Quality of air	x			
Vegetation and Invasive Plants				
Invasive and noxious weed encroachment (inventory and education, defining noxious vs. invasive	x			
Giant Reed *(Arundo donax)*	x			
Identification of useful plants	x			
Hillside vegetation	x			
Riparian vegetation change due to development	x			
Vegetation barriers to migrating fish	x			
Native plant identification	x			
Vegetation barriers	x			
Excessive vegetation	x			
Erosion/Soils				
Erosion (Salmon Creek)	x			x
Soils	x			
Soil surveys				
Other				
Historic sites registry	x			
National Registry for cultural history	x			
Smaller tributary identification	x			
Mining activities—Rich Gulch	x		x	
School boards and Shasta College involvement	x			

1.3 Project Location

The area included in the Stillwater–Churn Creek watershed assessment consists of the lands that receive precipitation that runs off, as surface flow, into Stillwater, Clover, or Churn creeks. Each of these creeks occupies a distinct watershed and is a discrete tributary to the Sacramento River. As tributaries to the Sacramento River, these streams are subject to the water quality standards set forth by the Water Quality Control Plan for the Sacramento River Basin and San Joaquin River Basin (Basin Plan), as revised (September 2004), established by the Regional Water Quality Control Board (RWQCB), Central Valley Division. The assessment area is located at the far northern end of the Central Valley of California, and is bounded on the north and northwest by the southernmost extent of the Klamath Mountains; on the south and southwest by the Sacramento River; and on the east by the nearly level to gently rolling landscape of the Stillwater Plain. The area encompassed by this watershed assessment is approximately 77,735 acres. The general location of the assessment area is shown in Figure 1.3-1, Watershed Assessment Area General Location Map.

The area included in the Stillwater–Churn Creek watershed assessment consists of the lands that receive precipitation that runs off, as surface flow, into Stillwater, Clover, or Churn creeks. Each of these creeks occupies a distinct watershed and is a discrete tributary to the Sacramento River.

1.4 Dominant Ecological Components and Ecosystem Processes

The study area is home to a variety of valued ecological components and ecosystem processes. Identifying components and processes that are especially influential—or dominant—focuses the watershed assessment on factors that currently control the uses and condition of the aquatic environment and will control them in the future. Management decisions that affect dominant components and processes have greater potential to affect the aquatic environment than decisions affecting less influential ecosystem elements.

Dominant ecological components and ecosystem processes in the Stillwater–Churn Creek watershed are ecosystem elements that:

- control the established and future uses and condition of aquatic resources;
- are important to the diversity, vigor and sustainability of biological resources; and
- are important to the community, as evidenced by the input provided by the TAC, the Alliance, and other stakeholders during the watershed assessment.

1.4.1 Topography and Climate

Topography influences hydrologic, geologic, and geomorphic processes; patterns of vegetation communities, terrestrial wildlife, fisheries and aquatic resources; and human geography. Regional climate exerts a controlling influence on the watershed hydrology by determining water and energy inputs and availability over various time spans. Like topography, regional climate also influences patterns of vegetation communities, terrestrial wildlife fisheries and

other aquatic resources; and human geography.

Topography within the study area is variable. Slopes over the large majority of the study area are less than 10 percent. Lands adjacent to and immediately upstream from the Sacramento River are nearly level. East and north of Redding, the topography ranges from nearly level to undulating, with steep slopes occupying the areas immediately adjacent to creeks. Further north, the topography becomes increasingly steep, and the northernmost portions of the study area are dominated by mountainous terrain with slopes steeper than 30 percent.

1.4.2 GEOLOGY, GEOMORPHOLOGY, AND SOILS

The rock types underlying the assessment area strongly influence surface drainage patterns, hill-slope stability, channel morphology, and partitioning of water into surface water and groundwater. Underlying or nearby rock types are the parent materials for local soils. Soil characteristics affect amounts and timing of runoff; erosion and the delivery of eroded materials to receiving waters (i.e., sedimentation); composition and distribution of plant communities, including wetlands; water quality; and human geography.

As with topography, the study area is a diverse assemblage of geologic, geomorphologic, and soil types. The steep landscapes in the northernmost sections are underlain by the sedimentary and metamorphic rocks of the Klamath Mountains. Soils in these areas generally are cobbly or gravelly and are less than 5 feet deep. Ancient river terraces north and east of Redding are composed of gravelly and cobbly alluvium and are characterized by high clay content. The nearly level lands adjacent to and immediately upstream from the Sacramento River are composed of gravelly and sandy alluvium deposited in recent time. Soils that develop in these materials generally are deeper than 5 feet and vary in texture from sandy to loamy.

1.4.3 HYDROLOGY

Included under the broad heading of hydrology are water availability (e.g., volume, distribution, timing) and water quality. Factors that influence water availability include climate, vegetation, geology, soils, and land and water use. Stillwater, Churn, and Clover creeks have hydrologic cycles characterized by very low flows in summer and early fall, brief peak flows in winter, and prolonged higher flows in spring. Flooding, a natural attribute of streams and rivers, is of increasing concern in the watershed. Conversion from non-urban to urban land uses has the potential to exacerbate flooding as permeable soils are replaced by impermeable surfaces. Conversion to urban uses can also affect the partitioning of water into surface water and groundwater by increasing the contribution to surface water resulting from the reduction in permeable ground surface.

The Basin Plan establishes water quality standards to protect the public health and welfare, enhance the quality of water, and serve the purposes of the Clean Water Act. These water quality standards designate beneficial uses of water and establish water quality criteria designed to protect those uses. Water quality affects municipal, industrial, agricultural, and in-stream water uses as well as the health of terrestrial habitats. Because changes in water quality can indicate changes in other watershed processes or components, measurements of water quality are a favored, non-biological indicator of watershed condition. Examples of parameters commonly measured to assess water quality are

inorganic and organic compounds, nutrients, metals, bacteria, dissolved oxygen, sediment, and temperature.

1.4.4 Biological Resources

Biological resources include botanical species and aquatic and terrestrial wildlife species and their associated habitats. Aquatic (i.e., freshwater) and terrestrial wildlife habitats are two of the existing, important uses of surface waters in the watershed. Freshwater habitat beneficial uses include preservation or enhancement of aquatic habitats. Terrestrial wildlife habitat beneficial uses include uses of water that support terrestrial or wetland ecosystems. Non-native, invasive plant species that degrade the suitability of habitat for native plants and animals is a concern within the assessment area.

Significant biological resources, including special aquatic sites and special-status species and their habitats, are particularly relevant to the Stillwater–Churn Creek watershed assessment. Significant biological resources that occur in the assessment area include riparian communities, seasonal wetlands, vernal pools, stream and pond habitats, and the organisms that occupy these habitats. The assessment area falls within the range of more than 100 special-status plant and animal species, including several listed species that depend on vernal pools; cold, freshwater environments; or riparian plant communities to complete crucial life-stages. In addition to other protections afforded under the environmental regulatory framework, biological resources in portions of the assessment area are protected by federal designation as critical habitat for threatened and endangered species, conservation easements, mitigation banks, and/or open-space set-asides.

The larger goal of watershed assessment is to identify and measure the success of actions—both policies and projects—aimed at maintaining and enhancing watershed health.

1.4.5 Land and Water Use and the Built Environment

This watershed assessment treats human use of land and water resources as a dominant ecosystem process that affects and is affected by other ecological components and processes. Today the watershed is experiencing unprecedented urban and suburban development. While this trend can enhance the economic and cultural vitality of the region, development also carries with it a potential to affect ecological processes and, ultimately, the suitability of the terrestrial and aquatic environments for beneficial uses. As previously noted, for example, impervious cover, such as roads, parking lots, and rooftops, can greatly reduce the ability of land to absorb precipitation, altering hydrologic pathways, increasing erosion and sedimentation, and expanding the frequency and extent of floods. The current trend toward more intensive land uses also increases the risk of wildfire in the watershed and challenges decision-makers to balance fuels management with other—potentially competing—ecological objectives.

1.5 Role of Ecological Endpoints in the Watershed Assessment

Watershed assessment moves beyond descriptions of existing conditions (also termed reference conditions) and the historical activities that took place in a watershed. The larger goal of watershed assessment is to identify and measure the

success of actions—both policies and projects—aimed at maintaining and enhancing watershed health. As the term is applied to this watershed assessment, watershed health is defined as:

> An index or estimate of the degree to which the generation and transport of surface water and its constituents within a watershed function so as not to impair beneficial and other reasonable uses of water.

Managing the health of a watershed requires an articulation of "ecological endpoints" that can be widely communicated and consistently applied to focus actions on achieving specific goals and to assess performance in meeting those goals. This watershed assessment report treats the existing and potential beneficial uses of surface water defined in the Basin Plan as its primary ecological endpoints. Additional ecological endpoints for this analysis include other reasonable uses of water not designated as "beneficial" (i.e., wastewater disposal), and other valued ecosystem components and processes identified by the TAC, the Alliance, and other stakeholders, to the degree that meaningful cause-and-effect linkages can be established with the aquatic environment.

The ten principal beneficial uses of surface water established in the Basin Plan applicable to the assessment area are:

- *Municipal and domestic supply:* uses of water for community or individual supply systems, including but not limited to drinking water.
- *Agricultural supply:* uses of water for farming, horticulture, or ranching.
- *Industrial supply:* uses of water for industrial purposes that do not primarily depend on water quality (e.g., mining, fire protection), and uses of water for hydropower generation (in this instance, uses for hydropower that is being generated are outside of the assessment area).
- *Groundwater recharge:* uses of water for natural or artificial recharge of groundwater for purposes of future extraction and maintenance of water quality.
- *Freshwater replenishment:* uses of water for natural or artificial maintenance of surface water quantity and quality.
- *Recreation*: uses of water for contact and non-contact forms of water recreation.
- *Freshwater habitat*: uses of water that support warm-water and cold-water ecosystems and associated habitats.
- *Migration of aquatic organisms*: uses of water that support habitats necessary for migration of aquatic organisms.
- *Spawning, reproduction, or early development*: uses of water that support habitats suitable for spawning, reproduction, or early development of fish.
- *Navigation*: uses of water for shipping, travel, or other transportation.

As previously mentioned, wastewater disposal, while not a beneficial use of surface water in the assessment area, is nonetheless considered a reasonable use and is therefore treated as an "ecological endpoint" in this watershed assessment. Other ecological endpoints included in this watershed assessment report because of their strong linkages to the aquatic environment are:

- *Water-Dependent Habitats*: wetlands and water-dependent terrestrial habitats, such as riparian corridors and forests, and the plant and wildlife resources supported by these habitats.
- *Stormwater Management and Conveyance*: uses of natural streams to

convey runoff and prevent flooding of property that can be damaged by water.

This watershed assessment report identifies how these ecological endpoints are potentially affected by changes in the dominant ecological components and ecosystem processes. It focuses on the existing and historical relationships between ecological components, ecosystem processes, and ecological endpoints, and strives to project, in a qualitative way, how natural or human-induced changes could diminish the ability of the watershed to achieve the desired endpoints.

1.6 Overview of the Watershed Assessment

In addition to this Introduction, this watershed assessment report consists of the following:

- *Executive Summary*: presents the salient elements of the assessment and focuses on watershed trends and recommended actions to respond to those trends.
- *Chapter 2, Historical Conditions*: describes and compares historical to current watershed conditions in a general manner.
- *Chapter 3, Current Conditions of Major Ecosystem Element*s: describes current watershed conditions that are most relevant to management of ecological endpoints on a resource-by-resource basis.
- *Chapter 4, Watershed Trends and Key Finding*s: describes natural and human-induced trends within the assessment area that have potential to affect ecological endpoints.
- *Chapter 5, Recommendations and Watershed Action Items*: presents recommendations for responding to trends that have potential to adversely affect ecological endpoints.
- *Project GIS Library* - contains an index to all cartographic data obtained to date, a brief description of these data, and the rating of applicability assigned to each data set; also includes maps and GIS databases for dominant features and processes in the watershed that are discussed in Chapter 2 and in Subchapters 3.1. through 3.11 of this assessment, including maps showing the locations of the watershed with respect to political, geographic, or ecological boundaries and human population centers; maps showing land use and ownership patterns; and delineation maps that categorize areas of the watershed that have similar ecological functions.
- *Project ENDNOTE Library*: contains bibliographic information and notations that describe each of the documents and cartographic datasets discovered to date.

Chapter 2
Historical Conditions and Synthesis of Information

The history of the watershed assessment area is reflected in its landforms, its rivers and streams, and its wildlife and vegetation. From the steep slopes in the north to the nearly flat valley floor, the landscape we see today offers clues to its past.

This chapter of the watershed assessment describes the historical conditions of the area. Section 2.1 provides a brief history of the people who have lived and worked in the area and the significant ways they have modified the landscape. Section 2.2 describes changes in landscape processes in the assessment area over time, and Section 2.3 describes changes in the biological systems of the assessment area.

Each of these sections is divided into four time periods:

- Pre-Columbian to 1850
- 1850 to 1920
- 1920 to 1970
- 1970 to present

The first of these periods, Pre-Columbian to 1850, covers Native American occupation of the assessment area up to the beginning of the Gold Rush in Shasta County. The second period, 1850 to 1920, corresponds to the era of rural development and mining. During the third period, 1920 to 1970, major infrastructure was constructed that continues to influence the assessment area; this period also involved significant urban growth. The fourth period, 1970 to present, is a time of continued population increases, urban growth, and changes in societal values. Figure 2.1, Timeline of Important Milestones in the Assessment Area, shows major events that have affected the assessment area and the surrounding region. All figures cited in this chapter are at the end of the chapter.

2.1 Human Influences

This section of the watershed assessment discusses the history of humans in the assessment area. It also discusses the principal human activities—mining, agriculture and ranching, railroads and roadways, and development of public services—that have had the greatest effects on the landscape processes and biological systems of the assessment area.

2.1.1 Aboriginal Peoples and Euro-American Exploration and Settlement

Pre-Columbian Era to 1850

Humans are thought to have occupied the assessment area for more than 7,000 years (USDA Forest Service Pacific Southwest Region 2003). The land use practices of the Native Americans who lived in the area before the arrival of European explorers and American settlers had relatively little effect on the broad landscape processes and biological resources of the area. Beginning with the influx of American settlers during the Gold Rush, settlement patterns and land use practices have had more profound effects on the natural resources of the area.

Humans are thought to have occupied the assessment area for more than 7,000 years.

The Achomawi, Atsugewi, Okwanuchu, Wintu, and Yana tribes are believed to have been the first people to inhabit Shasta County. When American settlers arrived in the 1850s, the Wintu were the only tribe in the assessment area. It is generally believed by anthropologists that the Wintu first settled in northern California approximately 1,000 to 1,200 years ago (Sundahl 2006). The Wintu inhabited the entire assessment area and were centered near current-day Redding (Mount Shasta Companion 2001).

The Wintu relied heavily on the aquatic resources of the assessment area and its vicinity. They also actively managed forest resources to meet their subsistence needs.

The Stillwater Wintu ethnographic group inhabited the Stillwater Plains area. It is uncertain when and under what circumstances their occupation of the area ended, although, according to Sundahl (2006), it is likely that "the population was displaced or decimated very early by Anglo-American settlement." As described by Sundahl from the diaries of May Southern, a long-time Shasta County resident and historian, the Wintu name for Stillwater Creek was "*chudick-sawal wocket*." *Wocket* means creek, *cudak* is a small woodpecker or sapsucker, and "*sa*wal*" is a "pool or spring of ritual significance."

The Wintu were a sedentary, foraging people who occupied permanent villages near rivers and streams (Mount Shasta Companion 2001). They were politically organized into independent tribelets, usually consisting of a single village, but sometimes composed of groups of two or three villages under the authority of a single headman or chief (Chase-Dunn et al. 1992). The Wintu had dense settlement patterns, with the largest villages containing about 250 people (Chase-Dunn et al. 1992). The precontact population of the Wintu is estimated at around 14,250 (Mount Shasta Companion 2001).

The Wintu relied heavily on the aquatic resources of the assessment area and its vicinity. They also actively managed forest resources to meet their subsistence needs. Their primary diet consisted of deer, rodents and other small mammals, acorns, and pine nuts, but they also depended heavily on seasonally abundant salmon runs in local rivers and streams as well as steelhead, Sacramento sucker, freshwater shellfish, and lamprey. In addition to eating the fresh fish, the Wintu preserved salmon by drying it for use throughout the year (VESTRA 2005). Dried salmon was processed into salmon flour and used in a variety of ways. Sundahl (2006) states that according to the ethnographic literature, "salt was plentiful in the [Stillwater] area and…the Stillwater people were a source of salt for the Indians to the north and west…; black bread made from acorn meal with red clay mixed in was a specialty of the Stillwater area" (Dubois 1935:11, 19-21, 25, as cited in Sundahl 2006). "Indians living on Stillwater plain were especially expert in making rabbit-skin robes or blankets. The skins were cut into strips and woven in checkerboard fashion" (Merriam 1955:24, as cited in Sundahl 2006).

Sundahl also reports that some places along Stillwater Creek were sacred to the Wintu. These include the site of the Olsen Petroglyphs, also known as Church Rock, the location of which is kept confidential to prevent vandalism and looting.

The first European explorers in the area were Russians traveling south along the Sacramento River around 1815. The Russians established several settlements along the California coast, but did not settle inland.

Beginning in the late 1820s, the Hudson's Bay Company, headquartered in Fort Vancouver in the Oregon Territory, sent Canadian, British, and French trappers into the region to trap beavers, otters, and foxes. The trappers came in parties ranging between 50 and 100 people and were the first to record and map trails in Shasta County (Smith 2005). One of the company's chief traders, Peter Skene Ogden, followed the Pitt River southwest to the Sacramento River and then back north during the winter of 1826–27 (Elliott 1910). Small advance parties from his expedition explored the country along this route, likely making excursions into the headwater areas of the assessment area.

Around this time (1820–1830), it was the Hudson's Bay Company's written policy to trap to extinction fur-bearing animals from streams south of the Columbia River to discourage American expansion and settlement of the region (Williams 1971, as cited in NRC 2004). The trappers were primarily focused on beaver, and by the late 1840s, the beaver populations were so reduced that unregulated trapping was discontinued (Smith 2005). The near-extirpation of the beaver in the region had a profound effect on the aquatic environment because beaver dams contribute to the development of extended riparian areas, create aquatic habitat, and influence hydrologic processes. The degree to which beavers shaped the historic stream and riparian habitats and the effects of trapping on beaver populations in the assessment area are not specifically known.

In 1832, Hudson's Bay trader John Work and his party introduced malaria into the area, causing an epidemic that wiped out entire Native American villages and killed thousands of Native Americans in the area (Smith 2005). By 1833, this epidemic reduced Native American populations in the Sacramento Valley by more than 75 percent. Some scholars argue that this huge reduction in Native American populations facilitated the settlement of Americans in the area (Cronon 1983). No information is available on the specific effects of the epidemic on people inhabiting the assessment area.

Although the Spanish established missions in many areas of California in the 1700s, they did not come as far inland as Shasta County. The northern Sacramento Valley remained uninhabited by Euro-American peoples until Americans began exploring and settling in the region during the 1840s.

In 1844, Pearson B. Redding, Lansford B. Hastings, and William Bennitz arrived in the area and applied for free land grants from the Mexican government (Smith 2005). The first official white settler in the region was Hastings, who settled at the foot of Castle Crags beside Lower Soda Springs. In 1847, Redding settled on 26,632 acres approximately 3 miles east of the Sacramento River between Cottonwood Creek and Salt Creek. Other white settlers soon followed.

Sundahl (2006) describes the relationship between the white settlers and the Wintu as one of "violent conflict." Accounts in the *Shasta Courier* in 1854 and 1855 describe violent reactions, including the shooting and hanging of many Wintu, apparently in response to the theft of livestock. In one incident in 1864, "Following the murders to two white women, one near Millville and the other at Bear Mountain,...it was estimated

that 500 local Indians, many of whom worked in ranch households and as ranch hands, were killed in one week alone" (Smith 1995, as cited in Sundahl 2006). According to Sundahl, the Wintu seem to have largely disappeared from Stillwater in the 1860s, although some Wintu returned to their traditional sites in the 1870s and 1880s. Records from this time indicate that they had good relationships with their white neighbors (Sundahl 2006).

By 1849, the Gold Rush was in full swing in Shasta County. A number of mining districts were formed in and near the assessment area, including Boomtown and Churn Town, which are both now part of Shasta Lake City, Buckeye, Iron Mountain, Leighton, Mountain Gate, Pine View, and Redding. Although gold was not discovered east of the Sacramento River, the timber and grazing lands in the assessment area became primary supply areas for the gold and copper miners who followed (SHN Consulting Engineers & Geologists and VESTRA 2001). Figure 2.2, Historical Place Names, illustrates the general location of Buckeye and some of the other early settlements in the assessment area.

1850 to 1920

The period from 1850 to 1920 brought considerable change to the assessment area and the larger region, including the expansion of agriculture and mining. During this period, several of the mining districts in the assessment area became well-established towns.

After the Gold Rush, copper and limestone mining became the major land use activity in the region, encouraging the further development of townships and other settlements. Over time, many of the miners turned their efforts to farming, ranching, and logging to support the growing population. The Homestead Act of 1862 provided for any citizen (except Indians) to claim 160 acres for $10 dollars under the condition that the individual would live on the land for at least 5 years.

Historical records document several homesteads in the assessment area as early as 1862. These homesteads include the John and Lucinda Bass (1862) and Samuel Gadfrey Luscher (1890) homesteads in Stillwater, the Alice and Edgar Pinson (1935) homestead in Buckeye, and the Charles Henry Bewin (1879), Samuel Goozee (1884), W. L. Tomlin (1885), Sarah E. Spann (1886), Peter Scherer (1886), and Samuel and Sarah Goozee (1888) homesteads in Redding (National Register of Historic Places 2005).

Loomis Corners, located adjacent to Stillwater Creek at the junction of the California–Oregon Trail and the Alturas Trail, was a stage stop, and a post office was established there in 1889 for the convenience of local ranchers and farmers. The post office, named Leighton for an early settler and the first postmaster, was discontinued before the turn of the century, probably because of changing demographics and the level of service required (U.S. Army Corps of Engineers 1977).

After the Gold Rush, copper and limestone mining became the major land use activity in the region, encouraging the further development of townships and other settlements.

The Buckeye mining district was located in the upper Churn Creek watershed northwest of Redding between Lake Boulevard and Oasis Road. The Buckeye township, named by an Ohio miner after the flowering buckeye, was settled in 1849 (Shasta County Historical

Society undated). In 1890, the population of Buckeye consisted of 1,447 Whites, two Chinese, and 37 Native Americans (Republican Free Press 2005). Redding's population in that year consisted of 1,680 Whites and 64 Native Americans (Republican Free Press 2005). By 1914, Redding's population had grown to approximately 5,000 people.

Enterprise, informally established in 1887, became the largest of the early townships. The inset beginning on the next page, "Enterprise: From Ranches to Redding," discusses the evolution of the Enterprise community.

Enterprise, informally established in 1887, became the largest of the early townships.

1920 to 1970

Between 1920 and 1970, there was a marked change in land use and settlement patterns in the region. California's increasing population generated the momentum for large infrastructure projects, such as the Central Valley Project (CVP) and the interstate highway system, most notably Interstate 5 (I-5). These projects directly affected the growth and development of the region, aided by reliable sources of energy and a sizeable workforce.

As the United States began to recover from the Great Depression, the construction of Shasta Dam beginning in 1938 offered job opportunities and attracted hundreds of families to the region. Communities founded during the mining era were repopulated during the dam boom, particularly in the upper Churn Creek watershed, and land speculation became profitable.

Three distinct cores of residential and commercial development—Project City, Central Valley, and Summit City—emerged along Shasta Dam Boulevard by the summer of 1938 in what is today the City of Shasta Lake (Rocca 2006). The three areas were known as "boomtowns." Lot sales started late in 1937, and real estate sales became feverish in the early spring of 1938 (Wiegel 1952). The populations of both the town of Redding and Shasta County as a whole had increased by an estimated 40 percent by the time Shasta Dam was completed in 1945 (Shasta County Historical Society 1955).

Several other important development projects during this era helped shape the assessment area. The U.S. Army Corps of Engineers (Corps) built a military base, the Shasta Redding Army Airfield, in 1942. The airfield was deeded to the City of Redding in October 1947 and became the Redding Municipal Airport. The airport is located in the eastern part of the assessment area, between Clover Creek and Stillwater Creek.

Another important development in the assessment area built during this era is Shasta College. The present campus, referred to as the Stillwater campus because its east side borders Stillwater Creek, was built in 1968 (Shasta College 2006). Shasta College is part of the Shasta-Tehama-Trinity Joint Community College District, which also owns 350 acres in Bella Vista. The District serves an area of approximately 10,000 square miles (Shasta College 2006).

During this period, many communities in the assessment area were expanding to accommodate population growth. The Enterprise community, for example, built a Community Hall in 1947 and the Enterprise Fire Hall in 1958. In 1966, the City of Enterprise was formally established. In that

Enterprise: From Ranches to Redding

The establishment and pattern of growth[1] of Enterprise serve as an example for the evolution of a rural area into an urban and residential center.

Enterprise is among the townships established in the assessment area after the arrival of American settlers following the Gold Rush. The earliest records show that the township evolved from adjacent "acreages" developed in the late 1880s. Clearly, however, settlers were present in the Enterprise area before the development of these acreages. We know this because records show that the name Enterprise came from the name of its school, which was established in 1884.

The four maps on the next page show the patterns of development in the Enterprise area from 1897 through 1947. The first development in the Enterprise area began in Sections 6 and 7. By 1947, residential and business development was present in all five of the sections.

According to J. L. Wall, an acreage of 80 acres in Section 6 and acreages from 47 to 89 acres in Section 7 were acquired in 1887. As shown on the upper left map, the Section 7 acreages were consolidated to become part of the 690-acre Van Balveren Ranch by 1897. Also by this time, the one-room Enterprise School had been built on the southwest corner of Hartnell Avenue and Churn Creek Road in Section 7. Land for the school was deeded by a Dr. A. A. Graham "with the provision that if there was ever any dancing there, the land would revert [back] to him."

By 1917, as shown on the upper right map, development was still confined to Sections 6 and 7. In 1916, E. P. Hilborn acquired the Van Belveren Ranch. E. Hemstead acquired 60 acres in Section 6 in 1902, and Mamie Hartnell acquired 4 acres in Section 7 in 1917. Hartnell Avenue and Hemsted Avenue were named for these early Enterprise residents. (The reason for the spelling discrepancy between Hemstead and Hemsted is unknown.)

The 4-acre parcel owned by Mamie Hartnell was the smallest of the parcels in the area at this time. Records from the Shasta County Assessor's office indicate that several other parcels in Sections 6 and 7 had been acquired by this time. Nearly all of them were larger than 30 acres, many were larger than 100 acres, and several exceeded 650 acres.

The lower left map shows that between 1917 and 1937, development began to extend into Sections 5 and 8. During this period, parcels still tended to be fairly large. Shasta County Assessor's office records indicate that four parcels in Section 8 were acquired between 1933 and 1936. Two of the parcels were 160 acres and the other two were 2 and 3 acres. By 1937, development in Section 5 consisted of a single 1-acre parcel. Development also proceeded in Sections 6 and 7. The Van Belveren Ranch in Section 7 changed hands twice before it was acquired by Jacob and Marie Graf, who established the Graf Dairy. Thirteen parcels in Section 8 were acquired between 1920 and 1937, ranging from 30 to 80 acres.

As shown on the lower right map, new development between 1937 and 1947 was concentrated in Section 8. Most of the land in Sections 6 and 7 continued to be devoted to ranching and agriculture, with the principal crops consisting of oat hay, wheat and other grains, vegetables,

[1] The information regarding the development of Enterprise comes from J. L. Wall, 1976. Enterprise: 1877–1976, Fulfillment of Its Name. Master's Thesis, California State University, Chico.

and grapes. Shasta County Assessor's office records show that most of the parcels acquired in Section 8 were much smaller than most of the other Enterprise parcels. Twelve of these parcels were under 2-1/2 acres, one was 4 acres, one was 95 acres, and one was 160 acres. According to Hall:

> *By 1947, the community had a store and golf course in Section 5. There was a school in Section 7 and a community hall and store with a gas station in Section 6. There were also two industries in Section 6: Hein Brothers gravel plant and B and D Lumber Company. In Section 8, there were an auto wrecking yard, Charles Halworth's, and a laundry. In Section 18…the people of Redding and Enterprise had a golf course: Riverview Golf and Club.*

> *Main roads were … a principal bond among the inhabitants of the area. From 1880 to 1927 the road now known as Bechelli Lane rather than Churn Creek Road was the principal road in the Enterprise area. This road went to Churn Creek Bottom and to Anderson. It was near the Freebridge Road and northward intersected the State Highway to Alturus. What is now known as Hartnell Avenue was a road leading from the principal road of the area to Palo Cedro, Millville, Oak Run, and Whitmore.*

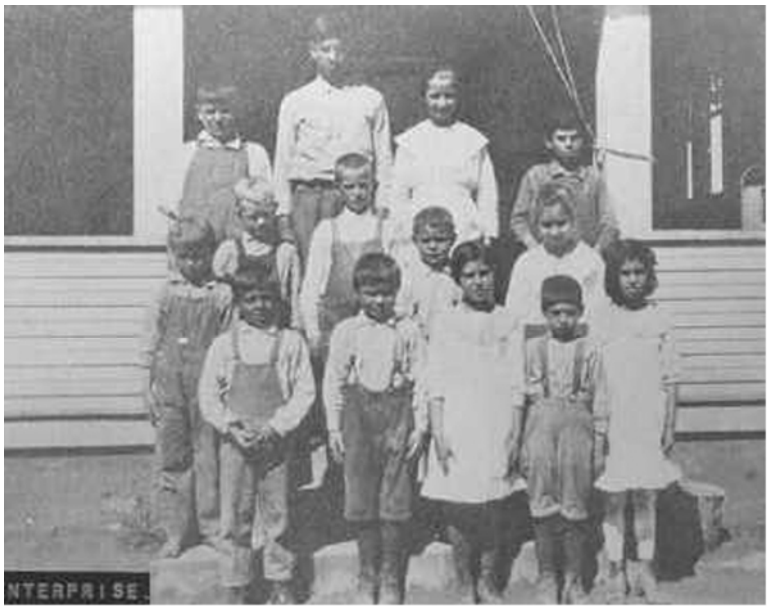
The decade between 1937 and 1947 is notable for the creation of subdivisions in the Enterprise area. Five subdivisions with 1/2- to 1-acre lots were formed during this period; all were located adjacent to existing roads.

During the next decade, 17 new subdivisions were formed. In some of these subdivisions, the parcels were between 1/2 and 10 acres, while in others, lot sizes were uniform, ranging from 60 feet by 100 feet to 100 feet by 160 feet. Most were also built along existing roads, but new roads, including Victor Avenue, were built to accommodate the new subdivisions.

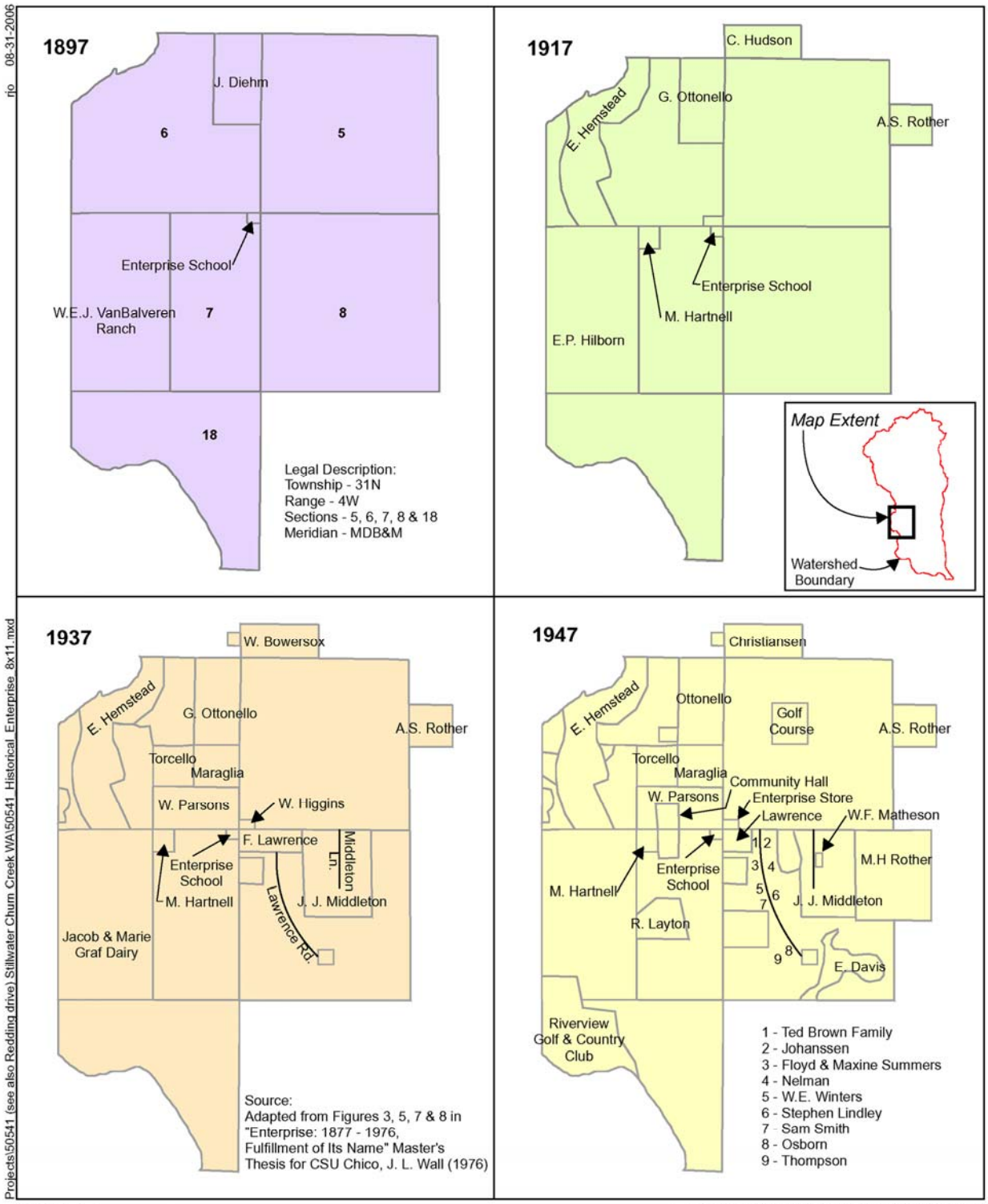
Between 1957 and 1966, 27 new subdivisions were formed. Rather than being built by local residents, many of these subdivisions were built by developers, who often began a new subdivision as soon as the previous one was completed. In 1966, the City of Enterprise was formally established. In that same year, the City of Enterprise embarked on a series of improvements, including widening streets, constructing sidewalks, and installing overhead wiring in 1966. (Herrick undated).

By 1970, Enterprise had taken on the character of a city. In the years that followed, more subdivisions were built and new businesses opened in the area. In addition to single-family homes, many apartment complexes were constructed. During the 1990s, the Hilltop Drive business area expanded greatly to include big box stores and other businesses. To accommodate the growing population, Enterprise also developed new parks and schools.

In 1977, the City of Enterprise was annexed to the City of Redding.



Students at Old Enterprise School, established 1894. (Photo circa 1918-1919; courtesy of Shasta Historical Society.)



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Projects\50541 (see also Redding drive) Stillwater Churn Creek WA\50541 Historical Enterprise 8x11.mxd

North State Resources, Inc.

Stillwater - Churn Creek Watershed Assessment

Historical Development of the Enterprise Area, 1897 - 1947

Closeup of Enterprise Four Corners in the 1950s. Old Enterprise School is in the Southwest corner. (Photo courtesy of Shasta Historical Society.)

Enterprise area in 1950s with Four Corners near center. (Photo courtesy of Shasta Historical Society.)

Closeup of Four Corners in 2004. (Photo courtesy of City of Redding.)

Enterprise area in 2004. (Photo courtesy of City of Redding.)

Four Corners, 1950s and 2004

same year, the City of Enterprise embarked on a series of improvements, including widening streets, constructing sidewalks, and installing overhead wiring in 1966 (Herrick undated).

In 1937, California became the first state to mandate that all cities and counties adopt general plans. Land use plans and policies were developed to guide land use in the assessment area starting in the late 1950s.

The Shasta County Department of Resource Management and the planning division of the City of Redding's Development Services Department were established in 1956 and 1958, respectively. The City of Redding's first zoning ordinance was adopted in 1956, and its first general plan was adopted in April 1958. Shasta County's first general plan was adopted in 1967. The Redding Redevelopment Agency was created by the Redding City Council in 1958 to facilitate the redevelopment of various Redding neighborhoods. These planning vehicles formalized the land use planning process and directed future growth. During this period, legislation was also passed to assist in making land use management decisions. One such act, the California Land Conservation Act of 1965, now referred to as the Williamson Act, provides incentives for conserving agricultural lands and open space in California.

1970 to Present

Before 1970, the population of the assessment area remained quite low and was widely scattered. From 1970 to the present, population growth and a stable economy have led to increased urban development throughout the region. Since the first census in 1850, the populations of the City of Redding and the City of Shasta Lake have increased dramatically. In the last decade alone, the City of Redding's population has increased by 61 percent (City of Redding 2006), with most of the increase due to migration from other areas. As of the 2000 Census, Shasta County's population was 163,256; Redding's population was 80,865; and the City of Shasta Lake's population was 9,008.

Similar to the economic boom experienced during the construction of Shasta Dam, the construction of the Trinity River Division of the CVP, including the Clear Creek Tunnel and Whiskeytown Dam, generated jobs and improved Redding's economy throughout much of the 1960s. Redding served as a railroad and highway terminal for equipment and materials for the project. Whiskeytown Dam, constructed on Clear Creek, was completed in 1963. An estimated 750 men worked on the Trinity River Division at its peak in the spring of 1963, and the total project cost $253 million (VESTRA 2005).

In 1977, the Enterprise area was annexed to the City of Redding. Growth in this area increased following annexation due to improved infrastructure. Growth in other parts of the assessment area was facilitated by construction of the CVP, which provided reliable sources of electricity to residents and commercial interests, increased the availability of developable land due to the decreased risk of flooding along the Sacramento River, especially in the Churn Creek Bottom, and provided water storage and conveyance capabilities to support urban growth.

From 1970 to the present, population growth and a stable economy have led to increased urban development throughout the region.

Only recently has urban development expanded throughout the assessment area, typically consisting of lower density residential and commercial uses. The biggest change in land use is rural urbanization, particularly from large ranches to ranchettes (Nash pers. comm. 2005). Urban development patterns continue to affect beneficial uses throughout the assessment area.

Currently, the Redding Redevelopment Agency is involved in four redevelopment projects, three of which are located in the assessment area: the Canby-Hilltop-Cypress Redevelopment Project, the SHASTEC Redevelopment Project, and the Buckeye Redevelopment Project.

The Canby-Hilltop-Cypress Redevelopment Project area was originally established in August 1981 and substantially amended in 1990 to encompass an overall area of 2,050 acres, stretching from Rancho Road in the south to North Market Street across the Sacramento River. This project was developed to address inadequate utility infrastructure, substandard and deteriorated public rights-of-way, irregular and nonconforming patterns of land subdivision, lack of a coherent and contiguous street circulation system, and severe housing and social needs. Some of the key public improvements that have been completed since 1981 include:

- Churn Creek overcrossing at Highway 44
- New access ramps at Highway 44/Friendly Road
- Realignment of Churn Creek Road from Cypress Avenue to Mistletoe Lane
- Widening of Hartnell Avenue overcrossing at I-5
- Drainage improvements to Little Churn Creek
- Waterline improvements along Churn Creek Road
- Sacramento River Trail extension to Hilltop Drive
- Mt. Shasta Mall renovation
- Signalization at the following intersections: Hartnell/Churn Creek Road, Cypress Avenue/Churn Creek Road, Mistletoe Lane/Churn Creek Road, Mistletoe Lane/Hilltop Drive, and Hartnell Avenue/Parson Jr. High

The SHASTEC Redevelopment Project is a cooperative project by the City of Anderson, the City of Redding, and the County of Shasta. The project area consists of approximately 4,100 acres extending from Abernathy Lane in Redding on the north to the vicinity of Riverside Avenue and North Street in Anderson on the south. One of the primary goals in forming the project area in July 1996 was to remove physical and economic barriers, thereby facilitating development around the Redding Municipal Airport which will benefit all three jurisdictions.

The Buckeye Redevelopment Project is a cooperative project created by the City of Redding and the County of Shasta in July 2000. The project area is approximately 1,063 acres situated in the northwest portion of Redding, where the city's boundary is contiguous with the Shasta County line. The northern portion of the project area is in unincorporated portions of Shasta County. Like for the SHASTEC Redevelopment Project, one of the primary goals is to remove physical and economic barriers, thereby encouraging new development that will benefit both the City of Redding and the County of Shasta.

During the period from 1970 to the present, the City of Redding adopted 19 area and specific plans within its overall planning area, 12 of which are located in the assessment

area. These area and specific plans have been incorporated into the City's General Plan; they provide more detailed policy direction that focuses on the unique character and issues associated with different geographic areas. Table 2.1 lists each of the area and specific plans that have been adopted to date, the size of the area covered, and the year adopted.

Residents today express concern about the development pressures that Churn Creek and its associated wetlands are facing (Phyllis Pollock pers. comm. 2005). According to the general plans for the City of Redding, the City of Shasta Lake, and the County of Shasta, the majority of land in the assessment area is now either developed or zoned for development. Sixty-four percent of the assessment area is zoned residential; the amount that has already been developed is unknown. Thirteen percent of the assessment area is classified as agricultural/mineral resources, although agriculture and mining are both declining in the assessment area as a result of residential and commercial pressures.

Table 2.1-1
City of Redding Area and Specific Plans for the Assessment Area*

Plan	Application Number	Acres	Year Adopted
Hilltop Drive	GPA-1-73	397	1973
Mt. Shasta Mall area	GPA-2-75	1,488	1976
Twin View	GPA-1-76	195	1976
Upper Churn Creek	GPA-3-79	2,170	1979
Sulphur Creek area	GPA-5-79	1,370	1979
Municipal airport area	GPA-1-82	8,500	1982
Enterprise area	GPA-5-82	6,400	1982
Quartz Hill Road area	GPA-8-84	7,083	1984
Hacienda Heights area	GPA-12-84	2,000	1985
Columbia area	GPA-9-85	1,465	1988
Oasis Road area	GPA-4-87	1,794	1988
Upper Stillwater	GPA-14-92	5,960	1994

Source: City of Redding General Plan Update and Environmental Impact Report: Background Report (City of Redding, Development Services Department, May 1996).
*For some plan areas, only a portion of the acreage is located within the assessment area.

Local citizens have also become increasingly aware of the effects of development on local streams. In 1990, the Churn Creek Task Force was formed by the Redding City Council to address concerns over the "declining state" of Churn Creek brought to its attention by property owners in the Churn Creek area. The Task Force, which was made up of a cross section of interested citizens and resource agency staff, prepared a report to the City Council (Churn Creek Task Force 1991) with findings and recommendations concerning the creek. Many of the issues and problems covered in the report remain today and are addressed in this watershed assessment.

Also in response to the effects of increasing development, non-profit organizations and governmental entities began to set aside land for wildlife habitat. The McConnell Foundation, a private, independent foundation established in 1964, has been a leader in protecting habitat in the assessment area while providing public spaces for hiking, bird watching, and observing plants and wildlife. The foundation's Lema Ranch, located north of Old Alturas Road between Churn Creek Road and Old Oregon Trail, is situated on 200 acres of rolling grasslands and dense chaparral as well as a variety of oak species. The property includes more than 4 miles of walking trails. Four ponds built by the Lema family in the 1950s have been improved to encourage aquatic plant communities. The Foundation's Churn Creek Trails, located just west of Lema Ranch adjacent to Churn Creek, provides another 4 miles of walking trails that traverse a blue oak woodland and a meadow that was once a farm. The trail routes were chosen to avoid wetlands on the property. Managers of these properties have instituted a program to establish or re-establish native perennial grasses while controlling or eliminating non-native species.

Trail through blue oak woodland at Churn Creek Trails. (Photo courtesy of the McConnell Foundation.)

The City of Redding is involved in several open space and preservation projects in the assessment area. Among these are the Clover Creek Preserve and the Old Oregon Trail Vernal Pool Restoration Area.

The Clover Creek Preserve is located in the Clover Creek floodplain south of Hartnell Avenue on Shasta View Drive. The 128-acre site contains a 6.7-acre lake within a 46-acre detention basin that will provide flood protection to more than 5,000 acres of the Clover Creek watershed; the detention basin area includes more than 10 acres of seasonal wetland, marsh, perennial pond, and riparian habitats. The goal of the preserve is to conserve and restore oak savannah, vernal pool, and wetland habitats to benefit wildlife. The preserve also includes approximately 50 acres of grassland with scattered vernal pools and 4.5 miles of walking and bicycle trails.

In 2003, the City of Redding entered into a Memorandum of Understanding with the California Department of Fish and Game (CDFG) to establish the Old Oregon Trail

Vernal Pool Restoration Area, a wetlands preservation/restoration area in the assessment area on both sides of Highway 44 south of Redding's Sports Complex. The purpose of the restoration area is to preserve and restore degraded vernal pools and their associated wetland and upland catchment areas. In addition, the area serves as mitigation for impacts on wetlands and endangered species in other areas both within and outside the assessment area. One of the goals of the restoration area is for the City to own and manage the lands with oversight and technical support provided by CDFG.

Another preserve, the 283-acre Clover Creek Ecological Preserve, is located along Stillwater Creek in the southern portion of the assessment area off Dersch Road. CDFG owns and manages the property to preserve habitat for wildlife, particularly avian species. The site also provides public access to the Sacramento River.

2.1.2 MINING

Because mineral ores are not highly exposed in the assessment area, mining activities have been concentrated along the upper reaches of Churn Creek and Stillwater Creek, including in Buckeye and Mountain Gate. Placer mining in the Buckeye mining district required stable water supplies and the removal of riparian and upland vegetation in order to extract gold-bearing alluvial materials. Water was also used to move processed materials off-site, with the waste products typically being discharged back into the aquatic environment. These activities resulted in alterations to aquatic, terrestrial, and riparian habitats within the assessment area. They also resulted in an influx of people and the infrastructure needed to support them.

Pre-Columbian to 1850

Pierson B. Reading washed out the first gold in Shasta County on a gravel bar at the mouth of Clear Creek in March 1848. By 1849, the Gold Rush was well underway. Following the discovery of gold in Shasta County, the town of Shasta became the most important commercial center in northern California, followed by Horsetown at the mouth of Clear Creek, and Lower Springs, which is approximately 2 miles southeast of Shasta (Smith 2005).

Various methods were used to collect the gold. At first, the miners used hand tools, such as gold pans, sluice boxes, long toms, rockers, and cradles, in and adjacent to the rivers and streams. During this period, they either worked alone or in small groups. Although many claims were staked, the mining techniques they used were not suitable for long-term operations. As the small placer claims were depleted, the mining operations became more sophisticated, using such techniques as hydraulic, dredging, and drift mining, all of which required larger capital investments than the earlier methods. The large mining companies that were formed diverted rivers and streams to expose the streambeds and dug deep shafts or tunnels into the earth west of the Sacramento River.

Shasta County's copper mining era began when copper was discovered in the early 1860s. The principal copper deposits are associated with the Klamath Mountains Geomorphic Province. These deposits are concentrated in a 30-mile, crescent-shaped copper-zinc belt extending from Iron Mountain northeastward to Backbone Creek and east to Ingot (Smith 2005). While this belt encompasses the northern perimeter of the assessment area, most of the copper mining

occurred north and west of the assessment area.

Gases released by copper smelters denuded area hillsides. (Photo dated 1915; courtesy of Shasta Historical Society.)

Copper was first mined at Copper City (now under Shasta Lake) in 1862. Iron Mountain became the most important copper district and included the Balaklala, Keystone, Mammoth, Mountain Copper, Shasta King, and Sultro mines (Smith 2005). Copper mining required significant investment in smelters, transportation systems, and labor. In 1897, production of copper in Shasta County surpassed that of gold. Between 1896 and 1919, Shasta County was one of the largest copper mining and smelting regions in the United States.

The Thompson copper mine was located adjacent to the East Fork of Stillwater Creek approximately 8 miles northeast of Redding. The general location of this mine can be gleaned from the copper locations shown on Figure 2.3, Geomorphic Provinces and Mine Data; discrepancies between historic place names preclude naming specific mine locations on this figure. This area was first prospected during the 1890s, when a shaft was sunk in the creek bottom and chalcopyrite-bearing quartz was encountered. The main pit, which was about 400 feet long and up to 35 feet deep, ran in a northeasterly direction (California Division of Mines and Geology 1974).

The first copper smelter in the region was built at Keswick, followed by the construction of three other smelters. The Keswick smelter operated from 1896 to 1905 (Peterson 1972). Fumes produced by the smelting process included sulfur dioxide gas, which is damaging to the respiratory system, is harmful to aquatic life, and is extremely toxic to plants. Releases of the gas from area smelters damaged or killed more than 153,000 acres of native vegetation from the Sacramento Canyon to below Red Bluff. Although information is not available concerning the vegetation that was present before the smelters were constructed, it is likely that, depending on aspect and elevation, oak woodlands and mixed-conifer species were replaced by the large fields of chaparral seen today.

Releases of sulfur dioxide from area smelters damaged or killed more than 153,000 acres of native vegetation from the Sacramento Canyon to below Red Bluff.

Violent protests concerning the effects of the smelters ensued, and copper companies were taken to court. By 1919, all the smelters had been closed by order of the courts (Smith 2005). Alternative methods were developed to process the ore, but the amount of copper mining greatly decreased because of the poor quality of the copper, high production costs, and competition (Smith 2005).

Limestone deposits associated with the copper-zinc belt were initially mined to support the copper smelters and local construction. Limestone was used as flux in the copper

mines (California Division of Mines and Geology 1974) and to provide materials required for Portland cement. The limestone was typically used locally because of the distance to large centers of consumption. Small quarries were operated between 1896 and 1937 to supply flux for the smelters in Shasta County. Several limestone mines were located in the northern portion of the assessment area. The largest of these early operations was the Holt and Gregg quarry in the upper Stillwater Creek watershed, where limestone was quarried and burned in kilns as early as 1884 (California Division of Mines and Geology 1974).

1920 to 1970

Development of the region's sand and gravel resources occurred concurrently with many of the public works projects during this era. Sand and gravel were used predominately in concrete aggregate and for road and highway construction, with the amount mined depending on the number and size of public works projects in progress at any one time.

In general, the most readily available sources of sand and gravel were alluvial deposits associated with creeks and rivers. This material was preferred by road builders because of its high quality at a relatively low cost. The clean, hard alluvial materials found in and adjacent to active channels were preferred for the production of Portland grade cement. Lesser grade materials, typically found further away from active channels, were typically used to produce the road base.

The abundance of high-quality alluvial materials in the assessment area led to the development of gravel mining operations along Churn Creek and Stillwater Creek as aggregate sources for construction projects, including roads, public facilities, shopping centers, and subdivisions, in the greater Redding area. A number of these mining operations have been abandoned because of depleted resources or high water tables. Depending on local groundwater conditions, some of the abandoned pits provided the conditions for the creation of lakes and ponds, for example, Ross's Pond, which is along Stillwater Creek upstream of Shasta College, and Shea's Ponds, which are upstream of the mouth of Clear Creek.

In 1957, the Flexiform Engineering and Mining Company leased the Thompson copper mine property on the East Fork of Stillwater Creek, opened the main pit, sank a two-compartment shaft to a depth of 60 feet, and prospected the surrounding area by bulldozer (California Division of Mines and Geology 1974). A carload of copper concentrate was shipped to a smelter in Tacoma in 1958 (California Division of Mines and Geology 1974). The property has been idle since 1959.

Calaveras Cement Company began mining limestone in the Mountain Gate and Gray Rocks areas in the 1950s.

The Shea Sand and Gravel mine was located in the assessment area immediately east of the Sacramento River opposite Clear Creek and 3½ miles downstream of South Bonneyview Road. The mine began operating in 1958 to supply aggregate materials for construction of the water conveyance tunnel between Lewiston and Whiskeytown reservoirs (California Division of Mines and Geology 1974). Its pits also provided mineral materials used in the construction of I-5. High water tables eventually limited the extraction of additional material.

From the onset of the Gold Rush through the 1940s, mining was the primary cause of large, unnatural sediment loads delivered to the

Sacramento River. The California Department of Water Resources estimated that 1.4 billion cubic yards of silt, sand, and gravel from mining operations were washed into the Sacramento River throughout the Central Valley (Buer and Parfitt 1980). Without a comprehensive sediment budget for the assessment area, it is unclear what the cumulative sediment contribution is in the context of the Sacramento River watershed.

1970 to Present

Mining, particularly for industrial minerals, including limestone, shale, and sand and gravel, persists in the assessment area. Most mining activity is located in the Mountain Gate area in the upper reaches of Stillwater Creek. Several large corporations operate quarries that provide material for the chemical, construction, and landscape industries. Intermittent sand and gravel operations have occurred along Stillwater Creek upstream of the airport and along Churn Creek upstream of Knighton Road, particularly to support large construction projects such as I-5 and the Redding Airport.

2.1.3 AGRICULTURE AND RANCHING

The relatively flat to gently rolling topography in the lower reaches of the assessment area along with the availability of water for irrigation facilitated the development of ranching and farming operations. Although many of the farms and ranches have been converted to urban uses, unincorporated areas along Churn Creek and Stillwater Creek continue to support agricultural activities.

Pre-Columbian to 1850

One consequence of the Hudson's Bay Company's policy of beaver extermination in much of the northwestern United States was that it helped set the stage for the advent of large-scale livestock ranching. When beaver were removed, their dams decayed and the small wetlands behind the dams drained, leaving fertile meadows that were exploited for livestock grazing by early ranchers. The hydrologic patterns of vast areas of western watersheds were significantly altered during this time as a result (Elmore and Beschta 1987, as cited in National Research Council 2004). However, the degree of beaver extermination and subsequent draining of wetlands in the assessment area is unknown.

Mining, particularly for industrial minerals, including limestone, shale, and sand and gravel, persists in the assessment area. Most mining activity is located in the Mountain Gate area in the upper reaches of Stillwater Creek.

The conversion of land to agricultural use in the assessment area increased rapidly during this period. Sheepherders were the first to graze the grasslands of the Stillwater Plains and bottom lands along the creeks. Many of the early ranches of California ran joint herds of sheep, cattle, and horses in the 1840s (SHN 2001). The early ranchers altered the landscape by constructing access roads, residences, and ranch structures.

1850 to 1920

Personal accounts of farming in the assessment area during this era documented dry farming, seasonal planting, and harvesting methods. According to one account, the work was done by horse and man power; in the fall, the soil was prepared by a single-furrow, horse-drawn walking plow, then seeded by machine to grain or hay (Smith undated). Wheat was the main cash crop, particularly on

the bottom lands adjacent to Churn Creek and Stillwater Creek.

Farming and ranching persist in the assessment area, particularly in unincorporated areas such as Churn Creek Bottom and Stillwater Plains.

Settlement patterns along Churn Creek and Stillwater Creek suggest that early residents had access to year-round water sources, either from surface water sources or hand-dug wells in alluvial materials. Interviews with long-term residents support the hypothesis that early settlers used water from these creeks to supply irrigation ditches constructed for ranching and agricultural operations. Water was diverted from these creeks to enhance grazing opportunities during the hot, dry summers. It is not known whether Stillwater and Churn creeks had only intermittent flows during this period, but they are now classified as intermittent by the USGS. Irrigated agriculture was prominent in the vicinity of Bella Vista and Churn Creek Bottom, particularly after the formation of the Anderson-Cottonwood Irrigation District (ACID) in 1914 and the Bella Vista Water District (BVWD) in 1957.

1920 to 1970

The construction of the ACID was specifically intended to provide water for agriculture. Historically, Stillwater and Churn creeks provided irrigation water for commercial agriculture and grazing in the assessment area. Rice and alfalfa were some of the crops grown prior to construction of the CVP. Additional lands, particularly in the Churn Creek Bottom, were developed for agricultural purposes after Shasta Dam was completed. Along Stillwater Creek, the establishment of the BVWD in 1957 resulted in modifications to agricultural practices, including the removal of diversion dams and the institution of irrigated crop rotation (Bob Nash, pers. comm. 2005). The BVWD provides water for domestic, industrial, and agricultural uses to residents in the east side of the assessment area.

1970 to Present

Farming and ranching persist in the assessment area, particularly in unincorporated areas such as Churn Creek Bottom and Stillwater Plains. In addition to traditional activities such as cattle grazing, forage production, and dairy farms, a number of new agricultural activities have been attempted with varying degrees of success. The subdivision of large ranches into ranchettes has provided opportunities to raise domesticated exotic species, such as llamas, emus, and goats. The production of strawberry nursery stock has expanded over the past 30 years, particularly along Stillwater Creek upstream of Shasta College.

Construction of ACID canal. (Photo circa 1915-1916; courtesy of Shasta Historical Society.)

2.1.4 RAILROADS AND ROADWAYS

Construction of the railroad connecting Sacramento with the Klamath Falls was important to the early development of the

Redding area. Later, creation of the highway system that crosses the assessment area facilitated the movement of people and goods in and out of the region. The first highways followed the terrain of the land, resulting in many sharp curves. The highways were later straightened and widened using various engineering techniques.

Pre-Columbian to 1850

Many settlers journeyed to the region via the California–Oregon Trail beginning in the mid-1800s. Today's Old Oregon Trail, west of Stillwater Creek between State Route (SR) 44 and Bear Mountain Road, is in approximately the same location as the historic trail. SR 299 was constructed along the alignment of the Alturas branch of the Old Oregon Trail.

1850 to 1920

In 1872, the first Shasta County railroad depot was constructed in Cottonwood, followed by a second depot in Anderson. Business districts developed around the depots to support the movement of people and goods in the area. When the tracks reached what today is the City of Redding, work stopped for 10 years (Smith 2005). The temporary end-of-the-line district was called Redding for B. B. Redding, a railroad land agent (Smith 2005). Construction of the railroad facilitated the growth of Redding, which quickly became the busiest and most important town in the region. In 1882, track laying resumed north from Redding, and new towns and settlements developed along the line.

In 1902, state aid was provided to counties for road construction (California Highways 2006). Most of these funds were devoted to maintenance, such as clearing storm debris and constructing retaining walls and culverts. In 1905, California began registering automobiles, and 2,475 cars were registered in that year. In 1911, the legislature passed the Chandler Act, which provided federal funds for roads to improve rural mail delivery. Rural Free Delivery started in Redding in 1913.

1920 to 1970

The three highways that cross the assessment area were all built during this era. The most prominent of these highways is I-5, which extends from the Mexican to the Canadian border. I-5 runs approximately northeast to southwest through the northern half of the assessment area and north to south through the southern half. Construction of I-5 began in 1957 and was completed in about 1964.

The other two highways in the region run approximately west to east. SR 299, constructed in the 1940s, follows the old mining route from Humboldt Bay to Alturas, crossing a number of creeks along the way, including Churn and Stillwater creeks. This route was designated U.S. 299 in October 1934 and was renamed SR 299 in 1964. SR 44 was constructed in 1935 to provide access to Lassen Volcanic National Park as well as the forested lands east of Redding, ultimately ending east of Old Station at SR 89. This route crossed Churn and Stillwater creeks as well as the headwaters of Clover Creek.

The primary road network in the assessment area was developed during this period in response to economic development and expanding populations. During this period, Shasta County and the City of Redding undertook a number of transportation/public works projects with the private sector, particularly in the Churn Creek and Clover Creek watersheds. Data limitations preclude an in-depth discussion of the road development process over time.

During the early phases of the construction of Shasta Dam, the railroad was relocated from the western side of the Sacramento River to the eastern side. Relocating the railroad required construction of several new bridges over Churn Creek and several tributaries. A substantial number of new roads were also constructed to serve the small communities established to support the construction of Shasta Dam.

1970 to Present

The continued growth within the assessment area since the 1970s is reflected in the expanded transportation network that exists today. In addition to roads, a number of trails have been constructed in response to increased demand for nonmotorized access to open space areas.

The ACID was organized in 1914 to provide irrigation water for agricultural interests between Redding and Cottonwood.

Figure 2.4, Road Densities 1984-2005, illustrates the pattern of road development between 1984 and 2005. In addition to the increase in actual road miles (not quantifiable with existing data), the standards for road construction/reconstruction have been modified to reflect changing societal values, including safety, reliability, comfort, and environmental awareness. Legal requirements have also led to substantial changes to existing roads (e.g., reconstruction, secondary access, paving).

2.1.5 PUBLIC UTILITY DISTRICTS

1850 to 1920

The Redding Electric Light and Power Company provided the first electric service to the City of Redding from a small hydroelectric plant on the Sacramento River. Pacific Gas & Electric Company (PG&E) acquired control of the facilities on October 3, 1919, under a merger authorized by the California Railroad Commission (City of Redding 2003). In 1916, a municipal street lighting system was established in Redding.

The Redding water supply and treatment facilities date back to the early 1900s. The first community water system was constructed by the Redding Water Company in 1886. The water was pumped from the Sacramento River and eventually replaced by a well near Jenny Creek approximately 200 feet from the river.

The ACID was organized in 1914 to provide irrigation water for agricultural interests between Redding and Cottonwood. The ACID constructed a series of canals that delivered Sacramento River water from Redding through Anderson to Cottonwood between 1914 and 1920, although additional construction occurred later. Originally, ACID water was delivered to the Churn Creek Bottom via a conduit attached to the old South Bonneyview Bridge. Eventually, this delivery system was upgraded to a pump facility just downstream of the old bridge abutment on the east bank of the Sacramento River. As an aside, a record from the period shows that a McCoy Fitzgerald sold his claims to the water rights for "the purpose of irrigation, watering livestock, domestic use and mechanical purposes," to the ACID for $10 in gold (Smith undated).

1920 to 1970

From 1937 to 1939, the City of Redding constructed its own water system. In 1966, the City of Redding entered into a water contract with the U.S. Bureau of Reclamation (Reclamation) that allows a maximum annual

diversion of 21,000 acre feet (af) or 18.7 million gallons per day (mgd). This contract authorized diverting water from Lake Redding on the Sacramento River as well as Whiskeytown Lake and Shasta Lake. In 1967, the City took over the Buckeye County Water District, which provided service to the area between Lake Boulevard and Oasis Road, and acquired its Reclamation contract, which allows for an additional maximum annual diversion of 6,140 af, or 5.4 mgd, from the CVP.

When the Bella Vista Water District upgraded its system, local residents abandoned surface water intakes located in Stillwater Creek for agriculture uses.

The City of Redding's wastewater system developed slowly until the 1950s, when approximately 20 percent of the City's approximately 5,200 acres was served. The need for expansion prompted the City to commission the development of a master plan. As a result, it added approximately 27 miles of sewer lines and relocated its wastewater treatment plant from near the Cypress Street Bridge in Redding to the present Clear Creek site, approximately 5.5 miles south (City of Redding 2006).

The City of Shasta Lake uses water pumped from intakes on Shasta Dam under contract with Reclamation. This water is conveyed to the Fisherman's Point Treatment Plant prior to distribution to end users.

Across the river from Redding, the Enterprise Public Utilities District was founded in 1949, and began providing water service to customers in 1950. Prior to this date, residents east of the Sacramento River relied on individual or community wells to provide water for domestic and industrial uses. The district eventually expanded to provide wastewater and storm drain services to residents in the expanding community of Enterprise. Between 1967 and 1977, various districts, including the Buckeye County Water District, the Cascade Community Services District, and the Enterprise Public Utilities District, were annexed to the City of Redding, resulting in the elimination of the existing treatment plants and the consolidation of wastewater treatment and disposal at the City of Redding's Clear Creek Regional Wastewater Treatment Plant (City of Redding 2006).

The BVWD was established in the mid-1950s, and the water system was constructed in 1965. When the BVWD upgraded its system, local residents abandoned surface water intakes located in Stillwater Creek for agriculture uses (Nash pers. comm. 2005). The Mountain Gate Community Services District was formed in 1956. This district provides water for municipal, industrial, and agricultural uses. The City of Anderson maintains a well field west of Airport Road that provides water service to some residents in the Wooded Acres subdivision between Clover Creek and Churn Creek. None of the public service districts discussed in this section use the surface waters of the assessment area.

1970 to Present

The City of Shasta Lake Water District was formed in 1975 to provide water for municipal, industrial, and agricultural uses. The water district currently serves 110,000 customers. Due to the age and configuration of the distribution system, the district is currently upgrading the system to ensure adequate service and provide some ability to accommodate growth.

The annexation of Enterprise in 1977 brought the Enterprise Public Utilities District's water, wastewater, and stormwater systems under the management of the City of Redding.

Over time, the City of Redding's water system has expanded dramatically. From 1978–1980, funds from a major water bond were used to improve the treatment of Sacramento River water at the Foothill Water Treatment Plant, located between Placer Street and SR 299. The project included the construction of a 24-mgd filtration plant, a new chlorination facility, and a 6-million-gallon covered storage reservoir (City of Redding 2003). In 1995, the 7-mgd Buckeye Water Treatment Plant was completed. Although this plant is west of the Sacramento River, it provides service to City of Redding customers across the river on the western side of the assessment area.

The assessment area…is subject to drastic changes in seasonal weather patterns, particularly with regards to extreme summer temperatures and highly variable rainfall patterns.

In 1987, the majority of the Clover Creek basin was placed within the Clover Creek Sewer Assessment District. This district facilitated the construction of a trunk sewer line that was needed to open up the area for more intensive development, primarily industrial, commercial, and residential. The rationale for developing this assessment district was the proximity to the Redding Municipal Airport and the abundance of industrially zoned land. Prior to construction of the line, septic systems were the only available means of sewage disposal, which severely restricted the rate of development. In 1990, the Stillwater Regional Wastewater Treatment Plant, which provides advanced secondary treatment, was constructed, and future expansions of the plant are projected to occur in two phases in 2013 and 2023.

2.2 Landscape Processes

This section describes historic landscape processes in the assessment area and changes in those processes over time. In this context, landscape processes include climate, topography, hydrologic and geomorphic processes, and fire. Understanding historic conditions and changes in landscape processes is necessary to identify important trends in the assessment area.

2.2.1 Topography and Climate

The topographic features in the watershed provide some variability in climatic conditions, particularly during the wet winters and hot summers. Because the assessment area is located at the north end of the Central Valley, it is subject to drastic changes in seasonal weather patterns, particularly with regards to extreme summer temperatures and highly variable rainfall patterns. The lowlands in the southern end are typically hotter in the summer and drier in the winter, whereas the upland terrain in the north end of the assessment area tends to be slightly cooler and have higher rainfall totals. Microclimates are also experienced by residents of the assessment area. Upslope breezes follow the riparian corridors and may provide noticeable cooling on summer evenings. Conversely, a summer evening in the commercial sector, for example, Mt. Shasta Mall, may be substantially warmer due to the large buildings and parking lots.

The assessment area has a Mediterranean climate, with average January temperatures varying between 36 and 55 degrees Fahrenheit (°F). On average, July temperatures range between 65 and 98°F. In a typical year, temperatures within the

assessment area exceed 100°F a number of times each summer with occasional days over 110°F. Winter storms typically begin in December or January and continue through April; low elevations preclude a measurable snow pack. Summer thunderstorms may provide substantial amounts of precipitation on a localized basis.

No contemporary climate data are available for the assessment area before approximately 1900. Our knowledge of historical climate trends is based on glacial cores, lakebed deposits, tree line inventories, and tree ring data.

Pre-Columbian to 1850

Based on tree ring data, epic droughts lasting more than 100 years are known to have occurred beginning in 1150 and 1350 (VESTRA 2005). A minor "ice age" occurred between the mid-1600s and the mid-1800s, prior to the arrival of American settlers to the region. This ice age was characterized by cool, moderately dry conditions.

1850 to 1920

Around 1850, as settlers began to arrive in the assessment area, the region experienced a marked shift in climate. The climate changed from the cool and moderately dry conditions of the previous two centuries to the relatively warm and wet conditions that have characterized the past 150 years (VESTRA 2005). It has been suggested that many of the landscape changes since the 1850s may be attributable to this shift in climate (Stine 1996). Although there is substantial information on Sacramento River floods during this period, flood information specific to the assessment area is not available.

Only recently has the issue of global climate change become an important part of water management.

1920 to 1970

Since the 1940s, annual average temperatures in the region have increased by approximately 2 to 4 °F, with the most pronounced warming during the winter and spring (Cayan et al. 2000).

Climate data show several multi-year droughts during the 1920 to 1970 period. A drought that occurred from 1929 to 1934 represented the most severe drought period for the assessment during this time period (Graumlich 1993; Graumlich and Brubaker 1986, as cited in VESTRA 2005). During this time, water runoff from the valley was 55 percent of the average recorded for the period 1901 to 1996 (Department of Water Resources 2006). Based on tree ring data, however, this drought was less severe than the epic droughts experienced around 1150 and 1350 (VESTRA 2005). Heavy precipitation leading to flooding also occurred in 14 of the 50 years of this period. The 1964 flood was notable for the damage it caused to homes and bridges in the Churn Creek and Stillwater Creek watersheds.

1970 to Present

Climate trends for the watershed region over the past 30 years show consistently hot, dry summers and cool, wet winters. The average annual precipitation for the 1971–2000 period is approximately 40 inches. The lowest annual precipitation on record during this period was 24.46 inches in 1976–1977, and the highest was 103 inches in 1982–1983 (WSRCD 2005).

Only recently has the issue of global climate change become an important part of water management. Initial research on climate risks

facing California water resources began in the early 1980s; by the end of that decade, state agencies had prepared the first assessments of state greenhouse gas emissions (Kiparsky and Gleick 2003). Regional hydrologic modeling has suggested that higher temperatures will greatly affect the timing and magnitude of runoff in California (Kiparsky and Gleick 2003). Currently, water agencies are considering the implications of climate change for the reliability and safety of water systems and are focusing more attention on integrating climate change into long-term planning.

Because no measurable snow pack is available to recharge the watershed, higher temperatures resulting from climate change would not affect the timing of runoff from storms. Rather, higher temperatures would result in higher evapotranspiration rates and reduced base flows. Higher temperatures and reduced base flows could stress aquatic life throughout the assessment area.

2.2.2 HYDROLOGIC PROCESSES

Pre-Columbian to 1850

Hydrologic conditions in the region during the Pre-Columbian era were seasonally variable, with most precipitation falling from November to March. Seasonally heavy rains swelled streams and rivers, causing over-bank flows that resulted in the deposition of fine materials on the floodplains.

Because the native peoples inhabiting the assessment area made only minor modifications to the landscape, it is likely that geomorphic processes in the assessment area were largely influenced by annual climatic variability and regional volcano-tectonic activity. Although punctuated by morphologic changes associated with random events, regional stream channels are thought to have exhibited a dynamic equilibrium between channel meandering, bank erosion, and sediment deposition (Mount 1995).

Based on the underlying geology, water in the assessment area during the Pre-Columbian era was likely not impaired, other than by variations in quantity and quality resulting from seasonal flow, temperature patterns, and fluvial and terrestrial geomorphic processes.

Vernal pools and other wetlands collect water and undoubtedly played an important role in moderating seasonal flooding during storm events. Moderation of storm events would have been most dramatic during drier years, when capture and retention of surface flows in vernal pool landscapes would have influenced riverine processes most strongly. During years of heavy precipitation, vernal pools experience prolonged periods of inundation, preventing these features from buffering the effects of subsequent rainfall on riverine systems.

1850 to 1920

Hydrologic conditions in the assessment area began to change during the period from 1850 to 1920 as a result of human influences. Changes in land use resulting from population growth, smelting operations, wood cutting for firewood and construction, mining, road building, and agricultural development modified the landscape, particularly in terms of vegetation and topography. A number of these modifications (e.g., railroad grades, tunnels, quarries, and hay fields) continue to influence hydrological functions in the assessment area. Although it is difficult to determine to what extent water quality was affected, it is reasonable to assume that these modifications to the landscape contributed to an increase in fine sediments discharged to the aquatic environment resulting from intensive land use activities. Changes to

upland landforms also occurred as a result of land management activities, particularly mining, urbanization, and agriculture. The landforms observed today were influenced by human activities during this era.

Trash was often disposed of in local creeks and carried away by rising flows …Local residents noted that streams now seem much cleaner than in the past.

California experienced major floods in 1862, 1904, 1907, and 1909. The 1862 flood was the largest known flood in California history, earning the nickname the "Great Flood." During the storm that produced the 1862 flood, it rained for nearly 4 weeks, inundating an almost 20-mile-wide area of the Sacramento–San Joaquin Valley for a distance of 250 to 300 miles. The 1909 storm dropped 57.41 inches in 20 days in the Feather River basin southeast of the watershed region, and it was estimated that 300,000 acres of the Sacramento Valley were inundated during the resulting flood. The effects of the 1907 and 1909 floods led to the overhaul of the California Flood Design Plan (Goodridge 1997). Although data concerning the storms that caused these floods are not available for the assessment area, it is likely that local streams overflowed their banks.

1920 to 1970

Urban growth characterized the period from 1920 to 1970. The expansion of residential and commercial development in the assessment area, particularly the growing network of highways and roads, increased the area of impermeable surfaces, resulting in more surface runoff that necessitated the construction of wastewater and stormwater facilities. Natural channels, ditches, culverts, and man-made channels were used as conduits in developing storm drainage networks in the Redding/Enterprise area.

Septic tanks were introduced during this period to collect and dispose of household wastes, replacing outhouses. Early septic systems were often poorly designed and increased the risk of surface and groundwater contamination. Trash was often disposed of in local creeks and carried away by rising flows. It is unknown to what extent this practice occurred and how it may have affected water quality, but local residents noted that streams now seem much cleaner than in the past (Elmer Smith pers. comm. 2005).

Flood data for this period indicate that flooding occurred locally in 1937, 1940, 1942, 1951, 1956, 1958, 1959, 1960, 1962, 1963, 1964, 1968, and 1970. There is no universally accepted definition of flooding, and the size of these floods is not known. The largest recorded flood flow on Churn Creek prior to 1974 was 3,160 cubic feet per second, which was measured at the "near Redding" (Newtown) gage on December 22, 1964 (City of Redding 1991). The U.S. Geological Survey (USGS) estimated that a peak flow of 4,860 cubic feet per second occurred at the Newtown gage site during the September 1959 flood (U.S. Army Corps of Engineers 1974); the gage was installed in 1960 following this flood.

The 1964 storm dumped nearly 13 inches of rain in Redding from December 18–22, resulting in the most damaging flood on record for Churn Creek up until that time. On December 22, floodwater was 2.5 feet deep in some homes along Churn Creek. The Churn Creek Bottom area was described as a "mud-red sea" of floodwater (U.S. Army Corps of Engineers 1974). The flood washed out two bridges on Churn Creek, damaged roads,

Illegal dumping continues to be a problem in the watershed. (Photo courtesy Western Shasta Resource Conservation District.)

Debris in and along Little Churn Creek. (Photo courtesy Western Shasta Resource Conservation District.)

contaminated domestic water supplies, and flooded nearly 730 acres of farmland and rural residential lands.

Rainfall during the storm that produced the 1964 flood was also exceptionally heavy in the Stillwater basin. Precipitation totals in the headwater regions totaled almost 19 inches, and lower portions of the basin received 10 inches of rain. Flooding occurred in a then-undeveloped area along Stillwater Creek near the Highway 299 crossing. Streambanks were eroded, and the bridge abutments were badly damaged by the floodflows.

Like urban growth, agricultural development has affected the hydrologic regime in the assessment area. Construction of the ACID facilities led to the use of flood irrigation. Water taken out of the Sacramento River for irrigation either infiltrated to groundwater or was returned to the river via Churn Creek. In 1940, ACID installed pumps on the east side of the Sacramento River near the current-day Bonnyview Bridge to service agricultural water demands in the area.

The amount of urban growth and its proximity to streams have increased the types and quantities of contaminants that enter area streams via surface runoff.

1970 to Present

In response to numerous septic tank failures in the Mountain Gate, Central Valley, and Summit City areas, the Shasta Lake Utility District built a sewer and wastewater treatment facility that was completed in 1975. The City of Redding expanded its sewer system to encompass the recently annexed Cascade and Enterprise areas. The Clear Creek Regional Wastewater Plant expanded and upgraded to an advanced secondary wastewater treatment plant in 1979, and additional upgrades occurred in 1898 and 1996. The advanced secondary Stillwater Wastewater Treatment Plant at the southern end of the assessment area began operation in 1990 and expanded the service provided by the City of Redding, particularly as it pertains to the Clover Creek Sewer Assessment District. The City of Redding wastewater system currently includes over 380 miles of interceptor and trunk sewers, fourteen sewage lift stations, and two secondary wastewater and effluent filtration treatment plants.

During this era, continued urban expansion and intermittent sand and gravel mining activities along Churn Creek and Stillwater Creek have altered the hydrology and geomorphic processes in the assessment area. The amount of urban growth and its proximity to streams have increased the types and quantities of contaminants that enter area streams via surface runoff; these contaminants include oil, grease, fuel, fertilizers, pet wastes, and pesticides. Recent educational efforts by the Rotary Club in cooperation with the City of Redding are designed to increase awareness of discharges to the storm drain system.

Additionally, reliance on stream courses to convey increased stormwater runoff has forced the channels to adjust (i.e., to incise) to accommodate “flashier” flows. Adjustments to the channel make the stormwater drainage system more efficient. Data limitations inhibit the ability to quantify changes in peak flows, although observations during large storm events suggest that some correlation could be made.

In the absence of sequential stream gage data, it is difficult to illustrate the extent to which the flow regime has changed over time. Conversations with long-term residents of the assessment area, including former employees of the USDA Forest Service (USFS) and CDFG, support the hypothesis that flow regimes have been modified as a result of urbanization of the assessment area. Increases in the amount of impervious surfaces may be correlated to changes in the flow regime, particularly in the urbanized portions of the assessment area. These changes may be characterized in terms of velocity, discharge, and variation in one or more water quality parameters. Increases in impermeable surfaces in a watershed frequently result in higher peak flows and lower base flows. Increases in localized flooding are thought to have resulted as a function of these changes (Churn Creek Task Force 1991).

In order to attenuate storm flows and reduce their magnitude, the use of retention/detention basins has been incorporated into the City of Redding General Plan since about 1990. Although the City of Redding has some documentation concerning the locations of these facilities, there has been no comprehensive evaluation of their effectiveness. Residents in the assessment area have suggested that some detention facilities, for example in Gold Hills, have not provided complete flood relief. At least two detention facilities have been proposed for the Oasis Road area, one just north of Oasis Road and one directly on Churn Creek just outside of the City of Redding limits.

Dams on the Sacramento River and Clear Creek have profoundly affected the downstream bedload. Since the dams were constructed, tributaries to the Sacramento River have played a more important role in contributing bedload to the river. A study conducted in 1980 by the California Department of Water Resources (DWR) suggested that gravel mining in the tributary streams of the assessment area leads to major reductions in their bedload contribution (Buer and Parfitt 1980). Subsequent efforts under the auspices of the Bay-Delta Authority, the U.S. Fish and Wildlife Service's (USFWS') Anadromous Fish Restoration Program, and the CDFG appear to have validated this hypothesis, based on the large number of projects that have been funded to improve alluvial habitat for aquatic organisms.

CDFG records indicate that during the 1960s and 1970s, 101,000 cubic yards of sand and gravel were extracted annually from alluvial deposits in and adjacent to Stillwater Creek, about 3 to 7 miles upstream from its confluence with the Sacramento River. The mined material was used in the construction of federal highways, the Redding airport, and other local development projects. Based on gravel budgets calculated by DWR, 19 times more gravel was being harvested from the Stillwater watershed during the 1970s than was contributed to the Sacramento River (Buer and Parfitt 1980).

Additionally, in many places, the channel has eroded to the point where it has hit hard pan, the impervious layer of soil beneath the topsoil. A local resident observed that streambeds in Stillwater Creek have eroded nearly 6 feet and attributes the degrading bed conditions to bank protection and mining (Bob Nash pers. comm. 2005). Establishment of the Shasta County Mining Ordinance in the late 1980s restricted removal of sand and gravel from the active channel.

A series of flooding events in 1985 affected a number of homes and outbuildings constructed in close proximity to Clover Creek in the Goodwater Avenue area. Many of these

structures were constructed on the floodway/floodplain of Clover Creek prior to Federal Emergency Management Agency (FEMA) mapping. The controversy surrounding these circumstances culminated in litigation against the City of Redding in 1995. This litigation focused attention on Clover Creek. The upstream development near the headwaters of Clover Creek and along Airport Road increased peak flows during high intensity rainfall events and flooded downstream residents. The detention facility in the Clover Creek Preserve was an outcome of this litigation. This detention facility was designed and constructed to accommodate current and future flows, as projected by the City of Redding General Plan.

The cumulative contribution of urban expansion and other land use factors is thought to have affected the extent of flooding and flood-related damage in the assessment area. Flooding during this era occurred in 1986, 1995, 1997, and 2005/2006. The 1986 storm was the result of a 9-day storm event, which contributed half of the average normal rainfall. Flooding occurred again in January and March 1995. The New Year's Day flood that occurred in late December 1996 and continued into January 1997 was considered the worst flood since 1862. Statewide, eight people died, 23,000 houses and 2,000 businesses were destroyed, and the state suffered $1.8 billion in economic losses.

Because of the lives lost and the economic damage suffered, the ecological benefits of periodic flooding are often ignored. These benefits include deposition of fine sediment on the floodplain, encouraging dynamic riparian vegetation, and flushing out fine sediment from spawning gravels.

2.2.3 FIRE

Natural and human-caused fires have been a source of disturbance to vegetation for thousands of years, influencing plant characteristics and vegetative patterns on the landscape (Tetra Tech, Inc. 1999). The rate and occurrence of fires are affected by climatic factors, such as temperature, humidity, and localized wind patterns. Fire severity is largely determined by climate, patterns of fuel accumulation, and ignition sources. Slope and topography are also important factors in determining the spatial distribution of fire. Evidence suggests that fire risks increase in lower elevations and along river corridors where human use is concentrated (Sapsis et al. 1996, as cited in Tetra Tech, Inc. 1999).

Pre-Columbian to 1850

Before American settlement, natural low-intensity fires occurred frequently throughout California, including the assessment area. Low-intensity fires are due in part to localized weather patterns, the types and density of vegetation, and seasonal climatic extremes.

Before American settlement, natural low-intensity fires occurred frequently throughout California, including the assessment area.

Frequent low-intensity fires can be beneficial because they prevent woody debris and brush from accumulating, help to preserve mature trees, and help to maintain diverse, multi-story forests with a minimal grass understory.

Prior to the arrival of white settlers, Native Americans used fire to manage and control their environment. The use of fire increased the yield of desired seeds and the availability of food. The Wintu are reported to have

burned the valley and hill slopes to improve materials for making baskets as well as to improve habitat for deer and other animals. Fire was also used as a tool to move mammalian game and insects collected for food (DuBois 1935, as cited in VESTRA 2005). Little is known about the timing of the fires set by Native Americans or the burning method.

1850 to 1920

Fire risk in the assessment area was particularly high during this era because early settlers used fire for lighting, cooking, and heating (Tetra Tech, Inc. 1999). These ignition sources were concentrated in the settlements that grew up around mining and farming activities. The City of Redding Fire Department was established in 1896, around the same time the townships were expanding.

1920 to 1970

In the 1940s and 1950s, ranchers in the assessment area used controlled burning to reduce the populations of non-native species and to increase well and spring yields. Many of the ranchers who employed this technique abandoned the practice in the 1960s because of air quality regulations and the difficulty of obtaining burning permits (SHN 2001).

The effectiveness of fire suppression has diminished since the 1970s, as evidenced by more intense fires that burn larger areas. Studies suggest that temperate areas that experienced low and frequent burns in the past have been the most adversely affected by fire suppression.

During this period, the interaction of human activities and droughts created an environment favoring large, high-intensity fires. Land use activities such as mining, grazing, and logging changed the existing vegetation patterns, often creating a monoculture that contributed to more frequent fires.

Figure 2.5, Fire History 1951-2004, shows the locations of the largest fires that have burned in the assessment area since 1950. At least six large wildland fires occurred during this period (California Department of Forestry and Fire Protection 2005), burning a total of 5,538 acres in the assessment area. The largest was the Airport Fire in 1954, which burned on both sides of Clover Creek west of the Redding Airport. Available records do not indicate the causes of these fires.

The development of urban areas in the region, particularly residential development, led to increased fire safety concerns and the implementation of fire suppression policies during this period. Fire suppression was successful in decreasing the frequency of low-intensity fires, but it resulted in a buildup of underbrush and ladder fuels (Tetra Tech, Inc. 1999), increasing the risk of larger, more intense fires.

1970 to Present

The effectiveness of fire suppression has diminished since the 1970s, as evidenced by more intense fires that burn larger areas. Studies suggest that temperate areas that experienced low and frequent burns in the past have been the most adversely affected by fire suppression (Stuart undated).

Since 1970, there have been nine large fires in the region that burned a total of 7,220 acres in the assessment area (California Department of Forestry and Fire Protection 2005) (Figure 2.5). The largest of these fires was the October 1999 Jones Fire, which burned a total of 26,202 acres, including 5,794 acres in the assessment area. The

Jones Fire was the second most damaging wildfire in California history in terms of the number of structures lost. According to the California Department of Forestry and Fire Protection (CDF), it burned 954 structures, including 176 homes, and there was one fatality, a volunteer firefighter. It is not known how many of the structures that burned were in the assessment area.

The Jones Fire began near the Clikapudi trail at Lake Shasta. A Redding *Record Searchlight* report describes the fire as follows: "Driven by 50 mile per hour winds, the fire roared through Jones Valley, Bella Vista and Palo Cedro…When it crossed into Bella Vista (jumping Highway 299), there were 150-foot flame lengths. By the time it was stopped, it had gone nearly 26 miles—stretching almost to the Sacramento River in Anderson" (Redding *Record Searchlight,* July 27, 2003). The cause of the Jones Fire remains undetermined, although it was believed to be accidental.

Another significant fire in the assessment area was the Union Fire in August 2000. That fire burned 350 acres, 320 of which were in the assessment area. Caused by "equipment use," the Union Fire destroyed four structures and caused approximately $500,000 in damages. It is not known how many of the burned structures were in the assessment area.

Residential and commercial structures in the assessment area continue to be highly susceptible to fire given their proximity to wildlands. The majority of the lands in the assessment area for which CDF is responsible are currently designated as having very high or high fire hazard severity.

To address fire concerns, the Mountain Gate Fire District was established on July 6, 1976; the City of Shasta Lake Fire Department was formed on December 9, 1994; the National Fire Plan (NFP) was developed in August 2000; and the Shasta County Fire Safe Council was formed in 2002. The Fire Safe Council serves as a forum for agencies, businesses, and community members to communicate and collaborate on issues pertaining to fire safety in Shasta County. The Council meets quarterly to share information and ideas on fuel reduction projects, funding opportunities, and activities to help support and educate Shasta County communities about wildfire safety.

2.3 Biological Systems

This section describes changes in the biological systems—botanical, wildlife, fish, and other aquatic resources—of the assessment area over time.

There is little information available that records the influence of very early Native Americans on natural resources in the assessment area. However, significantly more information is available on more recent Native American inhabitants, particularly the Wintu. The Wintu worked within the parameters of the natural environment to manage and maintain the resources available to them. Their activities likely created a patchy landscape that may have provided habitat for a greater diversity of plant and wildlife species. In contrast, the changes brought by the early settlers had a transformative effect on the assessment area. Perhaps the

Changes brought by the early settlers had a transformative effect on the assessment area. Perhaps the greatest of these was the introduction of non-native plant and animal species.

greatest of these was the introduction of non-native plant and animal species.

CDFG has identified a number of natural communities that occur in the assessment area. These communities include Great Valley cottonwood riparian forest, Great Valley oak riparian forest, Great Valley willow scrub, and Shasta chaparral. Vernal pool and blue oak woodlands also occur in the assessment area.

2.3.1 BOTANICAL RESOURCES

Pre-Columbian to 1850

There is no way of knowing all the types of vegetation that occurred in the assessment area in the distant past nor their specific locations. However, observations made by early American settlers as well as some of the vegetation communities we see today provide some clues to the past.

It is known that the Wintu used fire to remove brush and undergrowth from the upper Stillwater to the Anderson plains (Shasta Historical Society 1952). One description of the area at this time is that "A man on horseback would pass through the wild oats, knee-deep, in the spring time" (Shasta Historical Society 1952). Anecdotal information suggests that the Wintu may have used fire to maintain open grasslands suitable for growth of *Allium* and *Brodiaea*, the bulbs of which were important local food sources (Kocher undated). Acorns from blue oaks and valley oaks were also a very important staple in the Wintu diet (Kocher undated). Oak groves were burned to promote growth and to make it easier to collect acorns; it has also been suggested that burning of oak groves was used as a form of pest management (USDA Forest Service 1996).

In addition to using fire to manipulate food sources, the Wintu used fire to manage the plant species integral to their cultural life. Fire was used to increase the abundance of basket-making materials (VESTRA 2005); species used for making baskets included redbud, mock orange, hazelnut, choke cherry, and willow (Patton 1994, as cited in USDA Forest Service 1996). The tender, young shoots produced by these plants after burning provided basket-making material that was easier to work with. The Wintu also burned land to clear and fertilize patches of ground for sowing tobacco (Baumhoff 1978).

Spanish colonists began altering the composition and hydrology of California grasslands around 1769, when they introduced plants from the Mediterranean areas of Europe (Frenkel 1970). Until that time, perennial grasses such as purple needlegrass probably dominated most California grasslands (Heady 1988). The introduction of non-native plant species during this era, while significant, did not transform the assessment area; it did, however, set the stage for the significant and detrimental changes that occurred decades later.

The number of non-native plant species in California rose from 16 during the late 1700s and early 1800s to 79 during the mid 1800s, a nearly five-fold increase in just over 50 years. Available information suggests that the majority of non-native plants now established in California were introduced after this period, although some species may have been established earlier by animals or by way of trading networks connecting Native American communities to Spanish settlements in Mexico (Hendry and Kelley 1925, as cited in Bossard et al. 2000).

In the late 1840s, sheep were introduced from southern California into the Redding area (VESTRA 2005). Under conditions of heavy grazing and possibly drought, introduced

annuals out-competed most of the native species (Hendry 1931, Mack 1989, and Rejmánek et al. 1991, as cited in Dukes and Mooney 2003). Annual grasses such as *Avena* and *Bromus* that now dominate extensive areas of the assessment area were introduced during this period. These grasses use less of the available deep water over the course of a growing season than do native perennial grasses; they senesce earlier and have shallower roots (Holmes and Rice 1996; Gerlach 2000, as cited in Dukes and Mooney 2003). Hydrologic changes caused by grassland invaders may affect the establishment of native woody perennials (da Silva and Bartolome 1984, Gordon and Rice 1993).

A particularly problematic invasive plant that is now common and widespread throughout the assessment area is yellow star-thistle. It is likely that there were multiple introductions of yellow star-thistle to the United States (Luster et al. 2001) via contaminated alfalfa seed. Conversion of native grasslands to introduced forage species such as alfalfa was the primary vehicle for these introductions (Maddox and Mayfield 1985). Although there is no record of when yellow star-thistle was first detected in the assessment area, its seeds have been found in adobe bricks in California from the period between 1824 and 1848 (Hendry 1931, as cited by Zouhar 2002). It has been suggested that the excess water left by annual grasses early in the invasion process may have created favorable conditions for the subsequent introduction and establishment of yellow star-thistle (Dyer and Rice 1999).

Himalayan blackberry most likely was introduced to North America in 1885 as a cultivated crop (Bailey 1945, as cited in Bossard et al. 2000). By 1945 it had become naturalized along the West Coast. Himalayan blackberry colonizes areas initially disturbed and then neglected by humans and can dominate if not controlled. It is a strong competitor, and it rapidly displaces native species; its thickets produce such a dense canopy that the lack of light severely limits the growth of other plants (Bailey 1945, as cited in Bossard et al. 2000). The thickets are impenetrable to waterways and also reduce access for maintenance of fence lines, forestry practices, and recreational activities. Blackberry thickets are a considerable fire hazard.

Another extremely invasive plant that is now well-established in the assessment area is giant reed (commonly called Arundo), a tall perennial reed. This species was intentionally introduced to southern California from the Mediterranean countries of Europe in the 1820s as an erosion control agent in drainage canals and as thatching for the roofs of sheds, barns, and other buildings (Hoshovsky 1987). Subsequent plantings were made for the production of reeds for a variety of musical instruments, including bassoons and bagpipes (Bell 1986). It is unknown when giant reed became established in the assessment area.

1850 to 1920

From 1850 to 1920, land conversion adversely affected native plant communities in the assessment area. Valley, riparian, and upland habitats were all likely affected by the influx of settlers during the mining boom and the conversion of native grasslands and woodlands to agricultural and urban uses.

Native vegetation was also severely affected by the releases of sulfur dioxide gas from area copper smelters between approximately 1896 and 1919. As described above, these releases severely damaged or killed more than 153,000 acres of vegetation from the Sacramento Canyon to Red Bluff (SHN 2001).

These emissions denuded local hillsides within and adjacent to the assessment area. Even as late as 1915, trees were absent in the Kennett area near present-day Shasta Dam (Watkins pers. comm. 2005). The large brushfields seen today in the upper portions of the assessment area are indicative of the damaging effects of the smelters.

While native plant communities were being displaced or destroyed as a result of land uses and human activities, they continued to face landscape-scale changes resulting from non-native plant invasions. Adverse effects caused by non-native plants included altered abiotic conditions such as local hydrology and soil chemistry and biotic conditions such as soil fauna.

By 1860, the number of non-native plants recorded in the state had reached 134 species (Bossard et al. 2000), double the 79 species reported during the previous time period. While previously introduced species such as yellow star-thistle and giant reed continued to spread throughout the assessment area, new and equally noxious species were appearing. It is likely that tree-of-heaven was introduced to the assessment area during this time period. Until the 1890s, tree-of-heaven commonly was planted as an ornamental plant throughout California (Bossard et al. 2000). Like giant reed, tree-of-heaven is adept at displacing native riparian vegetation. It spreads rapidly by root sprouts; produces allelopathic chemicals that inhibit the growth of neighboring vegetation; and is shade-tolerant, allowing it to out-compete less shade-tolerant species (Lawrence 1991, Grime 1965).

Tamarisk may also have been introduced into North America by the Spanish at this time (Robinson 1965, as cited in Bossard et al. 2000). It was originally planted for erosion control, as a windbreak, for shade, and as an ornamental. The presence of tamarisk causes dramatic changes in geomorphology, groundwater availability, soil chemistry, fire frequency, plant community composition, and native wildlife diversity (Bossard et al. 2000). Similarly, scotch broom was introduced in the 1850s as an ornamental and to prevent erosion and stabilize dunes (Geickey 1957, Schwendiman 1977, as cited in Bossard et al. 2000). Scotch broom is a strong competitor and infestations can attain a biomass of over 44,000 to 50,000 kilograms per hectare in 3 to 4 years (Bossard and Rejmánek 1994; Wheelor et al. 1988, as cited in Bossard et al. 2000).

Even as late as 1915, trees were absent in the Kennett area near present-day Shasta Dam. The large brushfields that are seen today in the upper portions of the assessment area are indicative of the damaging effects of the smelters.

Plant communities in the assessment area were also affected by completion of the ACID canal system in 1920. Not only did these canals alter landscape drainage patterns, but they also allowed for additional conversion of land from native plant communities to agricultural uses in the Churn Creek Bottom area.

1920 to 1970

The period from 1920 to 1970 was marked by a dramatic increase in population and urban growth in the watershed assessment area. Figure 2.6, Vegetation Types 1932 and 1933, shows the distribution of vegetation types in the assessment area in 1932 and 1933. The Wieslander Vegetation Type Map collection is a dataset compiled in the 1920s and 1930s that includes photographs, species

inventories, plot maps, and vegetation maps covering the majority of California. The data provide a snapshot of California's vegetation in the early 20th century, allowing researchers and policy makers to examine changes in land use and cover over time.

One of the unintended effects of the highway system that developed during this period was that it allowed the efficient movement of weeds throughout the region.

Plant invasions during this period are well documented by floras (treatises describing the plants of a region or time) of California, which are helpful in tracking more recent invasions and range extensions. Jepson's first flora, published in 1925, recognized 292 established non-native species (Bossard et al. 2000), more than double the number of non-native plant species recorded approximately 80 years earlier. Red sesbania was introduced to California as an ornamental during this period and was later documented in riparian vegetation in 1987.

In 1959, Munz and Keck published an updated California flora that recognized 725 non-native plant species; in an updated supplement published in 1968, the number of recognized non-native species increased to 975 (Bossard et al. 2000). Although many of these species would not have occurred in the assessment area, this state-wide increase in non-native plants suggests that similar trends were occurring in many plant communities. It is well established that many non-native annual plants were particularly successful in invading valley grasslands.

Central Valley plant communities faced extreme stresses during the severe drought that extended from 1929 to 1934. As mentioned above, runoff from the valley during this drought was only 55 percent of the average recorded for the period from 1901 to 1996 (Department of Water Resources 2006). It is likely that plant communities suffered as a result and that many populations dwindled or were lost.

One of the unintended effects of the highway system… was that it allowed the efficient movement of weeds throughout the region.

1970 to Present

The introduction and spread of invasive plant species continued during this period. The 1993 *Jepson Manual* (Hickman 1993) recorded 1,023 species of invasive plants and a 1998 report placed the number at 1,045 (Randall et al. 1998, as cited in Bossard et al. 2000).

By 1985, yellow star-thistle had spread to about 8 million acres in California (Maddox and Mayfield, 1985). Extensive road building, suburban development, and expansion in the ranching industry since the 1960s all contributed to the rapid and long-range dispersal of yellow star-thistle seeds and the establishment of new satellite populations (Gerlach et al. 1998) in uplands and riparian areas.

There is photo-documentation showing the establishment of giant reed in upper Stillwater Creek in the 1980s (Bob Nash pers. comm. 2005). Giant reed is of significant ecological concern throughout the assessment area, and recent studies in the Stillwater Creek watershed reinforce the need to address this species. Unlike native riparian plants, giant reed provides little shading to the channel, leading to increased water temperatures and reduced habitat quality for aquatic species

such as the California red-legged frog and western pond turtle (Franklin 1996). Giant reed purportedly traps and stabilizes more sediment than native vegetation, thus decreasing channel size. It is also said to grow densely enough to substantially reduce the carrying capacity of small waterways (Robbins et al. 1951).

Giant reed in Stillwater Creek. (Photo courtesy of Western Shasta Resource Conservation District.)

One positive development is that in more recent years, vegetation has begun recolonizing in some of the areas once disturbed or destroyed by smelting, mining, and other past activities.

2.3.2 WILDLIFE

Pre-Columbian to 1850

It can be assumed that the native wildlife species we see in the assessment area today have been present for millennia. Because of the small numbers of Native Americans who inhabited the area, it can also be assumed that habitat for these species was relatively abundant. The first records concerning wildlife in the region are from early settlers' observations of the Wintu.

Deer and other wildlife were important food sources to the Wintu. In addition to using fire to manage vegetation, the Wintu used it to manipulate wildlife populations and behavior. Shrublands were burned to create openings that provided better foraging habitat for deer, and in the fall, many tribes used fire to drive game (DuBois 1935, as cited in USDA Forest Service 1996).

The Wintu also harvested grasshoppers (Order Orthoptera) by burning grasslands. The grasshoppers were obtained by encircling a grassy area, driving them into the center, and setting the grass on fire with wormwood torches. After the blaze had subsided, the grasshoppers were gathered for food (DuBois 1935, as cited in USDA Forest Service 1996).

As described above, the Hudson's Bay Company's fur-trade expeditions during this era decimated populations of beaver throughout northern California. Although it is unknown how many beavers in the assessment area were killed, it is known that beaver trapping in Shasta County ceased in the 1840s (Smith 2005). Decay of the beavers' dams and draining of the wetlands behind the dams resulted in the creation of fertile meadows that were used by early ranchers for livestock grazing. The hydrologic patterns of vast areas of western watersheds were significantly altered by the decimation of beaver populations (Elmore and Beschta 1987, as cited in NRC 2004), which in turn undoubtedly affected the composition of downstream animal communities (Pollock et al. 1986, as cited in Dukes and Mooney 2003).

The dense riparian vegetation that historically occurred along the Sacramento River and its tributaries provided important summer nesting habitat for neotropical migrants arriving from the south. Some of the species that presumably nested in the assessment region in larger numbers than seen today—including yellow-billed cuckoo, Bell's vireo, and willow flycatcher—are now listed as

threatened or endangered under the state and federal endangered species acts.

The region is also a link in the Pacific flyway, a major north-south migration route for waterfowl and shorebirds. Historically, the extensive network of wetlands and waterways throughout the Central Valley provided hundreds of square miles of lush wintering grounds for millions of waterfowl and shorebirds each year.

1850 to 1920

During the period from 1850 to 1920, land conversion was the most significant factor affecting wildlife in the assessment area. Although no information is available that describes the impacts of copper smelting on wildlife species, it is likely that many species were forced out of the areas damaged by sulfur fumes because of the lack of forage and cover available in the denuded landscape. In addition, native wildlife species were faced with an increasingly altered landscape in which to forage and find shelter because of the establishment of towns and the continued invasion and spread of non-native plants.

From 1850 to 1920, non-native wildlife also began to appear in the region. Chinese ring-necked pheasants were first introduced successfully in North America in 1881. The pheasants were trapped near Shanghai and released in Oregon's Willamette Valley. In 1889, individuals from the Oregon population were introduced into northern and central California (Hart 2005). Small populations of pheasants continue to persist in the lower reaches of the assessment areas. (Paul Uncapher, North State Resources, personal observation.)

The Virginia opossum was introduced to the San Jose area in 1895 for its meat and pelts. This species is well established throughout the assessment area. In the late 1800s, house sparrows were released in San Francisco; they were firmly established in the state by 1910 (Nature Ali Consulting 2005) and are now common in the assessment area. Domestic pigs first arrived in California with the Spanish in 1769, and it is likely that feral pigs had become established in the assessment area by the early 1900s. Throughout the following century, American settlers continued to transport domestic swine into the state (Barrett 1997).

Like vegetation communities, wildlife faced extreme stresses during the severe drought that extended from 1929 to 1934. It is likely that many wildlife populations declined or were destroyed as a result of this drought.

1920 to 1970

It is likely that European starlings became an invasive species during the 1950s. Initially introduced on the East Coast, post-breeding wanderers reached California by 1939, and breeding was established in the state by the 1950s (Nature Ali Consulting 2005). Starlings compete with native cavity nesters and will even displace nesting native birds and destroy their eggs.

During this period, the transportation network was expanded to accommodate development. Roads can fragment wildlife habitat and seriously interfere with the migration routes and dispersal of wildlife species. Our ability to quantify these impacts in the assessment area is limited due to large data gaps.

1970 to Present

Trapped out in the 1840s, beaver began reappearing in the assessment area during the 1970s. Since then, one resident noted that there appears to be increased woody

vegetation in Churn Creek (Hill pers. comm. 2005) as a result of beaver colonization.

Since the establishment of the BVWD, which obtains its water from the Sacramento River, Stillwater Creek is not subject to out-of-channel uses. One local resident believes that higher base flows in Stillwater Creek may have resulted in an increase in several wildlife species, including beaver, river otter,

Early American explorers and settlers…described vast quantities of "red fish meat" drying on the houses of the Indian villages all along the banks of the large valley rivers.

mountain lion, and a variety of birds (Bob Nash, pers. comm. 2005). Hydrologic data for the creeks in the watershed is extremely limited and provides no ability to evaluate trends. However, casual observations suggest that the flow in Stillwater Creek responds to climatic variation, and in wetter periods, it may flow longer during the summer. A cursory review of historic photos suggests that surface flow is typically intermittent in most of the creeks. Anecdotal information provided by long-term residents of the Churn Creek Bottom suggests that flows in lower Churn Creek correspond to varying degrees with ACID deliveries (twice a week during the irrigation period).

Wild turkeys, an introduced species, were observed in the Churn Creek area around 2000, and local residents report seeing increasing numbers of deer, bear, and mountain lion (Watkins pers. comm. 2005). Conversations with several professional wildlife biologists support the hypothesis that expansion of the urban environment into the wildland interface has resulted in increased observations of and encounters with various wildlife species. (Len Lindstrand, North State Resources, personal observation.)

2.3.3 Fish and Aquatic Resources

Pre-Columbian to 1850

Observations by early American settlers suggest that food sources for Native Americans included seasonally abundant salmon runs as well as steelhead, Sacramento sucker, freshwater shellfish, and lamprey. Salmon were reported to be particularly abundant in streams throughout the Central Valley prior to 1850 by early American explorers and settlers, who described vast quantities of "red fish meat" drying on the houses of the Indian villages all along the banks of the large valley rivers (Yoshiyama 1999).

1850 to 1920

During the period from 1850 to 1920, conversion of land, particularly to ranching and farming, was the most significant factor influencing aquatic communities in the assessment area.

One of the agriculture-related effects to aquatic communities during this era was from agricultural water development. When stream channels began to dry during the summer, ranchers installed pumps to access subsurface flow. The number and size of pumps used in the assessment area are unknown, but incidental trapping of fish most likely occurred.

During this early settlement era, small stock water and irrigation water storage ponds were built to sustain agriculture through the dry summers. These ponds provided habitat for native and non-native warm water fish species. After construction of the railroad through the region, fish were transported to

and from the area (Yoshiyama 1999, Moyle 2002). Landowners often introduced non-native fish species, such as largemouth bass and bluegill, into these ponds for their own use. Fish stocked in ponds likely escaped to the streams in the assessment area when the ponds overflowed during the winter rainy season and migrated to assessment area streams via the Sacramento River from other watersheds where they were also introduced. The introduction and successful establishment of non-native fish species creates competition for food resources and habitat. Additionally, non-native game fish are typically pisciverous and often prey on native fish species.

Landowners often introduced non-native fish species, such as largemouth bass and bluegill, into these ponds for their own use. …The introduction and successful establishment of non-native fish species creates competition for food resources and habitat.

Black bass were first introduced in San Mateo County in 1874 and have spread throughout most of the state, including to the assessment area. Bluegill were introduced to California in 1908 and became widely distributed during the following 20 to 30 years. It is not certain when these and other introduced aquatic species first established themselves in the assessment area, but it most likely occurred gradually from around 1900 until the present.

The bullfrog was first introduced to California in 1895 for meat and to augment native red-legged frog populations, which had declined due to overharvesting (Nature Ali Consulting 2005).

Gold seekers made use of the abundant Central Valley salmon runs. The salmon fishery was one of the major early industries during the Gold Rush and continued to increase, peaking between 1870 and 1880 (Yoshiyama 1999). Lucrative profits were made on domestic and international shipments from a high of 21 canneries operating at one time on the lower Sacramento River through about 1910.

Salmon canning began to decline after 1880, reflecting the cumulative effects of the extensive river and growing ocean commercial harvests and habitat degradation caused by mining debris washing into salmon-bearing streams and the impacts of railroad construction in the river canyons (McEvoy 1986, Yoshiyama 1999). The last cannery closed in 1919. Locally, salmon runs were observed to decline precipitously during the 1880s in the upper Sacramento River, which was primarily attributable to construction of the railroad north of Redding. The salmon were disturbed by the heavy blasting, many were taken for food, and others wantonly destroyed by railroad workers (Leitritz 1970). In addition, during this early period, toxic runoff from the copper mines surrounding the town of Kennett near the site of present day Shasta Dam began to detrimentally affect aquatic resources in the Sacramento River, regularly causing fish kills as far downstream as the town of Anderson (USFWS 1995).

1920 to 1970

While there are few records or accounts concerning the fishery resources in the assessment area during this time period, the single most significant event affecting the region's aquatic environment was the construction of Shasta Dam on the Sacramento River north of Redding. Fish counts at ACID dams prior to Shasta Dam's

construction during the late 1930s provide an estimate of the relative sizes for the spring and fall salmon runs of about 6,000 and 17,000, respectively, heading to the spawning grounds upstream of Redding (Hanson et al. 1940). However, it is now thought that these estimates were very conservative, underestimating the actual population size of all runs of salmon that inhabited the river at that time, since they did not account for the winter and late-fall runs (Yoshiyama 1999, Black 2001).

A study investigating the potential effects of Shasta Dam on the salmon fishery was initiated by the U.S. Bureau of Fisheries at the time of its design and construction. …The most biologically promising approach at the time was dubbed "The Stillwater Plan," which made note of the importance of Stillwater Creek as potential spawning habitat compared with other tributaries.

During the 1940s, local residents recalled seeing salmon in Little Salt Creek, a tributary of Churn Creek, and other tributaries when flows were suitable (Smith pers. comm. 2005). Surveys during the late 1930s, reported by Hanson et al. (1940), documented that a few fall-run salmon spawned and successfully reared in Stillwater and Churn creeks during years when early fall rains raised stream flows sufficiently to allow spawning in these intermittent creeks. Of the two streams, Stillwater Creek was thought to provide more suitable habitat for fall-run salmon spawning and rearing than Churn Creek when sufficient flows occurred. In fact, Hanson et al. (1940) commented on the surprisingly high productivity of aquatic insects that were fed upon by young salmon in Stillwater Creek even under conditions of intermittent flow.

After construction of Shasta and Keswick dams, access to approximately 50 percent of the available spawning habitat for Sacramento River salmon was blocked. Shasta Dam not only blocked migrating fish, but it altered the flow, sediment transport, and water temperature regimes of the river. Regulated flow releases changed the hydrologic and channel dynamics downstream, affecting the quality of habitat for all native fishes, including Chinook salmon and steelhead.

A study investigating the potential effects of Shasta Dam on the salmon fishery was initiated by the U.S. Bureau of Fisheries at the time of its design and construction (Hanson et al. 1940). The study evaluated a number of approaches to provide fish salvage to preserve salmon runs affected by lost habitat above the dam site. The most biologically promising approach at the time was dubbed "The Stillwater Plan," which made note of the importance of Stillwater Creek as potential spawning habitat compared with other tributaries:

> *"It [Stillwater Creek] had several advantages over other candidate tributaries including prime potential salmon habitat, downstream proximity to proposed salmon trapping facilities at Keswick Reservoir, and excellent prospects for being "rewatered." Most significantly, due to its intermittent flow, Stillwater Creek was unencumbered when it came to competing water rights."*

The Stillwater Plan was never pursued due to the expense associated with "re-watering" the channel during the summer months. This fish

salvage plan would have required importing water via a pipeline from the McCloud River or from the new Shasta Reservoir. Instead, fishery managers decided to build Coleman hatchery on Battle Creek; trap fish at Keswick Dam and haul them to the hatchery and other streams for spawning purposes; draw water from a sufficient depth in Shasta Lake, once filled, to keep river temperatures cold enough for salmon spawning throughout the year; and provide legal protections for salmon spawning in the river and its tributaries. Although salmon runs declined initially after completion of the dams, they seemed to recover by the mid to late 1950s (Slater 1963). In fact, the winter run of Chinook salmon grew to a sizeable run by the early 1960s (Slater 1963, U.S. Fish and Wildlife Service 1995). However, by the late 1960s to mid-1970s, salmon runs to the upper Sacramento Valley began their modern-day declines, presumably as a result of the cumulative impacts of further habitat degradation, dams, and water diversions (U.S. Fish and Wildlife Service 1995).

Agricultural development continued into this era, most notably in the alluvial floodplains of Churn and Stillwater creeks and the middle upland areas of Stillwater Creek. The establishment and development of water districts in the assessment area during this period began to shift water use away from the creeks. Local residents observed that the biggest change occurred in the 1960s and 1970s, when energy costs forced a shift to use of water district resources (Bob Nash pers. comm. 2005). Agricultural development during this era affected the quality and quantity of aquatic habitat; in-channel stock watering practices were especially detrimental to riparian communities.

Intense urbanization around Redding began during the 1970s and occurred particularly during the 1980s. According to local residents, extensive development occurred along Churn Creek, Clover Creek, and Stillwater Creek during this period, causing the loss of riparian habitats.

Road construction also affected the aquatic environment. SR 299 became a numbered route in October 1934, Highway 44 was constructed in 1935, and the historic legislative Route 9 was designated U.S. 99 in 1909 (later becoming I-5). All of these highways cross stream courses in the assessment area, often multiple times. Poorly designed or dysfunctional stream crossings inhibit fish passage. It is unknown how many of these have been replaced over time or to what extent they may have affected fish passage.

Road construction also demanded local abundant sources of high-quality alluvial material for concrete, the same material that provides the high-quality substrates required by aquatic organisms. In- and off-channel gravel mining described in previous sections occurred during low-flow periods, typically late spring through October. Figure 2.3 illustrates the general locations of mining activities, but site-specific data on these activities is limited.

1970 to Present

Similar to the period 1920 to 1970, the most significant change during the period 1970 to present was urbanization. Intense urbanization around Redding began during the 1970s and occurred particularly during the 1980s (Finley pers. comm. 2005). According to local residents, extensive development occurred along Churn Creek, Clover Creek, and Stillwater Creek during this period, causing the loss of riparian habitats

(Pollock pers. comm. 2005; Nash, pers. comm. 2005). The loss of riparian vegetation, coupled with suspected changes in the flow regime, are important factors that affect the quantity and quality of aquatic habitat critical for aquatic organisms.

Changes in the landscape continue to affect the quantity and quality of aquatic habitat. Since the creation of Shasta Dam in 1943, the channel bed material in the Sacramento River has become coarser, at least as far downstream as the Churn Creek confluence, and probably as far as the Stillwater Creek confluence (Buer 1981). This resulted from the retention of gravel and sediment by the dam that would otherwise have gradually moved downstream. The smaller-sized gravels, which are most suitable for salmon and steelhead redds, were not replaced by upstream sources as they were moved downstream. Lack of upstream gravel recruitment in the mainstem Sacramento River increased the importance of recruitment from tributaries below Shasta and Keswick dams, like Churn and Stillwater creeks.

Additionally, gravel mining, bank protection, and levees have reduced the quantity and quality of salmon spawning habitat in the assessment area as well as in the Sacramento River downstream. Functionally, gravel mining reduces the quantity of gravel available for stream transport, captures gravel from upstream reaches, and causes degradation of downstream reaches. Riprap reduces bank erosion and the natural meandering of the channel across its floodplain. Levees and berms restrict flood flows from spreading out onto floodplains and instead concentrate flows in the main channel, causing increased stream velocity and down cutting of the channel, which also results in scouring of spawning-sized gravel. Buer (1981) identified Stillwater Creek as one site of many along the upper Sacramento River where gravel mining was reducing spawning gravel recruitment to the river.

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Chapter 3
Current Conditions of Major Ecosystem Elements

This chapter of the watershed assessment report describes current watershed conditions that are most relevant to the management of ecological endpoints. The chapter is organized as follows:

- Section 3.1, Topography and Climate
- Section 3.2, Heritage Resources
- Section 3.3, Geology and Soils
- Section 3.4, Geomorphology, including Fluvial Geomorphology
- Section 3.5, Hydrology, Flooding and Water Use/Quantity
- Section 3.6, Water Quality
- Section 3.7, Land Use and Demographics
- Section 3.8, Botanical Resources
- Section 3.9, Wildlife Resources
- Section 3.10, Fisheries and Aquatic Resources
- Section 3.11, Fire History and Management

Figures for these sections are at the end of each section.

3.1 Topography and Climate

This section describes the topography and climate of the watershed assessment area. Topography and climate are fundamental characteristics that strongly influence many of the watershed resources and ecosystem processes described in this assessment, particularly vegetation, fish and wildlife, wetlands, and hydrology. This description of the topography and climate of the assessment area sets the stage for the sections that describe other watershed resources and processes.

The topography east of Redding is often described as "hummocky," and much of this landscape historically supported extensive vernal pool and vernal swale habitat, with patches still remaining.

3.1.1 Topography

The topography of the assessment area varies most strongly from north to south. The lowest elevation, approximately 500 feet above mean sea level (msl), occurs at the southern end of the assessment area near Redding. Redding is located at the northernmost extent of California's Central Valley. The topography in this portion of the watershed is flat to very gently rolling toward the east.

To the east and north of Redding are older alluvial terrace deposits that range in elevation from 500 to 1,000 feet above msl (U.S. Department of Agriculture 1974). One such terrace, Stillwater Plains, lies immediately north of the Redding Municipal Airport. These terrace deposits are crossed by Churn, Clover, and Stillwater creeks, which have alluvial floodplains that can be up to 1 mile wide in some places (U.S. Department of Agriculture 1974). The topography east of Redding is often described as "hummocky," and much of this landscape historically supported extensive vernal pool and vernal swale habitat, with patches still remaining.

North of the City of Shasta Lake, the topography changes from gently rolling to hilly. This portion of the watershed encompasses the southernmost extent of the Klamath Mountains. The elevation at the northern edge of the watershed is approximately 1,600 feet above msl, and the hills in this area are moderately steep with narrow ridgetops and valleys.

The morphological characteristics of a watershed, particularly channel slope and relief, are important in understanding the hydrology of the three watersheds. This is because the runoff response of a particular portion of a watershed varies with the steepness of its slopes as well as with the local and regional relief. Table 3.1-1 summarizes the slope characteristics of the assessment area.

TABLE 3.1-1
SLOPE CHARACTERISTICS: STILLWATER–CHURN CREEK WATERSHED

Percent Slope	Acres	Percent of Assessment Area
0-10%	56,868	73%
10-20%	8,019	10%
20-30%	4,203	5%
30-40%	3,520	5%
> 40%	5,118	7%
Total	77,727	100%

Source: USGS National Elevation Data

Approximately 12,840 acres, or 17 percent of the assessment area, consists of slopes greater

than 20 percent, and approximately 8,640 acres, or 11 percent of the assessment area, consists of slopes greater than 30 percent. In general, slopes are steepest in the upper (northernmost) portion of the assessment area (Figure 3.1-1, USGS National Elevation Data: Percent Slope.)

Development on steep slopes is discouraged and often prohibited by ordinances adopted by the governing boards of the three planning agencies in the assessment area. Areas with steep slopes typically remain in open space to minimize safety hazards associated with landslides and flooding, as well as to reduce erosion and sedimentation. The City of Redding, for example, limits development on slopes exceeding 20 percent and encourages the protection of such areas by generally classifying lands with slopes in excess of 20 percent as open space (City of Redding 2005). In the City of Shasta Lake, development and grading are typically prohibited on slopes in excess of 30 percent; these areas are typically reserved in permanent open space easements (City of Shasta Lake 2005). Depending on the zoning designation, Shasta County limits or prohibits development on lands with slopes exceeding 30 percent (Shasta County 2003).

3.1.2 CLIMATE

Regional climate exerts a controlling influence on a watershed's hydrology by determining water and energy inputs. The climate of the assessment area is Mediterranean, with summers that are generally dry, hot, and cloudless and winters that tend to be cool, rainy, and overcast. Table 3.1-2 shows key weather parameters for Redding.

TABLE 3.1-2
CLIMATOLOGICAL DATA FOR REDDING

WEATHER PARAMETER	MEASUREMENT
Average annual temperature[1]	62.0°F
Average high temperature in January[1]	55.3°F
Average low temperature in January[1]	35.7°F
Average high temperature in July[1]	98.3°F
Average low temperature in July[1]	64.7
Highest recorded temperature[1]	118°F
Lowest recorded temperature[1]	17°F
Average wind speed[1]	6.8 miles per hour
Average relative humidity[1]	65.5 percent
Average annual precipitation[1]	33.3 inches
Average days of precipitation per year[1]	84
Average total snowfall[2]	4.8 inches
Average number of clear days per year[1]	172
Average number of partly cloudy days per year[1]	77
Average number of cloudy days per year[1]	116

[1] Source: www.climatezone.com (2003)

[2] Western Regional Climate Center, www.wrcc.dri.edu, 1931-1979

Precipitation is a particularly important climatic factor. The precipitation characteristics of greatest interest include average annual precipitation, annual variability, seasonal distribution, type (rain or snow), frequency, and intensity with respect to both quantity and duration. In the assessment area, most precipitation falls during the winter and spring months—November through March—as rain, with the annual peak in total precipitation occurring in January. Normally, much of the

rainfall is generated by four or five major winter storms (Fridirici and Shelton 2000).

Two dominant storm types produce two different runoff results. Cold arctic storms deliver snow at mid- to high elevations, and the snowpack delays periods of maximum runoff until late spring and early summer. Warm Pacific storms generate snowpack at the highest elevations and intense rainfall at mid- and lower elevations. These intense storms saturate the soil, creating overland flow that becomes the source of streamflow during most of the floods that occur from November through March.

Native plant species have developed adaptive mechanisms that allow them to tolerate the stresses created by the Mediterranean climate.

Low summer humidity creates high solar intensity and high rates of evapotranspiration in plants. Native plant species have developed adaptive mechanisms that allow them to tolerate the stresses created by the Mediterranean climate, including evergreen leaves that are small, hardened, and grayish; drought-deciduous leaves that fall off during the dry season; photosynthetic rates that are higher in winter or spring when water is most available and temperatures are mild; shallow roots that collect the earliest rains; and deeper taproots that take in water at different soil depths.

Similar to the trends in topography and elevation within the watershed, climate and rainfall in the assessment area vary strongly from north to south. As elevation increases in the northern portion of the assessment area, temperatures tend to be lower and precipitation greater. Near the City of Shasta Lake, at 750 feet above msl, average annual precipitation from 1952 through 2004 was approximately 55 inches (Burns 2005). Most of this precipitation occurred during the winter months, with little falling as snow. Average high and low temperatures in the northern portion of the watershed tend to be slightly lower than those in Redding. In the more mountainous regions at the very northern edge of the watershed, average annual temperatures are even lower and precipitation greater than in the rest of the watershed, with a greater percentage falling as snow (U.S. Department of Agriculture 1974).

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3.2 Heritage Resources

This section discusses the archaeological and historical resources left by past inhabitants of the watershed assessment area. Historical resources in the assessment area provide an important link to the past and are necessary for understanding how the area and its people have changed over time.

3.2.1 Heritage Resources and Significant Archaeological Information

Archaeological artifacts are irreplaceable resources that provide clues to the history of a place and its people. They often provide a glimpse into the day-to-day activities that constitute the stories of past inhabitants. Because history is a continuum, these stories are not just the history of those who came before, they are also the history of our own cultural development.

Archaeological artifacts are protected by both federal and state regulations. The National Historic Preservation Act requires federal agencies to evaluate the effects of federal undertakings on historic properties that are included on or eligible for inclusion on the National Register of Historic Places (NRHP). The California Public Resources Code requires agencies to determine whether proposed projects would have effects on "unique archaeological resources," and requires consultation with the Office of Historic Preservation if a project may affect historical resources located on state-owned land.

Shasta County is known to have a long and rich history. Its first people were the Achomawi, Atsugewi, Okwanuchu, Wintu, and Yana tribal people (Smith 1999). The first white settlers, who arrived during the early part of the 1800s, were Russians moving south along the Sacramento River. They were followed by American, French, and British trappers in the late 1820s, who brought with them a disease that was catastrophic for the tribes in the region (Smith 1999). By the mid-1800s, the Gold Rush was in full swing, and developments began springing up throughout the county. Many of the miners became permanent settlers (Smith 1999), and the region eventually developed into what we see today.

Two culturally significant archaeological sites—the Benton Tract Site and the Olsen Petroglyphs—are located in the vicinity of the assessment area.

The assessment area was home to much of this unfolding drama. Two culturally significant archaeological sites—the Benton Tract Site and the Olsen Petroglyphs—are located in the vicinity of the assessment area. Both sites are listed on the NRHP, and other sites in the area may be eligible for listing.

The Benton Tract Site lies immediately adjacent to the western edge of the assessment area on the western bank of the Sacramento River in the city of Redding. It is a prehistoric site affiliated with the Wintu Tribe and early Mexican and Spanish explorers. Its periods of significance are from 500 to 1000 and from 1750 to 1900 (National Register of Historic Places 2005). The site is believed to be an early domestic camp.

The Olsen Petroglyphs (address restricted, Redding) are surviving examples of rock art created by the inhabitants of the assessment area prior to their first contact with European explorers and Euro-American settlers. The period of significance of these prehistoric archaeological features is from 1750 to 1900 (National Register of Historic Places 2005).

In addition to these two NRHP–listed archaeological sites, there are numerous other prehistoric sites located throughout the length of Stillwater Creek and its tributaries (Ledwith pers. comm. 2005). These sites are associated with the Wintu Tribe, or its predecessors, who historically occupied the entire assessment area. Interestingly, there is an ethnographic group of the Wintu called the Stillwater Wintu (Ledwith pers. comm. 2005).

The assessment area is in a part of the northern Sacramento Valley that is considered sensitive for historic sites dating primarily from the 1850s to the 1930s.

When the first Europeans arrived in the area, the Wintu occupied the flats, foothills, and mountains of the northern Sacramento Valley near present-day Redding (College of Siskiyous 2001). Because these aboriginal inhabitants relied heavily on aquatic resources, it is likely that there are many archaeological sites throughout the assessment area that have yet to be discovered. Prehistoric archaeological remains considered likely to occur in the assessment area include:

- scatters of lithic artifacts and debitage
- midden
- bedrock milling stations
- petroglyphs
- isolated finds of lithic tools
- excavated pits (housepits, graves, cooking features)
- Ghost Dance ceremonial locations
- traditional cultural property types, including traditional use locations

3.2.2 HISTORICAL RESOURCES

In addition to the prehistoric and ethnographic archaeological resources, the assessment area contains historical archaeological resources dating from the 1800s that represent the area's recent past. These resources offer insight into the development pattern of the present culture, including demographics, industry, and settlement locations.

The assessment area is in a part of the northern Sacramento Valley that is considered sensitive for historic sites dating primarily from the 1850s to the 1930s (North State Resources, Inc. 2005). Many surface artifacts have likely been lost over time as a result of construction and development. However, it is likely that many buried historic remains are present, since structures and buildings were located throughout the assessment area. There are several historical themes in the assessment area for which historical resources are likely present (North State Resources, Inc. 2005):

- Prominent people, including Major Pierson B. Reading, who washed out the first gold in Shasta County on a bar at the mouth of Clear Creek canyon in March 1848, and the John Stephen Patton Bass family, who arrived in the area in 1851.
- Early expeditions, including those of the Hudson's Bay Company trappers and Chiles, Hastings, and Fremont. Hastings arrived in the area by 1844 to apply for a land grant from Mexico.
- Trails and highways, including Highway 99 and the California–Oregon Trail. Highway 99 began as a horse and stagecoach trail extending from Mexico to Canada and in 1926 was designated U.S. No. 99. The California–Oregon Trail was used by emigrants beginning in the mid-1800s.
- Development and evolution of railroad, mining, and dam towns, including Buckeye, Silverthorn, Newtown, Pinegrove, Project City, Government Camp, Central Valley, Mountain Gate,

Tunnel Inn, Portal Inn, Bella Vista, Frazier Corners, Loomis Corners, Enterprise, Pacheco, and Coram.

- Mining activity, including gold, copper, and limestone mining.
- Southern Pacific Railroad and railroad logging.
- Historic supply route to the Keswick smelter from Bella Vista.
- Rancho Buena Ventura, Major Reading's Mexican Land Grant.
- Development and construction of Shasta Dam.

3.2.3 REFERENCES

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3.3 Geology and Soils

This section describes the geology and soils of the assessment area. Soils and the geologic substrates from which they form directly affect water quality, water availability, and other important aspects of the aquatic environment. Soils and geologic conditions also influence patterns of human development, leading to indirect effects on aquatic resources.

3.3.1 Geology

The assessment area is located at the northern end of the Central Valley. The Central Valley is essentially an enormous basin that is filled with sediments derived from ancient marine and adjacent upland environments. The marine-derived sediments accumulated before the sea retreated from the valley during the late Jurassic period approximately 145 million years before present (mybp) (Helley and Darwood 1985). During the last 5 million years, sediments continued to accumulate in the assessment area as alluvial deposits eroded from the Klamath and Cascade Mountains and were deposited on top of the older marine material. Additional accumulation of sediments occurred during the Ice Age, which was characterized by much wetter climatic conditions during the period 2 mybp to 0.01 mybp (Helley and Darwood 1985). Deposition of sediment continues into the present, mainly within and adjacent to active stream channels.

The Central Valley is essentially an enormous basin that is filled with sediments derived from ancient marine and adjacent upland environments.

The southern end of the Central Valley has more than 30,000 feet of accumulated sediments; within the assessment area, these sediments are much thinner. The veneer of sediments disappears completely in the northern quarter of the assessment area, where the hilly to mountainous landscape is underlain by bedrock. This pattern—bedrock in the northern portion of the assessment area, transitioning to ancient high river terraces composed of old, consolidated alluvium in the middle and southern portions, with recent floodplains at the confluences of active channels—is depicted in Figure 3.3-1, Geologic Surfaces.

3.3.2 Central Valley Geomorphic Province – Redding Basin

As shown in Figure 3.3-1, the southern three-quarters of the assessment area are underlain by high terrace, and valley bottom and floodplain deposits. These are the alluvial deposits of the Redding Basin, a subset of the Central Valley Geomorphic Province. The Redding Basin occupies the northernmost portion of the Central Valley and is characterized as a plain with low topographic relief interrupted by a dendritic drainage pattern locally controlled by the elevation of the Sacramento River. Most of the drainages in the assessment area are low gradient and are characterized by extensive deposits of alluvial sand and gravel (Dupras 1997).

Most of the drainages in the assessment area are low gradient and are characterized by extensive deposits of alluvial sand and gravel.

Three geologic formations of the Redding Basin occur within the assessment area. The oldest is the Chico Formation (Upper Cretaceous), which is composed of thick sequences of thinly bedded siltstones, sandstones, and shales deposited in a marine

environment. Exposures of this formation are evident in the middle reaches of the Churn and Stillwater creek drainages. The Red Bluff Formation is derived from continental sources, primarily poorly consolidated Pleistocene gravels that have eroded from the Cascade Range to the east of the Redding Basin. The Red Bluff Formation is a partially indurated, well-rounded boulder, cobble, and pebble conglomerate with a matrix of sand, silt, and clay (Dupras 1997). Red Bluff gravel is distinguished from younger stream gravels by its distinctive reddish color and its position on elevated river terraces and benches. Within the Red Bluff gravel, well-developed hardpans prevent the downward percolation of surface water (Dupras 1997). Where it is exposed, this hardpan has a tendency to control stream gradients.

The Tehama Formation overlies the Red Bluff Formation. It is composed of river-deposited sediments that range from clay to boulders. Gravels and cobbles are evidence that this formation is derived from Cretaceous and older sedimentary rocks in the Coast Ranges and Klamath Mountains to the west (Dupras 1997). Like the Red Bluff Formation, the Tehama Formation is locally cemented and indurated. The upper surface of the Tehama Formation has undergone considerable weathering, and it grades into the materials of the Red Bluff Formation below it and the younger, more recently deposited gravels of similar composition and appearance above it. Exposures of the Red Bluff and Tehama formations can be observed in stream banks and road cuts throughout the assessment area, particularly south of Route 299.

The geologic surfaces labeled in Figure 3.3-1 as valley bottoms and floodplains are the youngest surfaces in the assessment area. Though they are younger than the adjacent high terraces, they occupy lower topographic positions because they have been deposited in recent time as a by-product of down-cutting through the high terraces by present-day creeks and rivers. These areas are included in the Redding Basin/Central Valley Geomorphic Province and are composed of unconsolidated sands and gravels. These materials provide sources of aggregate and landscape materials to residents of the assessment area.

Klamath Mountains Geomorphic Province

The northern quarter of the assessment area is underlain by rocks of the Klamath Mountains Geomorphic Province, which extends from southern Oregon into northwestern California. This geomorphic province is characterized by a number of tectonic terranes that are composed of various accumulations of oceanic crust, outer mantle, and volcanic arcs that were attached to the coastline of ancient California during the early Cretaceous period (Dupras 1997).

One of these tectonic terranes, the Eastern Klamath Terrane, forms the northern portion of the assessment area. Approximately 500 million years ago, this region was covered by a deep ocean. Through subsequent tectonic uplift over several million years, the sea floor rose and was pushed against the western coast of the North American continent (Dupras 1997). Abundant coral colonies flourished, and continuing uplift eventually created current-day limestone formations, such as the McCloud Limestone, which underlies a portion of the assessment area. Other locally important rock units in the northern portion of the assessment area include the Copley Greenstone and various metamorphic and intrusive rocks.

3.3.3 MINERAL RESOURCES

Mining and mineral resources are important to the residents of Shasta County. Each person in Shasta County requires about 20 tons of freshly mined non-fuel minerals each year, which translates into over 3.5 million tons for Shasta County alone. This amount includes about 8 tons of sand and gravel to make concrete for homes, schools, offices and infrastructure (Shasta County 1998). At present, there are six different mineral resources under production in the county. They include the five mineral resources described in the Mineral Land Classification Study[1] report for Shasta County prepared in 1997 by the California Department of Conservation Division of Mines and Geology: limestone, crushed stone, alluvial sand and gravel, volcanic cinders, and diatomite. The other mineral resource currently being produced is gold (Shasta County 2004).

Mining and mineral resources are important to the residents of Shasta County. Each person in Shasta County requires about 20 tons of freshly mined non-fuel minerals each year, which translates into over 3.5 million tons for Shasta County alone.

Within the assessment area, limestone, crushed stone, and sand and gravel are currently mined in various locations. Figure 2.3 in Chapter 2 illustrates the type and spatial distribution of mineral extraction in the assessment area. Specific information on the nature and extent of these activities was not available. While the Klamath Mountains Geomorphic Province is well known as a source of precious metals (e.g., gold, silver, copper), it also includes extensive limestone deposits in various locations. Limestone, depending on its quality, has many industrial uses; however, the majority of it is used in the construction industry for Portland cement concrete. Although there are three discrete limestone formations in Shasta County, the McCloud Formation is the only one within the assessment area. Currently, limestone quarries in the general vicinity of Mountain Gate in the northern part of the assessment area provide a variety of products.

Crushed stone, typically hard crystalline rocks (e.g., limestone, chert, and shale), consists of rocks that are broken into angular fragments. It is produced from quarries and is used extensively for road base and asphalt concrete. Within the assessment area, these sources are associated with the Klamath Mountains Geomorphic Province, often in conjunction with outcrops of limestone, granite, or andesite.

Alluvial sands and gravels are deposited in riverine environments, although these aggregate deposits may be topographically elevated from the streams we see today. These deposits vary substantially in quantity and quality, depending on the type and nature of the depositional environment. The quality of the material (i.e., clean and hard) is a primary determinant of its value. Typically, aggregate that is well-sorted, smooth, and round provides high-quality material for Portland cement concrete. Quality is also affected by the degree of weathering. As an aside, dredger tailings are typically avoided due to excessive weathering characteristics.

[1] The Shasta County General Plan refers to the *Mineral Land Classification of Alluvial Sand and Gravel, Crushed Stone, Volcanic Cinders, Limestone, and Diatomite within Shasta County, California*, prepared in 1997 by the California Department of Conservation – Division of Mines and Geology, as the Mineral Land Classification Study.

3.3.4 SOILS

The Soil Survey of Shasta County Area, California (United States Department of Agriculture 1974) (Order 2 Soil Survey) presents Order 2 information for 73,459 acres—or about 94.5 percent—of the 77,734-acre assessment area. The Order 2 Soil Survey excludes public lands at the northern boundary of the assessment area administered by the Shasta-Trinity National Forest (STNF). The Order 2 Soil Survey is the primary source of the data provided in this subsection.

Soil surveys group soils on the basis of similar characteristics that affect land use and management. Order 2 Soil Survey information is intended to be used in planning for general agriculture, construction, and urban development.

The assessment area contains a large diversity of soils; in total, 29 individual soil series are recognized to occur. They differ in their appearance, composition, management requirements, and productivity, sometimes over very short distances (United States Department of Agriculture 1974). Soil texture influences the porosity and permeability of the soil horizon, thereby controlling the rate and type of runoff. Soil texture, along with slope, soil depth, and other attributes, is also a key factor in erosional processes. Typically, a fine-texture soil (e.g., clay) would be more susceptible to surface erosion and have a higher potential to contribute fine sediments to the stream network than a coarser texture soil (e.g., loam), thereby influencing aquatic habitat to varying degrees. In addition to the 29 soil series, the assessment area includes six miscellaneous land types (i.e., areas with little or no soil; excludes water).

Soil Associations

The 29 soil series and six miscellaneous land types in the assessment area are the building blocks for 84 soil map units, each composed of one or more series and miscellaneous land types. These 84 map units are aggregated into five broad soil associations. Soil associations occurring in the assessment area are:

- Millsholm-Sehorn-Gaviota Association
- Auburn-Goulding-Neuns Association
- Newtown-Red Bluff Association
- Churn-Perkins-Tehama Association
- Reiff-Cobbly Alluvial Land Association

The influence of geologic parent material, time-in-place, and slope on soil development is evident by comparing Figure 3.3-2, Broad Soil Associations, to Figure 3.3-1. Because similar soils develop on similar geologic surfaces, the gross boundaries of the geologic surfaces correlate to the boundaries of the broad soil associations. Broad soil associations occurring in the assessment area are described in the following paragraphs.

Millsholm-Sehorn-Gaviota Association

The Millsholm-Sehorn-Gaviota Association consists of well-drained and somewhat excessively drained sandy loams to loams, and silty clays to silty clay loams that occupy nearly level (i.e., 0 to 3 percent) to very steep (i.e., greater than 45 percent) slopes in the northern quarter of the assessment area. These soils are most common immediately north of the intersection of North Market Street and Interstate 5 (I-5) in Redding, and east of the East Fork of Stillwater Creek. They are underlain by sedimentary and metamorphic rocks. Portions of the assessment area not included in the Soil Survey are included in this association.

Auburn-Goulding-Neuns Association

The Auburn-Goulding-Neuns Association consists of well-drained gravelly loams and clay loams and very gravelly silty clay loams that occupy nearly level to very steep slopes in the northern quarter of the assessment area. They are underlain by partly metamorphosed volcanic rocks of the Eastern Klamath Terrane, and are extensive in the uppermost portion of the assessment area. This association includes portions of the assessment area that are outside the area covered by Order 2 Soil Survey information.

Newtown-Red Bluff Association

The Newtown-Red Bluff Association is the most extensive association in the assessment area, occupying 43,001 acres in the central and southern portions (i.e., about 58.5 percent of the area covered by the Order 2 Soil Survey, and about 55.3 percent of the assessment area). The Newtown-Red Bluff Association is composed of well-drained and moderately well-drained reddish clays and clay loams that formed in the ancient alluvium of the Red Bluff and Tehama Formations. Slopes are nearly level (i.e., 0 to 3 percent) to moderately steep (i.e., 10 to 30 percent), with most slopes less than 10 percent. Portions of this association are underlain by a clay layer or by an indurated hardpan at shallow depth. These slowly permeable subsurface layers combine with the gentle topography to form seasonally ponded vernal pools that provide habitat for plants and animals specifically adapted to such conditions.

Churn-Perkins-Tehama Association

Soils in the Churn-Perkins-Tehama Association occupy nearly level to moderately steep landscapes on low terrace positions in the southwest quarter of the assessment area. These are well-drained and moderately well-drained clay loams and silty clay loams formed in younger alluvium.

Reiff-Cobbly Alluvial Land Association

The Reiff-Cobbly Alluvial Land Association occupies the youngest geologic surfaces in the assessment area, which are the valley bottoms and floodplains south of the confluence of Churn Creek and the Sacramento River. Slopes are nearly level to gently sloping (i.e., 1 to 8 percent). Because of their young age, the soil profiles are not well developed, and consist of well-drained to excessively drained loamy fine sands to loams, and cobbly lands that are frequently flooded.

Miscellaneous Land Types

The six miscellaneous land types identified within the assessment area are:

- gravel pits
- riverwash
- rockland
- tailings and placer diggings
- water
- wet alluvial land

Hydrologic Soil Groups

The conversion of rural land to urban land usually increases erosion as well as the discharge and volume of runoff in a watershed by changing the watershed's response to precipitation (National Resources Conservation Service 1986). The most common effects are reduced infiltration of precipitation into the soil profile and decreased travel time for precipitation across the land surface. Both of these effects significantly increase runoff into and peak discharges of creeks and rivers.

The Order 2 Soil Survey classifies 77 of the 84 map units in the assessment area into one of

four hydrologic soils groups. (Seven of the map units are not grouped because they are dominated by miscellaneous land types that are too variable for meaningful grouping.) Hydrologic soil groups provide a relative ranking of soil map units in terms of the minimum rate of infiltration obtained for bare soil after prolonged wetting. Hydrologic soil groups also provide a relative ranking of the transmission rates at which water moves within the soil after having infiltrated the surface layer. The four hydrologic soils groups defined in the Soil Survey are as follows.

Group A Hydrologic Soil Group

Group A soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well- to excessively drained sand or gravel, and have a high rate of water transmission (i.e., greater than 0.30 inch per hour [in/hr]). All other conditions being equal, conversion of Group A soils from rural to urban use would be expected to result in relatively large increases in runoff.

Group B Hydrologic Soil Group

Group B soils have moderate infiltration rates when thoroughly wetted and moderate rates of water transmission (i.e., 0.15 to 0.30 in/hr). They consist chiefly of moderately deep to deep, moderately well- to well-drained soils with moderately fine to moderately coarse textures.

Group C Hydrologic Soil Group

Group C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water (e.g., hardpan, claypan). These soils have a low rate of water transmission (i.e., 0.05 to 0.15 in/hr).

Group D Hydrologic Soil Group

Group D soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clayey soils, soils with a permanent high water table, soils with a hardpan near the surface, and shallow soils over bedrock. These soils have very low rates of water transmission (0.0 to 0.05 in/hr). All other conditions being equal, conversion of Group D soils from rural to urban use would be expected to result in relatively small increases in runoff.

The distribution of Group A and B soils in the assessment area is depicted in Figure 3.3-3, Hydrologic Soil Groups A and B. Conversion from rural to urban use of the soils identified in Figure 3.3-3 would be expected to result in relatively large increases in runoff and increases in peak discharges in creeks and rivers, all other conditions being equal. About 26,990 acres in the assessment area are occupied by soils in Groups A and B (i.e., about 36.7 percent of the 73,459 acres mapped in the Order 2 Soil Survey). Of this total, all but about 150 acres are in Group B.

Hydric Soils

A hydric soil is one that is normally associated with wetlands and hydrophytic vegetation. Hydric soils are soils that are saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the uppermost layers. The concept of a hydric soil includes soils developed under sufficiently wet conditions to favor the establishment of plant communities that are specifically adapted to such conditions. The presence of hydric soil is one of three parameters (along with hydrophytic vegetation and wetland hydrology) that are needed to establish state and federal regulatory jurisdiction regarding discharge of fill into wetlands. Discharge of fill into

wetlands is regulated because of the ecological functions associated with wetlands—including flood attenuation, groundwater recharge, wildlife habitat, nutrient transformation, and sediment and pollutant removal—and because of their aesthetic value.

The Order 2 Soil Survey identifies map units that contain hydric soils, and distinguishes between map units for which the hydric soil is a major component (i.e., comprising 75 percent or more of the mapped area) or an inclusion (i.e., comprising less than 25 percent of the mapped area). The distribution of map units that contain hydric soils as major components and inclusions is shown in Figure 3.3-4, Map Units Containing Hydric Soils. Of the 73,459 acres considered in the Soil Survey, 30,787 acres (41.9 percent) contain components or inclusions that are hydric. However, of this total, only about 2,217 acres or 3 percent are map units with hydric components. For the great majority of map units that contain hydric soils, the hydric soils occur as inclusions (i.e., consisting of less than 25 percent of the mapped area; in most cases around 5 percent).

Septic tank filter fields ("leach fields") are widespread in parts of the assessment area not served by sewer systems.

Limitations for Septic Tank Filter Field

Septic tank filter fields ("leach fields") are widespread in parts of the assessment area not served by sewer systems. Septic tank filter fields are subsurface systems of perforated pipe that distribute effluent from a septic tank into natural soil, or in some cases into soil material placed specifically for the purposes of treatment and disposal. Soils

Discharge of fill into wetlands is regulated because of the ecological functions associated with wetlands…and because of their aesthetic value.

differ in their capacities to retain pollutants until deactivated or absorbed by plants. Highly pervious soils may permit transmission of nitrates to groundwater. Similarly, saturated soils allow runoff to carry pollutants directly to receiving waters without entering the soils. Soils that combine a limited capacity to retain water above slowly permeable layers and a seasonal water excess may allow water that is carrying pollutants to move laterally at shallow depths, entering streams before naturally occurring removal mechanisms are fully effective.

The Order 2 Soil Survey includes a relative ranking of the soils in the assessment area with respect to their suitability to function as septic tank filter fields. The soil properties considered in forming this ranking are those that affect absorption of effluent, and construction and operation of the leach field system. Properties that affect absorption are permeability, depth to water table or bedrock, and susceptibility to flooding. Slope is a soil property that affects layout and construction, and also the risk of erosion, lateral seepage, and down slope flow of effluent.

Soil map units that include soil series that are severely limited for use as leach fields are shown in Figure 3.3-5, Soil Map Units with Severe Limitations for Leach Fields. "Severe" means that soil properties are so unfavorable and so difficult to correct or overcome that they require major soil reclamation and special design. Of the 73,459 acres considered in the Order 2 Soil Survey, 66,283 acres (90.2 percent) contain component soil series that are severely limited in terms of

their ability to function as septic tank filter fields. The lack of consistent data with respect to location and age of on-site waste water treatment facilities (septic tank/drain fields) inhibits our understanding of the relationship between these facilities and soils with severe limitations. The City of Shasta Lake operates a wastewater treatment facility that routinely discharges treated effluent to upper Churn Creek. The City of Redding operates the Stillwater Wastewater Treatment Plant, which discharges treated effluent directly to the Sacramento River between the confluences of Clover and Stillwater creeks, downstream of the North Street Bridge.

3.3.5 REFERENCES

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3.4 Geomorphology, including Fluvial Geomorphology

3.4.1 Geomorphology of the Watersheds

Geomorphology, the study of landforms and the processes that form them, plays a key role in the types and locations of beneficial uses in the watershed assessment area. The physical processes and surficial features of the assessment area are inherent to various ecosystem elements. Geology, soils, topography, climate, and vegetation provide the basis for physical and chemical interactions between the earth's surface and the natural forces acting on it. Fluvial geomorphology integrates channel morphology (topography) with the flow regime, sediment, and vegetation available to the channel.

Various channel classification systems (e.g., Rosgen, Montgomery-Buffington) recognize that channels can be classified using a primary criterion, channel gradient. Simplistically, these systems identify three basic channel types: steep, moderate, and low gradient. Generally speaking, channels with gradients in excess of 10 percent are typically confined, characterized by coarse substrates (bedrock/boulder), and have little to no floodplains. Moderate channels may be partially confined, with gradients ranging from 2 to 10 percent, and are characterized by wider channels with alternating point bar sequences, gravel/cobble substrates, and localized floodplains. Lower gradient channels, typically less than 2 percent, are generally considered alluvial with well-developed floodplains; wide, shallow channels; and fine substrates (sand and silt).

Although no comprehensive channel classification has been performed in the assessment area, general observations during the development of this watershed assessment, supported by topographic data, indicate that most of the steep channels are in the upper reaches of the assessment area, primarily upstream of the City of Shasta Lake and Mountain Gate. The middle reaches of the streams in the assessment area can be generalized as moderate, and the lower reaches, primarily south of State Route 44 and State Route 299, exhibit some characteristics of alluvial systems.

3.4.2 Hillslope Processes and Relationship to Disturbance Mechanisms

Erosion is a natural process that loosens and removes sediment from hillslopes or channel beds and banks. This process is controlled by three primary factors: topography (steeper slopes result in faster runoff conditions and an increase in transport capacity); soil cover (e.g., vegetation, rocks, pavement, roofs); and flow regime (e.g., rainfall, runoff, irrigation). The variations in the topography of the assessment area are illustrated in Figure 3.1-1, which indicates that most of the streams in the assessment area (85 percent) are located on flat to gently sloping landscapes (slopes of 10 percent or less). This figure supports the observation that slope is a function of the geologic features and soils in the assessment area. Modifications to slope, soil cover, or the flow regime can have a direct bearing on the nature and degree of hillslope erosion.

Soils in the assessment area are susceptible to erosion because of the topography and the relatively low permeability associated with the clay lenses and hardpan layers found throughout the assessment area. When landscapes in the assessment area are devoid of vegetation, erosion takes place in the following manner. Surface runoff combined

Erosion on Little Churn Creek below Alma Avenue. (Photo courtesy of Western Shasta Resource Conservation District.)

Erosion on Churn Creek at Enterprise Park caused by high water in January 2006. (Photo courtesy of Western Shasta Resource Conservation District.)

with the beating action of raindrops causes rills to form in the soil surface. Runoff concentrated in rills and small channels is conveyed downslope, increasing in velocity and turbulence as it travels and picking up

Stream channels form and are maintained by the dynamic interaction of three fundamental components: flow regime… sediment flux… and vegetation… Natural and human-caused disturbances in the assessment area provide opportunities to modify the relationships between these components, either intentionally or unintentionally.

even more material. This process is known as rill erosion and is evident on unpaved dirt roads and freshly graded surfaces throughout the assessment area. Rill erosion can also be observed in parts of the assessment area that have been subjected to high-intensity fires, grazing, and other intensive vegetation management. Following the severe rainstorms in December 2005, rill erosion was evident in a variety of locations throughout the assessment area, even on the gentler slopes (Paul Uncapher, personal observation, 2005).

Mass wasting (landslides) can occur in various forms throughout the assessment area, including on hillslopes and in channels. Landslides are typically isolated occurrences of soil/rock movement in which finite amounts of materials are rapidly transported downslope. On hillslopes, landslides typically result from reduced soil strengths, often due to saturated conditions; modification of slope angle, including undercut or oversteepened slopes; and disruption of root strength resulting from vegetation management. Within the assessment area, landslides are typically small, isolated occurrences associated with vegetation management, mining activities (large-scale excavations), and various grading activities (road construction, commercial and residential development). To date, this watershed assessment has not identified landslides as major factor directly affecting beneficial uses in the assessment area.

3.4.3 Fluvial Processes and Relationship to Disturbance Mechanisms

Stream channels form and are maintained by the dynamic interaction of three fundamental components: flow regime (base, flood, and low flows), sediment flux (transport, storage, and deposition of sediment of various size classes), and vegetation (varying type, age class, and quantity). Natural and anthropogenic (human-caused) disturbances in the assessment area provide opportunities to modify the relationships between these components, either intentionally or unintentionally. Complex interactions between these components define the fluvial geomorphic environment and provide a diversity of physical structures, such as point bars, riffle-pool sequences, and floodplains that provide value to the human and natural environment. A change in one or more of these components may affect the processes and functions of a channel and its associated beneficial uses.

Flow Regime

The flow regime of a particular stream channel may have a large degree of annual and interannual variability. This variability is influenced by physical processes, such as climate, geology, and topography. Climate variability is typically reflected in the annual hydrograph, where flow is a function of rainfall timing and intensity, combined with the

storage and runoff characteristics of the watershed. The channels in the assessment area are typical tributaries to the Sacramento River in that they have very low water levels or are dry during the warm summer and fall; experience flood flows during the wet season; and may have sustained winter flows for some period of time. The tributaries to Churn and Stillwater creeks and, to a lesser degree, Clover Creek, can be characterized as intermittent, meaning that they flow part of the year. Some reaches of Churn and Stillwater creeks are characterized as perennial, meaning that they flow year-round, at least during wetter climatic periods.

A variety of disturbance mechanisms appear to influence the flow regimes in the assessment area, based on observations made during the development of this watershed assessment. The relationship between storm water runoff and flood flows is well documented in the literature and is discussed in depth in Section 3.5.

Modifications to the flow regime (changes in magnitude, frequency, and duration of flows) can result in substantial changes in channel morphology. Channel confinement can be observed on Little Churn Creek, where the channel has been encased with concrete to increase its capacity and convey flood flows away from developed areas. This process has disconnected the channel from the floodplain, thereby reducing the storage capacity of the floodplain deposits and preventing accretion of fine sediments in the floodplain.

Observations of Churn Creek suggest that base flows in this reach may have some correlation to the irrigation delivery schedule and the various irrigation practices. The topography and soils in this area, combined with the incised nature of the channel… suggest that the lower portions of Churn Creek may function similar to a drain for agricultural runoff.

Irrigating open space and outdoor recreation areas, particularly parks and golf courses, has the potential to influence base flows and the shallow groundwater table. While these flows do not directly influence channel morphology, there is a fundamental relationship between low flows and channel conditions. Throughout the assessment area, summertime runoff occurs as a result of various water management practices, with the storm drain system providing the conveyance mechanism for surface runoff to local creeks.

Historically, extensive agricultural irrigation occurred in the vicinity of Bella Vista and Churn Creek Bottom. Information provided during the interview process indicates that Stillwater Creek once provided water for a number of agricultural users. Improvements made by the BVWD eliminated the need for diversions from Stillwater Creek. Water rights are discussed in Chapter 3.5, Hydrology, Flooding, Water Use/Quantity.

The ACID provides water for agricultural interests in the southwest portion of the watershed between I-5 and Churn Creek, south of Bonnyview Road. ACID water deliveries occur during the period when agricultural users are irrigating their lands, typically May through September. The irrigation water is pumped from the Sacramento River downstream of the South Bonnyview Bridge. The ACID delivery system was constructed in the early 1900s and is primarily a series of open canals, headgates, and pipelines. It is the fifth largest diverter of water from the Sacramento River. Currently, the predominant irrigation practice is flood

Confined channel, Little Churn Creek, 2005. (Photo courtesy of Western Shasta Resource Conservation District.)

Unconfined channel, Little Churn Creek, 2005. (Photo courtesy of Western Shasta Resource Conservation District.)

irrigation, with bi-weekly water deliveries to subscribers in the service area. Observations of Churn Creek suggest that base flows in this reach may have some correlation to the irrigation delivery schedule and the various irrigation practices. The topography and soils in this area, combined with the incised nature of the channel as evidenced by berms and levees, suggest that the lower portions of Churn Creek may function similar to a drain for agricultural runoff.

Several other commercial activities in the Churn Creek Bottom may influence the flow regime in this reach. Aggregate mining upstream of Knighton Road is an ongoing activity that has the potential to modify the surface and subsurface hydrology. Golf courses along Churn Creek Road (Churn Creek and Tucker Oaks) require irrigation that may influence the base flows of the lower reaches of Churn Creek and Clover Creek. Cumulatively, commercial activities that occur during summer base flow conditions have the potential to affect various beneficial uses in the assessment area, including freshwater habitat, riparian vegetation, and contact recreation. These activities may also modify certain aspects of the flow regime by enhancing summer base flows.

Bridges and culverts…provide vehicular and pedestrian access across streams; route flow, sediment, and debris downstream; and provide the hydraulic control necessary to ensure the stability of the crossing. If one of these functions is changed, impacts to the environment…may be substantial and long lasting.

Sediment Flux

Aggradation and degradation are the main mechanisms for the storage and release of sediment in a stream channel (Brooks et al. 1997). Aggradation occurs when more sediment flows into a stream reach than the reach can either store or discharge, and the excess sediment is deposited on the stream bed and banks. Degradation occurs when sediment stored in the channel is remobilized.

Aggradation occurs naturally in alluvial (low-gradient) channels. In steeper channels, localized changes in the gradient may result in changes to the depositional environment. Aggradation may occur when material is introduced to the stream channel. Under natural conditions, organic and inorganic materials are introduced into the stream via landslides and bank erosion. The introduction of coarse wood and invasive riparian plants, such as giant reed (Arundo donax), foster conditions favorable to sediment deposition.

Bridges as well as roads and buildings placed near streams can affect their ability to convey water and move sediment. Figure 3.4-1 illustrates the road and surface water intersections in the assessment area. Casual observations suggest that most of these crossings are bridges and culverts. These features generally provide vehicular and pedestrian access across streams; route flow, sediment, and debris downstream; and provide the hydraulic control necessary to ensure the stability of the crossing. If one of these functions is changed, impacts to the environment—both human and natural—may be substantial and long lasting.

Channel degradation also occurs both naturally and through human activities. In the assessment area, degradation typically occurs in the steep-gradient channels in the upper portions of the assessment area as a result of erosion of the bed and banks during flood flows.

Anthropogenic impacts to channels in the assessment area occur through modifications to the flows. These modifications may increase transport capacity and reduce channel sinuosity. These processes tend to increase the accumulation of fine sediment in the channel downstream of the modifications, which encourages the establishment and growth of riparian vegetation in the downstream locations. Some of the primary anthropogenic activities that result in channel degradation are in-channel excavation for aggregate mining; placement of in-channel structures such as bridges, culverts, and slope protection structures; and conversion or removal of riparian vegetation. These activities may result in substantial modifications to bed and bank features, and conversion or removal of riparian vegetation. These modifications often result in increased channel gradients, thereby increasing the potential for scouring. Casual observations of Stillwater Creek suggests that channel scouring may be an ongoing process, particularly in areas subject to previous gravel extraction efforts. It is important to note that no systematic channel or aquatic habitat evaluations have been conducted within the watershed.

In areas where flow velocities have been reduced…aggradation of fine materials has promoted the growth of plant communities such as Arundo in the active channel…thereby increasing the potential for flooding.

Channel meanders reflect the adjustment of channels to flow, sediment, and vegetation. Meander patterns evolve through a combination of bank erosion on the outside and sediment deposition on the inside of bends. Various development policies and management practices have modified the meander patterns of channels throughout the assessment area. The cities of Shasta Lake and Redding continue the practice of using stream channels in the assessment area to convey runoff, efficiently reducing the potential for damage to, or loss of, property. As a result, the channels have become hardened and/or straightened in various locations. Two examples of creeks used to address flood flows are Boulder Creek and Little Churn Creek in Redding. In both of these creeks, the natural aggradation and degradation patterns that result in the formation of alternating point bars and functional floodplains have been lost. The increased magnitude and velocity of flows in these channels have resulted in channel incision and increased carrying capacity. In some instances, channels have been lined with concrete or are buried in pipes, further increasing the efficiency with which flows and sediment are conveyed while inhibiting the development of riparian vegetation. In some instances, the channels are also influenced by various building practices (e.g., subdivisions, commercial buildings, and parking lots).

An increase in sediment load often results in a substantial change in the nature and location of alluvial materials (sand and gravel) (Rosgen 1996). Although no systematic assessment of channel conditions has been performed, casual observations of numerous stream reaches in the assessment area suggest that these channels are responding to changes in flow and/or sediment regimes. In areas where flow velocities have been reduced (due to insufficient culvert size, bridge crossings, etc.), aggradation of fine materials has promoted the growth of plant communities such as giant reed in the active channel. The resulting change in grade and the addition of roughness have caused further decreases in the flow velocities, causing more deposition of

fines and further decreases in the capacity of the channel, thereby increasing the potential for flooding. Often, the active stream channel is forced to move and can erode stream banks; this process was observable during the December 31, 2005, flood event on the lower reach of Stillwater Creek downstream of Dersch Road (Paul Uncapher, North State Resources, Inc., personal observation 2006).

The cumulative effects of stream bank and bed erosion and the resulting channel adjustments lead to loss of property, loss of aquatic and wildlife habitat, decreased water quality, and greater risk of flood-related damage. Examples of these adjustments can be observed… throughout the assessment area.

An example of insufficient culvert size is on Clover Creek in the Goodwater area, where the ability of the channel to convey water has been exceeded as a result of increased runoff from upstream developments. Unfortunately, larger culverts that could accommodate larger flows have not been installed. As the flows have increased, they have been constrained by the limited capacity of the culverts, causing the deposition of materials that filled in the channel, further reducing its capacity. Evidence of this was observed where Rancho Road crosses Clover Creek on December 31, 2005, during a large rainstorm (Paul Uncapher, North State Resources, Inc., personal observation 2006).

Certain stream reaches in the assessment area have become incised due to erosion of the channel bed, altering discharge into the historic floodplains. Human efforts to straighten and/or confine the channel, gravel extraction, and encroachment on the floodplain have exacerbated these conditions. As a result, the stream banks bear increased stress during high flows, causing the channel to begin to erode outward, or laterally. The over-widened channel eventually fills with sediment. Over time, a new narrow channel forms in the widened channel bed and new floodplains develop on either side of the new channel at a lower elevation. The cumulative effects of stream bank and bed erosion and the resulting channel adjustments lead to loss of property, loss of aquatic and wildlife habitat, decreased water quality, and greater risk of flood-related damage. Examples of these adjustments can be observed at various locations throughout the assessment area (e.g., Churn Creek between Enterprise Park and Churn Creek Road).

Vegetated landscapes help to minimize the dislodgement and mobilization of soils in upland environments, and healthy riparian zones help filter runoff from the surrounding landscapes and encourage a diverse assemblage of riparian vegetation. Increases in urbanization, construction of roads and other infrastructure, vegetation management activities, and subsequent changes in the hydrology and morphology of the channels influence the location and type of riparian vegetation in the assessment area.

Although the Stillwater Creek area is less developed than the Clover Creek and Churn Creek areas, it has experienced similar changes to the upland and riparian environments. Grazing, agriculture, and other land uses in the upper assessment area continue to provide a source of fine sediment to the channels, thereby increasing the propensity for the establishment of invasive species like giant reed. Giant reed has been documented in channels throughout the assessment area and has been the focus of an investigation along Stillwater Creek. This investigation suggested that the cycle of increasing populations of giant reed coincides

with increased storage of fine sediments that can be mobilized during flood flows. Giant reed has also affected channel meandering and, in some cases, likely has caused excessive stream bank erosion that otherwise may not have occurred.

The wetland community along Churn Creek downstream of Dry Gulch provides an example of the complex interactions between riparian vegetation, sedimentation, and colonization by beavers. A casual review of historic air photos suggests that this reach once consisted of a sequence of alternating point bars and undercut banks. As the area became more urbanized, increases in sediment deposition and changes in the flow regime caused the reach to convert to a braided channel and associated riparian wetland. Although the wetland provides habitat for some riparian-dependent species, the underlying geomorphic processes have been modified and the beneficial uses have shifted to some extent. The channel no longer has the ability to respond to the current flow regime and appears to have a limited capacity to absorb flood events. This situation appears to be exacerbated to some degree by development activities designed to stabilize, confine, and harden the channel downstream.

Streams in broad valleys or otherwise unconfined settings naturally have access to their floodplains. In the assessment area, however, access to the floodplains has been impeded in part by the development of the transportation network. The characteristics of the floodplains—their flat topography, proximity to water, and abundant fuel—made them logical transportation routes through the assessment area. The historical association of some of the major roadways with the creeks in the assessment area is apparent from names like Churn Creek Road. The expansion of residential and commercial development in close proximity to these floodplains can influence the form and function of these alluvial features. Specifically, the removal of vegetation, grading, and placement of hardened surfaces are causal mechanisms that can affect a stream's ability to access floodplains.

As these transportation networks evolved, they became wider and further encroached on the riparian communities. The associated residential and commercial development continues to modify the riparian vegetation communities within the assessment area. The increase in the number of stream crossings (e.g., bridges, culverts) plays a role in confining and/or hardening segments of the stream and artificially influences the transport capacity of the stream network in terms of water, sediment, and woody material. In addition to increases in noxious and invasive riparian species, a large number of exotic species have been introduced into areas previously occupied by native riparian vegetation.

Streams benefit from the presence of woody vegetation on their banks and in their floodplains because such vegetation helps dissipate the energy associated with flowing water. Because of the lack of access to their floodplains, creeks in the assessment area tend to become incised and degrade towards a new base elevation. This incision and degradation drops the water table, thereby affecting the existing riparian vegetation, which relies on a reliable water source. The underlying strata (e.g., bedrock, hardpan), in conjunction with riparian vegetation, assists in controlling the level of incision that occurs up to a point, beyond which it may have a negative influence on the channel downstream. Anecdotal evidence provided in interviews suggests that the structure and composition of riparian vegetation has been

modified throughout the assessment area. Additional information on the type and location of riparian vegetation is provided in Section 3.10.

3.4.4 REFERENCES

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3.5 Hydrology, Flooding, and Water Use/Quantity

This section describes the surface water, groundwater, and wetland resources (see also Section 3.8, Botanical Resources) in the assessment area, focusing on their distribution in the assessment area, their current condition, and the ways they affect beneficial uses of surface water and other ecological endpoints.

3.5.1 Surface Water

The assessment area encompasses 77,735 acres at the northern end of the Sacramento Valley. Although the surface waters of Stillwater Creek, Churn Creek, and Clover Creek are contained within discrete topographic basins, they all drain into the east side of the Sacramento River between River Mile 280 and 285 (U.S. Army Corps of Engineers, 1999) across the river from the City of Anderson. Figure 3.5-1, Surface Waters, illustrates the drainage network that has developed in the assessment area, as well as the larger impoundments and collection areas.

The surface water hydrology of the assessment area is typical of watersheds in the northern end of the Sacramento Valley. The low elevations along the upper rim inhibit the development of a snowpack that can accumulate during any given year. Consequently, there is less time between precipitation events and runoff than in watersheds that are influenced by rain-on-snow events.

The assessment area contains a number of creeks that contribute flow to the Stillwater, Churn, and Clover creek watersheds, at least on a seasonal basis. Table 3.5-1 identifies the primary surface water features and their respective lengths. Clover Creek is included as a tributary to Stillwater Creek in this table. These creeks play a prominent role in the hydrology of the assessment area.

Table 3.5-1
Primary Surface Water Features

Name	Length (miles)
Tributary to Churn Creek	
Churn Creek	21.28
Newton Creek	4.01
Dry Gulch Creek	2.09
Buckeye Creek	3.23
Salt Creek	5.20
Boulder Creek	5.14
Little Churn Creek	5.00
Tributary to Stillwater Creek	
Stillwater Creek	14.29
West Fork Stillwater Creek	11.62
East Fork Stillwater Creek	8.89
Salmon Creek	9.17
Clough Creek	6.97
Clover Creek	9.26

Note: Table adopted from City of Redding, Draft Stormwater Quality Improvement Plan (2003).

Factors Affecting Surface Water Quantity

Natural hydrological conditions are a function of the size, precipitation patterns, topography, soils, and vegetative cover of a watershed. The size of the assessment area, its precipitation patterns, and its overall topography have changed little over time.

However, the amount of impermeable surfaces (e.g., pavement, foundations, roofs) has increased, reducing the infiltration capacity of soils in the assessment areas. Concurrently, changes in land use have resulted in changes to drainage patterns and type and distribution of vegetation.

The overall lack of storage in the assessment area results in a surface flow regime that has a high degree of seasonal variability. A preliminary review of USGS gage data for Churn Creek supports the observation that streams in the watershed respond to climatic variability. The base flow is typically low, with most runoff related to saturated soil conditions and storm events. Flood flows associated with runoff have been the focus of attention throughout the assessment area, particularly in conjunction with changes in land use. Actions intended to prevent or alleviate the impacts of flooding have directly influenced the surface waters in the assessment area.

Precipitation and its interception affect the amount, timing, spatial distribution, and quality of water added to a watershed from the atmosphere (Brooks et al. 1997). These elements are often altered from their natural balance through anthropogenic means. Infiltration, for example, is the process by which water enters the soil surface. If infiltration capacities are changed as a result of land use practices, the amount of precipitation that infiltrates the soils and the amount that runs off will be affected.

Runoff is the portion of the total precipitation that runs off the land surface or is discharged through exposed soil surfaces (e.g., cut slopes, stream banks). Impermeable surfaces, such as roads, parking lots, and roofs, increase the amount of runoff by inhibiting infiltration. They also tend to modify the intensity and timing of the runoff by providing more efficient flow and decreasing the amount of time it takes for water to run off. In an urban environment, these factors are important in the design of drainage systems that efficiently convey water and minimize flood hazards to the urban environment.

Grazing operations on agricultural lands have the potential to remove a high percentage of the vegetative cover and, in certain instances, modify the infiltration capacity of the soils, particularly clay-rich soils. While casual observations suggest that grazing occurs in a variety of locations throughout the assessment area, detailed information on these activities was not available for this assessment. The following discussion describes the general relationships between water resources and grazing.

Flood flows associated with runoff have been the focus of attention throughout the assessment area… Actions intended to prevent or alleviate the impacts of flooding have directly influenced the surface waters in the assessment area.

The infiltration capacity of the soil is influenced by the permeability of the soil surface and the rate at which precipitation infiltrates the soils. Soil erosion caused by grazing and, subsequently, sediment delivered to a water body can affect various water quality parameters (e.g., turbidity, suspended sediment, nutrients). When livestock concentrate repeatedly or in large numbers in a small area for water, shade, or other streamside attractions, streambank vegetative cover deteriorates and sediment is added to the water course (George 1995). Livestock waste concentration can also be a

source of pathogen and nutrient pollution; if large amounts of these nutrients enter a waterway, they can stimulate algae growth that uses up dissolved oxygen, reducing fish reproduction and survival (George 1995). Grazing-induced pollution can be reduced if sufficient vegetation is left in the uplands, riparian areas, and along streambanks. Preventing the concentration of livestock adjacent to riparian areas can also reduce water quality impacts.

Increases in urbanized land uses and, to a lesser degree, in agricultural land uses generally result in changes to the amount and complexity of vegetative cover over the landscape. These changes are important because vegetation serves a critical role in decreasing the amount of precipitation leaving the landscape as runoff as well as slowing down the runoff. In a manner of speaking, vegetation helps to regulate runoff and acts as a buffer by removing chemicals (organic and inorganic) from runoff and reducing contaminants in streams.

The maximum monthly precipitation on record for Redding was 22.93 inches in January 1995. The maximum hourly precipitation record for Redding was 4.09 inches in October 1992.

Precipitation patterns in the assessment area play an enormous role in the functioning of its hydrology. Annually, almost all precipitation in the assessment area falls in the form of rain, usually between October and March, and the amounts of rainfall in the assessment area are often quite variable, particularly with respect to the uplands in the northern portion of the assessment area.

The average annual rainfall in the general vicinity of Redding from 1931 to 2000 was approximately 40 inches (Western Regional Climate Center 2006). This average reflects the variability imposed on the record due to changes in measurement locations (downtown Redding versus Redding Airport).

As elevations increase in the northern portion of the assessment area, temperatures tend to be lower and precipitation greater. Near the City of Shasta Lake, at 750 feet above mean sea level, average annual precipitation from 1952 through 2004 was approximately 55 inches (Burns 2005). According to records from the Western Regional Climate Center (Normal, Means, & Extremes, 2005), the maximum monthly precipitation on record for Redding was 22.93 inches in January 1995. The maximum hourly precipitation record for Redding was 4.09 inches in October 1992. Regardless of the actual rainfall amounts, there is a hydrologic response that can be correlated to precipitation patterns throughout the assessment area.

The climatic records suggest that the amount and timing of precipitation in the assessment area has not changed, but the land use patterns that influence runoff characteristics (particularly during intense rainstorms) affect the rate and amount of precipitation allowed to exit the assessment area. The greatest factor effecting hydrology in the assessment area is urban and suburban development. Simplistically, this can be expressed in terms of land use, roads, and vegetation.

The establishment of noxious plants like giant reed (Arundo donax) has also affected the hydrology and geomorphology of streams in the assessment area. Giant reed is suspected of altering hydrological regimes and reducing groundwater availability by transpiring large amounts of water from semi-arid aquifers (Bossard et al. 2000). This species colonizes alluvial substrates in close proximity to

surface water. Because of their density, giant reed canes serve as an efficient sediment trap, thereby affecting the overall transport capacity of the channel. In certain circumstances, giant reed communities can cause the channel to migrate, resulting in on-site and downstream impacts to the physical, biological, and human environment. In addition to giant reed, a number of other noxious and invasive plants may play a role in influencing the quality and quantity of water in the assessment area. These species are discussed in Section 3.8 of this document.

A simplified approach has been applied to characterize the relationship between land use and runoff in the assessment area. This approach, based on criteria identified in the City-Wide Master Storm Drain Study prepared for the City of Redding in 1993, uses general plan designations to assess the runoff potential on a per-acre basis. The three general plans applicable to the assessment area—those for Shasta County and the cities of Redding and Shasta Lake—provide information on land uses and improvements in parts of the assessment area that could affect runoff and drainage characteristics. While these general plans differ in terms of specific land use designations, the designations are similar in terms of the locations and intensity of development.

For purposes of this assessment, land use categories in the three general plans have been aggregated in order to discuss the relationship between various land uses and the potential for stormwater runoff. This relationship is illustrated in Table 3.5-2, in which the acres for various land use designations are multiplied by the factors for each designation provided in the storm drain study. The outcome is the number of acres in each aggregated land use category in the assessment area that could be modified under the current general plan designations. Specific information on the actual area that has been modified to date is not available at the assessment area scale; therefore, this table should be viewed as a projection of the amount of stormwater runoff that would occur if the development allowed for in the general plans were to occur.

As Table 3.5-2 shows, roads are completely impermeable, meaning that runoff totals 100% of precipitation that falls on these roads. Many roads in the assessment area follow stream courses; runoff from these roads carries accumulated pollutants, such as oil and gas, directly into the adjacent streams.

This table suggests that more than 30 percent of the assessment area could be rendered impermeable due to construction of roads and other transportation-related features. A review of this data set indicates that the potential impermeable surfaces in Redding and the City of Shasta Lake could exceed 45 percent.

Table 3.5-3 characterizes the type, length, and average width of the aggregated road types in the assessment area to arrive at an estimate of the acres of impermeable surfaces that could affect stormwater runoff. For purposes of this assessment, all road prisms are assumed to be impermeable, although exceptions may be observed in various locations throughout the assessment area.

Section 3.8, “Botanical Resources,” provides a comprehensive description of the diverse assemblage of vegetation communities in the assessment area. While it is accepted that plants require water, the importance of vegetation as it relates to the flow regime is often overlooked. The relationship between vegetation and water can be viewed in terms of water availability and water use. Vegetation can

Table 3.5-2
Aggregated Land Uses – Potential Impermeable Surfaces

Aggregated Land Uses	Acres	Runoff Factor	Impermeable Area (acres)
Park, agriculture, federal lands	12,902	0.02	258
Residential, low density (1-5 acres/unit)	31,593	0.15	4,739
Residential, medium density (1-6 units/acre)	14,808	.35	5,183
Residential, high density (6+ units/acre)	3,089	.55	1,699
Public facilities, industrial, light commercial, mineral resources	9,728	.75	7,296
Commercial, airport	4,532	.90	4,079
Other[1] (roads)	1,110	1.0	1,110
Total	**77,762**		**24,364**

Source: City of Redding General Plan 2000; City of Shasta Lake General Plan 2004; Shasta County General Plan 2000.
[1]Other category includes some roads, but not included in GIS dataset.

intercept precipitation and decrease the rate of runoff; modify the porosity and permeability of the soil, resulting in changes in the water table and soil moisture; influence the available fuels, thereby increasing fire risk; and, in some instances, modify the microclimate to varying degrees. Conversely, the loss of or change to vegetation communities as a result of events or actions in the assessment area (e.g., fire, flood, pavement, plowing, establishment of non-native species) may have direct, indirect, and cumulative effects on the flow regime. These effects may occur throughout a water year, although they typically would be more noticeable during the wet season.

Vegetation management associated with forestry, agriculture, and recreational facilities influences the flow regime in the upland portions of the assessment area. Although not extensive, vegetation management, including mining, logging, and fuels management, that occurs in the upland portions may also influence the runoff characteristics in certain areas. In addition, wildfire can have an effect on runoff patterns, particularly with regards to loss of soil cover, changes in vegetation, increases in runoff, and in some instances, impacts from fire suppression activities (e.g., fire lines). For example, recent fires have resulted in substantial runoff and subsequent erosion in the upper reaches of Stillwater Creek (Paul Uncapher, North State Resources, Inc. personal observation 2006).

The area known as the Churn Creek Bottom is served by the ACID, which draws water from the Sacramento River immediately downstream of South Bonneyview Bridge and conveys it to subscribers on either side of I-5. The water is conveyed through a system of pipes and ditches and is typically applied using flood irrigation methods for various agriculture uses. Anecdotal observations and interviews with long-term residents suggest

Table 3.5-3
Aggregated Transportation Network—Impermeable Surfaces

Aggregated Road Types	Road Length (miles)	Road Prism Width (feet)	Impermeable Area (acres)
Private road, alley, trail	36.9	20	89.3
Arterial, local	530.8	35	2,257.8
Collector	43.7	45	238.2
Highway	35.4	150	679.2
Freeway (includes north and south lanes and ramps)	27.6	200	668.8
Total	**674.3**		**3,933.3**

that the summer flows in Churn Creek are influenced by the irrigation delivery patterns in this area.

Recreation facilities require varying degrees of vegetation management that influence the flow regime throughout the assessment area. Golf courses (Tierra Oaks, Churn Creek, and Tucker Oaks), parks, and open space have specific objectives for managing vegetation that affect the surface and groundwater resources of the assessment area.

Peak Flows and Flooding

A fundamental concern in developed watersheds is the interception, collection, and transport of runoff, particularly during wet weather. Peak flows are flows that exceed some nominal threshold and typically represent some degree of flooding. In its 1991 report to the City of Redding, the Churn Creek Task Force developed several findings that focused on peak flows and flooding.

While these findings were specific to Churn Creek, they are generally applicable to the entire assessment area. These findings are repeated in this section to reinforce the fact that floods continue to be a major issue in the assessment area (Churn Creek Task Force 1991):

- Finding 3: Soil compaction during construction operations, subsequent paving, and creation of impervious surfaces causes an increase in surface water runoff.
- Finding 4: The base flood elevations (100-year floodplain) for Churn Creek provided by FEMA for the National Flood Insurance Program are not currently valid (note: this statement was made in 1991).
- Finding 6: Chemical and organic pollutants will likely enter the stream at increasing rates as development continues.

Currently, there are no flow or water temperature gaging stations operating in the assessment area, although various technical studies have been prepared that provide some site-specific hydrologic information. The most comprehensive data set available to assess flood (peak) flows in the assessment area is from a USGS gaging station placed on Churn Creek at Newtown Creek from 1961 to 1972. The hydrologic record for this station is shown in Figure 3.5-2, USGS Gage, Churn Creek at Newtown Creek from 1961-1966, and Figure 3.5-3, USGS Gage, Churn Creek at Newtown Creek from 1966-1972. These hydrographs represent the most comprehensive data set available for water years 1961 through 1966 and 1966 through 1972, respectively.

Figures 3.5-2 and 3.5-3 indicate the extreme variability between base flows and peak flows. Peak flows are often categorized by the event size with which they are associated. For

example, the 100-year flow event is the discharge presumably likely to occur as a result of an event that has a 1 in 100 chance of occurring in any year. The 100-Year Flood is a regulatory standard used by federal agencies and most states to administer flood plain management programs. The 100-Year Flood Plain is used by the National Flood Insurance Program as the basis for insurance requirements nationwide, which is why flooding and peak flows are often categorized in this manner.

Figure 3.5-2 – USGS Gage, Churn Creek at Newtown Creek from 1961-1966

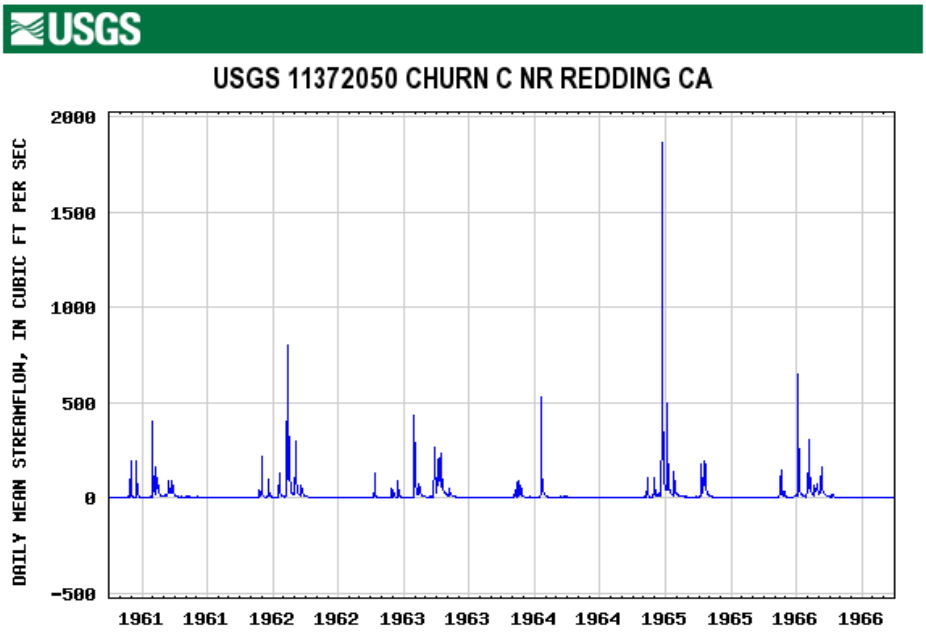

Figure 3.5-3 – USGS Gage, Churn Creek at Newtown Creek from 1966-1972

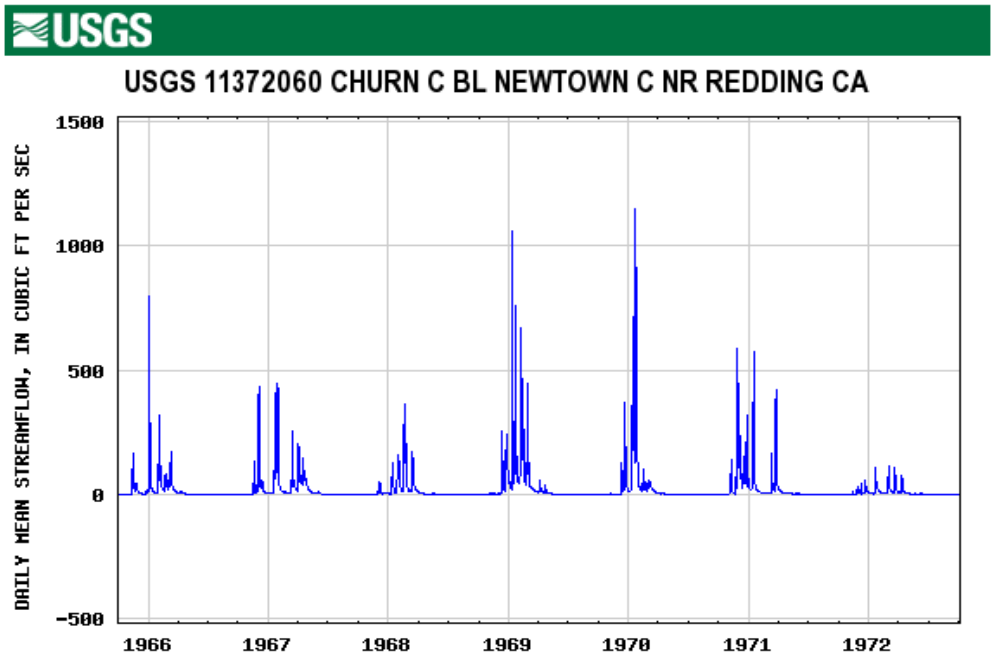

Table 3.5-4 illustrates flood flows that were projected for various locations in the assessment area using criteria established by FEMA and the U.S. Army Corps of Engineers, respectively. Note that these data are provided only for general reference. The methods and assumptions used in different estimates may in some cases make considerable differences in the magnitude of flow events. Due to the disparity of data, the 10-year and 50-year flow values were unavailable for the Stillwater Creek portion of the assessment area.

This table illustrates the variability of the assessment area in terms of size and runoff. The 100-year event in the Clover Creek drainage equates to 189 cubic feet per second (cfs) per square mile; in Churn Creek equates to 351 cfs per square mile; and in Stillwater Creek equates to 201 cfs per square mile. From a cumulative perspective, a 100-year event results in the contribution of approximately 26,400 cfs to the Sacramento River.

Table 3.5-4
Relative Flood Flow Values in the Assessment Area

Flood Location	Drainage Area (square miles)	10-Year Flow (cfs)	50-Year Flow (cfs)	100-Year Flow (cfs)
Churn Creek at Churn Creek Road	33.9	6,900	10,400	11,900
Clover Creek at mouth	6.4	750	1,080	1,210
Salt Creek at Churn Creek	5.0	1,590	2,270	2,470
Boulder Creek confluence with Churn Creek	4.0	1,070	1,460	1,650
Buckeye Creek	1.9	720	1,040	1,090
Stillwater Creek at Dersch Road	66	NA	NA	13,300
West Fork Stillwater Creek at mouth	18	NA	NA	7,000
East Fork Stillwater Creek at mouth	16	NA	NA	6,600
Salmon Creek at Old Alturas Road	6	NA	NA	2,100
Clough Creek at Hwy 44	5	NA	NA	1,800

NA = Not available
Sources: Churn and Clover creeks: Flood Insurance Study, City of Redding, California, Federal Emergency Management Agency, 1989.
Stillwater Creek: Flood Hazard Information, Clover Creek, Stillwater Creek, and Stillwater Creek Tributaries, Loomis Corner, California, Prepared for Shasta County by the U.S. Army Corps of Engineers, Sacramento District, 1977.

In addition to the contribution of water during runoff events, other factors influence the delivery and routing of water to the stream system. The flow of water depends on grade (steep is fast; flat is slow), roughness (smooth is fast), and efficiency of the delivery system (round is more efficient than square). As described in Section 3.4, a large proportion of the watershed is characterized by gentle to flat slopes and, consequently, a low-gradient stream network. Natural obstructions to flood flows include trees, brush, and other riparian vegetation that inhabit the riparian corridor or are delivered via upslope processes. During floods, these roughness elements tend to impede flows and may act as temporary dams that raise the water surface elevation, resulting in overbank flow that extends beyond the developed floodplain. As flows increase, these temporary dams may fail and cause a surge of water that could encounter additional obstructions downstream. The snowball effect can exponentially increase the flood flows for some period of time.

The Sacramento River influences the floods in the watershed to varying degrees. Although the CVP regulates flows in the river, high flows in the river can impede the discharge of flood flows from the watershed. Records indicate that floods in the lower reaches of Stillwater Creek and Churn Creek have been made larger by this phenomenon.

Stormwater Management

Management of runoff, including stormwater, is a critical element in planning for future development in the watershed. Ongoing efforts by the cities of Redding and Shasta Lake along with Shasta County are focused on the management of stormwater to reduce not only the potential for flooding, but also the potential effects of increased runoff on the physical processes and natural resources occurring in the watershed. Three general approaches to stormwater management are described in the following section: storm drainage, retention/detention basins, and natural waterways.

The development pattern described in Section 3.7 supports the fact that prior to the general planning process, stormwater management was implemented in response to specific developments throughout the watershed. The annexation of Enterprise and other areas into the City of Redding stimulated the requirement to establish a comprehensive drainage system on the western side of the watershed. The unincorporated areas of the watershed are not part of a comprehensive system and rely on local facilities to address stormwater runoff.

Storm Drainage

Presently, the watershed includes storm drain facilities that are diverse in terms of age and functionality. Figure 3.5-4, Stormwater Drains, Conveyance Features and Outfalls, illustrates the constructed storm drain facilities for the City of Redding. Table 3.5-5 provides an overview of the type and number of features that are used to alleviate runoff in the City of Redding. With few exceptions, the runoff captured by these features is eventually discharged into the Sacramento River.

High flows in the [Sacramento River] can impede the discharge of flood flows from the watershed. Records indicate that floods in the lower reaches of Stillwater Creek and Churn Creek have been made larger by this phenomenon.

Table 3.5-5
Constructed Storm Drain Facilities in the City of Redding

Facility	Unit of Measure
Storm drain inlets (number)	4,167
Storm drain outfalls (number)	867
Storm drain pipes (miles)	119.3
Storm drain channels (miles)	129.4

Detention/Retention Facilities

As previously discussed, increases in impermeable surfaces modify the flow regimes, particularly during wet conditions. A mechanism for managing or minimizing this occurrence is the use of detention and retention basins. A number of constructed and natural facilities attenuate stormwater runoff in locations throughout the assessment area.

Detention basins function to capture a certain volume of runoff from a storm event and release the water through a controlled outlet over a specified time period based on design criteria. Typically, detention basins function to disperse collected runoff for short periods of time (several hours to several days). The Clover Creek detention basin, located in the Clover Creek Preserve, is an example of this type of facility.

Retention basins may incorporate constructed elements or rely on topographic features to capture and retain runoff. These features typically have no surface discharge and rely on percolation to drain. A constructed retention basin can be observed at the northwest corner of Churn Creek Road and Victor Avenue.

In addition to constructed features, topographic depressions often serve as collection points for stormwater runoff. In many instances, these depressions meet the definition of vernal pools based on the availability of water and drainage characteristics. Certain areas of the watershed (e.g., Old Oregon Trail Mitigation Area) in the vicinity of Highway 44 contain examples of where this process has occurred and has been modified to some extent to reduce the impacts of stormwater runoff on vernal pools.

In the early 1990s, increasing development in the Clover Creek watershed led to increases in runoff and resulted in more frequent flooding that affected downstream residents and landowners who had built homes in the floodway or floodplain under County jurisdiction, prior to annexation by the City of Redding. This conflict between upstream development and downstream impacts to landowners resulted in building a detention basin intended to provide a comprehensive solution to this conflict. Construction of the detention basin provided the foundation for the development of the Clover Creek Preserve. The detention basin is now part of the preserve, which has become much more than a flood control measure. The City of Redding provides general maintenance of the preserve while the Wildlife Heritage Foundation monitors the site to ensure compliance with the easement and permit conditions.

The Clover Creek Preserve has restored and conserved approximately 128 acres of land that had been slated for residential development. Specific components of the preserve include the creation of the approximately 46-acre detention basin/floodplain area, with 10 to 15 acres of associated seasonal wetland, marsh, perennial pond, and riparian habitat; the enhancement or creation of 25 to 40 acres of oak woodland and 40 to 55 acres of

grassland with scattered vernal pools; and the construction of bike paths, walking trails, a parking area, and interpretive areas. In addition, there are ongoing efforts to reintroduce appropriate riparian vegetation to the rehabilitated channel (City of Redding, 2001).

Natural Waterways

Throughout the assessment area, the stormwater drainage system relies heavily on natural waterways to convey stormwater away from the developed areas. In some instances, the bed and banks of these waterways have been modified as part of the overall stormwater drainage system. Channel modifications are often in the form of trapezoidal channels, which are specifically designed to efficiently convey water. In some cases, channels can be completely encapsulated in concrete and run beneath developments, as has been done with Little Churn Creek in the vicinity of Churn Creek Road and Hartnell Boulevard. Other examples of such modifications can be observed adjacent to Churn Creek Road south of Highway 44. Because these modifications are intended to convey large amounts of runoff in an efficient manner, the amount of runoff and the rate at which it reaches waterways are increased substantially over the natural condition. No systematic evaluation has been conducted to assess the overall impact of these modifications to the watershed. The increased magnitude of flow entering the waterways and the resultant hardening of the channel can dramatically change the geomorphic processes described in Section 3.4.

Uses of Surface Water

The surface waters in the assessment area support a variety of uses, including the beneficial uses designated in the Basin Plan. However, because most of the streams in the assessment area are relatively small, they do not directly provide the full range of beneficial uses. For example, although the Basin Plan identifies municipal and domestic water supply as a beneficial use, there is no indication that the surface waters in the assessment area are used for municipal water supply purposes. Table 3.5-6 identifies a water right that has been issued for an unnamed spring, suggesting a source for domestic consumption. In addition to the service districts described in Section 3.7, wells provide source of domestic water in many unincorporated areas.

Throughout the assessment area, the stormwater drainage system relies heavily on natural waterways to convey stormwater away from the developed areas. In some instances, the bed and banks of these waterways have been modified as part of the overall stormwater drainage system.

A variety of agricultural activities rely on surface water to varying degrees, particularly in the incorporated areas of the assessment area along Stillwater Creek and in Churn Creek Bottom. Water use for agriculture occurs in two locations, on and off channel. Examples of on/in channel use are agricultural dams and diversions and livestock watering. Off channel use often occurs as small ponds or diversions for agricultural or industrial operations. Both forms of water use have an effect on hydrology in the watershed. Ponds and diversions, for example, can capture water from the landscape and reduce the amount entering streams during precipitation events.

The availability of, and proximity to, surface water supports a variety of recreational

Table 3.5-6
Water Rights Summary

Application	Diversion	Use	Average Diversion	Max. Storage (acre/feet)	Diversion Dates
AOO9726	Churn Creek	I	0.1 cubic foot/second	--	05/01-10/31
A018163	Unnamed spring/tributary to Churn Creek	E/D	900 gallons/day	--	01/01-12/31
A020924	Unnamed tributary to Churn Creek	R/S	--	2.5	10/01-05/01
A015470A	Unnamed tributary to Salmon Creek	S		0.2	10/01-04/01
A015470B	Unnamed tributary to Salmon Creek	S	--	4.8	10/01-04/01
A016502	Unnamed tributary to East Fork Stillwater Creek	I/R/S	0.6 cubic foot/second	709	10/01-5/31
A016549	Unnamed tributary to East Fork Stillwater Creek	H/R/S	--	243.5	10/01-5/31
A018169	Chicken Spring Gulch	H/I/R/W	--	145	11/01-03/01
A018799	Unnamed tributary to Stillwater Creek	I	--	200	11/01-04/01
A019394	Early Creek tributary to Clough Creek	I/S	--	37	11/01-02/01
A021082	Unnamed tributary to East Fork Stillwater Creek	R/S	--	48	10/01-06/01
A021109	Unnamed tributary to Stillwater Creek	H/I/R	--	228	11/01-04/01
A025417	Unnamed tributary to Deep Hole Creek	E/R/W	--	14	11/01-04/01
A025736	Unnamed tributary to Clough Creek	E/R/W	--	59	10/01-03/01
S002310	Stillwater Creek	I	1.33 cubic feet/second	--	03/01-05/31
S009759	Unnamed tributary to Deep Hole Creek	I	4,000 gallons/day	--	01/01-05/31
S009761	Unnamed tributary to Deep Hole Creek	I	4,000 gallons/day	--	01/01-05/31

Key: I = Irrigation, E = Fire Protection, W = Fish and Wildlife Protection and/or Enhancement, S = Stockwatering, R = Recreation, D = Domestic, H = Fish Culture

activities in the assessment area. Due to the quantity and quality (e.g., temperature, odor) of the water, the amount of contact recreation is limited. Interviews with long-time residents suggest that these waters have never been a preferred location for swimming and wading.

Non-contact recreational opportunities are provided in numerous locations due to the many access points available to residents and visitors in the assessment area. With three golf courses and numerous parks and open space areas, the assessment area supports many recreational activities, including golfing, biking, hiking, and hunting.

The surface waters in the assessment area provide a diverse array of habitat for a wide range of aquatic, riparian, and terrestrial biota. Directly or indirectly, more than 25 special-status plants and animals are associated with the surface waters of the assessment area. The Clover Creek Preserve and the Stillwater Plains Wetland Mitigation Bank provide substantial benefits to a wide array of special-status species.

Several other water uses occur within the assessment area that, while not designated as beneficial uses, play an important role in the flow regime. The discharge from municipal and industrial facilities, return flows from landscaped areas (parks, golf courses, and other irrigated areas), and use of recycled water all influence the timing and nature of surface flows in the watershed. While they may be more noticeable during the dry season, these uses occur to varying degrees all year long.

Various mineral material extraction and processing operations influence the flow regime in the assessment area, both by using water in their operations and by modifying the topography. Modifications to the topography, particularly near riparian areas, include the creation of pits that are subject to filling during periods of flooding or elevated groundwater. These pits are often used as "settling ponds" or for water storage to support the mining operations. These uses may influence water quality to some degree.

Water Rights

There are 16 recorded water rights identified in the assessment area. Table 3.5-6 provides an overview of these water rights in terms of location, use, quantity, and timing. Of these, only one provides for year-round domestic use. The remainder have seasonal restrictions based on the authorized beneficial use.

3.5.2 GROUNDWATER

Groundwater resources are invaluable. Groundwater comprises more than 97 percent of all liquid freshwater on earth and contributes about 30 percent of streamflows; nearly 50 percent of drinking water in the United States comes from wells (Brooks et al., 1997). It is important to understand the linkages between watershed characteristics and groundwater management, since they are intimately related. Improper management can cause over-exploitation of the groundwater supplies, and contamination can render the resource unusable for many purposes.

The assessment area is in the Redding Groundwater Basin. The Redding Groundwater Basin covers 510 square miles and has an estimated storage capacity of 5.5 million acre-feet for 200 feet of saturated thickness (Pierce 1983). The Redding Groundwater Basin consists of six subbasins: Anderson, Millville, Enterprise, Bowman, Rosewood, and South Battle Creek. The Anderson, Enterprise, and Millville subbasins are the primary aquifers that provide

Base flow, Churn Creek upstream of Knighton Road Bridge, 3/28/05. (Photo courtesy of Western Shasta Resource Conservation District.)

Peak flow, Churn Creek upstream of Knighton Road Bridge, 12/28/05. (Photo courtesy of Western Shasta Resource Conservation District.)

groundwater resources for the assessment area (Figure 3.5-5, Groundwater Basins and Hydrologic Units).

Throughout the assessment area, groundwater is used for municipal, domestic, commercial, and agricultural purposes. Well fields, developed to access the groundwater resources contained in the Redding Groundwater Basin, are operated and maintained by the cities of Redding and Anderson as part of the service area for these communities. Specific information on the locations of the well fields is restricted by the Homeland Security Act.

California's Groundwater Bulletin 118 (2003) reports that for the three subbasins in the assessment area combined, there are 62 well completion reports for irrigation and 4,696 well completion reports for domestic purposes. The Redding Groundwater Basin typically provides groundwater of good quality and quantity.

A review of hydrographs for long-term comparison of groundwater levels indicates a slight decline in levels associated with the 1976-77 and 1987-94 droughts, followed by a gradual recovery to the pre-drought conditions of the early 1970s and 1980s. Generally, the seasonal fluctuation ranges from 1 to 10 feet for normal and dry years. Overall, there do not appear to be any increasing or decreasing trends in groundwater levels. Details concerning groundwater monitoring in the Redding Groundwater Basin are available in Groundwater Levels in the Redding Groundwater Basin (Huckabay 1996).

Groundwater recharge is designated as a beneficial use, as defined by the Central Valley Regional Water Quality Control Board (RWQCB). The main sources of recharge into the groundwater basin in the assessment area are stream flows and direct infiltration of precipitation. Increases in impermeable surfaces have reduced the surface area available for direct infiltration. Additionally, water entering streams from the developed landscape can often carry pollutants that could be introduced to the groundwater, particularly during large runoff events. While it is generally accepted that this relationship exists, there are no data available to determine if this process is occurring within the assessment area.

The Redding Groundwater Basin typically provides groundwater of good quality and quantity…Overall, there do not appear to be any increasing or decreasing trends in groundwater levels.

3.5.3 WETLANDS

Wetlands are ecosystems that develop in landscape positions that are transitional between open water and dry land. They are protected under Sections 401 and 404 of the Clean Water Act.

Sites that support wetlands are saturated due to flooding, ponding, or high water table conditions at a frequency and duration sufficient to support a prevalence of vegetation adapted for life in saturated soil conditions. Some of the functions ascribed to wetlands are:

- groundwater recharge and discharge
- flood attenuation
- sediment stabilization/retention
- nutrient removal/transformation
- wildlife habitat
- recreation

Wetlands occur throughout the assessment area, but are most prevalent on nearly level to

gently sloping or undulating landscapes (i.e., uppermost slope gradient of 8 percent). As shown in Figure 3.3-4, hydric soils (a component of wetlands) are most likely to occur on nearly level, recent alluvial surfaces adjacent to creek channels, and on older, high terrace landforms. Although wetlands have potential to occur throughout the watershed, the area actually occupied by wetlands is relatively small. Data describing the areal extent of wetlands throughout the assessment area do not exist, but a rough estimate based on detailed mapping performed for specific parcels, and on the information presented in the Soil Survey of Shasta County Area, is that less than 1 percent of the gross assessment area is occupied by wetlands. Detailed wetland mapping of specific parcels in the assessment area typically identify wetland acreages in the range of less than 1 to 3 percent of gross land area.

Wetlands in the assessment area can be grouped on the basis of physical and biological similarity into four main types: seasonal wet meadow, vernal pool, riparian wetland, and fresh emergent wetland. Seasonal wet meadows occur throughout the assessment area, most commonly adjacent to creek channels. Particularly dense concentrations of seasonal wet meadows occur at the headwaters of the West Fork Stillwater Creek, north of Shasta Dam Boulevard (in the city of Shasta Lake) and west of Interstate 5; and in Churn Creek Bottom. Typical plant species include white-flowered navarretia *(Navarretia leucocephalus ssp. leucocephalus)*, Fitch's spikeweed *(Hemizonia fitchii)*, rough cat's ear *(Hypochaeris radicata)*, quaking grass *(Briza minor)*, annual hairgrass *(Deschampsia danthonioides)*, toad rush *(Juncus bufonius)*, leafybract dwarf rush *(Juncus capitatus)*, sweet vernal grass, and shiver grass. The primary functions of seasonal wet meadows are groundwater recharge and discharge, flood attenuation, and sediment stabilization/retention.

The biological attributes of vernal pools are described in Sections 3.8 and 3.9. Vernal pools (and other seasonally ponded features that are functionally similar to vernal pools) primarily occur in the southeastern portion of the assessment area, on the high terraces of the Stillwater Plains, south of Highway 44 and east and west of Airport Road. Prior to development, vernal pools were widespread in Redding east of the Sacramento River, in Enterprise, and along Hilltop Drive. The primary function of vernal pools is to provide unique habitat for plants and animals.

Riparian wetlands occupy landscape positions that are adjacent to flowing or open water and are routinely flooded. The biological attributes of riparian wetlands are described in Section 3.8.1 under Valley Foothill Riparian. The primary functions of riparian wetlands are wildlife habitat (mainly for fish and migratory birds) and flood attenuation.

Fresh emergent wetlands occupy small reservoirs, stock ponds and other features that impound water at depths shallow enough that they support a prevalence of vegetation that grows under submerged conditions and "emerges" through the water surface for at least part of their life span. The biological attributes of fresh emergent wetlands are described in Section 3.8.1 under Fresh Emergent Wetland. The primary functions of fresh emergent wetlands are flood attenuation, sediment stabilization/retention, nutrient removal/transformation, wildlife habitat, and recreation.

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3.6 Water Quality

3.6.1 Water Quality as a Unifying Theme for Watershed Management

Water quality encompasses the physical and chemical characteristics of water in waterways or water entering a waterway (Shilling et al. 2005). Groundwater and surface water quality is affected by natural physical and biological processes, land use practices, and water use practices in a watershed. The quality of surface waters produced by a watershed ultimately affects those waters downstream with which it converges and mixes as it flows through the stream network. In this way, surface waters ecologically link upstream watersheds with the water-dependent resources and water uses farther downstream. Measuring water quality is important to monitoring watershed condition because "changes in water quality indicate a change in some aspect of the terrestrial, riparian, or in-channel ecosystem" (Naiman et al. 1992).

3.6.2 Status of Water Quality Monitoring Activities in the Watershed

The discovery process for this watershed assessment revealed only one record of previous efforts to address water quality issues in the watershed assessment area. This effort was a citizen-based task force formed during the early 1990s to address public concerns regarding an apparent decline in the ecological health of Churn Creek (Churn Creek Task Force 1991). The principal water quality problems identified for Churn Creek prior to the early 1990s by this group were 1) an increase in erosion from newly developed construction sites, with subsequent siltation of the creek, transport of silt to the Sacramento River, and associated impacts on fish habitat; 2) increases in impervious surfaces due to soil compaction and construction of roads and parking lots, leading to accelerated surface water runoff and increased bank erosion; 3) changes in flood elevations caused by changes to the hydrology of the stream as a result of urbanization; 4) loss of riparian vegetation as a result of human encroachment into riparian areas, and the attendant effects on several water quality parameters; 5) increased water pollution and litter caused by development; and 6) occasional declines in water quality, notably increased nutrients, attributable to operations of the City of Shasta Lake's wastewater treatment plant. With the exception of the last issue, most streams in the Redding area have experienced these changes to varying degrees. Since the task force made its recommendations in 1991, some progress has been made to address at least several of these problems.

Because the archives maintained by the WSRCD contained only limited information on water quality for the assessment area, North State Resources, Inc., (NSR) sought additional data from several other sources, including the U.S. Environmental Protection Agency's (EPA's) STORET Legacy Database, Central Valley RWQCB records, City of Redding Water Utility, and the DWR Northern District office in Red Bluff.

No comprehensive water quality studies have been performed on the principal streams in the assessment area. Existing water quality data are limited to periodic, but infrequent, monitoring data collected by federal and state water resource agencies at various locations, regular discharge compliance monitoring of receiving waters and effluent at two wastewater treatment facilities, regular compliance monitoring of municipal groundwater wells, and case files associated

with the regulatory responsibilities of the RWQCB. While these data are not sufficient for rigorous quantification of changes or trends in the water quality of the watershed, they do provide a basis for a limited, general characterization of current water quality conditions.

3.6.3 REGULATORY ISSUES

A number of regulatory mandates govern surface water and groundwater quality standards. The federal Clean Water Act of 1973 (CWA) and the state Porter-Cologne Water Quality Control Act require that dischargers meet certain standards for managing chemical inputs and other pollutants that may affect beneficial uses. If water quality is impaired or threatened with impairment from point or nonpoint source pollution, the state is legally required to act to protect or improve the water quality. The EPA provides guidance and regulatory requirements for the state to act under the CWA, while the state implements programmatic actions to achieve water quality goals. The SWRCB is responsible for managing water quality in California's waterways.

The State of California, acting through nine Regional Water Quality Control Boards (RWQCBs), has designated beneficial uses and developed water quality criteria and standards for waters throughout the state, as required under Section 303 of the CWA. The designated beneficial uses and water quality standards for the Sacramento River basin, which includes the assessment area, are provided in the Basin Plan (RWQCB 2004). Although the Basin Plan does not identify specific beneficial uses for the water bodies in the assessment area, it states that "the beneficial uses of any specifically identified water body generally apply to its tributary streams" (RWQCB 2004). Therefore, the beneficial uses designated for the reach of the Sacramento River that borders the assessment area apply to the tributaries in the assessment area. These designated beneficial uses are identified in Table 3.6-1. The water quality objectives for surface water and groundwater in the Sacramento River basin are listed in Table 3.6-2. Additional information on specific classes of important toxic pollutants is provided in Table 3.6-3 and Table 3.6-4.

The CWA provides for regulation of the discharge of pollutants from point sources to waters of the United States, which is enforced through permitting programs under Sections 401 and 404 for hydromodification and discharges of fill to wetlands, and under the National Pollutant Discharge Elimination System (NPDES) for municipal, industrial, and agricultural wastewater and certain storm water discharges (e.g., municipal "MS4" storm sewer drain systems and construction site storm water Best Management Practices [BMPs] programs). The EPA and RWQCB also oversee integrated programs to address nonpoint source pollution, which is currently the leading cause of water quality impairments in California. Pertinent examples of programs developed to address nonpoint source pollution include the development of Total Maximum Daily Loads (TMDLs) for certain contaminants, the Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands Program, and the Watershed Management Initiative Program.

Table 3.6-1
Designated Beneficial Uses of Surface Waters of the Sacramento River Basin, Shasta Dam to Colusa Basin Drain, as Defined by the Sacramento–San Joaquin Basin Plan (RWQCB 2004)

Beneficial Use	Description	Identified as Beneficial Use for Upper Sacramento River Basin
Municipal and domestic supply (MUN)	Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.	X
Agricultural supply (AGR)	Uses of water for farming, horticulture, or ranching including, but not limited to, irrigation (including leaching of salts), stock watering, or support of vegetation for range grazing.	X
Industrial service supply (IND)	Uses of water for industrial activities that do not depend primarily on water quality including, but not limited to, mining, cooling water supply, hydraulic conveyance, gravel washing, fire protection, or oil well repressurization.	X
Industrial process supply (PRO)	Uses of water for industrial activities that depend primarily on water quality.	X
Groundwater recharge (GWR)	Uses of water for natural or artificial recharge of ground water for purposes of future extraction, maintenance of water quality, or halting of saltwater intrusion into freshwater aquifers.	X
Freshwater replenishment (FRSH)	Uses of water for natural or artificial maintenance of surface water quantity or quality.	X
Navigation (NAV)	Uses of water for shipping, travel, or other transportation by private, military, or commercial vessels.	X
Hydropower generation (POW)	Uses of water for hydropower generation.	X
Water contact recreation (REC-1)	Uses of water for recreational activities involving body contact with water, where ingestion of water is reasonably possible. These uses include, but are not limited to, swimming, wading, water-skiing, skin and scuba diving, surfing, white water activities, fishing, or use of natural hot springs.	X
Non-contact water recreation (REC-2)	Uses of water for recreational activities involving proximity to water, but where there is generally no body contact with water, nor any likelihood of ingestion of water. These uses include, but are not limited to, picnicking, sunbathing, hiking, beachcombing, camping, boating, tide pool and marine life study, hunting, sightseeing, or aesthetic enjoyment in conjunction with the above activities.	X
Commercial and sport fishing (COMM)	Uses of water for commercial or recreational collection of fish, shellfish, or other organisms including, but not limited to, uses involving organisms intended for human consumption or bait purposes.	

Table 3.6-1
Designated Beneficial Uses of Surface Waters of the Sacramento River Basin, Shasta Dam to Colusa Basin Drain, as Defined by the Sacramento–San Joaquin Basin Plan (RWQCB 2004)

Beneficial Use	Description	Identified as Beneficial Use for Upper Sacramento River Basin
Aquaculture (AQUA)	Uses of water for aquaculture or mariculture operations including, but not limited to, propagation, cultivation, maintenance, or harvesting of aquatic plants and animals for human consumption or bait purposes.	
Warm freshwater habitat (WARM)	Uses of water that support warm water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.	X
Cold freshwater habitat (COLD)	Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.	X
Estuarine habitat (EST)	Uses of water that support estuarine ecosystems including, but not limited to, preservation or enhancement of estuarine habitats, vegetation, fish, shellfish, or wildlife (e.g., estuarine mammals, waterfowl, shorebirds).	
Wildlife habitat (WILD)	Uses of water that support terrestrial or wetland ecosystems including, but not limited to, preservation and enhancement of terrestrial habitats or wetlands, vegetation, wildlife (e.g., mammals, birds, reptiles, amphibians, invertebrates), or wildlife water and food sources.	X
Preservation of biological habitats of special significance (BIOL)	Uses of water that support designated areas or habitats, such as established refuges, parks, sanctuaries, ecological reserves, or Areas of Special Biological Significance (ASBS), where the preservation or enhancement of natural resources requires special protection.	
Rare, threatened, or endangered species (RARE)	Uses of water that support aquatic habitats necessary, at least in part, for the survival and successful maintenance of plant or animal species established under state or federal law as rare, threatened or endangered.	
Migration of aquatic organisms (MIGR) (for COLD & WARM)	Uses of water that support habitats necessary for migration or other temporary activities by aquatic organisms, such as anadromous fish.	X
Spawning, reproduction, and/or early development (SPWN) (for COLD & WARM)	Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.	X
Shellfish harvesting (SHELL)	Uses of water that support habitats suitable for the collection of filter feeding shellfish (e.g., clams, oysters, and mussels) for human consumption, commercial, or sports purposes.	

Table 3.6-2
Water Quality Objectives for Surface Water and Groundwater as Defined by the Sacramento–San Joaquin Basin Plan (RWQCB 2004)

Water Quality Constituent	Water Quality Objective
Surface Water	
Bacteria	In waters designated for contact recreation, the fecal coliform concentration based on a minimum of not less that five samples for any 30-day period shall not exceed a geometric mean of 200/100 ml, nor shall more than ten percent of the total number of samples taken during any 30-day period exceed 400/100 ml.
Biostimulatory substances	Water shall not contain biostimulatory substances that promote aquatic growth in concentrations that cause nuisance or adversely affect beneficial uses.
Chemical constituents	Waters shall not contain chemical constituents in concentrations that adversely affect beneficial uses. Trace element water quality objectives are summarized in Table III-1 of the Basin Plan (SRWQCB, 1998)
Color	Water shall be free of discoloration that causes nuisance or adversely affects beneficial uses.
Dissolved oxygen (DO)	Monthly median of the mean daily dissolved oxygen concentration shall not fall below 85 percent of saturation in the main water mass, and the 95th percentile concentration shall not fall below 75 percent of saturation. The DO concentrations shall not be reduced below the following minimum levels at any time: Waters designated WARM 5.0 mg/l Waters designated COLD 7.0 mg/l Waters designated SPWN 7.0 mg/l
Floating material	Water shall not contain floating material in amounts that cause nuisance or adversely affect beneficial uses.
Oil and grease	Waters shall not contain oils, greases, waxes, or other materials in concentrations that cause nuisance, result in visible film or coating on the surface of the water or on objects in the water, or otherwise adversely affect the beneficial uses.
pH	The pH shall not be depressed below 6.5 nor raised above 8.5. Changes in normal ambient pH levels shall not exceed 0.5 in fresh waters with designated COLD or WARM beneficial uses.
Pesticides	No individual pesticides or combination of pesticides shall be present in concentrations that adversely affect beneficial uses. Specific pesticide objectives are summarized in Table III-2a of the Basin Plan (SRWQB, 1998)
Radioactivity	Radio nuclides shall not be present in concentrations that are harmful to human, plant, animal or aquatic life that result in the accumulation of radio nuclides in the food web to an extent that presents a hazard to human, plant, animal or aquatic life.
Salinity	No water quality objectives for salinity are applicable to the watersheds.
Sediment	The suspended sediment load and suspended sediment discharge rate of surface waters shall not be altered in such a manner as to cause nuisance or adversely affect the beneficial uses.

Table 3.6-2
Water Quality Objectives for Surface Water and Groundwater as Defined by the Sacramento–San Joaquin Basin Plan (RWQCB 2004)

Water Quality Constituent	Water Quality Objective
Settleable and suspended materials	Waters shall not contain suspended or settleable material in concentrations that cause nuisance or adversely affect the beneficial uses.
Tastes and odors	Water shall not contain taste- or odor-producing substances in concentrations that impart undesirable tastes or odors to domestic or municipal water supplies or to fish flesh or other edible products of aquatic origin, or that cause nuisance, or otherwise affect beneficial uses.
Temperature	The natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the Regional Board that such alteration in temperature does not adversely affect beneficial uses.
Toxicity	All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life. This objective applies regardless of whether the toxicity is caused by a single substance or the interactive effect of multiple substances.
Turbidity	Waters shall be free of changes in turbidity that cause nuisance or adversely affect the beneficial uses. Increases in turbidity attributable to controllable water quality factors shall not exceed the following limits: ▪ Where natural turbidity is between 0 and 5 Nephelometric Turbidity Units (NTU's), increases shall not exceed 1 NTU. ▪ Where natural turbidity is between 5 and 50 NTU's, increases shall not exceed 20 percent. ▪ Where natural turbidity is between 50 and 100 NTU's, increases shall not exceed 10 NTU's. ▪ Where natural turbidity is greater than 100 NTU's, increases shall not exceed 10 percent.
Groundwater	
Bacteria	In ground waters used for domestic or municipal supply the most probable number of coliform organisms over any seven-day period shall be less than 2.2/100 ml.
Chemical constituents	Ground waters shall not contain chemical constituents in concentrations that adversely affect the beneficial uses. At a minimum, groundwaters designated for use as domestic or municipal supply shall not contain concentrations of chemical constituents in excess of the maximum contaminant levels (MCL's) specified in Title 22 of the California Code of Regulations.
Radioactivity	At a minimum, ground waters designated for use as domestic or municipal supply shall not contain concentrations of radionuclides in excess of the maximum contaminant levels specified in Title 22 of the California Code of Regulations.
Tastes and odors	Ground water shall not contain taste- or odor-producing substances in concentrations that cause nuisance or adversely affect beneficial uses.
Toxicity	All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life. This objective applies regardless of whether the toxicity is caused by a single substance or the interactive effect of multiple substances.

Table 3.6-3
Relevant Information about Classes of Organic Contaminants

Organic Chemical	Environmental Source	Effects	Special Information
Organophosphate pesticides (diazinon, malathion, chlorpyifos)	Lawns, golf courses	Neurotoxin, acutely toxic	Very water soluble, persists in water for weeks-months
Pyrethroid pesticides (esfenvalerate, permethrin)	Lawns, golf courses	Neurotoxin, acutely toxic, some cause chronic toxicity (reproductive harm)	Not easily dissolved in water, found in sediment, persists in sediment up to a year
Organochlorine pesticides	Pesticides, many such as DDT, are currently illegal to use	Neurotoxin, but also many other chronic adverse effects	Very insoluble in water, commonly found in sediment, persists for long periods (75 years)
Polycyclic aromatic hydrocarbons (PAHs such as benzo[a]pyrene)	Combustion by-product (gasoline, wood, burning of just about any organic material)	Carcinogen, may cause tumors in fish	Insoluble in water, found in sediment, persists for decades under certain conditions
Dioxins	Combustion by-product involving reaction with chlorine; by-product of synthesis of some herbicides, found in bleached pulp mill effluent, incinerator emissions	Carcinogen, disrupts normal hormone function (endocrine disruptor)	Insoluble in water, persists for long periods of time in sediment if shielded from light
PCBs (polychlorinated biphenyls)	Hydraulic fluid, coolant, insulator, historically used in transformers, current source is manufacturing waste, currently illegal to use	Can interfere with reproduction in aquatic animals	Very insoluble in water, very persistent in sediment
Surfactants (detergents)	Numerous commercial and residential uses; either water via wastewater treatment plants or runoff	Can interfere with reproduction in aquatic animals.	Water soluble, are not persistent
Plasticizers (phthalates)	Commercial uses, makes plastics more pliable; wetting agent; found in wastewater effluent	Reproductive toxicant in fish and invertebrates	Low solubility in water, associated with sediment, persists for less than 1 month in most cases

Note: Table adapted from Shilling et al. 2005

Table 3.6-4
Relevant Information about Major Metal Contaminants

Metal	Environmental Source	Hardness-Dependent	Toxic Effects
Arsenic	Naturally occurring, used in some pesticides and herbicides, wood preservatives	No	Acute toxicity, reproductive toxicant
Lead	Mining, incineration of batteries, pigments	Yes	Acute toxicity, neurotoxicant, impairs reproduction
Mercury	Fungicide, many manufacturing processes; mining	No	Methylmercury form of greatest concern; endocrine disruptor, not acutely toxic
Cadmium	Used in a variety of industrial processes; most common in urban watersheds	Yes	Acute toxicity, a variety of physiological effects with long term exposure, including deformities of young
Copper	Mining, dormant sprays; fungicide used on boats	Yes	High toxicity with acute exposure; interferes with function of gills
Zinc	Mining, electroplating, roads (from worn tires), manufacturing of brass, steel, and iron alloys; dormant sprays	Yes	Acutely toxic; teratogenic with chronic exposures
Chromium	Numerous manufacturing processes, including tanning leather, manufacturing steel, aircraft industry	Hexavalent form not affected by hardness; trivalent form less water soluble, toxicity hardness dependent	Acutely toxic, possible carcinogen

Note: Table adapted from Shilling et al. 2005

3.6.4 Ongoing Discharges in the Stillwater–Churn Creek Watershed Regulated under the NPDES

City of Shasta Lake Wastewater Treatment Plant

The City of Shasta Lake operates a wastewater treatment facility on the upper reach of Churn Creek off Ironhorse Road. The facility was built in 1975 to address numerous septic tank failures in the areas of Central Valley, Summit City, and Mountain Gate. Upgraded in 1996, the treatment plant has an average dry-weather design capacity of 1.3 mgd and a peak design wet weather capacity of 5.2 mgd. It presently treats an average dry weather flow of 0.7 mgd.

A dilution of 10:1 is required for discharge to Churn Creek. Due to the limited dilution available in the creek, the treatment facility has been designed to achieve a relatively high-quality effluent. During the winter season, water is discharged to Churn Creek

only if water levels in the creek are high enough to meet the required 10:1 dilution standard. From late spring through early fall (April 15–October 15) or at any time when the instream dilution rate is less than 10:1, treated effluent is disposed of as reclaimed water on site by spray irrigation or discharged to a 410 acre-foot reservoir, where it is stored for later use. Reclaimed water is used for on-site irrigation, log deck sprinkling at Sierra-Pacific Industries' Shasta Lake mill site, and irrigation of off-site commercial landscaping. Future reclamation uses are proposed.

The City of Shasta Lake is required by its NPDES permit to regularly monitor and submit discharge monitoring reports on the water quality of the treatment plant's effluent and of the receiving water to the Regional Water Quality Control Board to ensure compliance with Basin Plan water quality standards for the Sacramento River and its tributaries, including Churn Creek. No evidence of significant compliance violations was obtained.

The vast majority of [the City of Redding's] storm water drainage is discharged into Churn and Clover creeks.

Tables 3.6-5 and 3.6-6 provide water quality data on treatment plant effluents for two recent years, 2005-2006. These data show that on average the effluent quality is quite high. Figure 3.6-1 shows that current dilution of the effluent is typically well within the dilution ratio compliance limit of 10:1.

City of Redding Stillwater Wastewater Treatment Plant

The City of Redding operates a wastewater treatment facility, the Stillwater Wastewater Treatment Plant, in the assessment area between Clover and Stillwater creeks off Airport Road. The treatment plant has an average dry weather design capacity of 4 million gallons per day and a peak design wet weather capacity of 12 million gallons per day. It presently treats an average dry weather flow of 2.8 million gallons per day. Because the Sacramento River has a large dilution capacity and can accommodate the current effluent flow, all of the effluent from the treatment plant is permitted to be discharged to the river. The discharge location is just upstream of the mainstem Sacramento River's confluence with Stillwater Creek.

The City of Redding is required by its NPDES permit to regularly monitor and submit discharge monitoring reports on the water quality of the treatment plant's effluent and of the receiving water to ensure compliance with Basin Plan water quality standards for the Sacramento River.

City of Redding Storm Water Quality Improvement Plan

Figure 3.5-4 and Table 3.5-5 in Chapter 3.5, "Hydrology, Flooding, and Water Use/Quantity," show the present distribution of the City of Redding's storm drainage system components located in the assessment area. The vast majority of storm water drainage is discharged into Churn and Clover creeks. The new Clover Creek Preserve and floodwater detention facility, located in the upper Clover Creek subbasin, is an integral component of the system.

In January 2003, the City of Redding submitted a draft Storm Water Quality Improvement Plan (SWQIP) and Notice of Intent to participate in the statewide general permit to comply with the requirements of the NPDES Storm Water Phase II Rule for the period 2003–2008. The SWQIP describes an

Table 3.6-5
2005-2006 Monthly Average Water Quality Data for the City of Shasta Lake Wastewater Treatment Plant Effluent at Discharge Point 001

Month	Effluent Dis-charge (MGD)	Chlorine (mg/L)	Suspended Solids (mg/L)	BOD (mg/L)	pH (pH unit)	Total Ammonia (mg/L)	Unionized Ammonia (mg/L)	Temperature (°C)	Turbidity (NTU)
2005									
Jan	1.32	0.01	2.00	3.00	6.50	0.17	0.0002	14.86	1.24
Feb	1.14	0.01	2.25	3.25	6.46	0.10	0.00012	15.20	1.19
Mar	1.27	0.01	2.00	3.00	6.47	0.16	0.0003	15.44	1.24
Apr	1.12	0.01	2.50	3.50	6.42	0.11	0.00017	15.40	1.47
May	–	–	–	–	–	–	–	–	–
Jun	–	–	–	–	–	–	–	–	–
Jul	–	–	–	–	–	–	–	–	–
Aug	–	–	–	–	–	–	–	–	–
Sep	–	–	–	–	–	–	–	–	–
Oct	–	–	–	–	–	–	–	–	–
Nov	0.95	0.01	2.00	3.00	6.24	0.51	0	16.08	1.20
Dec	1.58	0.01	2.00	3.00	6.22	0.21	0.0004	14.68	1.27
2006									
Jan	1.71	0.01	2.00	3.00	6.27	1.17	0.0023	14.32	1.66
Feb	1.34	0.01	2.00	3.00	6.34	0.17	0.00	13.78	1.55
Mar	1.72	0.01	2.20	3.00	6.48	0.19	0.00	13.46	1.43
Apr	1.86	0.01	2.00	3.00	6.42	0.15	0.00	14.25	1.19
May	–	–	–	–	–	–	–	–	–
Jun	–	–	–	–	–	–	–	–	–
Jul	–	–	–	–	–	–	–	–	–
Aug	–	–	–	–	–	–	–	–	–
Sep	–	–	–	–	–	–	–	–	–
Oct	–	–	–	–	–	–	–	–	–
Nov	–	–	–	–	–	–	–	–	–
Dec	1.26	0.01	2.00	3.00	6.31	0.21	0.00	13.70	0.78

Note: mg/L=milligrams per liter; MGD=million gallons per day;
Source: City of Shasta Lake Wastewater Treatment Plant

Table 3.6-6
2005-2006 Monthly Average Water Quality Data for the City of Shasta Lake Wastewater Treatment Plant Effluent at Discharge Point 002

Month	Effluent Discharge (MGD)	Chlorine (mg/L)	pH (pH unit)	NH3-T (mg/L)	NH3 -Un-I (mg/L)	Temperature (°C)	Turbidity (NTU)
2005							
Jan	0.40	0.01	7.90	0.56	0.019	14.6	10.5
Feb	–	–	–	–	–	–	–
Mar	2.87	0.01	6.55	0.79	0.0048	13.40	9.00
Apr	–	–	–	–	–	–	–
May	–	–	–	–	–	–	–
Jun	–	–	–	–	–	–	–
Jul	–	–	–	–	–	–	–
Aug	–	–	–	–	–	–	–
Sep	–	–	–	–	–	–	–
Oct	–	–	–	–	–	–	–
Nov	1.80	0.01	6.54	0.32	0.014	13.78	1.41
Dec	1.32	0.01	6.74	0.47	0.0071	10.08	5.48
2006							
Jan	2.36	0.01	6.46	0.72	0.003	10.53	5.19
Feb	–	–	–	–	–	–	–
Mar	1.37	0.01	6.60	0.32	0.005	11.25	7.90
Apr	2.96	0.01	6.81	0.30	0.0004	13.03	9.18
May	–	–	–	–	–	–	–
Jun	–	–	–	–	–	–	–
Jul	–	–	–	–	–	–	–
Aug	–	–	–	–	–	–	–
Sep	–	–	–	–	–	–	–
Oct	–	–	–	–	–	–	–
Nov	–	–	–	–	–	–	–
Dec	3.20	0.01	6.70	0.21	0.003	11.09	5.11

Note: mg/L=milligrams per liter; MGD=million gallons per day; Discharge 002 enters Churn Creek downstream of discharge point 001 and is used on an as needed basis.
Source: City of Shasta Lake Wastewater Treatment Plant

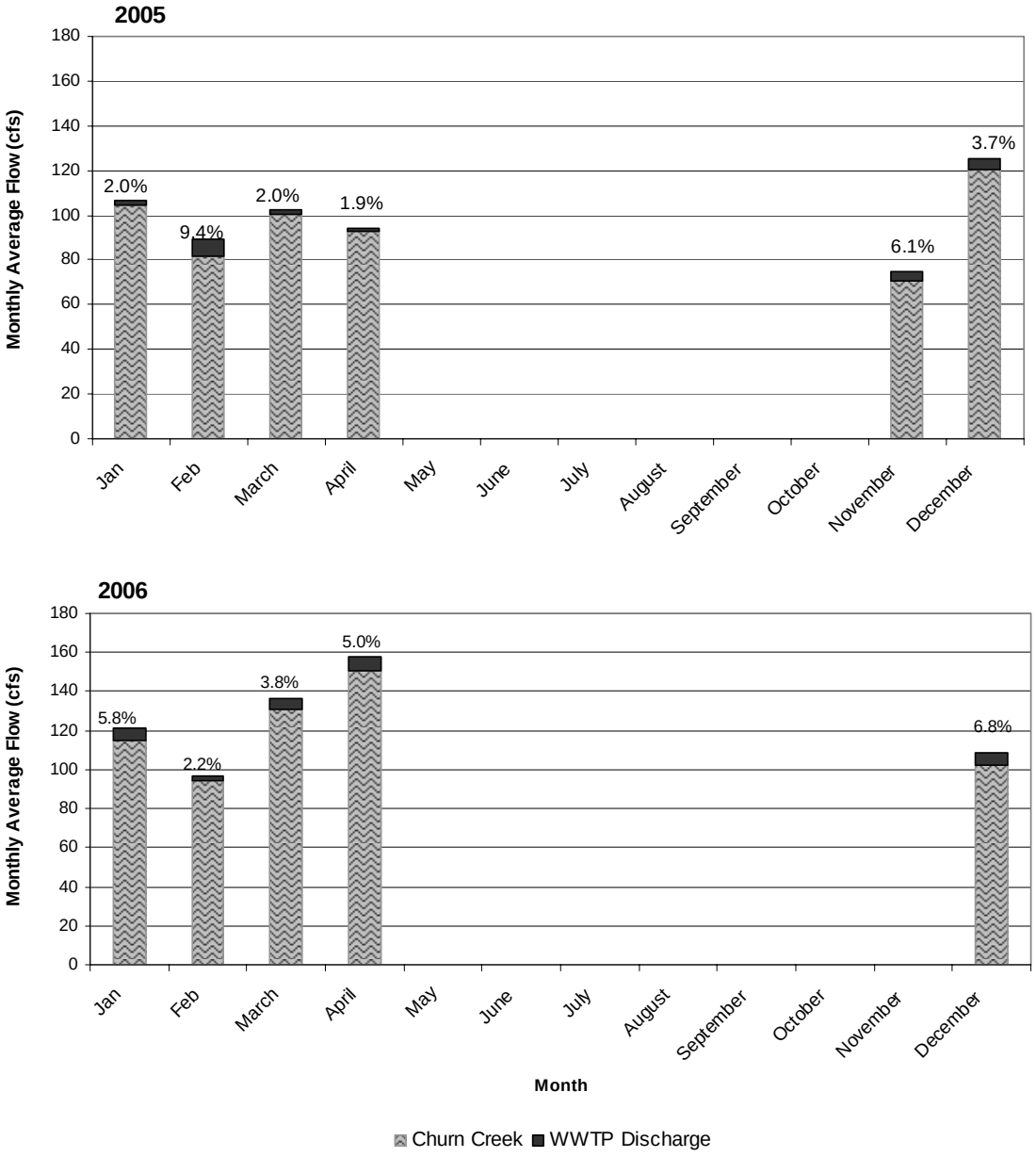

Figure 3.6-1. Monthly average flows for 2005-2006 in Churn Creek (herringbone-patterned bar) and treated wastewater discharges (solid bar) measured at the City of Shasta Lake Wastewater Treatment Plant during months when the plant discharged to Churn Creek. Actual dilution ratio, in percent, is shown above each bar.

evaluation and assessment approach that the City will implement to address problems with the water quality of storm water discharges. The City acknowledges that changes to the approach identified in the SWQIP are likely to occur as technologies improve or regulations change. The Storm Water Phase II Rule offers only general guidance, and the City retains a great deal of flexibility in choosing exactly how to satisfy the minimum control measure requirements.

The SWQIP emphasizes implementation of BMPs for landscape drainage and management of storm water runoff from construction sites to reduce erosion, sediment transport, and pollutants that are considered to significantly affect local surface water and groundwater resources. The statewide general NPDES permit (which the City will comply with through the SWQIP) covers small construction activities permitted by the City that will disturb from 1 to 5 acres of land. The SWQIP incorporates a watershed-based approach to assess and identify sources of high-priority pollutants and implement efficient and cost-effective control measures. Public awareness and citizen participation are encouraged through promotion of an "adopt-a-creek" volunteer stewardship program.

The SWQIP also outlines an effectiveness monitoring and evaluation strategy. The City will be required by the statewide general permit to provide regular reports on program progress in meeting Basin Plan water quality objectives.

Industrial and Construction Site Discharges

NSR searched the EPA's Envirofacts database to determine the number and type of permits under Section 401 of the Clean Water Act that have been issued for the assessment area.

Thirty-eight NPDES permits are active in Shasta County, of which seven permit discharges to the Sacramento River or creeks in the assessment area. Two of these permits were issued to the City of Shasta Lake and the City of Redding for their urban storm water runoff, two are for wastewater treatment facilities described above, and the remainder are for mining operations that discharge to West Fork Stillwater Creek (Table 3.6-7). The dischargers are responsible for monitoring and submitting regular discharge monitoring reports.

Thirty-two CWA Section 401 water quality certification applications for permits in the assessment area submitted since 1997 were on file with the RWQCB. The files showed that 14 water quality certifications had been issued, 12 had been waived, three are pending, two are incomplete, and one has been withdrawn. Although the 14 certifications do not contain specific water quality data, they do provide insight into the number and types of activities going on in the assessment area that may affect water quality. Eight of the water quality certifications were for projects such as the Clover Creek Preserve, Stillwater Plains Mitigation Bank, and Tarmac Wetland Rehabilitation project. Some of the other certifications were also issued for activities whose purpose is to address environmental concerns or preserve wildlife habitat.

The Surface Mining and Reclamation Act (1975) (SMARA) was enacted by the California Legislature to address the need for a continuing supply of mineral resources, and to prevent or minimize the negative impacts of surface mining on public health, property, and the environment, including water quality. Shasta County is responsible for enforcing the SMARA requirements. There are currently five active mining operations in the assessment

Table 3.6-7
Status of Selected National Pollutant Discharge Elimination System Permits in the Stillwater–Churn Creek Watershed

NPDES ID	Facility Name and Address	Facility Information	Drainage	Issue Date	Expiration Date
CA0080799	Bella Vista Water Supply Treatment Plant 700 Canby Road Redding, CA 96003	Water treatment facility	Churn Creek	6/5/1998	6/1/2003
CA0081191	Calaveras Cement Company/Lehigh Southwest 15390 Wonderland Blvd Redding, CA 96003	Crushed rock; Storm water discharge	West Fork Stillwater Creek	4/26/2002	4/1/2007
CA0083097	Fawndale Rock Quarry 15381 Fawndale Road Redding, CA 96003	Dimension stone; storm water discharge	West Fork Stillwater Creek	4/26/2002	4/1/2007
CA0084140	Mountain Gate Limestone Quarry 20285 Radcliff Road Redding, CA 96002	Crushed rock; storm water discharge	West Fork Stillwater Creek	12/6/2002	12/1/2007
CAU000071	City of Redding I-5 and 299 Redding, CA 96003	?	Churn Creek		
CAU000193	Shasta College 11555 Old Oregon Trail Redding, CA 96003	Land application of treated wastewater	Stillwater Creek	?	?
CA0079511	Shasta Lake Wastewater Treatment WGC Ironhorse Road Shasta Lake, CA 96019	Discharge treated wastewater	Churn Creek	9/7/2001	9/1/2006
CA004693	City of Shasta Lake 16349 Lake Blvd Shasta Lake, CA 96001	Storm water discharge	Churn Creek	1/28/2000	1/28/2005
CAU000286	Shasta County Mountain Gate Road Redding, CA 96003	?	?	10/17/2003	10/1/2008
CA0082589	Stillwater Wastewater Treatment Plan 6475 Airport Road Anderson, CA 96007	Discharge treated wastewater	Sacramento River	9/7/2001	9/1/2006

Source: Queried from USEPA Envirofacts Warehouse PCS database on 10/14/2005
? = Original record not recorded.

area: Eagle Crest Mine on Churn Creek near the Redding Airport, Gray Rocks Quarry in the headwaters of West Fork Stillwater Creek, and Faulkenbury Shale Quarry in the Spring Branch of West Fork Stillwater Creek near Mountain Gate, which are managed by the Lehigh Southwest Cement Company; Fawndale Quarry on West Fork Stillwater Creek, which is owned and operated by J.F. Shea Company; and the Mountain Gate Limestone Quarry on West Fork Stillwater Creek, which is owned and operated by the Stimpel-Wielbelhaus Company. Another mining operation, known as the Goat Ranch Quarry, is currently being proposed for the assessment area. This quarry would be located on upper Churn Creek in the vicinity of Little Churn Creek and Rich Gulch. (Walker, pers. comm. 2006).

3.6.5 Nonpoint Source Discharges

The RWQCB oversees the Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands Program, which requires monitoring and reporting of water quality affected by tailwater, operational, and storm water discharges from irrigated agricultural lands. Individual irrigators may obtain their own NPDES permit and monitor and report discharge conditions or they may opt to join a monitoring cooperative to obtain a conditional waiver to this requirement. The Shasta/Tehama Watershed Education Coalition (STWEC) manages discharge monitoring and reporting for many of the agricultural irrigators in western Shasta County. Currently, 20 percent of all streams in Shasta and Tehama counties that receive agricultural discharges from STWEC members are monitored on a rotating annual basis under the oversight of the STWEC Board of Directors, including streams in the assessment area (Swearingen, pers. comm. 2006).

Only a small portion (approximately 1 percent) of the assessment area consists of irrigated agricultural lands. Most of the irrigated agricultural land in the lower reaches of the watershed is concentrated in the Churn Creek Bottom area, which is serviced by ACID with between 175 and 215 agricultural accounts in the assessment area (Wanberg, pers. comm. 2006), and in the middle reach of Stillwater Creek, which is serviced by the BVWD, with nearly 300 agricultural accounts in the assessment area (Coxey pers. comm. 2006). A few irrigators also draft water from local streams for irrigation uses; however, most of the irrigation water is provided by the water districts. A number of irrigators in the assessment area have joined the STWEC and obtained a conditional waiver of the waste discharge requirement (Swearingen, pers. comm. 2006). Irrigators who have not joined the STWEC by December 2006 will be required to obtain an individual waste discharge permit and monitor discharge conditions (State Water Resources Control Board, June 2006 public notice).

3.6.6 General Water Quality Conditions and Identification of At-Risk Water Quality Parameters

Surface Water Quality

The stream flows and surface water quality in the principal streams of the assessment area vary greatly over the course of each year. In general, the stream flows are highly dependent on rainfall, with the streams flowing high during the winter and having little natural flow during the summer. This pattern is characteristic of the upper and lower reaches of the streams in the assessment area, although in some areas, irrigation return water and urban residential runoff contribute water during the summer.

Few data are available to comprehensively assess trends in water quality for the assessment area; however, periodic historical data (U.S. Environmental Protection Agency STORET database; California Department of Water Resources, unpublished data) and a monthly water quality time series for 2004–2005 (California Department of Water Resources, unpublished data) were obtained for Churn Creek and Stillwater Creek, which are summarized in Tables 3.6-8 through 3.6-11. The 2004-2005 data set is the most comprehensive and consistent surface water quality data available for the assessment area (Tables 3.6-8 and 3.6-9). Prior to that time, water quality was assessed intermittently by several agencies and allows for a comparison of general trends in water quality over time (Tables 3.6-10 and 3.6-11). Most of the water samples were collected in the lower reaches of Stillwater and Churn creeks downstream of the City of Redding, although, exceptions to this occurred in Churn Creek for some years as indicated by Table 3.6-10. The monthly patterns of water quality are similar for the two streams and are generally consistent over time and with those reported for other tributaries of the northern Sacramento Valley. Surface water quality is reported to be generally good. The water is classified as neutral to slightly alkaline and hard due to a relatively high content of carbonates of calcium and manganese.

The monthly patterns of water quality were similar for [Stillwater and Churn creeks] and were generally consistent with those reported for other tributaries of the northern Sacramento Valley. Surface water quality is reported to be generally good.

Nutrients and Contaminants

Reported nutrient levels are generally relatively low, but somewhat higher in Churn Creek than in Stillwater Creek. Livestock, pets, and failed septic systems contribute to the levels of fecal bacteria (E. coli) in the waterways. Runoff from impervious surfaces such as roadways, parking lots, and fueling stations increases oil, grease, and fuel in the waterways; these contaminant levels are generally highest in surface runoff during the first autumn rainstorms after long periods of seasonal summertime drought (Environmental Protection Agency 2000). Incidents of nuisance algae growth in Churn Creek were commonly reported in the 1970s and 1980s (Churn Creek Task Force 1991). These occurrences were attributed to wastewater discharges and septic tank leakage in the upper watershed. Historic high nutrient levels were reported for the upper Churn Creek watershed (Table 3.6-10). Current nutrient levels are somewhat lower than reported historic levels, but the degree of improvement since the upgrades to the City of Shasta Lake's Wastewater Treatment Plant were completed in 1996 are not clearly apparent from this data. Reported levels of pesticide residues and industrial chemicals were generally below detection limits, although one instance of the organophosphate Diazinon was detected in Churn Creek at 0.01µg/L in March 2001 (Table 3.6-8).

Suspended Solids and Turbidity

Turbidity and the levels of suspended sediment during winter runoff flows are naturally high for streams in the assessment area. However, notable increases in turbidity and sediment have been observed in recent years and are thought to be associated with development and certain land uses (Churn Creek Task Force 1991). Most recently, increased turbidity levels (including the

Table 3.6-8
Churn Creek Water Quality (Station No. A0-0790.00), October 2004-July 2005

Analyte	Units	No. of Months	Min	Max	Mean	MCL[a] DHS/EPA[b]	CMC[c]	CCC[d]
Dissolved ammonia (NH_3-N)	mg/L	10	0	0.04	–	N/A	N/A	N/A
Total aluminum	µg/L	10	2.7	995.0	180.7	1,000/N/A	750	87
Total arsenic	µg/L	10	0.2	1.1	0.5	50/10	340	150
Total calcium	mg/L	10	10.0	22.0	14.4	N/A	N/A	N/A
Dissolved chloride	mg/L	10	2.0	52.0	13.6	N/A	860	230
Total chromium	µg/L	10	0.7	3.9	1.5	50/100	16[e]	11
Total copper	µg/L	10	0.3	4.6	1.3	1,300 [f]	13	9
Total iron	µg/L	10	29.2	1,311.0	282.9	N/A	N/A	N/A
Total lead	µg/L	10	<R.L.	0.9	0.3	15 [f]	65	2.5
Total manganese	µg/L	10	1.3	47.2	10.8	N/A	N/A	N/A
Total magnesium	mg/L	10	6.0	10.0	7.9	N/A	N/A	N/A
Mercury (total inorganic)	ng/L	10	0.4	10.9	2.08	2,000	1,400	770
Total nickel	µg/L	10	0.4	2.6	0.9	100/N/A	470	52
Water temperature	°C	10	8.1	20.0	14.6	N/A	N/A	N/A
Dissolved oxygen	mg/L	10	6.1	14.6	10.7	N/A	N/A	N/A
pH	pH	10	7.0	7.9	7.3	N/A	N/A	N/A
Conductance	µS/cm	10	123.0	230.0	180.2	N/A	N/A	N/A
Hardness (as $CaCO_3$)	mg/L	10	55.0	96.0	68.6	N/A	N/A	N/A
Total alkalinity (as $CaCO_3$)	mg/L	10	45.0	76.0	64.6	N/A	N/A	N/A
Dissolved nitrite + nitrate	mg/L	10	0.2	1.1	0.6	N/A	N/A	N/A
Dissolved ortho-phosphate (as P)	mg/L	10	<R.L.	0.02	–	N/A	N/A	N/A
Total dissolved solids	mg/L	10	83	186	113.7	N/A	N/A	N/A
Total suspended solids	mg/L	10	<R.L.	44.0	10.8	N/A	N/A	N/A

Source: California Dept. of Water Resources, Northern District Office
Note: All measurements presented in this table based on a single grab sample per month.
mg/L = milligrams per liter; ng/L = nanograms per liter; µg/L = micrograms per liter; µS/cm = microsiemens per centimeter;
R.L. = below detection limit; N/A = not applicable
[a] Maximum allowable contaminant level;
[b] DHS: California Department of Health Services (Marshack 2003)/EPA: U.S. Environmental Protection Agency (EPA 2003);
[c] CMC: Criteria Maximum Concentration (EPA 2006) for protection of aquatic biota;
[d] CCC: Criteria Continuous Concentration (EPA 2006) for protection of aquatic biota;
[e] CMC for Chromium Vi;
[f] Regulatory action level

Table 3.6-9
Stillwater Creek Water Quality (Station No. A0-0795.00), October 2004-July 2005

Analyte	Units	No. of Months	Min	Max	Mean	MCL[a] DHS/EPA[b]	CMC[c]	CCC[d]
Dissolved ammonia (NH_3-N)	mg/L	10	0	0.02	--	N/A	N/A	N/A
Total aluminum	µg/L	10	2.4	2038.0	252.6	1,000/N/A	750	87
Total arsenic	µg/L	10	0.3	0.9	0.5	50/10	340	150
Total calcium	mg/L	10	11.0	23.0	15.8	N/A	N/A	N/A
Dissolved chloride	mg/L	10	5.0	39.0	18.3	N/A	860	230
Total chromium	µg/L	10	0.5	3.3	1.5	50/100	16[e]	11
Total copper	µg/L	10	0.5	6.3	1.3	1,300 [f]	13	9
Total iron	µg/L	10	2.2	3165.0	377.9	N/A	N/A	N/A
Total lead	µg/L	10	<R.L.	1.1	0.2	15 [f]	65	2.5
Total manganese	µg/L	10	1.3	112.0	14.9	N/A	N/A	N/A
Total magnesium	mg/L	10	4.0	8.0	5.5	N/A	N/A	N/A
Mercury (total inorganic)	ng/L	10	0.5	8.3	1.7	2,000	1,400	770
Total nickel	µg/L	10	0.4	3.0	0.8	100/N/A	470	52
Water temperature	°C	10	7.5	25.7	15.5	N/A	N/A	N/A
Dissolved oxygen	mg/L	10	4.9	14.8	11.3	N/A	N/A	N/A
pH	pH	10	7.2	7.9	7.4	N/A	N/A	N/A
Conductance	µS/cm	10	97.0	298.0	179.2	N/A	N/A	N/A
Hardness (as $CaCO_3$)	mg/L	10	44.0	90.0	61.4	N/A	N/A	N/A
Total alkalinity (as $CaCO_3$)	mg/L	10	39.0	66.0	53.9	N/A	N/A	N/A
Dissolved nitrite + nitrate (as N)	mg/L	10	0.01	0.9	0.3	N/A	N/A	N/A
Dissolved ortho-phosphate (as P)	mg/L	10	<R.L.	0.01	--	N/A	N/A	N/A
Total dissolved solids	mg/L	10	64.0	165.0	107.8	N/A	N/A	N/A
Total suspended solids	mg/L	10	<R.L.	103.0	19.5	N/A	N/A	N/A

Source: California Department of Water Resources, Northern District Office
Note: All measurements presented in this table based on a single grab sample per month.
mg/L = milligrams per liter; ng/L = nanograms per liter; µg/L = micrograms per liter; µS/cm = microsiemens per centimeter
R.L. = below detection limit; N/A = not applicable
[a] Maximum allowable contaminant level
[b] DHS: California Department of Health Services (Marshack 2003)/EPA: U.S. Environmental Protection Agency (EPA 2003)
[c] CMC: Criteria Maximum Concentration (EPA 2006) for protection of aquatic biota
[d] CCC: Criteria Continuous Concentration (EPA 2006) for protection of aquatic biota
[e] CMC for Chromium VI
[f] Regulatory action level

Insert Table 3.6-10

Table 3.6-10 Historical Water Quality Data for Churn Creek Station Nos. A0080500, A008100, A0084700, A0-00795.00

Blank back page for 11x17 Table 3.6-10

Insert 11x17 Table 3.6-11

Table 3.6-11 Historical Water Quality Data for Churn Creek Station Nos. A0079500 and A0-0790.00 (at Dersch Road Bridge)

Blank back page for 11x17 Table 3.6-11

duration that turbidity levels are noticeably elevated) are thought to be associated with recent wildland fires, development, and use of off-road vehicles in the Stillwater Creek watershed. Levels of suspended solids appear in the recent data to be higher in Stillwater Creek than in Churn Creek. No estimates for annual sediment loads were reported for either Churn or Stillwater creek; however, large accumulations (up to 3 feet thick) of fine sediment have been readily apparent in recent years at the mouth of Stillwater Creek, where it enters the Sacramento River (Marine, North State Resources, Inc., unpublished data, 2006).

Temperature

Water temperature patterns are similar for most tributaries in the assessment area and are highly influenced by ambient air temperatures throughout most of their reaches. The limited grab sample temperature records for Stillwater and Churn creeks indicate that water temperatures generally support coldwater fish habitat during the winter–spring season when the streams are flowing. Summer temperatures during the lowest, subsiding flows prior to channel dry-out were reported up to 20°C (68°F) in Churn Creek and 26°C (79°F) in Stillwater Creek. Late-spring and summer water temperatures may be higher in the lower reaches of Stillwater Creek because the channel is broader and therefore receives more sun exposure and, consequently, heating.

Groundwater Quality

Groundwater is an important source of water for municipal and agricultural uses in the assessment area. Although groundwater may seem protected from surface pollutants and contamination, it certainly is not. Recharge areas are areas where surface water infiltrates and percolates through soil and rock layers into an aquifer. Pollutants or contaminants can enter aquifers along with percolating surface water and potentially contaminate an otherwise clean source of water. The key to protecting groundwater quality is prevention. Land uses must employ BMPs to prevent contamination of surface water and soil in important groundwater recharge areas.

There has been more monitoring of the water quality of groundwater in the watershed than of surface water. Currently, DWR, the California Department of Health Services (DHS), irrigation districts, and municipalities all conduct some form of groundwater quality monitoring. In 2003, DWR published an updated Bulletin 118 on California's Groundwater, which includes summaries for individual subbasins within the Redding Groundwater Basin from 1994 to 2000, as required under DHS Title 22. These water quality results are summarized in Table 3.6-12.

The City of Redding also conducts routine water quality monitoring on its 14 municipal wells. These results are published annually in its Consumer Confidence Report. Currently, groundwater quality in the Redding sub-basin is of excellent quality, with some natural impairments (Table 3.6-13). These impairments include high levels of dissolved salts and chlorides (Lower Tuscan and Tehama formations) and localized areas with high iron, manganese, and nitrate.

Table 3.6-12
Water Quality in Public Supply Wells for Millville, Enterprise, and Anderson Groundwater Subbasins

Constituent Group	Number of Wells Sampled[1]	Number of Wells with a Concentration Above an MCL[2]
Inorganics – primary [3]	38	0
Radiological	52	0
Nitrates	38	0
Pesticides	21	0
VOCs and SVOCs [4]	32	0
Inorganics – secondary[5]	38	8

(Source: Groundwater Bulletin 118 (DWR 2003)

[1] Represents distinct number of wells sampled as required under DHS Title 22 program from 1994 to 2000

[2] Maximum Contamination Level. Each well reported with a concentration above an MCL was confirmed with a second detection above an MCL. It does not indicate the water quality delivered to the customer.

[3] Primary inorganics include aluminum, antimony, arsenic, asbestos, barium, beryllium, cadmium, chromium, cyanide, fluoride, mercury, nickel, nitrate, nitrate + nitrite, nitrite, selenium, thallium.

[4] VOCs are Volatile Organic Compounds (hydrocarbon-based compounds) and SVOCs are Semi-volatile Organic Compounds (often times pesticides).

[5] Secondary inorganics include aluminum (also a primary), copper, silver, iron, manganese, zinc, thiobencarb, foaming agents (MBAS), turbidity, color, odor, corrosivity, total dissolved solids or specific conductance, chloride, sulfate.

Table 3.6-13
Groundwater Quality in the Stillwater–Churn Creek Watershed (Enterprise Groundwater Basin)

Contaminant	Maximum Allowable Contaminant Level	Sample Date	Groundwater Analysis		Possible Sources of Detected Contamination in Drinking Water
			Highest Detected	Range Detected	
Primary Standards: Mandatory health-related standards established by the California Department of Health Services, Division of Drinking Water, and the U.S. Environmental Protection Agency					
Microbiological					
Total coliform bacteria	>5% of samples	Monthly	N/A	N/A	Naturally present in the environment
Turbidity (NTU)	TT=5 NTU	Daily	0.59	0.03-59	Soil runoff
Radioactive					
Cross alpha (pCi/L.)	15	Quarterly	ND	ND	Naturally present in the environment
Inorganic					
Aluminum (ppb)	1000	Dec 97/ Apr 99	ND	ND	Erosion of natural deposits; residue from some surface water treatment processes
Arsenic (ppb)	50	2004/2005	19	ND-19	Erosion of natural deposits, residue from glass and electronics production waste
Barium (ug/L)	N/A	2004/2005	192	ND-192	Erosion of natural deposits, discharges of oil drilling wastes from metal refineries
Chromium (ug/L)	N/A	2004/2005			Erosion of natural deposits, discharges from pulp mills and chrome plating
Fluoride (ppm)	1	2004/2005	0.15	ND-0.15	Erosion of natural deposits, water additive which promotes strong teeth; discharge from fertilizer and aluminum factories
Nitrate (N03) (ppm)	45	2002	14.8	1.37-14.8	Erosion of natural deposits, runoff from fertilizer use, leaching from septic tanks, and sewage
Nickel (ppb)	100	2004/2005	5	ND-5	Erosion of natural deposits, discharge from metal

Table 3.6-13
Groundwater Quality in the Stillwater–Churn Creek Watershed (Enterprise Groundwater Basin)

Contaminant	Maximum Allowable Contaminant Level	Sample Date	Groundwater Analysis		Possible Sources of Detected Contamination in Drinking Water
			Highest Detected	Range Detected	
Copper (ppm) 0 sites above AL out of 60 samples	AL-1.3	1992	ND	ND	Erosion of natural deposits, corrosion of household plumbing systems, leaching from wood preservatives
Lead (ppb) 0 sites above AL out of 60 samples	AL-15	1992	ND	ND	Erosion of natural deposits, corrosion of household plumbing systems
Volatile Organic					
Haloacetic Acid (HAA5) (ppb)	60	Quarterly	N/A	N/A	By-product of drinking water chlorination
Total Trihalomethanes (TTHMs) (ppb)	100	Quarterly	N/A	N/A	By-product of drinking water chlorination
Secondary Standards: Aesthetic standards established by the California Department of Health Service, Division of Drinking Water					
Inorganic					
Hardness (mg/l)	N/A	2004/2005	152	39-152	Found in ground and surface water
Iron (ppb)	300	2004/2005	104	ND-104	Erosion of natural deposits
Manganese (ppb)	50	2004/2005	71	6/71	Erosion of natural deposits
Sodium (mg/l)	N/A	2004/2005	91	ND-91	Found in ground and surface water
Unregulated					
Inorganic					
Boron (ppb)	AL=1000	2004/2005	415	ND-415	Erosion of natural deposits

Source: Adapted from City of Redding Water Quality Report for Municipal Wells, M. Siebert, pers. comm.

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3.7 Land Use and Demographics

This section examines current land use patterns in the watershed assessment area and the policies that guide them. Public policy decisions affecting land use have perhaps the greatest effect on current and future beneficial uses of the assessment area, including water quality, recreational opportunities, wildlife habitats, and fisheries.

Public policy decisions affecting land use have perhaps the greatest effect on current and future beneficial uses of the assessment area.

Agencies and other entities have management authority over lands in the assessment area, either because they own the land or have been designated to manage it. These include Shasta County, the incorporated cities of Redding and Shasta Lake, the U.S. Bureau of Land Management (BLM), the USFS, and The U.S. Bureau of Reclamation (Reclamation). Decisions made by these parties not only affect the ecological health and integrity of the assessment area, but they also influence public perceptions and values that will determine the prioritization of resource conservation measures. As populations grow and development pressures increase, these decisions will become increasingly difficult.

The following primary data sources were used for this section of the watershed assessment:

- City of Redding General Plan, 2000
- City of Redding Zoning Ordinance (amended 2005)
- Shasta County General Plan, 1998 (amended 2004)
- Shasta County Zoning Plan (as amended through July 2003)
- City of Shasta Lake General Plan, 1999
- City of Shasta Lake Zoning Plan
- USFS STNF Land and Resource Management Plan (LRMP), 1995
- BLM, Redding Resource Management Plan (RMP) and Record of Decision, 1993
- Oasis Road Specific Plan, 2006

3.7.1 Land Use Designations, Plans, and Policies

Land use designations, plans, and policies will determine how lands in the assessment area will be used in the future; they therefore have the potential to significantly influence the beneficial uses of the watersheds in the assessment area. Entities involved in these planning decisions include the Shasta County Department of Resources Management–Planning Division, the City of Redding Development Services Department–Planning Division, and the City of Shasta Lake Development Services Department.

General Plans

Under California law, all cities and counties must prepare a general plan. A general plan is a legal document that serves as a kind of "constitution" for land use and development activities within the particular government's jurisdiction. It primarily addresses the use of the privately and publicly owned land resources located within the government's jurisdiction, for example the County of Shasta or the City of Redding.

A county-level general plan is not a detailed, parcel-specific policy statement; rather, it establishes a generalized pattern of future land use that provides the basis for more detailed, local plans. In contrast, a city-level general plan is a long-range document intended to guide the future physical development of the city. These plans are

organized into seven mandatory elements: land use, circulation, housing, conservation, open space, noise, and safety. Within each of the elements, the general plans have three primary components: baseline condition and issues; goals and policies; and plan maps.

Shasta County General Plan

The planning boundaries of the Shasta County General Plan primarily encompass the eastern half of the assessment area, as well as smaller areas to the northwest and southwest (Figure 3.7-1, Land Use). This plan was most recently amended in September 2004 and will guide land use planning through 2025 (County of Shasta 2004). The Community Organization and Development Pattern element of the Shasta County General Plan establishes policies related to the organization and relationships of the community types present in Shasta County; the living environments they offer; and the locations of development in relation to these communities. These policies were developed in order to maintain and enhance the quality of their environments. This element includes several objectives that influence land use decisions in the assessment area:

- To promote a development pattern which will accommodate, consistent with the other objectives of the Plan, the growth that will be experienced by Shasta County.
- To guide development in a pattern that will provide opportunities for present and future County residents to enjoy the variety of living environments which currently exist within the County.
- To guide development in a pattern that will respect the natural resource values of County lands and their contributions to the County's economic base.
- To guide development in a pattern that will minimize land use conflicts between adjacent land users.
- To recognize that the major economic resources for achieving the development pattern will come from the private sector, rather than government, and that the General Plan, as the expression of community values, will guide the use of these resources.

City of Redding General Plan

The planning boundaries of the City of Redding General Plan encompass most of the west-central portion of the assessment area (Figure 3.7-1). This plan was adopted by the City in 2000 and is intended to guide land use planning within the City through the year 2020 (City of Redding 2000). The Community Development and Design Element of the general plan states the following about the role and effects of land use policies:

> *Land use policies and the General Plan Diagram affect every property in the City. They determine how people can use/develop their land and what they can reasonably expect to develop next door, down the street, or across town. They provide for overall consistency and compatibility between land uses and can be a determining factor in quality of life. The policies…also have a direct bearing on traffic, the feasibility of public transportation, and the quality of the air.*

City of Shasta Lake General Plan

The planning boundaries of the City of Shasta Lake General Plan are within the northwestern portion of the assessment area (Figure 3.7-1). This general plan was adopted in 1999 and is intended to guide land use planning within the city through the year 2020 (Diaz Associates 1999). The following statement from the Land Use element of the general plan identifies some of the concerns surrounding

land use decisions within the City of Shasta Lake:

> *The Land Use Element and the Land Use and Circulation Map constitute the physical framework for the general plan, which designates the proposed location, distribution, and extent of land uses… Land use was a specific area of concern identified as being key to the development of the City of Shasta Lake. Some of the major issues identified included an evaluation and establishment of urban, rural, and urban reserve boundaries. This was accomplished by identifying areas that currently lack infrastructure that would be required to develop in an orderly manner through the development of Area Plans.*

Zoning Plans

Zoning plans are local ordinances specifically intended to implement a general plan. The zoning plans, together with zoning maps, set forth parcel-specific requirements for how lands may be used in the present and near future. They include specific listings of the types of land uses allowed in each zoning district as well as detailed development requirements, such as building heights and setbacks from property lines. Additional goals of zoning plans include the promotion and protection of the public health, safety, peace, morals, comfort, convenience and general welfare; and protection of the social and economic stability of residential, commercial, industrial, resource production, and recreational activities within the county through the orderly, planned use of the land (Shasta County as amended July 2003). Land use within the assessment area is under the jurisdiction of Shasta County and the cities of Redding and Shasta Lake. Land uses classified by each of these entities are discussed in Section 3.7.4.

Federal Management Plans

The assessment area includes lands owned and managed by the BLM, Reclamation, and the USFS (Figure 3.7-2, Land Ownership.) Use of these lands is not subject to local general plans or zoning ordinances, but is instead governed by federal land use policies. These policies tend to be more limited in scope since they do not involve private lands, and they are generally restricted to activities directly related to the agency's public mandate and authority.

Bureau of Land Management — Redding Resource Management Plan

BLM's Redding Resource Management Plan (RMP) (BLM 1993) governs land use on 2,283 acres of land within the assessment area; these lands occur in scattered parcels at the northern edge of the assessment area (Figure 3.7-2). Planning issues addressed in the RMP include land tenure adjustments, such as land acquisition, exchange, and sale; recreation management; access; and forest management, including harvesting, herbicide use, and special-status species. The RMP provides plan-wide guidance on the management of cultural resources, fire, grazing, minerals, vegetation, water quality, wildlife and fish habitats, and other resources and issues. The plan proposes development of a greenway between Shasta Dam and Redding, protection of deer winter range, maintenance of water quality, development of mineral resources, maintenance of forest products supply, and protection of special-status species for the portions of the assessment area that fall within the area covered by RMP.

Shasta-Trinity National Forest Land and Resources Management Plan

The STNF LRMP governs land use on 1,106 acres of land within the assessment area (USDA Forest Service 1995); these lands occur in scattered parcels at the northernmost edge of the assessment area and are managed in accordance with guidelines for the Shasta Unit Management Area 8 (Figure 3.7-2). The LRMP guides management on the STNF. It integrates a mix of management activities that allow use and protection of forest resources, meet the needs of guiding legislation, and address local, regional, and national issues. The LRMP individually addresses the management of each natural resource on the National Forest, including water, riparian areas, timber, minerals, fisheries, wildlife, fire, and heritage resources. The Shasta Unit is managed to ensure that the use of renewable resources is compatible with public recreation or other values contributing to public enjoyment. Vegetation is managed to maintain healthy forest stands, wildlife habitat, good scenic quality, and public health and safety, and to reduce fire hazards (USDA Forest Service 1995). Fish habitat is managed to enhance inland coldwater and warmwater fisheries for sport fishing and a wildlife prey base (USDA Forest Service 1995). Management of threatened, endangered, and sensitive species focuses on protecting, enhancing, and restoring their habitat.

Per capita income for the Central Valley as a whole is among the lowest in the country and consistently lags behind the rest of California. However, Shasta County tends to have a higher per capita income than the other northern Central Valley counties.

Bureau of Reclamation

Reclamation owns and manages 54 acres of land within the assessment area. This land is located off Shasta Dam Boulevard (State Route 151) and is currently set aside as an easement associated with operation of Shasta Dam (Hobbs, pers. comm. 2006.) (See Figure 3.7-2).

3.7.2 Regional Demographics and Land Use Patterns

The following section describes the regional demographics and land uses at a county-wide level to allow for comparison with the assessment area data described in Section 3.7.3, "Assessment Area Demographics and Land Use Patterns."

Economics

Per capita income is the average annual income per individual in a given area and is often used as an approximate indicator of a region's economic health. It is also a way to measure a community's standard of living. Regions with a higher per capita income tend to have more educational, recreational, and entertainment opportunities. However, using per capita income alone as an economic indicator can be misleading as lower-income areas often have a lower cost of living (Great Valley Center 2005).

Per capita income for the Central Valley as a whole is among the lowest in the country and consistently lags behind the rest of California (Great Valley Center 2005). However, Shasta County tends to have a higher per capita income than the other northern Central Valley counties, Tehama, Glenn, Butte, and Colusa. In 2002, the average per capita income in Shasta County was $25,500 to $27,700; in Butte and Colusa counties, it was $22,500 to $24,500; and in Glenn and Tehama counties,

it was $20,500 to $21,500 (Great Valley Center 2005).

Several indicators suggest that Redding is economically similar to the rest of Shasta County (Table 3.7-1). Per capita income in 2000 was slightly higher in Redding than in the rest of the county, although median household income was similar. Measures of poverty, consisting of the number of individuals and families with incomes below the poverty level, were also similar. Shasta County has 15.4 percent of individuals and 11.3 percent of families that fall below the poverty line compared with 15.6 percent of individuals and 11.3 percent of families in the City of Redding (U.S. Census Bureau 2000).

The City of Shasta Lake lags behind the rest of the county economically, with lower average per capita income and lower median household income. The City of Shasta Lake also has a greater proportion of individuals and families with incomes below the poverty level than the rest of Shasta County. Some of this disparity in income may be the result of educational levels attained (U.S. Census Bureau 2000). Redding tends to have a more educated population than the county as a whole, with a greater proportion of the population having attained a bachelor's degree or higher. The proportion of individuals with a high school degree or higher tends to be lower in the City of Shasta Lake than in the county as a whole.

Demographics

The population of the Central Valley is growing rapidly. From 1990 to 1999, the Central Valley's population increased faster than that of any other California region. The Central Valley's population is predicted to grow by another 24 percent between 2000 and 2010, which is substantially faster than the 15 percent growth predicted for the state as a whole (Great Valley Center 2005). Such a growth rate will increase pressures on traffic circulation, schools, and many other public services. Projected growth rates in the Central Valley vary by subregion, with the lowest growth predicted for the northern portion of the valley (14 percent) and the greatest predicted for the northern San Joaquin Valley (29 percent) (Great Valley Center 2005).

More than half of the Central Valley's population growth is from migration, a majority of which is from California's coastal regions. Population growth of Shasta County between 1990 and 1999 was greater than that of the surrounding counties and is predicted to continue to be high. It is expected that from 1990 to 2010, the population of Shasta County will have increased by 32 to 44 percent (Great Valley Center 2005). In contrast, the populations of the nearby Central Valley counties of Glenn, Butte, and Tehama are expected to have increased by only 18 to 31 percent during this period. Much of this growth will be the result of continued migration from coastal areas of the state (Great Valley Center 2005).

In general, Shasta County is not ethnically diverse, although a number of ethnicities are represented. The population is nearly 90 percent white; the next largest ethnic group is Hispanics and Latinos, who make up just 5 percent of the population (Table 3.7-2). Redding and the City of Shasta Lake are both slightly more ethnically diverse than Shasta County as a whole. African Americans and Asians are better represented in Redding, while the City of Shasta Lake has a greater proportion of individuals of Hispanic/Latino and American Indian descent.

Table 3.7-1
Census 2000 Economic Characteristics of the Watershed Assessment Area

Economic Indicator	Shasta County	City of Redding	City of Shasta Lake
Income			
Per capita income	$17,738	$18,207	$13,678
Median household income	$34,335	$34,194	$26,275
Individuals below poverty level	24,556 (11.3%)	12,307 (11.3%)	1,804 (12.4%)
Families below poverty level	5,006 (15.4%)	2,400 (15.6%)	396 (16.5%)
Education			
High school graduate or higher	83.3%	85.2%	76.1%
Bachelor's degree or higher	16.6%	19.4%	6.8%

Source: U.S. Census Bureau 2000

Table 3.7-2
Census 2000 Demographic Characteristics of the Watershed Assessment Area

Demographic Indicator	Shasta County	City of Redding	City of Shasta Lake
Age			
Median age	38.9	36.7	36.5
65 years and over	15.2%	15.5%	13.1%
Race and Ethnicity			
White	89.3%	88.7%	87.8%
Black or African-American	0.8%	1.1%	0.7%
Hispanic or Latino	5.5%	5.4%	6.2%
American Indian and Alaska Native	2.8%	2.2%	4.4%
Asian	1.9%	3.0%	0.4%
Native Hawaiian/Pacific Islander	0.1%	0.1%	0.1%
Some other race	1.7%	1.6%	2.0%

Source: U.S. Census Bureau 2000

Although the median age in Shasta County tends to be young, there is some indication that the demographics of the area are shifting toward an increasingly older population. According to a recent 2-year study that focused on aging issues in the northern part of the state, multiple factors are creating this shift, including the exporting of youth from rural North State communities; the inability of college and university graduates to return home after graduation; the aging-in-place of North State residents; an increasing life expectancy; and smaller family size (Center for Economic Development 2005a). It is also due in part to an influx of retirees, who are choosing to take advantage of the region's natural beauty, affordability, rural atmosphere, and quality of life (Center for Economic Development 2005b).

Regional Land Use Patterns

This section describes the major land uses in the region (e.g., Shasta County as a whole). Land uses within the watershed assessment area are discussed in Section 3.7.3. The major land use classifications discussed are:

- agriculture
- timber
- public lands
- residential
- mining
- parks and open space

Shasta County encompasses nearly 2.5 million acres of land and is one of the largest counties in the northern Central Valley. With a population of approximately 175,700 and just three incorporated areas, the county is almost entirely rural. Therefore, agriculture, timber, public lands, and mining are all important components of Shasta County.

Agriculture

Agriculture is not a dominant industry in Shasta County, but it does account for an important segment of the County's economic base. The County's total land area in farms was 333,828 acres in 2002 (USDA 2002), and the total market value of farm products was $64,204,000 (County of Shasta 2005). Field crops and livestock sales each accounted for nearly one-third of this total. Other significant agricultural commodities include nursery stock, particularly strawberry nursery stock, apiary products, orchard crops, and livestock products (County of Shasta 2004).

In Shasta County, the number of farms has been slowly increasing and the average farm size has been decreasing since 1987.

Cattle production is the single most valuable agricultural commodity produced in Shasta County, valued at nearly $23 million. The cattle graze on over 350,000 acres located throughout the county.

The top harvested crops include hay, alfalfa hay, wild rice, and mint. Hay is the largest crop produced in Shasta County, with an average of 42,932 tons each year since 1995. Also worth noting is the county's production of queen bees, which accounted for over 33 percent of queen bees in the state in 2003 (Center for Economic Development 2005a). In Shasta County, the number of farms has been slowly increasing and the average farm size has been decreasing since 1987 (County of Shasta 2004).

The California Land Conservation Act of 1965, commonly referred to as the Williamson Act, enables local governments to enter into

contracts with private landowners for the purpose of restricting specific parcels of land to agricultural or related open space use. In return, landowners receive property tax assessments that are much lower than normal because they are based on farming and open space uses as opposed to full market value. Local governments receive an annual subvention (subsidy) of foregone property tax revenues from the state via the Open Space Subvention Act of 1971. In the 2003 tax year, Shasta County enrolled a total of 172,819 acres in Williamson Act contracts. Figure 3.7-3 depicts where Williamson Act contracts are located within the watershed assessment area.

Timber

One of Shasta County's most valuable resources is its timberland. In 2002, Shasta County was the third ranking timber county in the state. Shasta County land dedicated to commercial forest management provides not only building materials, energy for industrial processes, firewood, County revenue for roads and schools, and employment opportunities, but also wildlife habitat, recreational opportunities, aesthetic enjoyment, and protection of watershed functions (County of Shasta 2004). Maintaining timber operations and preserving valuable timberlands are important to the economic base and the natural resource values of Shasta County. Of the County's total acreage, 50.7 percent (approximately 1,231,000 acres) is dedicated to commercial forest uses (County of Shasta 2004). In 2002, 613,495 acres of non-federally owned timberlands were in designated timber preserve zones, pursuant to California's Forest Taxation Reform Act of 1976; these lands represent nearly half of the County's timberlands and approximately 87 percent of privately owned timberlands (County of Shasta 2004). No major timber harvest plans were identified within the assessment area.

Public Lands

Approximately 59 percent of the land in Shasta County and almost 96 percent of the land in the assessment is privately owned. The 41 percent of the Shasta County land that is publicly owned is managed by five federal and state entities: BLM, Reclamation, the National Park Service (NPS), USFS, and the State of California. In the assessment area, a much smaller percentage, 4 percent, is publicly owned; this land is managed by three federal agencies: BLM, Reclamation, and USFS. Additional public lands within the county are administered by the Bureau of Indian Affairs (BIA), and other federal and local public agencies. Public lands are an important resource in Shasta County. They draw economic income from recreation and tourism and also provide residents with important opportunities for relaxation and exercise.

A breakdown of ownership acreages for Shasta County as a whole and for the assessment area is provided in Table 3.7-3.

Within the assessment area, BLM, Reclamation, and USFS each own and manage lands, primarily at the northern limits of the assessment area (Figure 3.7-2). BLM also owns land adjacent to the Sacramento River near the southwestern boundary of the assessment area.

Table 3.7-3
Land Management/Ownership in Shasta County and the Stillwater–Churn Creek Watershed Assessment Area

Ownership/Management	Shasta County Acres (%)	Assessment Area Acres (%)
Unclassified (private and Bureau of Indian Affairs)	1,448,340 (59%)	74,292 (95.6%)
U.S. Forest Service	732,431 (30%)	1,106 (1.4 %)
Bureau of Land Management	126,971 (5%)	2,283 (2.9%)
National Park Service	109,170 (4%)	0 (0%)
State of California	26,087 (1%)	0 (0%)
Bureau of Reclamation	20,220 (1%)	54 (0.1%)

Residential

Shasta County is one of the largest and most populous counties in the northern Sacramento Valley. Its population in 2004 was 175,700 (Center for Economic Development 2005a). The area is currently experiencing rapid growth as a result of the high quality of life it offers, including national forests, mountain ranges, and residential areas relatively free from the major crime and traffic that plague major urban areas (County of Shasta 2004).

The area is currently experiencing rapid growth as a result of the high quality of life it offers, including national forests, mountain ranges, and residential areas relatively free from the major crime and traffic that plague major urban areas.

Within Shasta County, the total number of housing units increased by 1.9 percent in 2004, with a majority of this growth attributed to development of single-family housing units. Shasta County is largely rural, and approximately 40 percent of single-family housing units are outside city limits. The largest urban area in the county is the City of Redding, which had 36,017 total housing units in 2004, an increase of 1.6 percent from 2003 (Center for Economic Development 2005). The second largest urban area is the City of Shasta Lake, which had 4,100 housing units in 2004, an increase of 2.0 percent from 2003 (Center for Economic Development 2005). The three incorporated towns in Shasta County, the cities of Redding, Shasta Lake, and Anderson, are all located within the Central Valley portion of the county.

Mining

Although mining, particularly for gold, was a more significant land use in the past, industrial mining is still important to the economy of Shasta County. At present, there are six different mineral resources under production in the county. They include the five mineral resources described in the Mineral Land Classification Study[1] report for Shasta County prepared in 1997 by the California

[1] The Shasta County General Plan refers to the Mineral Land Classification of Alluvial Sand and Gravel, Crushed Stone, Volcanic Cinders, Limestone, and Diatomite within Shasta County, California, prepared in 1997 by the California Department of Conservation – Division of Mines and Geology, as the Mineral Land Classification Study.

Department of Conservation – Division of Mines and Geology: alluvial sand and gravel, crushed stone, volcanic cinders, limestone, and diatomite. The other mineral resource currently being produced is gold (County of Shasta 2004). In 2002, the latest year for which production information is available, Shasta County produced 462,000 tons of sand and gravel, 852,000 tons of crushed stone (including limestone used for construction), and 51,000 tons of volcanic cinders (County of Shasta 2004). These resources are used within the county for construction activities and road construction.

Parks and Open Space

Parks and open space areas provide a means for safe recreation and other activities, and serve to improve community health on many levels. Open space designations encompass the floodplains of local waterways and areas of 20 percent or greater in slope, while "Park" designations encompass established recreational facilities. These spaces increase the physical and emotional health of the community members by encouraging physical activity (City of Redding 2004). They also create a stronger sense of community among individuals and neighborhoods through involvement in community-based activities, such as outdoor concerts, sporting events, and fairs.

As discussed above under "Public Lands," there is an extensive amount of publicly owned land in Shasta County. Most these lands are managed by BLM, USFS, and Reclamation and allow for multiple recreational uses by the public. Key public lands within the county include the Shasta-Trinity National Forest, Whiskeytown-Shasta-Trinity National Recreation Area, Lassen National Park, Lassen National Forest, BLM holdings, McArthur-Burney Falls Memorial Park, Castle Crags State Park, Ahjumawi Lava Springs State Park, and Shasta Historic Park. County parks and recreational facilities include Balls Ferry, Battle Creek, and Lake Britton fishing accesses, French Gulch Park, and Hat Creek Park.

The City of Redding 2004 Parks, Trails, and Open Space Master Plan (City of Redding 2004) covers an 83-square-mile planning area that includes most of the southern portion of the assessment area and details the recreational opportunities in the area.

Parks

The City's overall planning area has 83 developed and undeveloped parks sites totaling approximately 985 acres. Because these parks are not evenly distributed throughout the planning area, there are many residents without ready access to these areas. The current city-wide ratio of improved parkland is 6.78 acres per thousand people, which is below the 10-acre goal adopted in the 2000 General Plan (Recreation Element, Goal R-4). The City's most populous region, the southwest region, has the lowest service level, with only 5.2 acres of developed parkland per thousand people. Parks within the planning area range from neighborhood parks smaller than 5 acres to regional parks that are generally larger than 50 acres. The planning area also includes natural area parks that balance recreation opportunities and natural resource protection. Larger parks include the Turtle Bay Exploration Park and Museum along the Sacramento River, which includes a visitor's center, museum, and arboretum; and the Martin Luther King, Jr. Center, which includes a 3-acre park and the Shasta County Multi-Cultural Center, and hosts after-school tutoring and group recreation activities.

Trails and Bikeways

Trails and bikeways in the planning area seek to link neighborhoods with major destinations, such as shopping areas, schools, and parks. Currently, there are over 31 miles of trails and 73 miles of bikeways within the City's planning area. These include the 10-mile-long Sacramento River Trail, which follows the Sacramento River through the center of Redding and passes through lush riparian habitat. The Pacific Crest Trail, which extends 2,600 miles from Canada to Mexico, covers 154 miles through Shasta County, approximately two-thirds of which is on USFS land, with the remainder on private land.

Open Space

Currently, the City's planning area has 8,000 acres designated as Greenway, although much of this is privately owned and inaccessible to the public. Approximately 1,500 acres are publicly owned open space land, much within the floodplain of the Sacramento River and a dozen tributaries. [Acreage in the floodplain is eligible for the Community Rating System (CRS) Program under FEMA. CRS is a voluntary incentive program encouraging community floodplain management in exchange for discounted flood insurance premium rates.] Additional open space areas are composed of steep terrain with slopes of 20 percent or greater.

Like Shasta County, the assessment area is not ethnically diverse, although Redding and the City of Shasta Lake have slightly more ethnic diversity than the county as a whole. Also like Shasta County, the assessment area appears to be trending toward an increasingly older population.

3.7.3 Assessment Area Demographics and Land Use Patterns

Demographics

There are 19 census tracts and 52 census block groups in the assessment area. By comparing population distribution from the U.S. Census to allowable growth areas under the various general plans, areas that are trending toward increased development in the future can be identified. The highest population densities are located in the City of Redding in the west-central portion of the assessment area. The City of Shasta Lake, at the northwest boundary of the assessment area, also supports higher population densities.

The population of the assessment area has steadily risen since the first census was taken in 1850. For example, from 1960 to 2000, Shasta County's overall population nearly tripled. It is expected that from 1990 to 2010, the population in Shasta County will have increased by 32 to 44 percent (Great Valley Center 2005). The City of Redding and City of Shasta Lake have experienced the greatest growth and are expected to continue to trend in that direction.

Like Shasta County, the assessment area is not ethnically diverse, although Redding and the City of Shasta Lake have slightly more ethnic diversity than the county as a whole. Also like Shasta County, the assessment area appears to be trending toward an increasingly older population.

Although it is possible to make some general conclusions concerning the demographic characteristics of the assessment area, it is not possible to make specific comparisons or determine trends in census data over a long time frame because census boundaries do not

correspond to the assessment area boundaries. In addition, census tracts and block boundaries vary for each census, typically increasing in size as population density decreases.

Land Use Patterns in the Assessment Area

Within the assessment area, there are 10 broad categories of land use: agriculture, commercial, federal lands, industrial, mineral resources, park, public facilities, residential–low density (less than 2 units per acre), residential–medium density (between 2 and 6 units per acre), and residential–high density (more than 6 units per acre) (Figure 3.7-1). The specific General Plan land use designations associated with each of these broad land use categories are summarized by planning jurisdiction in Table 3.7-4. The major land use type within the assessment area is residential, encompassing approximately 64 percent of the assessment area, followed by agriculture/mineral resources (13 percent) and park/open space/public lands (10 percent). Commercial (4.4 percent), industrial (4.1 percent), and public facilities (3.3 percent) constitute the remainder of the land uses within the assessment area.

Table 3.7-4
Stillwater–Churn Creek Watershed Assessment Area
General Plan Land Use Designations

General Plan Designation	Acres	Portion of Assessment Area
RESIDENTIAL		
City of Redding		
1 unit/5 acres+	25	0.03%
1 unit/1 to 5 acres	499	0.64%
1 to 2 units/acre	751	0.97%
2 to 3.5 units/acre	6,372	8.19%
3.5-6 units/acre	1,069	1.37%
6 to 10 units/acre	1,259	1.62%
10 to 20 units/acre	717	0.92%
City of Shasta Lake		
Rural Residential A (2 acres/unit)	380	0.49%
Rural Residential B (5 acres/unit)	763	0.98%
Suburban Residential (3 units/acre)	2,361	3.04%
Urban Residential (10 units/acre)	997	1.28%
Urban Residential High (20 units/acre)	80	0.10%

Table 3.7-4
Stillwater–Churn Creek Watershed Assessment Area
General Plan Land Use Designations

General Plan Designation	Acres	Portion of Assessment Area
Shasta County		
1 unit/2 acres	4,339	5.58%
1 unit/5 acres	1,172	1.51%
2 units/acre	726	0.93%
3 units/acre	36	0.05%
Rural Residential A	21,552	27.71%
Rural Residential B	2,863	3.68%
Suburban Residential	3,205	4.12%
Suburban Residential – 2 units per acre	43	0.06%
Suburban Residential – 3 units per acre	245	0.32%
Urban Residential	10	0.01%
Urban Residential – 12 units per acre	26	0.03%
Residential Subtotal	**49,490**	**63.64%**
COMMERCIAL		
City of Redding		
General Office	289	0.37%
Limited Office	57	0.07%
General Commercial	768	0.99%
Heavy Commercial	510	0.66%
Regional Commercial	480	0.62%
Neighborhood Commercial	32	0.04%
Shopping Center	137	0.18%

Table 3.7-4
Stillwater–Churn Creek Watershed Assessment Area
General Plan Land Use Designations

General Plan Designation	Acres	Portion of Assessment Area
City of Shasta Lake		
Commercial	132	0.17%
Village Commercial	25	0.03%
City Center Commercial	17	0.02%
Mixed Use	512	0.66%
Shasta County		
Commercial	286	0.37%
Mixed Use	90	0.12%
Retail Commercial	14	0.02%
Service Commercial	92	0.12%
Commercial Subtotal	**3,441**	**4.42%**
INDUSTRIAL		
City of Redding		
General Industrial	1,445	1.86%
Heavy Industrial	200	0.26%
City of Shasta Lake		
Industrial	735	0.95%
Shasta County		
Industrial	360	0.46%
Planned Industrial	422	0.54%
Industrial Subtotal	**3,202**	**4.12%**

Table 3.7-4
Stillwater–Churn Creek Watershed Assessment Area
General Plan Land Use Designations

General Plan Designation	Acres	Portion of Assessment Area
PUBLIC FACILITIES		
City of Redding		
Airport Service	1,123	1.44%
Public Facility – Institutional	655	0.84%
Public Facility – School	142	0.18%
City of Shasta Lake		
Public Facilities	287	0.37%
Shasta County		
Public/Institutional	10	0.01%
Public Facility	370	0.48
Public Facilities Subtotal	**2,587**	**3.33%**
PARK/OPEN SPACE/PUBLIC LANDS		
City of Redding		
Greenway	2,868	3.69%
Park	429	0.55%
Park-Golf	36	0.05%
Recreational	22	0.03%
City of Shasta Lake		
100-year Floodplain	411	0.53%
Community Park	120	0.15%
Shasta County		
Federal Lands	3,208	4.13%
Greenway	537	0.69%
Habitat Resource	141	0.18%

Table 3.7-4
Stillwater–Churn Creek Watershed Assessment Area
General Plan Land Use Designations

General Plan Designation	Acres	Portion of Assessment Area
Natural Habitat	98	0.13%
Subtotal Park/Open Space/Public Lands	**7,870**	**10.12%**
RESOURCES		
Agricultural – Croplands	236	0.30%
Agricultural – Small Scale, Crops, Grazing	4,796	6.17%
Mineral Resources	5,030	6.47%
Subtotal Resources	**10,062**	**12.94%**
UNKNOWN USES/ROADS		
City of Redding	976	1.26%
City of Shasta Lake	66	0.08%
Shasta County	68	0.09%
Subtotal Unknown Uses/Roads	**1,110**	**1.43%**
TOTAL	**77,762**	**100%**

Sources: Shasta County General Plan, City of Redding General Plan 2000, City of Shasta Lake General Plan.

Residential

General plan designations falling under the residential categories identified in Table 3.7-4 encompass approximately 64 percent (49,490 acres) of the assessment area, with more than half of these residential lands within the planning jurisdiction of Shasta County. The majority of these residential land use designations (64 percent [31,674 acres] of the residential total) consist of lower density residential, followed by medium-density residential (30 percent [14,847 acres]) and high-density residential (6 percent [2,969 acres]).

The density of lands in the assessment area classified as residential varies considerably. For example, within the assessment area lands under the jurisdiction of the City of Redding, there are seven residential land use designations ranging from rural residential to high-density residential that encompass 10,692 acres (13.7 percent) of the assessment area. These land use designations range from a low density of 5 acres per residential unit (A/U) to a high density of 10 to 20 residential units per acre (U/A). Medium-density residential land use designations, such as 1 to 2 units per acre, 2 to 3.5 units per acre, and 3.5 to 6 units per acre, are the most common designations

within the assessment area. High-density residential land use designations consist of 6 to 10 units per acre and 10 to 20 units per acre, while low-density residential designations include 1 unit per 5 acres plus and 1 unit per 1 to 5 acres.

In the portions of the assessment area under the jurisdiction of Shasta County, there are 11 residential land use classifications (refer to Table 3.7-4) (i.e., Rural Residential, Suburban Residential, Mixed Use, etc.) that encompass 34,217 acres (44 percent). Lower density residential designations (1 unit per 2 acres, 1 unit per 5 acres, Rural Residential A and Rural Residential B) comprise the majority of the residential land use designations under Shasta County jurisdiction, encompassing 29,926 acres (38.5 percent) of the assessment area. Rural Residential A lands (21,552 acres [27.2 percent]) comprise the largest general plan land use designation within the assessment area. Medium-density residential land use designations encompass a total of 4,255 acres (5.5 percent) of the assessment area and include the following general plan land use designations: 2 units per acre, 3 units per acre, Suburban Residential, Suburban Residential–2, and Suburban Residential–3. High-density residential land use designations consist of Urban Residential and Urban Residential–12 and total only 36 acres (0.04 percent) of the assessment area.

In the portions of the assessment area under the jurisdiction of the City of Shasta Lake, there are five residential land use classifications that encompass 4,581 acres (5.9 percent) of the assessment area. Medium-density residential uses, consisting entirely of the Suburban Residential (3 units/acre) land use designation, comprise the majority of the City of Shasta Lake residential land use designations, encompassing 2,361 acres (3 percent) of the overall assessment area. High-density residential land use designations consist of Urban Residential (10 units per acre) and Urban Residential High (20 units per acre), while low-density residential designations include Rural Residential A (1 unit per 2 acres) and Rural Residential B (1 unit per 5 acres).

Commercial

The commercial land use classification covers a broad range of uses, from general office to shopping centers. These land use designations constitute 4.4 percent (3,441 acres) of the assessment area. The majority of these lands, comprising 2,273 acres, are located within the City of Redding (Figure 3.7-1).

In the portions of the assessment area under the jurisdiction of Shasta County, there are four commercial land use classifications that encompass 482 acres (0.6 percent) of the assessment area. These commercial land use designations are Commercial (286 acres), Mixed Use (90 acres), Retail Commercial (14 acres), and Service Commercial (92 acres).

There are seven commercial and office land use designations within the assessment area under the jurisdiction of the City of Redding: General Office, Limited Office, General Commercial, Heavy Commercial, Regional Commercial, Neighborhood Commercial, and Shopping Center. General commercial areas, such as those around the city, are the most predominant commercial designation, encompassing 768 acres (1 percent) of the assessment area, followed by Heavy Commercial (510 acres), Regional Commercial (480 acres), Shopping Center (137 acres), and Neighborhood Commercial (32 acres). Office uses range from Limited

Office (57 acres), typically consisting of office space blended into residential areas, to General Office (289 acres), consisting of large-scale office complexes.

There are four commercial and office land use designations within the assessment area under the jurisdiction of the City of Shasta Lake: Mixed Use (512 acres), Commercial (132 acres), Village Commercial (25 acres), and City Center Commercial (17 acres).

Lands in the assessment area classified as park vary considerably by use, ranging from developed park facilities and golf courses to open space areas, greenways, and flood protection zones. General plan designations falling under this category encompass 7,870 acres (10.1 percent) of the assessment area.

Industrial

General plan designations falling under industrial categories encompass 3,202 acres (4.1 percent). The majority of these lands, comprising 1,645 acres, are located within the City of Redding.

In the portions of the assessment area under the jurisdiction of Shasta County, there are two industrial land use designations: Industrial (360 acres) and Planned Industrial (422 acres).

In the portions of the assessment area under the jurisdiction of the City of Redding, there are two industrial land use designations: General Industrial (1,445 acres) and Heavy Industrial (200 acres). The majority of these industrial lands are located in the southern half of the assessment area along Airport Road, south of SR 44. Another cluster of industrial land use designations is located south of Oasis Road and west of I-5.

In the portions of the assessment area under the jurisdiction of the City of Shasta Lake, there are two industrial land use designations: Industrial (735 acres) and Industrial Light (40 acres). The largest industrial facility within the City of Shasta Lake is the Knauf Fiberglass Plant, located in the Shasta Lake Industrial Park along Pine Grove Avenue.

Park

Lands in the assessment area classified as park vary considerably by use, ranging from developed park facilities and golf courses to open space areas, greenways, and flood protection zones. General plan designations falling under this category encompass 7,870 acres (10.1 percent) of the assessment area.

In the portions of the assessment area under the jurisdiction of Shasta County, there are four general plan land use designations grouped under this category: Federal Lands (3,208 acres), Greenway (537 acres), Habitat Resource (141 acres), and Natural Habitat (98 acres). As previously discussed, the majority of the federal land within the assessment area is owned and managed by BLM (2,283 acres) and the USFS (1,106 acres). Greenway areas in the assessment area consist of open space/riparian zones adjacent to the Sacramento River, the Stillwater Plains Mitigation Bank, and the southernmost segment of Stillwater Creek.

In the portions of the assessment area under the jurisdiction of the City of Redding, there are four general plan land use designations grouped under this category: Greenway (2,868 acres), Park (429 acres), Park-Golf (36 acres), and Recreational (22 acres). Within the assessment area, the City has established extensive protected riparian zones, designated as Greenway, along several streams, including Churn Creek, Clover Creek,

Salt Creek, and Stillwater Creek, as well as the Sacramento River. The largest public park in the assessment area is Enterprise Community Park, which is located east of Churn Creek and west of Victor Avenue. Golf courses in the assessment area include Tierra Oaks in the Stillwater Creek watershed, Gold Hills Golf Course and Churn Creek Golf Course in the Churn Creek watershed, and Anderson Tucker Oaks Golf Club in the Clover Creek watershed. Notable open space areas within the assessment area include the Lema Ranch; the Old Oregon Trail Vernal Pool Restoration Area and Stillwater Plains Mitigation Bank, both of which include several acres of vernal pool habitat; and the Stillwater Riverfront Property, a 310-acre site that encompasses over 100 acres of valley oak woodland.

In the portions of the assessment area under the jurisdiction of the City of Shasta Lake, there are two general plan land use designations grouped under this category: 100-year Floodplain (411 acres) and Community Park (120 acres). Lands located within the 100-year floodplain of Churn Creek and Salt Creek and their tributaries are maintained as open space/greenway areas to provide flood protection within the City of Shasta Lake. The largest park facility in the city is the Margaret Polf Regional Park.

Additionally, scattered throughout the assessment area are lands that have been set aside for the conservation of wildlife and their habitat. Table 3.7-5 below provides a non-comprehensive list of these areas (Nelson pers. comm. 2006). Additional information is needed to determine where other such sites are located, their size, managing entity, and whether each site is accomplishing the goals for which it was established. Such information would be useful for future management decisions regarding the protection of wildlife species and their habitat in the assessment area.

Public Facilities

Lands classified as public facilities within the assessment area include schools, airports, and institutional facilities (i.e., wastewater treatment plant). General plan designations falling under this category encompass 2,587 acres (3.3 percent) of the assessment area.

In the portions of the assessment area under the jurisdiction of Shasta County, there are two General Plan land use designations grouped under this category: Public Facility (370 acres) and Public/Institutional (10 acres). The largest public facilities land use designation within lands under the jurisdiction of Shasta County is Shasta College, located east of I-5 and north of SR 299.

In the portions of the assessment area under the jurisdiction of the City of Redding, there are three general plan land use designations grouped under this category: Airport Service (1,123 acres), Public Facility–Institutional (655 acres), and Public Facility–School (142 acres). The largest public facilities land use designation within lands under the jurisdiction of the City is Airport Service, which encompasses the Redding Municipal Airport, located directly west of Stillwater Creek. The largest land area designated as Public Facility–School is Simpson College, located east of I-5 and south of SR 299, between Churn Creek and Stillwater Creek. The McConnell Foundation's Lema Ranch is the largest area designated as Public Facility–Institutional. The City's Corporation Yard and Solid Waste Transfer Station and the adjacent Big League Dreams Sports Complex, located north of SR 44 along Viking Way, are designated as Public Facilities–Institutional. Other public facilities within the assessment

Table 3.7-5
Lands Set Aside for the Protection of Wildlife Species and Their Habitat

Name	Location	Purpose	Description
Stillwater Plains Mitigation Bank	On Stillwater Plains in the southwestern portion of the assessment area	Mitigation for vernal pools and associated species as well as the valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*)	Private
Clover Creek Preserve	Clover Creek south of SR 44	Open space recreation, protection of vernal pools, and flood control	City of Redding
Churn Creek unique plant community	South side of Oasis Road near I-5	Protection of a rare/unique plant community growing on exposed marine sediments	Conservation easement
SR 44 vernal pool complex	North and south of SR 44 between Stillwater and Clover creeks	Protection of vernal pools	Conservation easement
Planned mitigation bank	On the northern edge of and contiguous with Stillwater Plains Mitigation Bank	Mitigation for vernal pools and associated species	Private land
North Anderson ecological preserve	North bank of the Sacramento River just east of Clover Creek	Protection of riparian habitats	CDFG managed lands
Mountain Gate Shasta salamander easement	Approximately one mile northeast of Mountain Gate	Conservation of Shasta salamander habitat (*Hydromantes shastae*)	Conservation easement
Gray Rocks Shasta salamander easement	At or near Gray Rocks quarry area	Conservation of Shasta salamander habitat	Conservation easement

area include the City's Stillwater Wastewater Treatment Plant, located east of Airport Road and adjacent to the Sacramento River, at the southernmost boundary of the assessment area.

In the portions of the assessment area under the jurisdiction of the City of Shasta Lake, there is one general plan land use designation for this category: Public Facilities (287 acres). Public facilities within the City of Shasta Lake include the Buckeye Waste Transfer Station, City of Shasta Lake Wastewater Treatment Plant, and City Hall.

Agriculture

The only lands in the assessment area classified as Agriculture are under the jurisdiction of Shasta County. The general plan land use types for the agriculture category include Agricultural–Small Scale, Crops, Grazing (4,796 acres) and Agricultural–Croplands (236 acres). The total acreage of 5,032 acres comprises 6.5 percent of the

Agricultural lands within the assessment area are associated with the rich, fertile soils in the Churn Creek Bottom area… and the Stillwater Creek valley… Agricultural uses are in close proximity to the Sacramento River, Stillwater Creek, Salmon Creek, Clough Creek, Churn Creek, Clover Creek, and their immediate tributaries.

assessment area. Agricultural lands within the assessment area are associated with the rich, fertile soils in the Churn Creek Bottom area at the southwest boundary of the assessment area and the Stillwater Creek valley between SR 299 and SR 44. A variety of agricultural crops are produced on these lands, including hay/alfalfa, corn, and strawberries. These lands are also used for livestock grazing. Agricultural uses are in close proximity to the Sacramento River, Stillwater Creek, Salmon Creek, Clough Creek, Churn Creek, Clover Creek, and their immediate tributaries.

Mineral Resources

Lands classified as Mineral Resources occur only on lands under the jurisdiction of Shasta County. A total of 5,030 acres (6.5 percent) of the assessment area consists of lands designated as Mineral Resources. These lands are within the headwaters of several creeks, including Churn Creek, Salt Creek, and Stillwater Creek. Mineral resources in the assessment area include sand and gravel and limestone. Currently, there are six mines operating within the assessment area. They include Gray Rocks Quarry located east of I-5 and north of Mountain Gate in the Gray Rocks area of the assessment area. Gray Rocks Quarry has a projected surface disturbance at 2050 of approximately 236 acres. Falkenbury Shale Quarry is located west of I-5 just northwest of Mountain Gate and north of the Spring Branch of West Fork Stillwater Creek. Falkenbury Shale Quarry has a projected surface disturbance at 2050 of approximately 355 acres. Eagle Crest Pit was recently made inactive. The pit is located in Churn Creek Bottom approximately one-half mile west of Airport Road in the city of Redding. Churn Creek Pit is located near I-5 and Twin View Boulevard in the City of Redding. The remaining mines are Mountain Gate Limestone Quarry and Fawndale Quarry, both of which are located east of I-5 in the Mountain Gate area.

3.7.4 Services and Circulation

Service Providers

Existing Services

Nearly all the areas within the City of Redding and the City of Shasta Lake have full city services, including sewer, water, electrical power, solid waste handling, and police and fire protection (Figure 3.7-4, Generalized Service Areas.) Shasta County provides police and fire protection in coordination with CDF, and solid waste handling. Two independent community service districts, Mountain Gate Community Services District and Bella Vista Water District, provide water to most of the remaining unincorporated areas of the assessment area. The service boundaries for each of these districts are shown in Figure 3.7-4. These water districts rely exclusively on Central Valley Project water allocations from Reclamation. In addition, the City of Anderson provides water to the Wooded Acres subdivision, west of Clover Creek. No

No wastewater treatment services are provided in the unincorporated areas of the assessment area. These areas use septic systems, which restricts higher density development in these areas.

wastewater treatment services are provided in the unincorporated areas of the assessment area. These areas use septic systems; as described in Section 3.3 (Figure 3.3-5), soils in the watershed are characterized as severely limited for leach fields, which restricts higher density development in these areas.

Solid waste generated in the parts of the assessment area under the jurisdiction of Shasta County and the City of Redding is ultimately delivered to the West Central Landfill, which is located west of the assessment area in the Clear Creek watershed. Within the City of Redding, the Solid Waste Transfer Station accepts City-collected and privately hauled residential, commercial, and industrial refuse, green waste, recyclables, and household hazardous materials, with all non-recyclable and non-hazardous waste being hauled by transfer trucks to the West Central Landfill. Solid waste in the City of Shasta Lake is disposed of at the Buckeye Waste Transfer Station.

Future Services

There are no current plans to expand water service contracts within the assessment area. It is anticipated that water will continue to be supplied by the cities of Redding and Shasta Lake, BVWD, and the Mountain Gate Community Services District under existing long-term water contracts with Reclamation. Future development requiring water service on unincorporated lands not presently located within a community services district would need to make a request to be annexed into a particular services district.

Within their respective city limits, sewer services are provided by the cities of Redding and Shasta Lake. Any future extensions of sewer service could occur only with annexation of new areas to the city having jurisdiction. Redding General Plan Policy CDD1B limits the approval of proposed annexations to one or more of the following conditions:

- More logical service area boundary
- Elimination of an existing island of Shasta County land
- Efficient provision of urban services
- Resolution of existing safety concerns
- Neutral or positive fiscal impact to the City of Redding

The City of Shasta Lake General Plan has an Implementation Measure in the Public Facilities Element, Implementation Measure PF-1, which states that, "If cost effective, require annexation to the City as a condition of extending City services."

Recreation Facilities

Existing Facilities

The majority of BLM lands in the assessment area are located to the north and east of the City of Shasta Lake, although there are additional small areas in the northeastern corner of the assessment area at the headwaters of Deep Hole Creek and on the eastern bank of the Sacramento River at the end of Knighton Road, where gravel is mined. There are no designated parks on lands managed by the BLM within the assessment area. Lands within the assessment area managed by the STNF encompass approximately 1,106 acres at the extreme northern edge of the assessment area. There are no designated parks or campgrounds on these lands. There are no state- or county-maintained parks located within the assessment area.

The parks and recreation facilities located within the assessment area consist of golf courses, regional parks, natural area parks, community parks, large neighborhood parks,

small neighborhood parks, and school parks-joint facilities. The primary park facilities in the City of Shasta Lake are the Margaret Polf Regional Park and adjacent Harold J. "Bizz" Johnson Ballpark. These facilities encompass 120 acres at the extreme eastern edge of the city on the south side of SR 151. Facilities associated with this park include children's playgrounds, ballparks, a bike track, picnic facilities, and walking trails.

Golf courses located within the assessment area include Tierra Oaks Golf Course (Stillwater), Gold Hills Golf Course and Churn Creek Golf Course (Churn Creek), and Anderson Tucker Oaks Golf Club (Clover Creek). The 200-acre Lema Ranch, located within The McConnell Foundation property, is designated open space and contains 4 miles of walking trails that are open to the public. A another important regional recreational facility is the Big League Dreams Sports Complex, which provides facilities for a variety of sports, including baseball, softball, volleyball, basketball, and roller blade sports. Smaller recreational facilities in the City of Shasta Lake include Clair Engle Park and Central Valley Ball Park. Table 3.7-6 provides a summary of parks and recreational facilities in the assessment area operated by the City of Redding.

Enterprise Park is the largest regional park in the assessment area and supports a number of recreational amenities, including a picnic pavilion, Kid's Kingdom, playgrounds, fountain, roller hockey rink, soccer fields, and a disc golf course.

Planned Facilities

No large-scale recreational facilities are currently planned for Shasta County or the City of Shasta Lake. Both of these entities will continue to promote the construction of multi-use trail systems, including bicycle lanes, in the future.

The City of Redding adopted the Redding Parks, Trails, and Open Space Master Plan in 2004. The plan identified a then-current level-of-service for park facilities of 6.78 acres per thousand people, which was below the General Plan's 10-acre goal (Recreation Element, Goal R4). Based on the findings in this plan, the City has placed a priority on park acquisition and/or development, with the greatest emphasis on providing large neighborhood parks of between 5 and 15 acres. The plan also identifies the need to provide a City-owned multi-use recreational center in each quadrant of the City, two of which are located within the assessment area. These recommendations will be subject to future review and approval by the City. Similar to Shasta County and the City of Shasta Lake, Redding will continue to develop multi-use trail systems, particularly along greenways/open space areas that provide linkages to various developments.

Traffic Circulation

Existing Conditions

Traffic circulation in the assessment area is facilitated by a conventional grid road system over undulating terrain. Circulation within the assessment area is primarily constrained by the Sacramento River at the southwestern boundary of the assessment area. Various roadway types are present within the

No large-scale recreational facilities are currently planned for Shasta County or the City of Shasta Lake. Both of these entities will continue to promote the construction of multi-use trail systems, including bicycle lanes, in the future.

Table 3.7-6
City of Redding Park Facilities within the Stillwater–Churn Creek Watershed Assessment Area

Park Name and Address	Park Type	Developed (acres)	Undeveloped (acres)
Enterprise Park 1755 El Vista Street	Regional	25.00	69.59
Clover Creek Preserve 3705 Shasta View Drive	Natural area	106.00	23.00
Buckeye Park 3500 Hiatt Drive	Community	9.40	17.80
Alta Mesa Park 3600 Scorpius Drive	Large neighborhood	6.75	--
Bob White Park 931 Springer Drive	Small neighborhood	0.43	--
Clover Creek Park 2555 Clover Creek Street	Small neighborhood	1.00	1.30
Foxtail Park 1460 Foxtail Court	Small neighborhood	0.84	--
Minder Park 1210 Minder Drive	Small neighborhood	1.00	--
Northridge Park 960 Hillsdale Court	Small neighborhood	0.75	--
Peppertree Park 500 Peppertree Lane	Small neighborhood	1.84	--
Ravenwood Park 2001 Charade Way	Small neighborhood	0.76	--
Stillwater Heights Park 4525 Lynbrook Loop	Small neighborhood	1.85	--
Valley Ridge Park 5414 Valley Ridge Park	Small neighborhood	1.00	0.47
Western Oaks Park 2370 Western Oaks Drive	Small neighborhood	2.10	--
Enterprise High School 3411 Churn Creek Road	School Park-Joint Facility	1.50	--
Simpson University 2211 College View Drive	School Park-Joint Facility	6.50	--

assessment area, including alley, arterial, collector, freeway, highway, and local roadway systems. In addition, there are private roadways associated with single-family, multi-family, and mobile home park developments. Locations of roadway intersections at waterways (i.e., bridges, culverts) are provided in Figure 3.4-2, Intersection of Roads and Surface Waters. Table 3.7-7 shows the total length of each roadway type mapped within the assessment area.

I-5 is a north-south flowing freeway that bisects the assessment area near the western boundary (Figure 3.7-5 Traffic Circulation.) State highway systems within the assessment area include SR 44, SR 151, SR 273, and SR 299. Each of these state highways flows in an east-west direction and intersects with I-5 along the western boundary of the assessment area (Figure 3.7-5.) The freeways and highways that cross the assessment area are managed by the California Department of Transportation (Caltrans).

Local streets make up a large percentage of the roadway system within the assessment area. Local streets are typically two-lane, paved systems that primarily service residential areas. Depending on the planning jurisdiction in which they are located, local streets are managed by the City of Redding, the City of Shasta Lake, or Shasta County. Private roads may be one or two lanes and paved or unpaved, with residents and homeowners' associations responsible for their maintenance.

Table 3.7-7
Summary of Road Lengths in the Stillwater–Churn Creek Watershed Assessment Area

Roadway Type	Total Road Length (miles)
Alley	2.25
Arterial	39.8
Collector	43.67
Freeway[1]	27.59
Highway[1]	35.41
Local	491
Private–multi-family	3.37
Private–mobile home park	10.55
Private road–single-family	20.33
Unimproved	0.36
Total length	**674.33**

[1]GIS calculated north and south bound lanes separately when there are open medians between lanes of traffic.

Future Improvements

Road circulation in the assessment area is generally adequate, as measured by local and statewide standards. In order to accommodate future planned growth and to avoid major urban congestion, the following major road improvements within the assessment area are planned within the next 10 years, according to the Shasta County Regional Transportation Plan:

- Expand I-5 from four to six lanes from Riverside Drive in Anderson to SR 299E in Redding (Caltrans)
- Make capacity and operational improvements on SR 44 from Airport Road to Deschutes Road, including expansion from two to four lanes, a new interchange at Stillwater Road, and closure of the Gilbert Road connection (Caltrans)
- Widen Airport Road to four lanes between SR 44 and Rancho Road/Fig Tree Lane (City of Redding)
- Widen Rancho Road to four lanes from Debbie Lane to Shasta View Drive, and re-align the intersection of Churn Creek Road, Rancho Road, and Victor Avenue into a single intersection (City of Redding)
- Realign Old Oregon Trail between Viking Way and Old SR 44 (City of Redding)
- Widen Hilltop Drive overcrossing at SR 44 (City of Redding)
- Extend Knighton Road west to SR 273, including construction of new bridge over the Sacramento River (Shasta County)
- Construction of new bike lanes adjacent to portions of College View Drive, Old Oregon Trail, and Old Alturas Road (Shasta County)
- Extension of Pine Grove Avenue to the east (City of Shasta Lake)

Long-term major improvements to the transportation network extending beyond the 10-year planning window will need to be identified and appropriate funding allocated by the local jurisdictions and the Shasta County Regional Transportation Planning Agency.

Environmental stewardship in road design and construction, including storm water runoff from roads, by Caltrans, Shasta County, the City of Redding, and the City of Shasta Lake has continued to improve, primarily in response to stricter permitting guidelines. It is anticipated that this trend of increasing environmental stewardship will continue as new transportation projects are developed in the future.

Environmental stewardship in road design and construction, including storm water runoff from roads, by Caltrans, Shasta County, the City of Redding, and the City of Shasta Lake has continued to improve, primarily in response to stricter permitting guidelines.

3.7.5 Major Development and Construction Activities, Present and Known Planned

The City of Redding is a rapidly expanding urban area, and there are several planned suburban, commercial, and industrial developments. This section focuses on known planned developments that will have a significant influence on land use in the assessment area. Below is a list of existing and planned large-scale developments in the assessment area and the waterbodies with which they are most closely associated. The information for this list was derived from aerial photography and applications for proposed development available at Shasta County and the cities of Redding and Shasta Lake.

Existing Development

- Hacienda Heights off Shasta View Drive subdivision (Churn Creek tributaries)
- Tierra Oaks Estates and Village at Tierra Oaks (Stillwater Creek)
- Gold Hills Subdivision and Golf Course (Dry Gulch Creek)
- Wooded Acres Subdivision (Clover Creek)
- Lake Boulevard Commercial Retail Center (Boulder Creek tributaries)
- Hilltop Drive Commercial Retail Center (Churn Creek tributaries)
- Victor Avenue Commercial Development (Churn Creek tributaries)
- Hartnell Avenue Commercial Development (Churn Creek)
- Old Oregon Trail Commercial Development (Stillwater and Clover Creeks)
- Viking Way City Facilities and Big League Dreams Park (Clover Creek)
- Shasta Gateway Industrial Park (Churn Creek)
- Knauf Fiberglass Plant (Churn Creek)
- Commercial and Office Development off Shasta Dam Boulevard (Churn Creek tributary)
- Simpson College (Churn Creek and Stillwater Creek)
- Shasta College (Stillwater Creek)

Planned Development

- Victoria Knolls and Oasis Knolls subdivisions (Salt and Dry creeks)
- Stone Creek subdivision (Clover Creek)
- Shastina Ranch off Rancho Road (Clover Creek)
- Clover Creek Village subdivision (Clover Creek tributary)
- East Stillwater Business Park (Stillwater Creek)
- Oasis Road Specific Plan and Redding Oasis Center (Churn Creek and Salt Creek)
- North Airport Business Park (Stillwater Creek tributary)
- Tarmac Road/Shasta View Drive Commercial and Office Development (between Clover Creek and Churn Creek)
- Windsor Estates off Cascade Boulevard (Churn Creek tributaries)
- Deer Creek Manor off Pine Grove (Churn Creek tributary)
- Kingston Estates and Hazelwood Subdivisions (Churn Creek tributaries)
- Sherwood Forest Estates off Cascade Boulevard (Churn Creek tributaries)
- Shasta Regional Auto Mall (Churn Creek tributaries)

Factors Affecting Development

As previously discussed, land use within the assessment area is regulated by both the general plans and zoning plans that have been adopted by the three planning entities: Shasta County, City of Redding, and City of Shasta Lake. There may also be local ordinances (e.g., grading, tree preservation, floodplain) that may help shape how future development will evolve in the assessment area. Other factors that may affect future development in the assessment area include environmental and permitting authorization, availability of services, and natural hazards.

Environmental and Permitting Authorization

Future development will be subject to a variety of environmental and permitting approval processes that could further modify development proposals. Key environmental and permitting approvals that may be required include one or more of the following:

- Compliance with the California Environmental Quality Act (CEQA)

- Compliance with the National Environmental Policy Act (NEPA) for projects with federal funding and/or approval actions and/or on federal land
- Issuance of a Section 404 Clean Water Act permit from the U.S. Army Corps of Engineers (Corps)
- Compliance with both the Federal Endangered Species Act (ESA) and California Endangered Species Act (CESA) for projects that could affect a listed species (U.S. Fish And Wildlife Service and/or National Marine Fisheries Service for ESA and the California Department of Fish and Game for CESA)
- Compliance with Section 106 of the National Historic Preservation Act for cultural resources
- Issuance of a Section 1602 Streambed Alteration Agreement from the California Department of Fish and Game for projects that will divert or obstruct the natural flow of water; change the bed, channel, or bank of any stream; or use any material from a streambed
- Issuance of a permit from the local Environmental Health Department (i.e., well permit, septic permit, water re-use and reclamation permit, underground storage tank permit)
- Issuance of a permit from the Central Valley Regional Water Quality Control Board: Waste Discharge Requirements for discharge of waste or waste water to land that may affect water quality; NPDES Permit when proposing to discharge waste into any surface water (construction and/or operational); and Section 401 Clean Water Act Water Quality Certification for projects discharging fill into waters of the United States
- Issuance of a Water Rights Permit from the SWRCB when proposing to divert water from a stream or river.

The Corps' permitting process is trending toward being more restrictive on the amount of discharge allowed in waters over which it has jurisdiction… In addition, the Corps is now requiring establishment of conservation easements to protect or avoid wetlands.

The Corps' permitting process is becoming more restrictive on the amount of discharge allowed in waters over which it has jurisdiction, which has resulted in fewer lots and smaller building pads for recent development projects. In addition, the Corps is now requiring the establishment of conservation easements to protect or avoid wetlands and other waters of the United States within proposed developments.

Availability of Services

Residential, commercial, office, and industrial uses require the availability of services in order to develop up to the maximum permitted densities in the various general plans. The utilities/services which are the most limiting factors for development within the assessment area are water service (drinking and fire protection), sewer service, and roads (including secondary emergency access). Undeveloped areas within and adjacent to the City of Redding and City of Shasta Lake cores either have sewer and water services available or are located in reasonable proximity to existing infrastructure; these areas are the most likely to experience higher density development in the future. Rural areas within Shasta County located within the water service areas of the Bella Vista Water District and Mountain Gate Community Services District typically lack sewer service. In areas lacking community sewer service, septic tanks and septic leach fields are required. Since residences with septic systems typically require 2 or more

acres, rural areas within the assessment area are expected to experience much lower density development.

Natural Hazards

Development on steep slopes (i.e., greater than 20 percent) and within flood prone areas is discouraged, and often times prohibited under an adopted ordinance by the three planning agencies that have jurisdiction in the assessment area. These areas typically remain in open space in order to minimize safety hazards associated with landslides and flooding, as well as to reduce erosion and sedimentation.

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3.8 Botanical Resources

The watershed assessment area encompasses a wide diversity of vegetation communities that support many plant species. This diversity results primarily from the large size and the varying geologic landforms, topography, and climate of the assessment area. The assessment area extends from the northernmost portion of the Sacramento Valley in the south to the mountainous region at the Lake Shasta divide to the north.

Vegetation communities in the assessment area range from oak woodland and grassland communities to hardwood-conifer and foothill-woodlands. Several of the vegetation communities represent the northernmost occurrences of these communities in California. The assessment area also includes many riparian and wetland communities associated with the Stillwater, Churn, and Clover Creek systems and portions of the Sacramento River as well as a number of vernal pool and other seasonal wetland complexes (see also Section 3.5, Hydrology, Flooding, and Water Use/Quantity).

This section describes the vegetation communities in the assessment area as well as sensitive botanical resources and threats posed by invasive plant species.

3.8.1 Characterization and Distribution of Vegetation Communities

For this watershed assessment, vegetation communities were classified and described using vegetation mapping information from the Fire and Resource Assessment Program, a project of CDF's Land Cover Mapping and Monitoring Program (LCMMP). The LCMMP uses the CALVEG system (Parker and Matyas 1981) as its primary vegetation classification system; however, it also provides a data set that has been "cross-walked" from CALVEG into the vegetation classification system described in the Guide to Wildlife Habitats of California (Mayer and Laudenslayer 1988), which tends to be somewhat more simplistic than the CALVEG system. The Guide to Wildlife Habitats classification was developed for use with the CDFG's California Wildlife-Habitat Relationships System (CWHR) to provide a means of describing both vegetation communities and wildlife habitats.

Vegetation communities in the assessment area range from oak woodland and grassland communities to hardwood-conifer and foothill-woodlands. Several of the vegetation communities represent the northernmost occurrences of these communities in California.

The assessment area is characterized by CWHR habitats typical of the northern Central Valley, foothill woodlands, and low-elevation forest habitats occurring within northern California. The habitats in the assessment area are agricultural, annual grassland, barren, blue oak woodland, blue oak–foothill pine, ponderosa pine, mixed chaparral, montane hardwood, montane hardwood–conifer, urban, fresh emergent wetland, valley-foothill riparian, and valley oak woodland. Dominant plant species and species composition in these habitats vary, with dramatic changes often occurring in relation to aspect, slope, geologic substrate, or juxtaposition with other habitats.

The dominant habitat in the assessment area is blue oak woodland. Urban and blue oak-foothill pine habitats are the next most abundant. Barren, ponderosa pine, fresh

emergent wetland, montane hardwood-conifer, and valley-foothill riparian are the least common habitats in the assessment area. The relative proportions of the habitats occurring within the assessment area are shown in Table 3.8-1, and their boundaries are shown in Figure 3.8-1, Habitats. These habitats are described below.

Table 3.8-1
Summary of Habitats Occurring in the Stillwater–Churn Creek Watershed

CWHR Habitat	Acres	Percent of Total
Agricultural	5,131	6.6%
Annual grassland	10,651	13.7%
Barren	501	0.6%
Blue oak woodland	17,184	22.1%
Blue oak–foothill pine	12,218	15.7%
Fresh emergent wetland	820	1.1%
Mixed chaparral	4,765	6.1%
Montane hardwood	8,450	10.9%
Montane hardwood–conifer	899	1.2%
Ponderosa pine	805	1.0%
Urban	13,288	17.1%
Valley–foothill riparian[1]	1,939	2.5%
Valley oak woodland	1,083	1.4%
Total	77,735	100%

[1] Due to constraints associated with the methods and scale of the LCMMP mapping, valley-foothill riparian habitat is assumed to occur as the stream features shown in Figure 3.8-1 and is therefore likely to be over-represented.

Agricultural

Agricultural habitats include pastures, orchards, and irrigated/dryland row and field crops. Generally, these areas are scattered throughout the assessment area, with the most extensive occurrences in the lower Churn Creek and the mid- to lower Stillwater Creek watersheds. Within this habitat, the native plant species composition has been changed by the agricultural practice(s) used. Pastures are both irrigated and non-irrigated and typically are used for various stock animals. Orchards in the assessment area include various nut and fruit crops. Typical irrigated/dryland row and field crops include hay, alfalfa, and other grains.

Annual Grassland

Annual grasslands occur as small inclusions within other woodland, hardwood, or hardwood-conifer habitats and as extensive areas covering a large portion of some landscapes. Annual grasslands are generally scattered throughout the assessment area, with the most extensive occurrences located in the southern portion of the assessment area. This habitat is characterized as moderate to dense herbaceous cover dominated by annual grasses and forbs.

Many of the species present within the grasslands also occur as understory plants in the adjacent woodland habitat types. Dominant species include wild oat (*Avena* spp.), cheatgrass (*Bromus tectorum*), yellow starthistle, medusa-head (*Taeniathrum caput-medusae*), rattail grass (*Vulpia myuros*), silvery hairgrass (*Aira caryophyllea*), wall barley (*Hordeum murinum*), filaree (*Erodium botrys*), rose clover (*Trifolium hirtum*), vetch (*Vicia* sp.), and Douglas's lupine (*Lupinus nanus*).

Many seasonal (vernal) wetland inclusions occur within the annual grassland habitats in the form of vernal swales and pools and seasonal wet meadows. These features also occur as small inclusions within many woodland habitat types. Vernal pools and swales are characterized as large to small depressions that become ponded during the wet season. Seasonal wet meadows are generally inclusions that become saturated or ponded with a very thin "sheet" of water at the surface during the wet season. The seasonal ponding and/or saturation in these features is mainly a result of the geologic substrate (e.g., shallow rock shelf, hardpan, clay layer, etc.), but may occasionally result from landscape drainage patterns. Vernal pools are discussed in more detail below.

Many seasonal (vernal) wetland inclusions occur within the annual grassland habitats in the form of vernal swales and pools and seasonal wet meadows. These features also occur as small inclusions within many woodland habitat types.

Plant species composition in all of these seasonal wetlands is diverse and is dominated by an open to dense layer of herbaceous annual and perennial species that are often found only in these seasonally wet habitats. These habitats support many uncommon and several sensitive plant species. Dominant species include popcorn flower (*Plagiobothrys* sp.), navarretia (*Navarretia* sp.), Sacramento mesamint (*Pogogyne zizyphoroides*), cowbag clover (*Trifolium depauperatum*), white-tipped clover (*T. variegatum*), field owls-clover (*Castilleja campestris*), Mediterranean barley (*Hordeum marinum* ssp. *gussoneum*), harvest brodiaea (*Brodiaea coronaria*), tidy-tips (*Layia fremontii*), dwarf cliff sedum (*Parvisedum pumilum*), yellow carpet (*Blennosperma nanum*), Fremont's goldfields (*Lasthenia fremontii*), bractless hedge-hyssop (*Gratiola ebracteata*), slender hair grass (*Deschampsia danthonoides*), coyote thistle (*Eryngium castrense*), wooly marbles (*Psilocarphus brevissimus*), and white hyacinth (*Triteleia hyacinthina*).

Barren

Barren habitats include areas generally supporting little or no vegetation. Within the assessment area, this habitat typically consists of rock outcrops, but also includes gravel bars and tailings as well as areas of bare soil or rock. Vegetation that does occur in these areas includes open tree or shrub cover, with sparse herbaceous cover. Barren is an uncommon habitat within the assessment area. Most occurrences are located in the Mountain Gate area, which is in the northern part of the assessment area, and consist mainly of limestone and other rock outcrop formations.

Blue Oak Woodland

Blue oak woodland is the dominant habitat in the assessment area. It is scattered throughout the assessment area; however, the largest occurrences are within the headwater areas of both Churn and Stillwater creeks and the eastern portion of the Stillwater Creek watershed. The blue oak woodlands within the assessment area represent the northernmost extent of this habitat type in California.

The blue oak woodlands are characterized as open to moderate canopied woodlands with an open understory. Dominant tree species include blue oak (*Quercus douglasii*), with occasional foothill pine (*Pinus sabiniana*) and

interior live oak (*Quercus wislizenii*). Shrubs are generally sparse and include poison oak (*Toxicodendron diversiloba*), buckbrush (*Ceanothus cuneatus*), white leaf manzanita (*Arctostaphylos viscida*), and common manzanita (*A. manzanita*). A moderate to dense herbaceous layer, dominated by annual grasses and forbs, also occurs in the blue oak woodlands. Typical species include medusa-head, rattail grass, cheat, wild oat, silvery hairgrass, filaree, rose clover, and blue dicks (*Dichelostemma capitatum*).

Although blue oak woodlands are the dominant habitat type in the assessment area, their continued survival is threatened by a lack of regeneration. The blue oak, an apparently common and well-adapted species, is now regenerating poorly over much of its range likely due at least in part to the effects of livestock grazing and the invasion of non-native plant species, such as ripgut brome, soft brome, and yellow starthistle. (Swiecki and Bernhardt 1998). Gordon et al. (1989) suggested that competition for soil water with non-native annual species contributes to the increased rate of blue oak seedling mortality in California woodlands. Gordon and Rice (1993) found that soil water potential was negatively density-dependent (i.e., soil water potential decreased with increased density of herbaceous species) and remained highest when blue oaks were grown without competitors. Furthermore, Gordon and Rice (1993, 2000) concluded that blue oak seedling growth, gas exchange rates, and survivorship were negatively related to the rate and extent of soil water depletion that was, in part, due to soil water competition with non-native herbaceous plants.

Native species such as the blue oak depend on summer soil moisture reserves for growth and survival. Yellow starthistle, however, uses deep soil moisture reserves earlier than blue oak. Thus, when starthistle infestations are high, native species can experience drought conditions even in years with normal rainfall. (Weed Research and Information Center 2001.)

Specific information on the regeneration of blue oaks in the assessment area is not available; however, it is likely that many blue oak woodlands are slowly being lost as older trees die out.

Although blue oak woodlands are the dominant habitat type in the assessment area, their continued survival is threatened by a lack of regeneration. The blue oak…is now regenerating poorly over much of its range, likely due at least in part to the effects of livestock grazing and the invasion of non-native plant species.

Evidence suggests that oak trees are an important component of the ecosystem that serve a valuable role in retention of nutrients, which in turn contributes to long-term ecosystem sustainability. Blue oaks function to reduce surface runoff, water erosion, and stream water sediment, and they have been found to display a striking ability to enhance soil organic matter concentrations and nutrient pools beneath their canopies (Dahlgren et al. 1997). Thus, the loss of blue oak woodlands may lead to an increase in the amount of nutrients that find their way into surface waters in the assessment area.

In January 2005, an amendment to CEQA regarding the preservation of oak woodlands took effect. The amendment requires counties to make a specific effort to determine whether projects they consider may lead to a significant environmental impact as

Blue oak woodland is the dominant habitat in the assessment area. (Photo courtesy of North State Resources, Inc.)

a result of the conversion of oak woodlands. The bill adds Public Resources Code (PRC) 21083.4, which creates two new requirements for counties (it does not apply to other public agencies). First, counties must now determine whether or not a project may result in a conversion of oak woodlands that will have a significant effect. Second, if there may be a significant effect, they must employ specified mitigation measures.

Blue Oak–Foothill Pine

Blue oak–foothill pine is scattered throughout the assessment area. This habitat is somewhat similar to the blue oak woodlands, but has a much greater tree and shrub component. Dominant tree species include blue oak, foothill pine, and interior live oak. Additionally, shrub species diversity is greater than in the blue oak woodlands. Dominant shrubs include poison oak, white leaf manzanita, common manzanita, buckbrush, yerba santa (*Eriodictyon californicum*), birch-leaf mountain mahogany (*Cercocarpus betuloides*), toyon (*Heteromeles arbutifolia*), California redbud (*Cercis occidentalis*), and coffeeberry (*Rhamnus* sp.). The herbaceous layer is similar in composition to that of the blue oak woodlands; however, cover and species composition in this habitat is more variable.

Fresh Emergent Wetland

Although relatively uncommon, fresh emergent wetlands are scattered throughout the assessment area. This habitat generally occurs within the various small reservoirs, farm ponds, tailings ponds, and other small

Although relatively uncommon, fresh emergent wetlands are scattered throughout the assessment area. This habitat generally occurs within the various small reservoirs, farm ponds, tailings ponds, and other small marshy areas found in the assessment area.

marshy areas found in the assessment area. Occasionally, this wetland habitat occurs as a complex with valley-foothill riparian vegetation. Plant species composition, density, and cover varies, depending on many factors, including soil characteristics, upland slope and upstream gradient, water depth, and duration of inundation. Vegetative cover ranges from open water to areas with dense thickets or vegetative mats. Fresh emergent vegetation is characterized as a mixture of herbaceous annuals and perennials, emergent monocot species, and floating/submergent species. Typical species include spike rush (*Eleocharis macrostachya*), water montia (*Montia fontana*), hairy quillwort (*Marsilea vestita*), white water buttercup (*Ranunculus aquatilis*), beardgrass (*Polypogon* sp.), bermuda grass (*Cynodon dactylon*), ammannia (*Ammannia robusta*), lythrum (*Lythrum hyssopifolium*), narrow-leaved cattail (*Typha angustifolia*), waterweed (*Elodea* spp.), duckweed (*Lemna* spp.), knotweed (*Polygonum* spp.), rushes (*Juncus* spp.), sedges (*Carex* spp.), and bulrush (*Scirpus acutus*).

Mixed Chaparral

Mixed chaparral occurs in scattered locations throughout the assessment area, with the most extensive occurrences in the upper Churn Creek watershed. Mixed chaparral occurs as open to dense stands of shrubs or as small inclusions within other woodland habitats. Dominant species include whiteleaf manzanita, common manzanita, California redbud, buckbrush, poison-oak, birch-leaf mountain mahogany, and yerba santa. Brewer oak (*Quercus garryana* var. *breweri*), snowdrop bush (*Styrax officinalis*), and deerbrush (*Ceanothus integerrimus*) are common species components in the upper portion of the assessment area. The herbaceous layer is sparse to moderate and is dominated by various grasses and forbs.

Montane Hardwood

Montane hardwood habitat is scattered throughout the assessment area, with most occurrences in the upper and lower regions of the assessment area. Montane hardwood habitat includes nearly pure to mixed stands dominated by hardwood tree species with a variable understory. The dominant tree species depends on the geographic location. In the lower region of the assessment area, montane hardwood habitats are dominated by moderate to dense stands of interior live oak. In the upper region, the dominant species is canyon live oak (*Quercus chrysolepis*), although occasional interior live oak stands also occur. California black oak (*Quercus kelloggii*) is also a relatively common component within the montane hardwood habitats in the upper portion of the assessment area. Though uncommon, this species also occurs in several areas in the lower portion of the assessment area, and represents some of the lowest-elevation California black oak sites in California. In areas where both interior live oak and California black oak occur, oracle oak (*Quercus x morehus*), the somewhat rare hybrid species of these two oak trees, is present. Shrub species composition is variable, and may include poison-oak, whiteleaf manzanita, common manzanita, California redbud, buckbrush, and yerba santa. The herbaceous layer is sparse to moderate and is dominated by various grasses and forbs.

Montane Hardwood–Conifer

Montane hardwood–conifer habitat occurs in the upper region of the assessment area. This habitat includes a variable mixture of conifer

and hardwood overstory trees with an open to dense understory. Dominant conifer species include ponderosa pine (*Pinus ponderosa*) and foothill pine. Hardwood composition varies and includes interior live oak, California black oak, canyon live oak, blue oak, and occasional big-leaf maple (*Acer macrophyllum*). Shrub species composition varies and includes whiteleaf manzanita, western redbud, buckbrush, poison oak, birch-leaf mountain mahogany, brewer oak, California hazelnut (*Corylus cornuta* var. *californica*), and California buckeye (*Aesculus californica*). The herbaceous layer is sparse to moderate and is dominated by various grasses and forbs.

Ponderosa Pine

Ponderosa pine habitat is uncommon in the assessment area, occurring in the upper portion at the Shasta Lake divide. This habitat is characterized by open to dense conifer stands dominated by ponderosa pine. Associated tree species include foothill pine, canyon live oak, California black oak, and occasional big-leaf maple. Shrub species present include California redbud, buckbrush, poison oak, snowdrop bush, and whiteleaf manzanita. The herbaceous layer is moderate and is dominated by various grasses and forbs.

Urban

Urban habitat in the assessment area consists of areas that are characterized as urban, commercial, suburban, and, in some cases, rural residential. Generally, these areas include homes and commercial development, but may also include parks, yards, cemeteries, and all associated landscaping. Small "woodlots" or other native vegetation areas may also occur as small inclusions within this habitat type. Urban is a relatively common habitat in the assessment area, encompassing approximately 17 percent of the assessment area. Urban habitat in the assessment area is continuing to increase. The largest urban areas in the assessment area include the cities of Redding and Shasta Lake and their vicinities.

Valley-Foothill Riparian

Valley-foothill riparian habitat is scattered throughout the assessment area, and is generally associated with the various streams. This habitat is variable in distribution and extent within the assessment area occurring as thin stringers or patches along small drainages, ditches, and streams, as well as large corridors growing along various creeks and the Sacramento River. Occasionally, riparian habitat occurs as a complex with fresh emergent wetland vegetation. The valley-foothill riparian habitats in the assessment area represent the northernmost occurrences of this habitat type in California.

Dominant tree species include Fremont cottonwood (*Populus fremontii*), shining willow (*Salix lasiandra*), black willow (*Salix gooddingii*), valley oak (*Quercus lobata*), Oregon ash (*Fraxinus latifolia*), white alder (*Alnus rhombifolia*), and red willow (*Salix laevigata*). The understory varies from open to very dense and includes trees and shrubs such as sandbar willow (*Salix exigua*), Himalayan blackberry (*Rubus discolor*), California blackberry (*Rubus ursinus*), mugwort (*Artemisia douglasiana*), California buckeye, coffeeberry (*Rhamnus* spp.), blue elderberry (*Sambucus mexicana*), California button-willow (*Cephalanthus occidentalis*), spicebush (*Calycanthus occidentalis*), mock orange (*Philadelphus sp.*), ninebark (*Physocarpus capitatus*), western azalea (*Rhododendron occidentale*), and mule fat (*Baccharis salicifolia*). Common lianas (vines) include California grape (*Vitis californica*),

pipevine (*Aristolochia californica*), and virgin's bower (*Clematis ligusticifolia*). The ground layer is typically moderate to dense and is dominated by rushes (*Juncus* spp.) and sedges (*Carex* spp.) along with various grasses and forbs.

Valley Oak Woodland

Valley oak woodland is an uncommon habitat in the assessment area, generally occurring on historic or current alluvial floodplain terraces, typically in valley bottom areas. In the assessment area, most of these woodlands occur in the lower portion in areas associated with lower Churn Creek and the Sacramento River, and in the middle portion along Stillwater Creek. Somewhat small stands of valley oak also occur in the upper portion of the assessment area between the City of Shasta Lake and Mountain Gate. These occurrences represent the northernmost valley oak woodland stands in California.

Dominant species in this habitat include valley oak with occasional interior live oak, blue oak, and foothill pine. The understory ranges from open to moderate and includes poison-oak, blue elderberry, California wild grape, coffeeberry, California blackberry, and Himalayan blackberry. The herbaceous layer is moderate to dense and is dominated by various grasses and forbs.

3.8.2 Sensitive Botanical Resources

As previously described, the assessment area includes a wide variety of vegetative communities and habitat components that support a large diversity of plant species, including several known and many potentially occurring sensitive botanical resources. To aid in determining occurrences of sensitive botanical resources, a list of sensitive plant species known to occur or potentially occurring in the assessment area was developed.

For the purposes of this assessment, sensitive plant species are vascular plants that are (1) designated as rare or listed as threatened or endangered under Endangered Species Act (ESA) or California Endangered Species Act (CESA); or (2) are proposed for rare, threatened, or endangered status; and/or (3) are state or federal candidate species for listing as threatened or endangered; and/or (4) are included on the California Native Plant Society (CNPS) List 1A, 1B, 2, 3, or 4. The U.S. Forest Service (USFS) and Bureau of Land Management (BLM) also maintain a list of sensitive species occurring on lands under their authority. However, only a small portion (approximately 4.3%) of the assessment area is managed by these agencies. Therefore, for the purposes of this assessment, USFS and BLM sensitive species are not included in the discussion of sensitive plants below.

Valley oak woodland is an uncommon habitat in the assessment area, generally occurring on historic or current alluvial floodplain terraces, typically in valley bottom areas. In the assessment area, most of these woodlands occur in the lower portion in areas associated with lower Churn Creek and the Sacramento River, and in the middle portion along Stillwater Creek.

Potentially occurring sensitive plant species were determined in part using several database searches, a request for and review of USFWS species lists for Shasta County and for the 7.5-minute USGS quadrangles that encompass the assessment area boundary

(U.S. Fish and Wildlife Service 2005), and professional experience within the assessment area and vicinity. The most current lists of sensitive plant species were reviewed to confirm the present status of these species (California Department of Fish and Game 2006a, 2006b).

The California Natural Diversity Database (CNDDB) was reviewed for records of sensitive plant species within or near the assessment area. Specifically, the CNDDB was reviewed for records of sensitive plant species within the assessment area boundary and within 5 miles of the boundary. The CNDDB is a database consisting of historical observations of sensitive plant species, wildlife species, and special plant communities. The CNDDB also includes the Natural Communities Program that maintains records of California's rare natural plant communities. Special plant communities included in this program are also considered sensitive plant resources for the purposes of this evaluation. While the CNDDB reports sightings, it is not a comprehensive list of plant and wildlife species that may occur in a particular area.

Additional database searches were conducted using the CNPS Electronic Inventory. The Electronic Inventory allows users to query the Inventory of Rare and Endangered Vascular Plants of California (California Native Plant Society 2005) using a set of variable search criteria. The criteria used for the CNPS query included all CNPS List 1A, 1B, 2, 3, and 4 plants occurring in Shasta County in the vegetation communities and elevational range occurring in the assessment area and vicinity.

Based on the evaluation criteria for potentially sensitive plant species, the database searches, and the habitat characteristics and attributes in the assessment area, it was determined that 55 sensitive plant species are known to occur or potentially occur in the assessment area. These 55 species are summarized in Table 3.8-2. Additionally, the CNDDB contains records of four special plant communities: Great Valley Cottonwood Riparian Forest, Great Valley Mixed Riparian Forest, Great Valley Valley Oak Riparian Forest, and Great Valley Willow Scrub.

Vernal pools in the watershed have been designated critical habitat for vernal pool species such as slender Orcutt grass. (Photo courtesy of North State Resources, Inc.)

The locations of known special-status plant species occurrences and special plant communities reported by the CNDDB are shown in Figure 3.8-2, Locations of Special-status Plants and Special Plant Communities in the CNDDB. Many of the special-status plant species and special plant community occurrences in the assessment area represent the northernmost locations of these species in California.

…55 sensitive plant species are known to occur or potentially occur in the assessment area.

In addition to sensitive plant species, the assessment area contains federally designated critical habitat for vernal pool species, including the federally listed slender Orcutt grass (Orcuttia tenuis). Critical habitat is defined in Section 3(5)(A) of the Federal ESA as "(i) the specific areas within the geographical area occupied by a species, at the time it is listed in accordance with the ESA, on which are found those physical or biological features (I) essential to the conservation of the species and (II) that may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by a species at the time it is listed, upon a determination that such areas are essential for the conservation of the species." The designation of critical habitat directly affects only federal agencies, by prohibiting actions they fund, authorize, or carry out from destroying or adversely modifying critical habitat. Individuals, businesses, and other non-federal entities are not affected by the designation of critical habitat so long as their actions do not require a permit, a license, funding, or other support from a federal agency.

The critical habitat for vernal pool species within the assessment area boundary is shown in Figure 3.8-3, Boundaries of Critical Habitat for Vernal Pool Species.

Holland (1998) estimated that almost three-quarters of vernal pool habitats in the Central Valley of California had been lost by 1997. … In recent years, vernal pool habitats have been lost primarily due to widespread urbanization. In the assessment area, vernal pool habitat is concentrated to the south, in the Stillwater Plains and along the Churn Creek terrace.

Vernal pools are a unique kind of wetland ecosystem. Vernal pool habitat is dependent upon specific soil and climatic conditions and supports flora and fauna that are specifically adapted to its unique inundation and desiccation patterns. Many California vernal pool species are found nowhere else in the world.

Further, while most of California's grasslands are now dominated by non-native plant species, vernal pools remain a haven for native plants, with 75-90 percent of plant species found in vernal pools being native (Holland and Jain 1988, Jokerst 1990, Spencer and Rieseberg 1998). However, when exotic grasses in the uplands are ungrazed for several years, vernal pool margin and swale natives experience microhabitat conversion due primarily to shading from the build-up of thatch. The grass thatch inhibits the germination of native annuals, but has little if any retarding effect on the germination and growth of exotic grasses (U.S. Fish and Wildlife Service 2004).

Holland (1998) estimated that almost three-quarters of vernal pool habitats in the Central Valley of California had been lost by 1997. Historically, much of this loss was a result of the conversion of vernal pools to agriculture and water conveyance and storage projects (Frayer et al. 1989, Kreissman 1991). In recent years, vernal pool habitats have been lost primarily due to widespread urbanization. In the assessment area, vernal pool habitat is concentrated to the south, in the Stillwater Plains and along the Churn Creek terrace (Figure 3.8-4, Vernal Pool Habitat in the Assessment Area).

Table 3.8-2
Special-Status Plant Species Potentially Occurring in the Stillwater–Churn Creek Watershed

Common Name *(Scientific Name)*	Current Status[1]	Habitat[2]	Comments
Shasta ageratina *(Ageratina shastensis)*	CNPS 4	BAR, BOP, MHC	Potentially occurring in limestone outcrop habitats. Known from the Shasta Lake area.
Henderson's bent grass *(Agrostis hendersonii)*	CNPS 3	AGS, BOW, BOP	Potentially occurring in vernal pool and other seasonal wetland habitats. Known occurrences within the lower Stillwater Creek and Churn Creek watersheds.
Sanborn's onion *(Allium sanbornii)*	CNPS 4	BOP, MCH, MHC	Potentially occurring in chaparral, cismontane woodland, and lower montane coniferous forest habitats. Known nearby occurrence on Oasis Road, where it occurs with *Astragalus pauperculus* and *Eriogonum tripodum*.
Bent-flowered fiddleneck *(Amsinckia lunaris)*	CNPS 1B	AGS, BOP, MHC	Potentially occurring in cismontane woodland and valley and foothill grassland habitats. Known from the Shasta Lake area
Mallory's manzanita *Arctostaphylos malloryi*	CNPS 4	MCH, MHC, PPN	Potentially occurring in chaparral and lower montane coniferous forest habitats.
Shasta County arnica *(Arnica venosa)*	CNPS 4	BOP, MHC, PPN	Potentially occurring in cismontane woodland and lower montane coniferous forest habitats. Known from the Shasta Lake area.
Marbled wild ginger *(Asarum marmoratum)*	CNPS 2	MHC, PPN	Potentially occurring in lower montane coniferous forest habitats. Known occurrence in the upper Sacramento River Canyon.
Depauperate milk-vetch *(Astragalus pauperculus)*	CNPS 4	AGS, BOP, MCH, MHC	Potentially occurring in chaparral, cismontane woodland, and valley and foothill grassland habitats. Known nearby occurrence on Oasis Road, where it occurs with *Allium sanbornii* and *Eriogonum tripodum*.
Moonwort *(Botrychium minganese)*	CNPS 2	BOP, MHC	Potentially occurring in hardwood-conifer and cismontane woodland habitats.
Moonwort *(Botrychium montanum)*	CNPS 2	BOP, MHC	Potentially occurring in hardwood-conifer and cismontane woodland habitats.
Callahan's mariposa lily *(Calochortus syntrophus)*	CNPS 3	BOP, MHC, PPN	Potentially occurring in cismontane woodland and lower montane coniferous forest habitats. Known occurrence from the lower Pit River watershed.
Butte County morning-glory *(Calystegia atriplicifolia* ssp. *buttensis)*	CNPS 1B	MCH, MHC, PPN	Potentially occurring in chaparral and lower montane coniferous forest habitats.

Table 3.8-2
Special-Status Plant Species Potentially Occurring in the Stillwater–Churn Creek Watershed

Common Name *(Scientific Name)*	Current Status[1]	Habitat[2]	Comments
Buxbaum's sedge *(Carex buxbaumii)*	CNPS 4	FEW, VRI	Potentially occurring in marsh and riparian habitats.
Bristly sedge *(Carex comosa)*	CNPS 2	AGS, FEW, VRI	Potentially occurring in marsh, riparian, and valley and foothill grassland habitats.
Geyer's sedge *(Carex geyeri)*	CNPS 4	MHC, PPN	Potentially occurring in lower montane coniferous forest habitats. Known occurrence in the upper Sacramento River Canyon.
Bottlebrush sedge *(Carex hystericina)*	CNPS 2	FEW, VRI	Potentially occurring in marsh and riparian habitats.
Flaccid sedge *(Carex leptalea)*	CNPS 2	FEW, VRI	Potentially occurring in marsh and riparian habitats.
Pointed broom sedge *(Carex scoparia)*	CNPS 2	FEW, VRI	Potentially occurring in marsh and riparian habitats. Known occurrence in the nearby Anderson/Balls Ferry area.
Fox sedge *(Carex vulpinoidea)*	CNPS 2	FEW, VRI	Potentially occurring in marsh and riparian habitats. Many nearby occurrences in the Anderson and Balls Ferry area.
Shasta clarkia *(Clarkia borealis* ssp. *arida)*	CNPS 1B	BOP, MHC, PPN	Potentially occurring in cismontane woodland and lower montane coniferous forest habitats.
Northern clarkia *(Clarkia borealis* ssp. *borealis)*	CNPS 1B	MCH, MHC, PPN	Potentially occurring in chaparral, cismontane woodland, and lower montane coniferous forest habitats. Known nearby occurrence along the lower McCloud Arm of Lake Shasta.
Silky cryptantha *(Cryptantha crinita)*	CNPS 1B	AGS, BOW, BOP, MHC, VRI, VOW	Potentially occurring in cismontane woodland, lower montane coniferous forest, riparian forest, riparian woodland, and valley and foothill grassland habitats (gravelly streambeds). Several known occurrences in the Stillwater Creek and Churn Creek watersheds.
California lady's-slipper *(Cypripedium californicum)*	CNPS 4	MHC, PPN	Potentially occurring in lower montane coniferous forest habitats.
Clustered lady's-slipper *(Cypripedium fasciculatum)*	CNPS 4	MHC, PPN	Potentially occurring in lower montane coniferous forest habitats.
Mountain lady's-slipper *(Cypripedium montanum)*	CNPS 4	BOP, MHC, PPN	Potentially occurring in cismontane woodland and lower montane coniferous forest habitats.

Table 3.8-2
Special-Status Plant Species Potentially Occurring in the Stillwater–Churn Creek Watershed

Common Name *(Scientific Name)*	Current Status[1]	Habitat[2]	Comments
Four-angled spikerush *(Eleocharis quadrangulata)*	CNPS 2	FEW, VRI	Potentially occurring in emergent marsh habitats and stock ponds. Several known occurrences in the mid- to lower Stillwater Creek and Churn Creek watersheds.
Tripod buckwheat *(Eriogonum tripodum)*	CNPS 4	AGS, BOP, MCH	Potentially occurring in chaparral, cismontane woodland, and valley and foothill grassland habitats. Known nearby occurrence on Oasis Road, where it occurs with *Allium sanbornii* and *Astragalus pauperculus*.
Butte County fritillary *(Fritillaria eastwoodiae)*	CNPS 3	BOP, MCH, MHC, PPN	Potentially occurring in chaparral, cismontane woodland, and lower montane coniferous forest habitats. Known nearby occurrences in the lower Squaw Creek and lower Pit River watersheds.
Boggs Lake hedge-hyssop *(Gratiola heterosepala)*	CE, CNPS 1B	AGS, BOW, BOP	Potentially occurring in vernal pool and other seasonal wetland habitats.
Vanilla-grass *(Hierochloe odorata)*	CNPS 2	FEW, VRI	Potentially occurring in marsh and riparian woodland habitats. Known occurrence in upper Sacramento River Canyon.
Red Bluff dwarf rush *(Juncus leiospermus* var. *leiospermus*)	CNPS 1B	AGS, BOW, BOP	Potentially occurring in vernal pool and other seasonal wetland habitats. Several known occurrences in the mid- and lower Stillwater Creek and Churn Creek watersheds.
Dubious pea *(Lathyrus sulphureus* var. *argillaceus)*	CNPS 3	BOP, MHC, PPN	Potentially occurring in cismontane woodland and lower montane coniferous forest habitats.
Legenere *(Legenere limosa)*	CNPS 1B	AGS, BOW, BOP	Potentially occurring in vernal pool and other seasonal wetland habitats. Known occurrences in the lower Stillwater Creek watershed.
Cantelow's lewisia *(Lewisia cantelovii)*	CNPS 1B	BAR, BOP, MCH, MHC, PPN	Potentially occurring in chaparral, cismontane woodland, and lower montane coniferous forest habitats. Known nearby occurrence along the upper Sacramento River arm of Shasta Lake.
Howell's lewisia *(Lewisia cotyledon* var. *howellii)*	CNPS 3	BAR, BOP, MCH, MHC, PPN	Potentially occurring in chaparral, cismontane woodland, and lower montane coniferous forest habitats. Known from the lower McCloud River watershed.
Bellinger's meadowfoam *(Limnanthes floccosa* ssp. *bellingeriana)*	CNPS 1B	BOP, MHC	Potentially occurring in cismontane woodland habitats.

Table 3.8-2
Special-Status Plant Species Potentially Occurring in the Stillwater–Churn Creek Watershed

Common Name *(Scientific Name)*	Current Status[1]	Habitat[2]	Comments
Awl-leaved navarretia *(Navarretia subuligera)*	CNPS 4	BOP, MCH, MHC, PPN	Potentially occurring in chaparral, cismontane woodland, and lower montane coniferous forest habitats.
Shasta snow-wreath *(Neviusia cliftonii)*	CNPS 1B	BOP, MHW, MHC, PPN, VRI	Shasta County endemic species. Potentially occurring in the vicinity of limestone, and in cismontane woodland, lower montane coniferous forest, and riparian woodland habitats. Known occurrence in the upper Stillwater Creek watershed; also several nearby known occurrences along the lower McCloud and Pit River arms of Lake Shasta.
Northern adder's-tongue *(Ophioglossum pusillum)*	CNPS 2	AGS, FEW	Potentially occurring in marsh, swamp, and grassland (mesic) habitats.
Slender Orcutt grass *(Orcuttia tenuis)*	FT, CE, CNPS 1B	AGS, BOW, BOP	Potentially occurring in vernal pool and other seasonal wetland habitats. Several known occurrences in the mid- and lower Stillwater Creek watershed.
Ahart's paronychia *(Paronychia ahartii)*	CNPS 1B	AGS, BOW	Potentially occurring in vernal pool and other seasonal wetland habitats, and seasonally mesic grassland habitats. Known nearby occurrences in the Millville Plains area.
Narrow-petaled rein orchid *(Piperia leptopetala)*	CNPS 4	BOP, MHC, PPN	Potentially occurring in cismontane woodland and lower montane coniferous forest habitats.
Bidwell's knotweed *(Polygonum bidwelliae)*	CNPS 4	BOP, MCH, MHC, PPN	Potentially occurring in chaparral, cismontane woodland, and lower montane coniferous habitats.
White-beaked rush *(Rhynchospora alba)*	CNPS 2	FEW, VRI	Potentially occurring in marsh and riparian woodland habitats.
Brownish beaked-rush *(Rhynchospora capitellata)*	CNPS 2	FEW, MHC, PPN	Potentially occurring in lower montane coniferous forest and marsh habitats.
Hoary gooseberry *(Ribes roezlii* var. *amictum)*	CNPS 4	BOP, MHC, PPN	Potentially occurring in cismontane woodland and lower montane coniferous forest habitats.
Marsh skullcap *(Scutellaria galericulata)*	CNPS 2	FEW, MHC, PPN	Potentially occurring in lower montane coniferous forest and marsh habitats.
Canyon Creek stonecrop *(Sedum paradisum)*	CNPS 1B	MCH, MHC, PPN	Potentially occurring in chaparral and lower montane coniferous forest habitats.

Table 3.8-2
Special-Status Plant Species Potentially Occurring in the Stillwater–Churn Creek Watershed

Common Name *(Scientific Name)*	Current Status[1]	Habitat[2]	Comments
English Peak greenbriar *(Smilax jamesii)*	CNPS 1B	FEW, MHC, PPN	Potentially occurring in lower montane coniferous forest, and marsh habitats. Known nearby occurrences in lower Pit River watershed.
Small bur-reed *(Sparganium natans)*	CNPS 4	FEW	Potentially occurring in marsh habitats.
Obtuse starwort *(Stellaria obtusa)*	CNPS 4	MHC, PPN, VRI	Potentially occurring in lower montane coniferous forest and riparian woodland habitats.
Slender false lupine *(Thermopsis gracilis* var. *gracilis)*	CNPS 4	BOP, MCH, MHC, PPN	Potentially occurring in chaparral, cismontane woodland, and lower montane coniferous forest habitats. Known occurrences in the upper Stillwater Creek watershed; also several nearby known occurrences along the lower McCloud and Pit River arms of Lake Shasta.
Siskiyou false-hellbore *(Veratrum insolitum)*	CNPS 4	MCH, MHC, PPN	Potentially occurring in chaparral and lower montane coniferous forest habitats.
Oval-leaved viburnum *(Viburnum ellipticum)*	CNPS 2	MCH, MHC, PPN	Potentially occurring in chaparral, cismontane woodland, and lower montane coniferous forest habitats. Nearby known occurrence in the Jones Valley area of Shasta Lake.

[1]Status definitions:
FE = Federally listed as endangered
CE = State listed as endangered
CNPS 1B = CNPS List 1B
CNPS 2 = CNPS List 2
CNPS 3 = CNPS List 3
CNPS 4 = CNPS List 4

[2] Habitat designations as described in section 3.8.1. AGR = agricultural, AGS = annual grassland, BAR = barren, BOW = blue oak woodland, BOP = blue oak–foothill pine, FEW = fresh emergent wetland, MCH = mixed chaparral, MHW = montane hardwood, MHC = montane hardwood–conifer, PPN = ponderosa pine, URB = urban, VRI = valley-foothill riparian, VOW = valley oak woodland.

In 1996, in an effort to secure threatened and restorable vernal pool resources, the Natural Resources Conservation Service (NRCS) purchased a perpetual conservation easement on 128 acres in the Stillwater Plains. In 2000, the 834-acre Stillwater Plains Mitigation Bank was established near this holding, thereby expanding protection for the core of the vernal pool ecosystem. Vernal pools are also protected within the Clover Creek Preserve south of Highway 44, and conservation easements have been established for the Highway 44 vernal pool complex north and south of Highway 44 between Stillwater and Clover creeks.

3.8.3 Non-native, Invasive Species and Noxious Weeds

The scientific community has come to view invasive species as posing serious threats to biological diversity, second only to the threats resulting from habitat loss and fragmentation

Sesbania infestation near Kids Kingdom at Enterprise Park. (Photo courtesy of Western Shasta Resource Conservation District.)

Giant reed on East Fork Stillwater Creek during flood conditions. (Photo courtesy of Western Shasta Resource Conservation District.)

(Bossard et al. 2000). Invasive species present complex management issues; even when the species are no longer being actively introduced, they continue to spread and invade new areas. Invasive species affect native species and habitats in several ways, including by altering nutrient cycles, fire frequency and/or intensity, and hydrologic cycles; by creating changes in sediment deposition and erosion; by dominating habitats and displacing native species; by hybridizing with native species; and by promoting non-native animal species (Bossard et al 2000).

The likelihood that additional invasive plant species will establish themselves successfully in the assessment area increases with continuing urban and suburban development, particularly in lands adjacent to watercourses. This development is invariably accompanied by a variety of non-native horticultural species used in landscaping, some of which have the potential to become invasive. Many invasive plants occurring in wildland settings are being further spread by the increase in disturbances associated with expanding development. Additionally, ponds and other water features such as drainages increasingly used in landscaping or associated with development are a potential source of invasive aquatic species, particularly considering that many watercourses in the assessment area that historically were dry during the summer months now experience perennial flows.

Several community groups . . . have implemented programs to actively remove some invasive species from certain locations in the assessment area.

The presence of some invasive plant species in the assessment area has recently been well documented. In 2004, the WSRCD prepared the Stillwater Creek Watershed Noxious Weed Inventory (WSRCD 2004).

This inventory shows that Stillwater Creek is experiencing alteration and degradation as a result of invasive plant species, particularly giant reed *(Arundo donax)*. Surveyors regularly observed Arundo infestations throughout the inventories they conducted on mainstem Stillwater Creek beginning at the confluence of the East and West Forks of Stillwater Creek, and ending at the mainstem's confluence with the Sacramento River. It was concluded that mainstem Stillwater Creek is most likely infested with Arundo throughout its entire length. The lower reaches of East Fork Stillwater Creek were also found to be infested, with Arundo creating a solid wall of vegetation on both sides of the creek in some reaches. Salmon Creek and Clough Creek were found to be free of Arundo.

Several community groups, for example, the Redding Rotary Stream Team, have recently identified additional invasive species [e.g., tree-of-heaven (*Ailanthus altissima*) and scotch broom (*Cytisus scoparius*)] and specific occupied sites and have implemented programs to actively remove some invasive species from certain locations in the assessment area.

The California Invasive Plant Council (Cal-IPC) is a non-profit organization founded in 1992 that proposes and facilitates solutions to problems caused by invasive plants. Cal-IPC has created a list of Exotic Pest Plants of Greatest Ecological Concern in California (Cal-IPC 1999), which highlights exotic plants that pose serious problems in wildland and urban areas. Many of the plant species included on this list are known to occur in the assessment area. These species are described in Table 3.8-3.

Table 3.8-3
Exotic Pest Plants of Greatest Ecological Concern Occurring in the Stillwater–Churn Creek Watershed

Common Name *(Scientific Name)*	Current Cal-IPC Status[1]	Habitat[2]	Comments
Giant reed *(Arundo donax)*	List A-1	Aquatic	Known to occur throughout Stillwater Creek and Churn Creek.
Yellow star-thistle *(Centaurea solstitialis)*	List A-1	Upland	Common throughout the Stillwater Creek and Churn Creek watersheds, particularly in previously disturbed woodland, grassland, and agricultural areas.
Pampas grass *(Cortaderia selloana)*	List A-1	Upland	Relatively common as an ornamental species. Potentially occurring within wildland settings.
Scotch broom *(Cytisus scoparius)*	List A-1	Upland	Known to occur within the Stillwater Creek and Churn Creek watersheds, but is not currently widespread. Shasta County has recently implemented eradication efforts for this and other broom species along Shasta Dam Boulevard and the I-5 corridor.
French broom *(Genista monspessulana)*	List A-1	Upland	Known to occur within the upper Churn Creek watershed. Shasta County has recently implemented eradication efforts for this and other broom species along Shasta Dam Boulevard and the I-5 corridor.
Perennial pepperweed *(Lepidium latifolium)*	List A-1	Upland	Known to occur within the Stillwater Creek and Churn Creek watersheds, but is not currently widespread.
Himalayan blackberry *(Rubus discolor)*	List A-1	Aquatic	Common throughout the Stillwater Creek and Churn Creek watersheds, particularly in riparian and agricultural areas.
Medusa-head grass *(Taeniatherum caput-medusae)*	List A-1	Upland	Common throughout the Stillwater Creek and Churn Creek watersheds, particularly in previously disturbed woodland, grassland, and agricultural areas.
Salt cedar *(Tamarix* sp.)	List A-1	Aquatic	Known to occur within the Stillwater Creek and Churn Creek watersheds, but is not currently widespread.
Tree-of-heaven *(Ailanthus altissima)*	List A-1	Aquatic/ upland	Common throughout the Stillwater Creek and Churn Creek watersheds, particularly in riparian areas.
Red brome *(Bromus madritensis* ssp. *rubens)*	List A-2	Upland	Known to occur within the Stillwater Creek and Churn Creek watersheds, but is not currently widespread.
Edible fig *(Ficus carica)*	List A-2	Aquatic/ upland	Known to occur within the Stillwater Creek and Churn Creek watersheds, but is not currently widespread.
Pennyroyal *(Mentha pulegium)*	List A-2	Aquatic	Common throughout the Stillwater Creek and Churn Creek watersheds, particularly in marsh, seasonal wetland, irrigated pastures, and riparian habitats.
Bouncing bet *(Saponaria officinalis)*	List A-2	Upland	Known to occur within the Stillwater Creek watershed.

Table 3.8-3
Exotic Pest Plants of Greatest Ecological Concern Occurring in the Stillwater–Churn Creek Watershed

Common Name *(Scientific Name)*	Current Cal-IPC Status[1]	Habitat[2]	Comments
Black mustard *(Brassica nigra)*	List B	Upland	Common throughout the Stillwater Creek and Churn Creek watersheds, particularly in previously disturbed woodland, grassland, and agricultural areas.
Italian thistle *(Carduus pycnocephalus)*	List B	Upland	Known to occur within the Stillwater Creek watershed. Rapidly becoming more widespread in rights-of-way and dry pastures.
Bull thistle *(Cirsium vulgare)*	List B	Aquatic/ upland	Known to occur throughout the Stillwater Creek and Churn Creek watersheds.
Veldt grass *(Ehrharta erecta)*	List B	Upland	Known to occur within the Stillwater Creek and Churn Creek watersheds, but is not currently widespread.
Tall fescue *(Festuca arundinacea)*	List B	Upland	Known to occur within the Stillwater Creek and Churn Creek watersheds, but is not currently widespread.
English ivy *(Hedera helix)*	List B	Upland	Relatively common as an ornamental species. Potentially occurring within wildland settings.
Velvet grass *(Holcus lanatus)*	List B	Upland	Known to occur within the Stillwater Creek and Churn Creek watersheds, but is not currently widespread.
St. John's wort *(Hypericum perforatum)*	List B	Upland	Known to occur within the Stillwater Creek and Churn Creek watersheds.
Yellow water iris *(Iris pseudoacacia)*	List B	Aquatic	Known to occur within the Stillwater Creek and Churn Creek watersheds. Invasive plant in aquatic habitats.
Parrot's feather *(Myriophyllum aquaticum)*	List B	Aquatic	Occurs throughout the Stillwater Creek and Churn Creek watersheds in marsh, pond, and ditch habitats.
Harding grass *(Phalaris aquatica)*	List B	Upland	Known to occur within the Stillwater Creek and Churn Creek watersheds, but is not currently widespread.
Curlyleaf pondweed *(Potamogeton crispus)*	List B	Aquatic	Occurs throughout the Stillwater Creek and Churn Creek watersheds in marsh, pond, ditch, and riverine habitats.
Black locust *(Robinia pseudoacacia)*	List B	Aquatic/ upland	Occurs within the Stillwater Creek and Churn Creek watersheds, particularly in riparian areas.
Common mullein *(Verbascum thapsus)*	List B	Aquatic/ upland	Known to occur within the Stillwater Creek and Churn Creek watersheds.
Periwinkle *(Vinca major)*	List B	Upland	Known to occur within the Stillwater Creek and Churn Creek watersheds.
Hydrilla *(Hydrilla verticillata)*	Red alert	Aquatic	Potentially occurring in marsh, pond, and ditch habitats. Previous eradication efforts have occurred in gravel ponds within the lower Churn Creek watershed.

Table 3.8-3
Exotic Pest Plants of Greatest Ecological Concern Occurring in the Stillwater–Churn Creek Watershed

Common Name *(Scientific Name)*	Current Cal-IPC Status[1]	Habitat[2]	Comments
Chinese tallow tree *(Sapium sebiferum)*	Red alert	Upland	Known to occur within the Stillwater Creek and Churn Creek watersheds.
Scarlet wisteria tree *(Sesbania punicea)*	Red alert	Upland	Known to occur within the Stillwater Creek and Churn Creek watersheds.
Rough cat's-ear *(Hypochaeris radicata)*	Need more information	Aquatic/ upland	Common throughout the Stillwater Creek and Churn Creek watersheds, particularly in vernal pool and other seasonal wetlands, and riparian habitats.
No common name *(Parentucellia viscosa)*	Need more information	Upland	Known to occur within the Stillwater Creek watershed.
Chinese pistache *(Pistacia chinensis)*	Need more information	Upland	Known to occur within the Stillwater Creek and Churn Creek watersheds.
Pyracantha *(Pyracantha angustifolia)*	Need more information	Upland	Known to occur within the Stillwater Creek and Churn Creek watersheds.
Tall vervain *(Verbena bonariensis)*	Need more information	Upland	Known to occur within the Stillwater Creek and Churn Creek watersheds.
Slender wild oat *(Avena barbata)*	Annual grasses	Upland	Common throughout the Stillwater Creek and Churn Creek watersheds, particularly in previously disturbed woodland, grassland, and agricultural areas.
Wild oat *(Avena fatua)*	Annual grasses	Upland	Common throughout the Stillwater Creek and Churn Creek watersheds, particularly in previously disturbed woodland, grassland, and agricultural areas.
Rip-gut brome *(Bromus diandrus)*	Annual grasses	Upland	Common throughout the Stillwater Creek and Churn Creek watersheds, particularly in previously disturbed woodland, grassland, and agricultural areas.
Italian ryegrass *(Lolium multiflorum)*	Annual grasses	Aquatic/ upland	Common throughout the Stillwater Creek and Churn Creek watersheds, particularly in irrigated pastures, seasonal wetlands, and riparian habitats.

[1]Status definitions:
List A-1: Most invasive wildland pest plants, widespread; List A-2: Most invasive wildland pest plants, regional;
List B: Wildland pest plants of lesser invasiveness; Red alert: Species with potential to spread explosively; infestations currently restricted.
More information needed: Species about which more information is needed; Annual grasses: Annual grass species.

[2] Habitat designations as described in Section 3.8 of this document; however, for simplicity these habitat types have been lumped into either an Aquatic or Upland sub-classification. Aquatic = fresh emergent wetland and valley-foothill riparian. Upland = agricultural, annual grassland, barren, blue oak woodland, blue oak–foothill pine, mixed chaparral, montane hardwood, montane hardwood–conifer, ponderosa pine, urban, and valley oak woodland.

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3.9 Wildlife Resources

The watershed assessment area encompasses a wide diversity of vegetation communities that provide habitat for many wildlife species. The assessment area includes the northernmost portion of the Sacramento Valley in the south and extends to the mountainous region at the Shasta Lake divide to the north. Because of the transitional geographic location of the assessment area, the area supports a diverse assemblage of wildlife species, including a mixture of species typically found in the Central Valley, foothill, and low- to mid-elevation mountainous regions of northern California.

This section describes the wildlife habitat and terrestrial and aquatic species present in the assessment area. In addition, it discusses sensitive wildlife resources and other important wildlife issues.

3.9.1 Wildlife Habitats

Wildlife habitats in the assessment area were characterized using vegetation mapping information available from the LCMMP. As previously described, the LCMMP provides a data set that has been "cross-walked" from CALVEG into the classification system described in Mayer and Laudenslayer (1988), which was developed for use with CDFG's CWHR system. The CWHR system is commonly used to describe wildlife habitats; it also provides a tool to predict wildlife species occurrences by geographic location and habitat type.

The assessment area is characterized by CWHR habitats typical of the northern Central Valley, foothill woodlands, and low-elevation forest habitats in northern California. The habitats in the assessment area include agricultural, annual grassland, barren, blue oak woodland, blue oak–foothill pine, ponderosa pine, mixed chaparral, montane hardwood, montane hardwood–conifer, urban, fresh emergent wetland, valley-foothill riparian, and valley oak woodland. Descriptions and a map of these habitats are presented in Section 3.8, Botanical Resources.

Because of the transitional geographic location of the assessment area, the area supports a diverse assemblage of wildlife species, including a mixture of species typically found in the Central Valley, foothill, and low- to mid-elevation mountainous regions of northern California.

To describe the diversity of wildlife species in the habitats occurring in the assessment area, the CWHR database system (version 8.0) was used. The CWHR is a predictive system based on scientific information concerning wildlife species and their habitat relationships. Fish and invertebrates are not included in the CWHR system. The goal of the CWHR habitat classification system is to identify and classify vegetation types important to wildlife, and to recognize and logically categorize major vegetative complexes at a scale sufficient to predict wildlife-habitat relationships. The CWHR model output is typically a list of wildlife species that potentially occur in an area, based on habitats present, habitat elements present, and geographic location. Thus, applications of CWHR include characterization of wildlife habitats and identification of special habitat elements occurring in a particular area.

The criteria used for the CWHR query for this watershed assessment included habitat type

(agricultural, annual grassland, barren, blue oak woodland, blue oak–foothill pine, ponderosa pine, mixed chaparral, montane hardwood, montane hardwood–conifer, urban, fresh emergent wetland, valley-foothill riparian, and valley oak woodland) and county (Shasta). All habitat stages were included, and no habitat elements were excluded. The query result provides a general index of wildlife species occurrences within the habitats present in the assessment area and a general idea of the relative value of these habitats in terms of wildlife species. Table 3.9-1 lists the wildlife species known or strongly suspected to occur in the assessment area based on a query of the CWHR database. The list generated by the database was reviewed and refined to include only those species known or strongly suspected to occur in the assessment area.

Table 3.9-1
Wildlife Species Potentially Occurring in the Assessment Area

Amphibians and Reptiles		
Pacific giant salamander	Western pond turtle	Racer
Rough-skinned newt	Western fence lizard	Striped racer
Ensatina	Sagebrush lizard	Gopher snake
Black salamander	Western skink	Common kingsnake
Shasta salamander	Western whiptail	California mountain kingsnake
Western spadefoot	Southern alligator lizard	Common garter snake
Western toad	Northern alligator lizard	Western terrestrial garter snake
Pacific chorus frog	Rubber boa	Western aquatic garter snake
Red-legged frog	Ringneck snake	Night snake
Foothill yellow-legged frog	Sharp-tailed snake	Western rattlesnake
Bullfrog		
Birds		
Pied-billed grebe	Red Phalarope	White-Breasted Nuthatch
Eared grebe	Bonaparte's Gull	Pygmy Nuthatch
Western grebe	Ring-Billed Gull	Brown Creeper
Clark's grebe	California Gull	Rock Wren
American whi'i'e pelican	Herring Gull	Canyon Wren
Double-crested cormorant	Thayer's Gull	Bewick's Wren
American bittern	Glaucous-Winged Gull	House Wren
Great blue heron	Caspian Tern	Winter Wren
Great egret	Forster's Tern	Marsh Wren
Snowy egret	Black Tern	American Dipper
Green heron	Rock Dove	Golden-Crowned Kinglet
Black-crowned night heron	Band-Tailed Pigeon	Ruby-Crowned Kinglet
Turkey vulture	Mourning Dove	Blue-Gray Gnatcatcher
Greater white-fronted goose	Greater Roadrunner	Western Bluebird
Snow goose	Barn Owl	Mountain Bluebird
Ross' goose	Flammulated Owl	Townsend's Solitaire

Table 3.9-1
Wildlife Species Potentially Occurring in the Assessment Area

Canada goose	Western Screech Owl	Swainson's Thrush
Tundra swan	Great Horned Owl	Hermit Thrush
Wood duck	Northern Pygmy Owl	American Robin
Gadwall	Burrowing Owl	Varied Thrush
Eurasian wigeon	Spotted Owl	Wrentit
American wigeon	Long-Eared Owl	Northern Mockingbird
Mallard	Short-Eared Owl	California Thrasher
Blue-winged teal	Northern Saw-Whet Owl	European Starling
Cinnamon teal	Lesser Nighthawk	American Pipit
Northern shoveler	Common Nighthawk	Cedar Waxwing
Northern pintail	Common Poorwill	Phainopepla
Green-winged teal	Black Swift	Orange-Crowned Warbler
Canvasback	Vaux's Swift	Nashville Warbler
Redhead	White-Throated Swift	Yellow Warbler
Ring-necked duck	Black-Chinned Hummingbird	Yellow-Rumped Warbler
Lesser scaup	Anna's Hummingbird	Black-Throated Gray Warbler
Bufflehead	Calliope Hummingbird	Townsend's Warbler
Common goldeneye	Rufous Hummingbird	Hermit Warbler
Barrow's goldeneye	Belted Kingfisher	Macgillivray's Warbler
Hooded merganser	Lewis' Woodpecker	Common Yellowthroat
Common merganser	Acorn Woodpecker	Wilson's Warbler
Ruddy duck	Red-Breasted Sapsucker	Yellow-Breasted Chat
Osprey	Nuttall's Woodpecker	Western Tanager
White-tailed kite	Downy Woodpecker	Spotted Towhee
Bald eagle	Hairy Woodpecker	California Towhee
Northern harrier	Northern Flicker	Rufous-Crowned Sparrow
Sharp-shinned hawk	Pileated Woodpecker	Chipping Sparrow
Cooper's hawk	Olive-Sided Flycatcher	Lark Sparrow
Red-shouldered hawk	Western Wood-Pewee	Sage Sparrow
Swainson's Hawk	Willow Flycatcher	Savannah Sparrow
Red-Tailed Hawk	Hammond's Flycatcher	Fox Sparrow
Ferruginous Hawk	Dusky Flycatcher	Song Sparrow
Rough-Legged Hawk	Pacific-Slope Flycatcher	Lincoln's Sparrow
Golden Eagle	Black Phoebe	White-Throated Sparrow
American Kestrel	Say's Phoebe	Harris's Sparrow
Merlin	Ash-Throated Flycatcher	White-Crowned Sparrow
Peregrine Falcon	Western Kingbird	Golden-Crowned Sparrow
Prairie Falcon	Loggerhead Shrike	Dark-Eyed Junco
Ring-Necked Pheasant	Northern Shrike	Black-Headed Grosbeak
Wild Turkey	Plumbeous Vireo	Blue Grosbeak
Mountain Quail	Cassin's Vireo	Lazuli Bunting
California Quail	Hutton's Vireo	Indigo Bunting
Virginia Rail	Warbling Vireo	Red-Winged Blackbird

Table 3.9-1
Wildlife Species Potentially Occurring in the Assessment Area

Sora	Steller's Jay	Tricolored Blackbird
Common Moorhen	Western Scrub-Jay	Western Meadowlark
American Coot	Yellow-Billed Magpie	Yellow-Headed Blackbird
Sandhill Crane	American Crow	Brewer's Blackbird
Killdeer	Common Raven	Brown-Headed Cowbird
Black-Necked Stilt	Horned Lark	Hooded Oriole
American Avocet	Purple Martin	Bullock's Oiuole
Greater Yellowlegs	Tree Swallow	Purple Finch
Willet	Violet-Green Swallow	Cassin's Finch
Spotted Sandpiper	Northern Rough-Winged Swallow	House Finch
Long-Billed Curlew	Bank Swallow	Red Crossbill
Western Sandpiper	Cliff Swallow	Pine Siskin
Least Sandpiper	Barn Swallow	Lesser Goldfinch
Baird's Sandpiper	Mountain Chickadee	Lawrence's Goldfinch
Dunlin	Chestnut-Backed Chickadee	American Goldfinch
Long-Billed Dowitcher	Oak Titmouse	Evening Grosbeak
Common Snipe	Bushtit	House Sparrow
Wilson's Phalarope	Red-Breasted Nuthatch	
Mammals		
Virginia Opossum	Western Mastiff Bat	Coyote
Vagrant Shrew	Brush Rabbit	Red Fox
Shrew-Mole	Black-Tailed Jackrabbit	Gray Fox
Broad-Footed Mole	California Ground Squirrel	Black Bear
Little Brown Myotis	Western Gray Squirrel	Ringtail
Yuma Myotis	Douglas' Squirrel	Raccoon
Long-Eared Myotis	Northern Flying Squirrel	Fisher
Fringed Myotis	Botta's Pocket Gopher	Ermine
Long-Legged Myotis	Western Pocket Gopher	Long-Tailed Weasel
California Myotis	California Kangaroo Rat	American Mink
Western Small-Footed Myotis	American Beaver	American Badger
Silver-Haired Bat	Western Harvest Mouse	Northern River Otter
Big Brown Bat	Deer Mouse	Western Spotted Skunk
Western Red Bat	Dusky-Footed Woodrat	Striped Skunk
Hoary Bat	Black Rat	Mountain Lion
Spotted Bat	House Mouse	Bobcat
Townsend's Big-Eared Bat	California Vole	Wild Pig
Pallid Bat	Common Muskrat	Elk (Introduced Rocky Mountain Subspecies)
Brazilian Free-Tailed Bat	Western Jumping Mouse	Mule Deer (Black-Tailed)

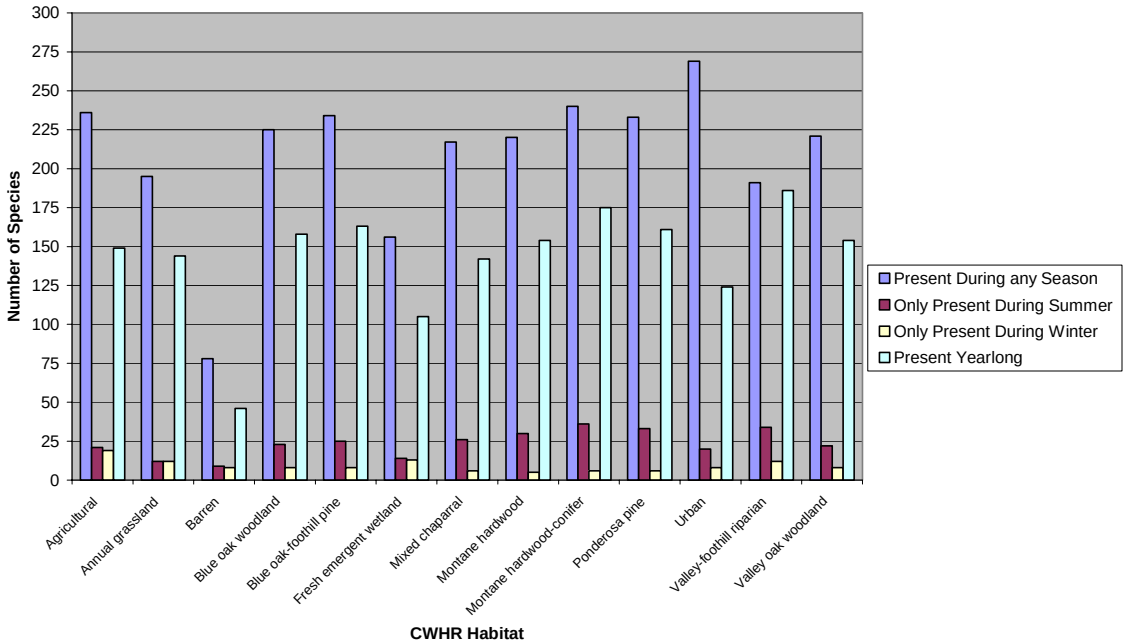
The relative values of habitats are also expressed in terms of the seasonal occurrences of wildlife species. The wildlife habitats and species relationships are depicted in Figure 3.9-1, Wildlife Species Richness and Seasonal Occurrence.

As shown in Figure 3.9-1, the habitats in the assessment area support many wildlife species. For all seasonal occurrences, urban, montane hardwood-conifer, and agricultural habitats support the largest number of species, although there is little overall variance among habitat types. In terms of true wildland habitats (i.e., not including urban and agricultural), montane hardwood–conifer, blue oak–foothill pine, and ponderosa pine support the largest number of species. For summer visitors and breeding species, montane hardwood–conifer, valley-foothill riparian, and ponderosa pine habitats support the largest number of species. Valley-foothill riparian, montane hardwood–conifer, and blue oak–foothill pine habitats support the largest number of species inhabiting the assessment area on a year-round basis (i.e., resident species).

Wildlife Habitat Fragmentation and Connectivity

For many species, the landscape is a mosaic of suitable and unsuitable habitat types. Environmental corridors are segments of land that provide a link between these different habitats while also providing cover. On a broader level, corridors also function as avenues along which wide-ranging animals can travel, plants can propagate, genetic interchange can occur, populations can move in response to environmental changes and natural disasters, and threatened species can be replenished from other areas. In California, environmental corridors often consist of riparian areas along streams, rivers, or other natural features. In addition, the rivers and streams themselves may serve as migration corridors for anadromous fish.

Figure 3.9-1
Wildlife Species Richness and Seasonal Occurrence
Within the Stillwater-Churn Creek Watershed by CWHR Habitat Type



Wildlife occurring in the assessment area have highly variable home ranges and related habitat requirements. The need for migration or other movement within or among habitats also varies. Small rodents, for example, may have a small home range, being able to meet all their biological needs in an area less than 1/4--acre in size. However, large ungulates, such as black-tailed deer (*Odocoileus hemonius*), may need a much larger area to meet all their biological needs. Thus, the presence of environmental corridors that allow movement between habitats is an important factor in the maintenance of wildlife populations and overall wildlife health.

Habitat conversion, commercial/residential development and related infrastructure and activities in the assessment area are all factors that affect habitat size and location, and the ability of wildlife to make use of habitats and persist in a given area. Roads, transmission lines, large tracts of residential homes, and commercial development may all result in partial or complete barriers to wildlife and certainly fragment wildlife habitat.

The continued presence of undeveloped or relatively undeveloped habitats throughout the watershed is an important factor for the continued maintenance of the wildlife populations that occur in the assessment area. These areas are also important for maintaining some level of habitat connectivity between the assessment area and adjacent watersheds.

Approximately 17 percent of the assessment area, predominately areas in and around the cities of Redding and Anderson, is highly urbanized. Additionally, a greater proportion of the assessment area has been converted to, and/or fragmented by, suburban and rural housing and other commercial development. As a result of conversion, urbanization, and other development, many wildlife species have been negatively affected; however, some show little or no effect and others may show a positive effect. Acorn woodpeckers (*Melanerpes formicivorus*), for example, are dependent on oak woodland and oak woodland-foothill pine habitats in the assessment area. This species is negatively affected by encroachment and urbanization due to the direct loss and fragmentation of these habitats, whereas house finches may thrive in urbanized or semi-urbanized habitats. Generally, the type of urbanization and related development occurring in the assessment area tends to negatively affect wildlife that require relatively large areas of habitat, while favoring species, including many non-native species, that are better adapted to smaller, fragmented, and/or urban habitats.

Relatively large undeveloped areas are scattered throughout the assessment area. The largest of these areas occur in the northern, northeastern, and eastern portions of the assessment area. The continued presence of undeveloped or relatively undeveloped habitats throughout the watershed is important for the continued maintenance of the wildlife populations that occur in the assessment area. These areas are also important for maintaining some level of habitat connectivity between the assessment area and adjacent watersheds.

3.9.2 SENSITIVE WILDLIFE RESOURCES

As previously described, the assessment area includes a wide variety of vegetation communities and habitat components that support a large diversity of wildlife species, including many sensitive wildlife species. To aid in assessing the status of sensitive wildlife

resources, a list of sensitive wildlife species known to occur, or to potentially occur, within the assessment area was developed.

For the purposes of this evaluation, sensitive wildlife species include species that are (1) listed as threatened or endangered under ESA or CESA; (2) are proposed or petitioned for federal listing as threatened or endangered; (3) are state or federal candidates for listing as threatened or endangered; and/or (4) are identified by the CDFG as species of special concern. For potentially occurring sensitive wildlife species, resident or breeding species are emphasized, although seasonally occurring (e.g., non-breeding species, spring or winter migrants) species are also included because habitats in the assessment area are important to many of these species as well. The USFS and BLM also maintain a list of sensitive species occurring on lands under their authority. However, only a small portion (approximately 4.3%) of the assessment area is managed by either of these agencies. Therefore, for the purposes of this assessment, USFS and BLM sensitive species are not included in the discussion of sensitive animals below.

Potentially occurring sensitive wildlife species were determined in part by several database searches, a request for and review of the USFWS species lists for Shasta County and for the 7.5-minute USGS quadrangles that encompass the assessment area boundary (U.S. Fish and Wildlife Service 2005), and professional experience within the assessment area and vicinity.

The CNDDB was reviewed for records of sensitive wildlife species within the assessment area and areas within 5 miles of the assessment area boundary. The CNDDB is a database consisting of historical observations of special-status plant species,

Black-tailed deer is a common species in the watershed. (Photo courtesy of Western Shasta Resource Conservation District.)

wildlife species, and special plant communities. It is limited to reported sightings and is not a comprehensive list of plant and wildlife species that may occur in a particular area.

The CWHR system was also queried to identify sensitive wildlife species that potentially occur in the habitats within the assessment area. These query results were then refined at the watershed-specific level to assist with development of the list of potentially occurring sensitive wildlife species. Finally, the most current lists of sensitive wildlife species were reviewed to confirm the present status of these species (California Department of Fish and Game 2005a, 2005b).

Based on the evaluation criteria for potential sensitive wildlife species, the database searches, and the habitat characteristics and attributes within the assessment area, 35 sensitive wildlife species are known to occur or were determined to potentially occur in the assessment area. These 35 species are

The Pacific fisher, which is a state species of concern and a candidate for federal listing under the Endangered Species Act, is found in the northern portion of the assessment area. (Photo courtesy of North State Resources, Inc.)

summarized in Table 3.9-2. The locations of known special-status wildlife species occurrences reported by the CNDDB are shown on Figure 3.9-2, Locations of Special-status Wildlife Species in the CNDDB.

As discussed in Section 3.8, vernal pools are a unique kind of wetland ecosystem. In California, where extensive areas of vernal pool habitat developed over a long geological timeframe, unique suites of animals have evolved that are specially adapted to the unusual conditions of vernal pools. Holland (1998) estimated that almost three-quarters of vernal pool habitats in the Central Valley of California had been lost by 1997. As a result, many of the species uniquely adapted to these vernal pool habitats have also experienced a severe decline, and have subsequently been listed as federally threatened or endangered. The assessment area contains areas of federally designated critical habitat for vernal pool species, including the federally listed vernal pool fairy shrimp and vernal pool tadpole shrimp. Critical habitat includes areas of habitat considered essential to the conservation of a listed species and often requires special management considerations or protection. The critical habitat in the assessment area for vernal pool species is shown on Figure 3.8-3.

3.9.3 OTHER WILDLIFE ISSUES

Non-Native Wildlife

Similar to non-native plants and invasive weeds, many non-native wildlife species occur throughout northern California, including in the assessment area. Commonly occurring non-native wildlife species within the assessment area include the bullfrog (*Rana catesbeiana*), Chinese ring-necked pheasant (*Phasianus colchicus*), wild turkey (*Meleagris gallopavo*), European starling (*Sturnus vulgaris*), brown-headed cowbird (*Molothrus ater*), house sparrow (*Passer domesticus*), opossum (*Didelphis virginiana*), black rat (*Rattus rattus*), house mouse (*Mus musculus*), and wild boar (*Sus scrofa*). Many of these non-native species are known to have detrimental impacts on native species and habitats. Bullfrogs, for example, are known to directly out-compete many native aquatic species, while European starlings are known to out-compete native bird species for critical nest cavities. Most non-native wildlife species occurrences have been established for quite some time; however, the continued encroachment by development and agriculture into wildland settings furthers the spread of many of these species, particularly on a local level.

Table 3.9-2
Special-Status Wildlife Species Potentially Occurring in the Assessment Area

Common Name *(Scientific Name)*	Status[1]	Habitat[2]	Comments
Vernal pool fairy shrimp (*Branchinecta lynchi)*	FT	AGR, AGS, BOW, BOP, MCH, MHW, URB, VOW	Potentially occurring in vernal pool and other seasonal wetland habitats. Known occurrences in mid- and lower Stillwater Creek and Churn Creek watersheds.
Vernal pool tadpole shrimp *(Lepidurus packardi)*	FE	AGR, AGS, BOW, BOP, MCH, MHW, URB, VOW	Potentially occurring in vernal pool and other seasonal wetland habitats. Known occurrences in mid- and lower Stillwater Creek and Churn Creek watersheds.
Valley elderberry longhorn beetle *(Desmocerus californicus dimorphus)*	FT	AGR, BOW, BOP, URB, VRI, VOW	Potentially occurring in riparian and upper floodplain terrace habitats that contain blue elderberry shrubs. Known from the nearby Turtle Bay area in Redding to the west and the Anderson/Balls Ferry area to the south. Potential habitat occurs throughout the Stillwater Creek and Churn Creek watersheds.
Shasta salamander *(Hydromantes shastae)*	CT	BAR, BOP, MCH, MHW, MHC, PPN	Shasta County endemic species. Potentially occurring in mixed-conifer, woodland, and chaparral habitats, especially near limestone. Occurs in the upper portion of the Stillwater Creek watershed.
Western spadefoot toad *(Spea hammondii)*	CSC	AGR, AGS, BOW	Potentially occurring in grassland habitats containing vernal pool and other seasonal wetland habitats. Known occurrence in the southeastern portion of the Stillwater Creek watershed is likely the northern-most occurrence for this species in California.
California red-legged frog *(Rana aurora draytonii)*	FT	AGR, AGS, BOW	Redding represents the northern extent of this species' historic range, although currently there are no known occurrences in the vicinity. Potentially occurring in emergent wetlands, stock ponds, and other wetland habitats.
Foothill yellow-legged frog *(Rana boylii)*	CSC	VRI	Potentially occurring in stream and associated riparian habitats. Potentially occurring in riverine habitats, although likely limited to upper portions of Stillwater Creek and Churn Creek watersheds. Many known nearby occurrences in tributaries to Shasta Lake.
Northwestern pond turtle *(Clemmys marmorata marmorata)*	CSC	AGR, FEW, URB, VRI	Potentially occurring in riverine and other wetland habitats. Adjacent upland habitats serve as nesting areas. Known occurrences throughout the Stillwater Creek and Churn Creek watersheds.

Table 3.9-2
Special-Status Wildlife Species Potentially Occurring in the Assessment Area

Common Name *(Scientific Name)*	Status[1]	Habitat[2]	Comments
California horned lizard *(Phrynosoma coronatum frontale)*	CSC	AGS, BAR, BOW, BOP, MCH, MHW, MHC, PPN	Potentially occurring in annual grassland, blue oak woodland, hardwood, and hardwood-conifer habitats.
Double-crested cormorant *(Phalacrocorax auritus)*	CSC	FEW, VRI	Common in riverine and other large wetland habitats in the Redding area. Occurs in the Stillwater and Churn creek watersheds. Special-status designation pertains to rookery (colonial nesting) sites. No known rookeries in the Stillwater Creek and Churn Creek watersheds.
Barrow's goldeneye *(Bucephala islandica)*	CSC	FEW, VRI	Uncommon fall and winter migrant in the general Redding area. Occurs within the western portion of the Stillwater Creek and Churn Creek watersheds, primarily in the Sacramento river. Special-status designation pertains to nesting sites. No longer known to breed in California.
Sharp-shinned hawk *(Accipiter striatus)*	CSC	AGR, BOW, BOP, MHW, MHC, PPN, VRI, VOW	Potentially occurring in hardwood-conifer and woodland habitats. Occurs in the Stillwater Creek and Churn Creek watersheds.
Cooper's hawk *(Accipiter cooperi)*	CSC	AGR, BOW, BOP, MHW, MHC, PPN, VRI, VOW	Potentially occurring in hardwood-conifer and woodland habitats. Occurs in the Stillwater Creek and Churn Creek watersheds.
Golden eagle *(Aquila chrysaetos)*	CSC	AGR, AGS, BOW, BOP	Uncommon fall and winter migrant to primarily the eastern portion of Shasta County. Occurs in open woodland and grassland habitats in the Stillwater Creek and Churn Creek watersheds during fall/winter.
Ferruginous hawk *(Buteo regalis)*	CSC	AGR, AGS, BOW, BOP	Uncommon fall and winter migrant to primarily the eastern portion of Shasta County. Occurs in open woodland and grassland habitats in the Stillwater Creek and Churn Creek watersheds during fall/winter.
Swainson's hawk *(Buteo swainsoni)*	CT	AGR, AGS, BOW, BOP, VOW	Rare spring and fall/winter migrant to the eastern portion of Shasta County. Potentially occurs in open woodland and grassland habitats in the Stillwater Creek and Churn Creek watersheds during spring and fall migration.
Northern harrier *(Circus cyaneus)*	CSC	AGR, AGS, BOW, BOP	Common fall/winter migrant and uncommon summer resident of Shasta County. Occurs in open woodland and grassland habitats in the Stillwater Creek and Churn Creek watersheds.

Table 3.9-2
Special-Status Wildlife Species Potentially Occurring in the Assessment Area

Common Name *(Scientific Name)*	Status[1]	Habitat[2]	Comments
Bald eagle *(Haliaeetus leucocephalus)*	CE, FT (FPD)	AGR, AGS, BAR, BOW, BOP, FEW, MHW, MHC, PPN, VRI, VOW	Potentially occurring in riverine and lacustrine habitats. Common at Shasta Lake, and potential nests could occur within the upper portion of the Stillwater Creek watershed due to proximity of the lake. Known nearby nest in the Cove Creek inlet, immediately north of the upper Stillwater Creek watershed boundary. In addition, local known nest site at the large pond features north of Shasta College.
Osprey *(Pandion haliaetus)*	CSC	AGR, AGS, BAR, BOW, BOP, FEW, MHW, MHC, PPN, VRI, VOW	Potentially occurring in riverine and lacustrine habitats. Common at Shasta Lake and relatively common along the Sacramento River in the Redding area during the fall/winter. Several known nest sites in the lower Churn Creek watershed.
Merlin *(Falco columbarius)*	CSC	AGR, AGS, BOW, BOP, MHW, MHC, URB, VRI, VOW	Rare fall and winter migrant to primarily the eastern portion of Shasta County. Occurs in open woodland and grassland habitats in the Stillwater Creek and Churn Creek watersheds during fall/winter.
Prairie falcon *(Falco mexicanus)*	CSC	AGR, AGS, BOW, BOP, VOW	Uncommon fall and winter migrant and rare summer resident of primarily the eastern portion of Shasta County. Occurs in open woodland and grassland habitats in the Stillwater Creek and Churn Creek watersheds during fall/winter.
Peregrine falcon *(Falco peregrinus)*	CE	AGR, AGS, BAR, BOW, BOP, FEW, MHW, MHC, PPN, URB, VRI, VOW	Rare fall and winter migrant to, and rare summer resident of, Shasta County. Fall/winter migrants occur in hardwood-conifer, woodland, riparian, and grassland habitats in the Stillwater and Churn creek watersheds. Eyries (nest sites) usually occur in cliff habitats. Nearest eyrie sites are located along Lake Shasta. Potential habitat within the upper Stillwater Creek watershed.
Short-eared owl *(Asio flammeus)*	CSC	AGR, AGS, BOW	Rare fall/winter migrant and summer resident of Shasta County. Potentially occurring in open woodland, grassland, and open agricultural habitats in the Stillwater Creek and Churn Creek watersheds. Known occurrence within the southeastern portion of the Stillwater Creek watershed.
Vaux's swift *(Chaetura vauxi)*	CSC	MHW, MHC, PPN, URB, VRI	Potentially occurring in hardwood-conifer and woodland habitats. Known to occur as a spring and fall migrant species.

Table 3.9-2
Special-Status Wildlife Species Potentially Occurring in the Assessment Area

Common Name *(Scientific Name)*	Status[1]	Habitat[2]	Comments
Willow flycatcher *(Empidonax traillii brewsteri)*	CE	AGR, VRI	Potentially occurring in riparian habitats and other habitats as a spring and fall migrant species. Does not breed locally.
Loggerhead shrike *(Lanius ludovicianus)*	CSC	AGR, AGS, BOW, BOP, MCH	Potentially occurring in hardwood-conifer, woodland, and grassland habitats. Known to occur as fall migrant species in eastern portion of Stillwater Creek watershed.
Purple martin *(Progne subis)*	CSC	AGR, BOP, MHC, PPN, URB, VRI	Potentially occurring in hardwood-conifer, woodland, and riparian habitats. The nearby Pit River arm of Shasta Lake is one of the few known breeding sites in Shasta County and northern California.
Yellow warbler *(Dendroica petechia)*	CSC	AGR, FEW, VRI	Potentially occurring in riparian habitats. Uncommon spring migrant and summer resident. Known to occur in Stillwater Creek and Churn Creek watersheds.
Yellow-breasted chat *(Icteria virens*	CSC	AGR, FEW, VRI	Potentially occurring in riparian habitats. Uncommon spring migrant and summer resident. Known to occur in Stillwater Creek and Churn Creek watersheds.
Tricolored blackbird *(Agelaius tricolor)*	CSC	AGR, FEW	Potentially occurring in riparian, emergent wetland, grassland, and open agricultural habitats. Uncommon spring and fall/winter migrant. Known to occur occasionally in the Stillwater Creek and Churn Creek watersheds. Recent breeding colony known from the lower Clover Creek drainage.
Spotted bat *(Euderma maculatum)*	CSC	AGR, AGS, BAR, BOW, BOP, FEW, MCH, MHW, MHC, PPN, URB, VRI, VOW	Potentially occurring in hardwood-conifer, woodland, agricultural, grassland, and riverine habitats. Prefers rock outcrops and cliffs as roost sites.
Townsend's big-eared bat *(Plecotus townsendii)*	CSC	AGR, AGS, BAR, BOW, BOP, FEW, MCH, MHW, MHC, PPN, URB, VRI, VOW	Potentially occurring in hardwood-conifer, woodland, agricultural, grassland, and riverine habitats. Prefers caves as roost sites, but also uses various man-made structures such as attics and buildings.

Table 3.9-2
Special-Status Wildlife Species Potentially Occurring in the Assessment Area

Common Name *(Scientific Name)*	Status[1]	Habitat[2]	Comments
Pallid bat *(Antrozous pallidus)*	CSC	AGR, AGS, BAR, BOW, BOP, FEW, MCH, MHW, MHC, PPN, URB, VRI, VOW	Potentially occurring in hardwood-conifer, woodland, agricultural, grassland, and riverine habitats. Uses various structures for roosting, including snags, bark, buildings, bridges, and cliffs.
Western mastiff bat *(Eumops perotis)*	CSC	AGR, AGS, BAR, BOW, BOP, FEW, MCH, MHW, MHC, PPN, URB, VRI, VOW	Potentially occurring in hardwood-conifer, woodland, agricultural, grassland, and riverine habitats. Prefers rock outcrops and cliffs as roost sites; however, various other structures are also used.
Pacific fisher *(Martes pennanti)*	FC, CSC	BOP, MHW, MHC, PPN	Currently a candidate for federal listing as threatened or endangered. Occurs immediately adjacent to the upper boundaries of the Stillwater Creek and Churn Creek watersheds at the Shasta Lake divide. Potential habitat within the upper Stillwater Creek and Churn Creek watersheds.

[1]Status definitions:
FC = Candidate species for federal listing as threatened or endangered; FE = Federally listed as endangered;
FT = Federally listed as threatened; FPD = Proposed for federal delisting; CE = State listed as endangered
CSC = California species of special concern; CT = State listed as threatened
[2] Habitat designations as described in Section 3.8.1 of this document. AGR = agricultural, AGS = annual grassland, BAR = barren, BOW = blue oak woodland, BOP = blue oak–foothill pine, FEW = fresh emergent wetland, MCH = mixed chaparral, MHW = montane hardwood, MHC = montane hardwood–conifer, PPN = ponderosa pine, URB = urban, VRI = valley-foothill riparian, VOW = valley oak woodland.

The Shasta Salamander, which is state-listed as threatened, is found in the upper portion of the Stillwater Creek watershed. (Photo courtesy of North State Resources, Inc.)

Hunting

Sport hunting occurs throughout the unincorporated portions of the assessment area. The most common game species are waterfowl, black-tailed deer, Chinese ring-necked pheasant, wild turkey, wild boar, California quail (*Callipepla californica*), and mourning dove (*Zenaida macroura*). Less common game species in the assessment area include the band-tailed pigeon (*Columba fasciata*) and black bear (*Ursus americanus*).

3.9.4 REFERENCES

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3.10 Fisheries and Aquatic Resources

This section provides a description of the distribution and current status of fishery resources and special-status fishes and their habitat within the assessment area.

The primary habitats supporting fish and other aquatic organisms in the watershed assessment area are dominated by Stillwater, Churn, and Clover creeks. Additionally, numerous small ponds, mostly privately-built impoundments on small tributaries, provide habitat for fish and other aquatic organisms. The Sacramento River is directly linked to the watersheds in the assessment area and forms the southwest boundary of this watershed assessment.

3.10.1 Fish Species and Habitat Relationships

Stillwater, Churn, and Clover creeks are seasonally intermittent tributaries to the Sacramento River. Stream flow in these creeks is generally driven by rainfall and shallow groundwater input during the fall through early summer months. Historically, as reported by people interviewed for this assessment and as described in some historic documents (e.g., Hanson et al. 1940), most of the streams in the Stillwater and Churn Creek watersheds dried up during the summer through early fall months. However, under current watershed conditions, small levels of flow may be observed even during the summer in certain restricted portions of Stillwater and Churn creeks. Most of this observed flow during summer months is thought to be attributable to urban water runoff and drainage and agricultural irrigation runoff.

Intermittent tributary streams provide seasonal flows conveying upland-derived nutrients, sediment, and organic matter such as woody debris to the mainstem Sacramento River, and they serve an important role in providing seasonally available aquatic habitat for various life stages of fish that inhabit the river. Fish seasonally use these intermittent creeks for spawning, rearing, and refuge from mainstem river flood flows until receding creek flows cue fish to migrate back to the river or to take refuge in permanent pools that are sustained by groundwater and remain through the summer. A growing body of recent evidence has demonstrated the value and importance of intermittent tributaries and other seasonally inundated habitats, such as floodplains, as non-natal rearing habitat for anadromous salmonids (Maslin et al. 1997, Moore 1997, McEwan 2001, Moyle 2002, Sommer et al. 2005). This issue continues to be a key concern of fishery resource managers.

Stillwater, Churn, and Clover creeks are intermittent tributaries that provide seasonally available habitat to fish and other aquatic organisms.

Fish Community Composition

Background research for this assessment revealed that little fish survey data have been collected for the tributary streams in the assessment area. No historical records were found that specifically characterize and quantify the fish community of any stream in the assessment area. Therefore, information for this section of the watershed assessment was obtained from a small number of sampling records provided by CDFG and other fishery researchers, anecdotal reports from

local residents, and inferred similarities with other local streams.

Fish species known or suspected to inhabit the streams in the assessment area include native and non-native resident and anadromous fish. Table 3.10-1 provides a list of fish species that occur in the mainstem Sacramento River at various times of the year, some of which can occur in Stillwater, Churn, and Clover creeks.

Table 3.10-1
Locally Occurring Fish Species, Including Threatened, Endangered, and Sensitive Fish Species

Common Name *(Scientific Name)*	Federal/ State Status[1]	General Habitat Description	Comments
Central Valley ESU[2] steelhead (*Oncorhynchus mykiss irideus*)	T/--	Requires cold flowing water, clean spawning gravel, and diverse riverine habitat for rearing. Spawns and rears in the mainstem Sacramento River and its tributaries.	Native; Sacramento River and the assessment area provide suitable spawning, rearing, and migration habitat; portions of assessment area are designated Critical Habitat.
Central Valley fall/late fall-run ESU Chinook salmon (*Oncorhynchus tshawytscha*)	SC/--	Requires cold flowing water, clean spawning gravel, and diverse riverine habitat for rearing. Spawns and rears in the mainstem of the upper Sacramento River.	Creeks in the assessment area and the Sacramento River provide suitable spawning, rearing, and migration habitat.
Central Valley spring-run ESU Chinook salmon (*Oncorhynchus tshawytscha*)	T/T	Requires cold flowing water, clean spawning gravel, and diverse riverine habitat for rearing. Spawns and rears in perennial tributaries and the mainstem of the Sacramento River. Rears for a time in the Delta estuary.	Sacramento River provides suitable spawning, rearing, and migration habitat; non-natal rearing occurs in the assessment area tributaries; portions of assessment area are designated Critical Habitat.
Sacramento River winter-run ESU Chinook salmon *(Oncorhynchus tshawytscha*)	E/E	Requires cold flowing water, clean spawning gravel, and diverse riverine habitat for rearing. Spawns and rears in the mainstem of the upper Sacramento River. Rears for a time in the Delta estuary.	Sacramento River provides suitable rearing, spawning, and migration habitat. The assessment area provides non-natal rearing habitat.
Brown trout (*Salmo trutta*)	--/--	Requires cold flowing water, clean spawning gravel, and diverse riverine habitat for rearing. Spawns and rears in the mainstem Sacramento River and its tributaries. Favor large streams with cover in the form of submerged rocks, undercut banks, and overhanging vegetation.	Introduced sport species; occasionally observed in mainstem Sacramento River and tributaries near valley floor.

Table 3.10-1
Locally Occurring Fish Species, Including Threatened, Endangered, and Sensitive Fish Species

Common Name *(Scientific Name)*	Federal/ State Status[1]	General Habitat Description	Comments
Rainbow trout (*Oncorhynchus mykiss*)	--/--	Requires cold flowing water, clean spawning gravel, and diverse riverine habitat for rearing.	Native, resident trout species; sympatric with anadromous phenotype (i.e., steelhead); seasonally spawns in and/or inhabits mainstem river and tributaries
Pacific lamprey *(Lampetra tridentata)*	--/--	Spawn in freshwater rivers and streams with juveniles found in slow-moving current, silty bottom habitats. Spring-summer spawner; juveniles require 5-7 years for freshwater rearing.	Native fish species common to Sacramento River basin; rarely observed in intermittent streams.
River lamprey *(Lampetra ayresii)*	--/--	The biology of river lampreys has not been studied in California; general habitat and life history thought to be similar to Pacific lamprey.	Native fish species thought to be common. Actual distribution and abundance is unknown.
Western brook lamprey (*Lampetra richardsoni*)	--/--	Inhabits gravel riffles and runs of clear, cool streams. Ammocoetes occur in muddy and sandy backwaters and pools of streams.	Native, resident lamprey species; thought to be widely distributed in Sacramento Valley streams, though information on them is rare.
Green sturgeon, southern DPS (*Acipenser medirostris*)	T/SC	Green sturgeon require streams, rivers, and estuarine habitat as well as marine waters during their lifecycle.	Native; spawns throughout the mid-upper mainstem Sacramento River. Adults and juveniles observed frequently at Red Bluff.
White sturgeon *(Acipenser transmontanus)*	--/--	White sturgeon require streams, rivers, and estuarine habitat as well as marine waters during their lifecycle.	Native; spawns throughout the mid-upper mainstem Sacramento River; observed less frequently than green sturgeon near Red Bluff.
American shad *(Alosa sapidissima)*	--/--	Feed and mature in the Sacramento-San Joaquin delta. Adults migrate up and spawn in main channels of rivers over a wide variety of substrates. Juveniles seasonally progress into saltwater habitat; entering salt water in late summer and autumn.	Introduced species common downstream of Red Bluff. River temperatures are too cold near Redding for successful spawning.
Threadfin shad (*Dorosoma petenense*)	--/--	Often schooling, occurring in large rivers, reservoirs, lakes, and swamps. Prefer the presence of smooth, steep-sided surfaces such as dams, cement-lined pools and rip rapped streams.	Introduced, naturalized, forage species. Uncommon.

Table 3.10-1
Locally Occurring Fish Species, Including Threatened, Endangered, and Sensitive Fish Species

Common Name *(Scientific Name)*	Federal/ State Status[1]	General Habitat Description	Comments
Black bullhead (*Ameiurus melas*)	--/--	Inhabits pools, backwaters, and sluggish current over soft substrates in creeks and small to large rivers; impoundments, oxbows, and ponds.	Introduced, naturalized, sport and forage species. Uncommon in the upper River and tributaries in the watershed area.
Brown bullhead (*Ameiurus nebulosus*)	--/--	Occurs in pools and sluggish runs over soft substrates in creeks and small to large rivers. Also found in impoundments, lakes, and ponds. Rarely enters brackish waters	Introduced, naturalized, sport and forage species. Uncommon in the upper River and tributaries in the watershed area.
Channel catfish (*Ictalurus punctatus*)	--/--	Inhabit rivers and streams with slow to moderate current over sand, gravel, or rock substrates. Prefer clean, well oxygenated water.	Introduced, naturalized, sport species.
White catfish (*Ameiurus catus*)	--/--	Prefer sluggish, mud-bottomed pools, open channels, and backwaters of small to large rivers; also in lakes and impoundments.	Introduced, naturalized, sport species. Most common catfish species in the Sacramento River above Red Bluff.
Black crappie (*Pomoxis nigromaculatus*)	--/--	Clear warm pools of streams, lakes, ponds, sloughs, and reservoirs. Prefer shallow waters with aquatic vegetation.	Introduced, naturalized, sport species; escape from ponds into local streams.
White crappie (Pomoxis annulauris)	--/--	Clear warm pools of streams, lakes, ponds, sloughs, and reservoirs. Prefer shallow waters with aquatic vegetation.	Introduced, naturalized, sport species; escape from ponds into local streams.
Bluegill sunfish (*Lepomis macrochirus*)	--/--	Clear warm pools of streams, lakes, ponds, sloughs, and reservoirs. Prefer shallow waters with aquatic vegetation.	Introduced, naturalized, sport and forage species.
Green sunfish (*Lepomis cyanellus*)	--/--	Clear warm pools of streams, lakes, ponds, sloughs, and reservoirs. Prefer shallow waters with aquatic vegetation.	Introduced, naturalized, sport and forage species.
Redear sunfish (*Lepomis microlophus*)	--/--	Clear warm pools of streams, lakes, ponds, sloughs, and reservoirs. Prefer shallow waters with aquatic vegetation.	Introduced, naturalized, sport and forage species.
Largemouth bass (*Micropterus salmoides*)	--/--	Inhabits clear, vegetated lakes, ponds, swamps. Also in backwaters and pools of creeks and rivers. Prefers quiet, clear water and over-grown banks.	Introduced, naturalized, sport species.

Table 3.10-1
Locally Occurring Fish Species, Including Threatened, Endangered, and Sensitive Fish Species

Common Name *(Scientific Name)*	Federal/ State Status[1]	General Habitat Description	Comments
Smallmouth bass (*Micropterus dolomieui*)	--/--	Inhabits shallow rocky areas of lakes, clear and gravel-bottom runs and flowing pools of rivers, cool flowing streams and reservoirs fed by such streams.	Introduced, naturalized, sport species.
Spotted bass (*Micropterus punctulatus*)	--/--	Inhabits clear, gravelly flowing pools and runs of creeks and small to medium rivers.	Introduced, naturalized, sport species.
Redeye bass *(Micropterus coosae)*	--/--	Inhabits rocky runs and pools of creeks and small to medium rivers.	Introduced, naturalized, sport and forage species.
Common carp (*Cyprinus carpio*)	--/--	Streams, ponds, lakes, sloughs and reservoirs with clear to turbid waters and aquatic vegetation over mud or silt; most common in warm waters.	Introduced, naturalized, non-game species. Common.
California roach (*Lavinia symmetricus*)	--/--	Inhabit small intermittent and perennial tributaries of large streams with moderate gradient.	Native, non-game species; locally abundant in the watershed area and foothill tributaries to the Sacramento River.
Goldfish (*Carassius auratus*)	--/--	Warm lakes, ponds, and sloughs with aquatic vegetation over soft bottoms.	Introduced, non-game species, escape from pet trade and ornamental ponds. Relatively uncommon.
Golden shiner (*Notemigonus crysoleucas*)	--/--	Clear quiet streams, lakes, ponds, and swamps over mud, sand or rocks; usually near aquatic vegetation.	Introduced, naturalized, forage species; escape from bait dealers and from ponds to local streams. Rare.
Hardhead (*Mylopharodon conocephalus*)	--/SC	Quiet deep pools of large, warm, clear streams over rocks or sand.	Common, native, non-game species.
Hitch (*Lavinia exilicauda*)	--/--	Ponds, lakes, reservoirs, and warm sluggish streams and sloughs; usually with vegetation.	Native, non-game species. Uncommon in the upper Sacramento River and assessment area.
Sacramento blackfish (*Orthodon microlepidotus*)	--/--	Lakes, reservoirs, sloughs, and sluggish streams with shallow, warm, usually turbid waters.	Native, non-game species, not common in the watershed area.

Table 3.10-1
Locally Occurring Fish Species, Including Threatened, Endangered, and Sensitive Fish Species

Common Name *(Scientific Name)*	Federal/ State Status[1]	General Habitat Description	Comments
Sacramento pikeminnow (*Ptychocheilus grandis*)	--/--	Inhabits rocky and sandy pools and runs of small to large rivers. Common in clear, warm streams. Small pikeminnow are found in shallow water with cover and lower velocities.	Common, native, non-game species; locally, seasonally abundant in river and tributaries.
Sacramento splittail (*Pogonichthys macrolepidotus*)	--/SC	Inhabits backwaters and pools of rivers and lakes. Tolerant of brackish water.	Native, non-game species; historically occurred near Redding, however, range is not thought to presently extend above Red Bluff.
Speckled dace (*Rhinichthys osculus*)	--/--	Inhabits sand and gravel runs of small to large rivers.	Native, non-game species. Common in the watershed area and foothill tributaries to the Sacramento River.
Prickly sculpin (*Cottus asper*)	--/--	Clear, cool creeks and rivers and lakes over gravel or rocks.	Common, native, non-game species; more common of the two sculpins inhabiting mainstem Sacramento River and tributaries.
Riffle sculpin (*Cottus gulosus*)	--/--	Clear, cool creeks and rivers and lakes over gravel or rocks.	Common, native, non-game species. Less common of the two sculpins inhabiting the Sacramento Valley streams with perennial flows.
Sacramento sucker (*Catostomus occidentalis*)	--/--	Found in reservoirs and cool-water rivers or streams with sand, gravel, or cobble bottom.	Native, non-game species; locally abundant during spring spawning season.
Western mosquitofish (*Gambusia affinis*)	--/--	Most abundant in lower reaches of streams. Inhabits standing to slow-flowing water; most common in vegetated ponds and lakes, backwaters and quiet pools of streams.	Introduced, naturalized species used for biological control of mosquito larvae; locally, seasonally abundant near locations where released in standing pools and intermittent streams.
Striped bass *(Morone saxatilis)*	--/--	Striped bass regularly move between salt and freshwater, and usually spend much of their lifecycles in estuaries. Migrate into freshwater and spawn in early summer.	Introduced. Common downstream of Red Bluff. River temperatures are too cold near Redding for successful spawning.

Table 3.10-1
Locally Occurring Fish Species, Including Threatened, Endangered, and Sensitive Fish Species

Common Name *(Scientific Name)*	Federal/ State Status[1]	General Habitat Description	Comments
Three-spine stickleback (*Gasterosteus aculeatus*)	--/--	Inhabits vegetated areas, usually over mud or sand.	Native, non-game species; prefer backwater areas, especially with dense aquatic vegetation, along Sacramento Valley streams.
Tule perch (*Hysterocarpus traskii*)	--/--	Inhabits mud to gravel-bottomed pools and runs of small to large, low-elevation rivers and lakes. Usually occurs near emergent aquatic plants or overhanging banks.	Native, non-game species; riverine population ranges into some tributary streams.

Sources: Hanson et al. (1940), Leidy (1998) Moyle (2002); CDFG unpublished data; Maslin et al. (1997)
[1] Status definitions E = endangered; T = threatened; SC = Species of Concern; C = Candidate species; PT= petitioned threatened; NW = listing not warranted.
[2] ESU = evolutionarily significant unit
[3] DPS = distinct population segment

Resident Fish

Warmwater resident species, such as the non-native sunfishes and catfishes, typically prefer ponds, lakes, and slow-moving stream habitats, including well-shaded backwaters. These species favor habitats with submerged and emergent vegetation and rocky cover. Many warmwater species have been widely distributed by fishery managers and landowners for stocking lakes and ponds within the assessment area (Manji pers. comm. 2006). Warmwater fish species generally tolerate a wide range of temperatures (from 35 to 90 °F) and dissolved oxygen levels (from near 0 percent to fully saturated with oxygen), which allows them to inhabit intermittent creeks late into the summer season when flows allow. Some of those interviewed for this assessment reported that warmwater fishes survive in the deeper pools and channel areas ponded by beavers that remain as flows recede and other portions of the stream channel go dry during the summer. Examples of such pools may be observed along Churn Creek during the summer months downstream of Lake Boulevard, upstream up 299, Hartnell Avenue, Victor Avenue, and Knighton Road, and in Stillwater Creek near Shasta College and downstream of the Union School Road, Highway 44, and Dersch Road crossings.

While the few records and observations from stakeholders suggest that a number of warmwater non-native fishes inhabit streams in the assessment area, their relative abundance is unknown.

Non-native warmwater fish species may prey upon or otherwise compete with native fish populations where they co-occur. Highly altered aquatic environments tend to favor colonization by introduced species (Moyle 2002). While the few records and observations from stakeholders suggest that a number of warmwater non-native fishes inhabit streams in the assessment area, their relative abundance is unknown. Where non-

native species have had an impact on native species, such as salmon, stream restoration projects in the Central Valley, including at nearby Clear Creek, have incorporated measures to reduce features favoring non-native warmwater predators, such as abandoned gravel mining pits that form backwater ponds (U.S. Fish and Wildlife Service 1995; U.S. Bureau of Reclamation 1999).

Native fish species such as rainbow trout, California roach, hardhead, Sacramento pikeminnow, Sacramento sucker, three-spine stickleback, and tule perch commonly use intermittent streams for some portion of their life cycle. These species thrive in the foothill tributaries of the Central Valley, especially those that have not been highly altered (Moyle 2002). California roach are common in tributary reaches and over-summer in permanent pools. Hardhead may spawn in intermittent tributaries, but more commonly use perennial streams; however, juvenile hardhead are regularly observed rearing in intermittent streams. Rainbow trout, Sacramento pikeminnow, and Sacramento suckers spawn in most local intermittent and perennial tributaries, and juveniles may be found rearing until flows recede in intermittent streams. These species require cool, clean streams with loose gravel and cobble streambeds to successfully reproduce. Three-spine stickleback and tule perch inhabit the lower reaches of the streams in the assessment area for spawning and rearing.

Native, non-game fish species receive little attention compared to game fish and the salmonid species; however, these species fill important ecological roles in intermittent stream ecosystems. For instance, the high biomass of Sacramento suckers that spawn and rear in the intermittent tributaries to the upper Sacramento River provides food for juvenile salmon and steelhead, as well as for a number of avian and terrestrial animals that inhabit riparian habitats of the watersheds (Moore 1997, Leidy 1998).

Anadromous Fish

Chinook salmon and steelhead are anadromous fish species, meaning they spend part of their lives in the ocean, where they feed and grow to adulthood, and then return to freshwater to spawn. Four races, or runs, of Chinook salmon are present in the Sacramento River: fall-, late-fall, winter-, and spring-run. Fall- and late-fall runs are the most abundant in the upper Sacramento River. Sacramento River steelhead spawning migrations occur during the fall and winter months, with spawning occurring from winter through spring. Figure 3.10-1, Life History of Sacramento River Chinook Salmon and Steelhead, provides the relative seasonal timing and abundance of anadromous salmonids that inhabit the upper Sacramento River and its tributaries.

Each life stage of the anadromous salmonid species has particular habitat requirements. Vogel and Marine (1991) and Moyle (2002) were consulted for the following general habitat criteria for Sacramento River salmon and steelhead. Spawning and egg incubation requires suitable combinations of water velocity, depth, temperatures (generally less than 60°F), dissolved oxygen (generally greater than 5-7 parts per million [ppm]), and

The high biomass of Sacramento suckers that spawn and rear in the intermittent tributaries to the upper Sacramento River provides food for juvenile salmon and steelhead, as well as for a number of avian and terrestrial animals.

clean, loose, gravel substrates. Newly emerged fry and juvenile salmonids require rearing habitat that provides a diversity of physical features as they grow, including slow and fast water areas, rock and vegetative cover for refuge from predators and for production of invertebrate prey, large woody debris for cover, cool water temperatures (generally less than 68 °F), and sufficient flows to allow successful emigration to the estuary and ocean environments. Shortly after hatching, salmon and steelhead fry may be found in shallow, slow, nearshore areas over fine substrates. As they grow, juveniles seek faster and deeper portions of the stream channel with larger substrate and cover features, such as boulders and large woody debris. Adult salmon, particularly spring- and winter-run, require holding and staging habitats during the summer in proximity to their spawning grounds with adequate depth, temperatures (generally less than 64°F), dissolved oxygen (generally greater than 5-7 ppm), and cover, where they can complete their final sexual maturation prior to spawning. The lack of holding and staging habitat excludes winter- and spring-run salmon spawning in intermittent streams, including Stillwater and Churn Creek.

In addition to the anadromous salmonids, several other anadromous species occur in the Sacramento River near Redding, including Pacific lamprey, river lamprey, white sturgeon, green sturgeon, and striped bass. The white sturgeon is a large sturgeon species that

The intermittent streams near Redding provide important non-natal rearing habitat for Chinook salmon and, to some extent, spawning habitat for fall-/late-fall run Chinook salmon and steelhead.

Spawning salmon near Gold Hills Golf Club. (Photo courtesy of Don Rich.)

supports an important sport fishery. Within the assessment area, it is thought to spawn to some extent between Red Bluff and Redding (U.S. Fish and Wildlife Service 1995). The green sturgeon also inhabits the Sacramento River and, like white sturgeon, is thought to spawn in the assessment area between Red Bluff and Redding (Adams et al. 2002, 2005). Striped bass may also migrate to spawn in the Sacramento River upstream of Red Buff in small numbers now that the Red Bluff Diversion Dam gates are out during the early portion of their spawning run (U.S. Fish and Wildlife Service 1995). Of these species, however, only Pacific lamprey and river lamprey are likely to use the streams in the assessment area for spawning. Since these species require year-round rearing habitat, they would be restricted to the reaches that carry flow year round.

The intermittent streams near Redding provide important non-natal rearing habitat for Chinook salmon and, to some extent, spawning habitat for fall-/late-fall run Chinook salmon and steelhead (Maslin et al. 1997,

1998, 1999, Baumgartner pers. comm. 2006). However, there are no recent quantitative data on the extent to which salmon and steelhead use these intermittent streams. According to the Anadromous Fish Restoration Program (AFRP) Working Paper (U.S. Fish and Wildlife Service 1995), most of these tributaries (including Churn and Stillwater creeks) have resident rainbow trout populations in upstream perennial reaches and, for many, there are anecdotal accounts of steelhead runs in the past.

Some steelhead and fall/late-fall Chinook salmon are known to spawn in Stillwater and Churn creeks, although most of these salmon are thought to be "strays" originating from other nearby established spawning populations (Fisher pers. comm. 2006). Peak flows that occur during heavy fall and winter storms likely attract salmon from the Sacramento River. The attraction of salmon to these stream flows is probably increased because the river flow does not increase proportionally during storm events, since Shasta Dam captures most of the storm runoff upstream of Redding (U.S. Fish and Wildlife Service 1995). The number of steelhead and rainbow trout spawning and rearing in Stillwater and Churn creeks is uncertain, although this species is regularly observed in these creeks (Baumgartner pers. comm. 2006; Fisher pers. comm. 2006).

CDFG estimated that from 1967 through 1991, a total of as few as 10 up to 1,600 (adult and grilse) fall-run Chinook salmon spawned, collectively, in various intermittent tributaries to the Sacramento River. Although the actual numbers of fall-/late-fall run Chinook salmon that spawn in Stillwater and Churn creeks is not regularly monitored, this analysis indicates that, as a general rule, the number is relatively small, varies widely between years, and varies widely among individual intermittent streams.

Following are general accounts of fish distributions and aquatic habitat in the principal streams of the assessment area. No detailed aquatic habitat surveys were conducted for this assessment; therefore, aquatic habitat characteristics were determined at a reconnaissance level of detail. Because this information is based on a few fragmented surveys and anecdotal reports, the lack of mention of a species does not preclude its potential to occupy otherwise suitable stream habitat in the assessment area.

Stillwater Creek

There are approximately 83 miles of primary stream channel (i.e., mainstem creek and tributaries with a distinct bed and bank and a reach slope no greater than 4 percent as determined from a USGS 7.5-minute series topographic map) providing potential fish habitat in the Stillwater Creek subbasin (Figure 3.10-2, Stream Channel Gradients of Principal Tributaries in the Stillwater-Churn Creek Watershed)[1]. There are no barrier falls reported for this stream. There are, however, a large number of bridge and culvert road crossings and an unquantified number of small impoundments; fish passage conditions at the culverts or impoundments were not evaluated as part of this assessment. Based on cursory reconnaissance by NSR staff and interviews of residents, most of the lower reach is a broad gravel-bed, riffle-and-pool channel with a narrow riparian corridor and a few vegetated mid-channel bars that do not shade the entire channel. The upper reaches

[1] These criteria are based on the observed local intermittent stream channel conditions typical of sites occupied by fish and general criteria for anadromous salmonids provided by Montgomery et al. (1999).

of the west and east forks transition to narrow, well-shaded, gravel/cobble-bed riffle-pool-step pool channels. Some local residents reported a perception that sedimentation and siltation of the streambed in the lower reaches of the creek have increased in recent years as a combined result of erosion and reduced frequency of flushing by flood flows (Hawes pers. comm. 2006). No recent records were obtained quantifying the actual levels of stream siltation occurring or identifying any impairment to fisheries or degradation of water quality in the creek. The mobilization of increased silt and sediment discharges from local streams carried to the Sacramento River during periods of high flow is known to be harmful to salmon eggs in spawning areas (Churn Creek Task Force 1991).

Juvenile rainbow trout, adult and juvenile suckers, and California roach were relatively common… [G]reen sunfish, redeye bass, and juvenile Chinook salmon were collected in the East Fork [of Stillwater Creek]…Juveniles of all four races of Chinook salmon are documented or suspected to rear in the lower reaches of Stillwater, Churn and Clover creeks.

Fall-run and late-fall run salmon historically and currently ascend and spawn in Stillwater Creek during years of sufficient fall rains (Hanson et al. 1940; Baumgartner pers. comm. 2006). Hanson et al. (1940) estimated that approximately 4 to 5 percent of the habitat in Stillwater Creek was suitable for salmon spawning during years of sufficient water. No comparable present-day estimates of aquatic habitat quality are available for this stream. The most apparent change in the assessment area since the 1930s and 1940s that may affect stream habitat is residential and commercial development and the related land use changes.

Leidy (1998) sampled fish in portions of the West Fork of Stillwater Creek from near Mountain Gate to its confluence with the East Fork. Juvenile rainbow trout, adult and juvenile suckers, and California roach were relatively common throughout this reach. Additionally, green sunfish, redeye bass, and juvenile Chinook salmon were collected in the East Fork downstream of Union School Road, indicating that salmon had likely spawned at least that far upstream in 1997-98.

Juveniles of all four races of Chinook salmon are documented or suspected to rear in the lower reaches of Stillwater, Churn, and Clover creeks (Maslin et al. 1997; Baumgartner pers. comm. 2006). Although the assessment area doesn't support spawning populations of all races of Chinook salmon, it does provide

Pair of spawning salmon near the Hill Boulevard bridge, November 2005. (Photo courtesy of Brad Dupre.)

important non-natal rearing habitat for all the races. Sampling conducted by Professor Paul Maslin and students (California State University, Chico) during the 1990s identified fall-, spring-, and winter-run juveniles in the lower reaches of Stillwater and Churn Creeks. Winter-run fry appeared to exhibit this behavior more than the other races. It was also discovered that the distance juvenile Chinook move upstream is variable, depending on tributary characteristics such as size, gradient, and habitat quality (Maslin et al. 1997).

Residents interviewed reported that several warmwater species occur throughout Stillwater Creek, including carp, bluegill, bass, Sacramento pikeminnow, Sacramento sucker, and catfish.

Churn Creek

There are approximately 40 miles of primary stream channel providing potential fish habitat in the Churn Creek subbasin (Figure 3.10-2). No barrier falls were reported on the mainstem of Churn Creek. However, there is a large number of bridge and culvert road crossings and utility crossings, and a number of unquantified impoundments; fish passage conditions at the culverts, utility crossings, and impoundments were not evaluated as part of this assessment. Based on cursory reconnaissance by NSR staff and interviews of residents, most of the lower reach below Highway 299 is a channelized alluvial gravel bed, riffle-and-pool channel, with a narrow, highly interrupted riparian corridor that provides some shade to the channel. Residential, commercial, and municipal development occurs nearly continuously along this reach. The upper reaches of the mainstem and its tributaries transition to narrow cobble/boulder-bedded riffle-pool, step-pool, and cascade channels. In the upper reaches, remnant mine tailings and other associated features are common in and adjacent to the stream channel. The channel in this reach is confined in some locations by roadbeds. A narrow overhanging riparian corridor, including numerous non-native landscaping plants and invasive species, and adjacent upland trees on hill slopes provide shade to the channel in the upper reaches. Urban debris, sediment in runoff, invasive plants, pollutant contamination in storm water, and wastewater discharges have been reported to degrade the aquatic habitat of Churn Creek (Churn Creek Task Force 1991, resident interviews). Increased sediment discharges carried to the Sacramento River are known to be harmful to incubating salmon eggs in spawning areas near the mouth of Churn Creek (Churn Creek Task Force, 1991).

In recent years, small numbers of fall-run and late-fall run Chinook salmon have been observed and photographed in Churn Creek in the vicinity of Gold Hills Golf Course during 2004 and below a box culvert on Hill Boulevard during 2001.

A few fall-run and late-fall run Chinook salmon have been reported to historically spawn in the lower reaches (below Boulder Creek) and continue to be observed today when early fall rains result in sufficient stream flow (Hanson et al. 1940; U.S. Fish and Wildlife Service 1995; Baumgartner pers. comm. 2006). In recent years, small numbers of fall-run and late-fall run Chinook salmon have been observed and photographed in Churn Creek in the vicinity of Gold Hills Golf Course during 2004 and below a box culvert on Hill Boulevard during 2001 (Brad Dupre; Gail Rich, personal communications). A small number of steelhead are also reported to spawn and rear at least seasonally in Churn Creek (U.S. Fish

and Wildlife Service 1995). However, the reproductive success of salmon and steelhead spawning in this stream is not certain (Baumgartner pers. comm. 2006).

Juveniles of all four races of Chinook salmon are documented or suspected to rear in the lower reaches of Stillwater, Churn, and Clover creeks (Maslin et al. 1997, 1998; Baumgartner pers. comm. 2006). Although the assessment area doesn't support spawning populations of all races of Chinook salmon, it does provide important non-natal rearing habitat for all races of Chinook salmon. It was also discovered that the distance juvenile Chinook move upstream is variable, depending on tributary characteristics, such as size, gradient, and habitat quality (Maslin et al. 1997).

Residents interviewed reported several warmwater species to occur throughout Churn Creek, including carp, bluegill, and "pike" (assumed to be the native Sacramento pikeminnow).

Clover Creek

No natural barrier falls were reported for Clover Creek. However, a partial barrier to fish passage created by erosion below a culvert occurs at the Churn Creek Road crossing about 700 feet upstream of the Sacramento River confluence; the numerous other road crossings were not evaluated regarding their effects on fish passage. The channel of Clover Creek above the Churn Creek Road crossing is best described as a shallow swale/braided channel with an intermittent bed and bank. The streambed is dominated by bedrock, hardpan, cobble, sand, and silt deposits. The highly seasonal flows and largely unsuitable habitat for fish above this point preclude habitation by most fish species.

However, the lowest reaches of Clover Creek provide suitable habitat for non-natal rearing of salmon and steelhead. In December 2003, Jim Nelson and Steve Baumgartner from CDFG conducted a fish survey on lower Clover Creek downstream of Churn Creek Road bridge. Although the creek was running fast and turbid as a result of recent rains, juvenile Chinook salmon were captured. Based on length-at-date criteria for the upper Sacramento River, these juveniles were classified as winter-run Chinook salmon.

3.10.2 SENSITIVE AQUATIC RESOURCES

Riparian habitats

Natural riparian systems are considered some of the most diverse, dynamic, and complex biophysical habitats on the terrestrial portion of the earth (Brooks et al. 1997). (See also Sections 3.8 and 3.9.) Riparian communities consist of plants that grow adjacent to streams or lakes and often have root systems in close proximity to the water table. Such communities exist in both wet and dry climates. Although riparian vegetation consumes a large amount of water, including groundwater, such communities often are valuable for stream bank protection, wildlife habitat, and the protection of adjacent aquatic ecosystems. The riparian plant community has a significant influence on the stream environment; stream depth, current velocity, substrate composition, cover, temperature, nutrient input, and bank stability can change dramatically when the riparian plant community is altered. Although riparian systems make up only a small percentage of the total land area, their hydrologic and biological functions must be considered in determining water and other resource management goals for entire watersheds.

Establishment of riparian vegetation in alluvial floodplain areas takes place sequentially as

one plant community replaces another over time. This biological process (known as "succession") is dependent on the process of erosion and deposition. In the assessment area, the process typically starts where cottonwood and willow seeds germinate at the water's edge of a newly formed sandbar, resulting in a band of young trees. Once the stand is established, growth is rapid. Eventually, as this process is repeated year after year, the emerging forest develops a gradient in height and age, sometimes referred to as a gallery forest (California Resources Agency 1989). Establishment of these successive communities in the assessment area has been prevented as a result of the straightening and incision of the stream channels that have prevented the alternation of erosion and deposition.

Non-native invasive plant species can displace native species, reducing habitat complexity and altering the natural balance between riparian and aquatic communities … Stillwater Creek has seen the greatest encroachment of giant reed, but it is present throughout sections of Churn Creek.

Riparian communities are among the most important habitats for wildlife because of their high floristic and structural diversity, high biomass (and therefore high food abundance), and high water availability. In addition to providing breeding, foraging, and roosting habitat for a diverse array of animals, riparian communities provide corridors for migrating wildlife, connecting a variety of habitats throughout a region.

Riparian habitat also functions as shaded riverine aquatic (SRA) cover. The vegetation contributing to SRA habitat is considered to be extremely important for maintaining cooler water temperatures, especially in lower elevation areas.

Valley foothill riparian habitat is found in valleys bordered by sloping alluvial fans, slightly dissected terraces, lower foothills, and coastal plains. It is generally associated with low-velocity flows, floodplains, and gentle topography (Mayer and Laudenslayer Jr. 1988). In the assessment area, common overstory species include valley oak (*Quercus lobata*), Mexican elderberry (*Sambucus mexicana*), black walnut (*Juglans californica*), arroyo willow, narrowleaf willow, California buckeye (*Aesculus californica*), and Fremont cottonwood. Co-occurring shrubs and herbaceous species include Himalayan blackberry (*Rubus discolor*), California blackberry (*Rubus ursinus*), California wild grape (*Vitis californica*), pipevine (*Aristolochia californica*), bedstraw (*Galium spp.*), common horsetail (*Equisetum arvense*), and mugwort (*Artemisia douglasiana*).

Non-native invasive plant species can displace native species, reducing habitat complexity and altering the natural balance between riparian and aquatic communities. One example is giant reed, which has significantly affected the riparian habitat in Stillwater Creek. Giant reed does not provide as much shade as mature valley foothill riparian and therefore can allow water temperatures to increase. Further, giant reed encroaches on the channel, constricting flow and channelizing the creek. This encroachment has the potential to seriously change the hydrology of the channel and cause further problems (addressed in Section 3.5, Hydrology, Flooding, and Water Use/Quantity). In addition to giant reed, invasive plants such as Himalayan blackberry (*Rubus discolor*), scotch broom (*Cytisus scoparius*), tree-of-heaven (*Ailanthus altissima*), and rattlebush

(*Sesbania punicea*) have been identified in the watersheds. Stillwater Creek has seen the greatest encroachment of giant reed, but it is present throughout sections of Churn Creek. Rattlebush has been identified in Churn Creek above the Knighton Road Bridge.

Changes in land use have altered or eliminated riparian habitats in the watersheds. Urbanization has reduced the complexity and continuity of riparian corridors, which is directly affecting the fish and wildlife resources. The removal of riparian vegetation and encroachment of development have a direct effect on riparian corridors in the assessment area, but residential and commercial development also indirectly affects the riparian corridors. Increased urbanization and increases in impermeable surfaces increase the rate and amount of precipitation running off the landscape, which has increased erosion. More rapid storm runoff, along with stream channelization, results in downcutting of the streambed and lowering of the groundwater table, with subsequent dessication and death of riparian vegetation. The results of such processes are two-fold: first, large, more mature riparian trees are lost, and, second, exposed soils are subject to colonization by non-natives like giant reed. Although erosion and succession of plant species is a natural process for riparian systems, the frequency and magnitude of flood events in addition to the inability of the channels to meander and colonization by invasive plants have prevented riparian zones from developing complex communities.

Ideally, flows in excess of channel capacity would overflow onto floodplains where healthy riparian vegetation and associated debris provide a substantial resistance to flow and act as filters, or traps, for sediment. By dissipating floodwaters, the riparian vegetation and associated debris can reduce peak flow discharges downstream. Furthermore, during bank overflows, opportunities are available for germination and establishment of certain riparian plant species. Unfortunately, waters in the assessment area are often prohibited from accessing their floodplain. Even in areas where there is some access to the floodplain and existing riparian vegetation, discharge has increased to the point that the channel has been forced to incise to convey the increased discharge water. This process eliminates any potential to reduce downstream flooding. The continued incision, straightening, and constriction of the channel have prevented the natural succession of riparian communities.

Riparian areas are critical aquatic habitat elements because they provide cover, shade, and food for aquatic organisms. Riparian areas provide shade and temperature benefits, sediment, nutrient and chemical regulation, stream bank stability, and inputs of large woody debris and organic matter to the channel. Riparian vegetation that is adjacent to a river, a component of SRA habitat, is included as an element of essential fish habitat (EFH) for Chinook salmon. The quality and complexity of riparian areas in the assessment area have been affected to the extent that they do not provide their maximum benefit to the aquatic ecosystem.

Activities such as cattle grazing and bank protection not only degrade riparian habitat quality, but they directly suppress regeneration of the riparian plant community. The watersheds have experienced degradation as a result of land use practices such as agricultural diversion, channelization, bank and levee protection, livestock grazing, gravel mining, and urbanization. It is this collective sum of land use practices in the

assessment area that has degraded the riparian habitat and led to the existing condition.

In 1989, the Resources Agency of California prepared the Upper Sacramento River Fisheries and Riparian Habitat Management Plan, which defines riparian habitat preservation on Sacramento River tributary streams as a priority. The purpose of the plan is to preserve remaining riparian habitat and restore high-quality riparian ecological systems on Sacramento Valley tributary streams. The plan defines four goals that will help preserve and restore riparian systems:

- Preserve what riparian vegetation remains
- Restore remaining riparian vegetation to high-quality habitat
- Restore lands that have been put into other uses
- Conserve remaining riparian vegetation through appropriate land stewardship on those lands remaining in private ownership

The plan also provides specific recommended solutions and ways in which the above goals can be accomplished.

The fall/late-fall run Chinook salmon, a federal and state species of concern, and steelhead, which is federally listed as threatened, are known to spawn at least periodically when early fall and winter rainfall result in sufficient flows in Stillwater and Churn creeks.

Threatened, Endangered, and Sensitive Fish Species

There are seven special-status fish species that occur in the upper Sacramento River and tributaries in or adjacent to the assessment area; five are anadromous and two are resident (Table 3.10-1). Four are listed as threatened or endangered under the federal and/or state endangered species acts and the other three are species of concern. The salmon and steelhead runs listed as endangered or threatened under state or federal laws are known to use the intermittent streams in the assessment area at least seasonally as non-natal rearing habitat. The fall/late-fall run Chinook salmon, a federal and state species of concern, and steelhead, which is federally listed as threatened, are known to spawn at least periodically when early fall and winter rainfall result in sufficient flows in Stillwater and Churn creeks. While the Sacramento splittail, a federal species of concern, is occasionally reported in the Sacramento River upstream of Red Bluff, intermittent streams in the assessment area do not provide habitat for this fish. Hardhead, a state species of concern, are relatively common in the upper Sacramento River and may be found seasonally in the lower reaches of intermittent streams near their confluence with the river.

Critical Habitat

The ESA of 1973, as amended, defines critical habitat as 1)

- specific areas within the geographical area occupied by the species at the time of listing, if they contain physical or biological features essential to conservation; those features may require special management considerations of protection; and
- specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation. Portions of Stillwater and Churn creek were designated critical habitat for Central Valley spring-run ESU Chinook salmon

and Central Valley ESU steelhead in the Department of Commerce's National Marine Fisheries Service final ruling published September 2, 2005 (Federal Register 70: 52488-52627), effective January 2, 2006. Figure 3.10-3 , Designated Critical Habitat for Federally-listed Anadromous Salmonids, depicts geographic distribution of federally designated critical habitat in Stillwater and Churn creeks, as well as reported historic extent of occupied habitat.

The Department of Commerce justified including these streams under this critical habitat designation using the following bases:

"…their use during winter and early-spring months for non-natal rearing by juvenile spring-run Chinook salmon and steelhead. Though current use is likely low, it is expected to increase in the near future as a result of habitat restoration and range expansion in Battle and Clear Creeks. The CHART [Critical Habitat Assessment and Review Team] concluded these streams provide several PCE's [primary constituent elements] that are important for juvenile non-natal rearing, which represents a unique life-history strategy that is essential for the conservation of the ESU because of its contribution to improved growth conditions and refugia from high water and catastrophic events. In addition, the CHART concluded that these streams will require special management efforts for flood control, residential and commercial development, agricultural management, and habitat restoration to protect and maintain the conservation value of these habitats for spring-run Chinook." (NMFS 2004).

Essential Fish Habitat

The NMFS has designated the upper Sacramento River and most local tributaries inhabited by salmon, including Churn and Stillwater creeks, as EFH, as mandated by the Magnuson-Stevens Sustainable Fisheries Act (Public Law 104-297), to stop or reverse the continued loss of fish habitats. Toward this end, Congress mandated the identification of habitats essential to managed species and measures to conserve and enhance these habitats. The Act requires cooperation among NMFS, the Fishery Management Councils, and federal agencies to protect, conserve, and enhance "essential fish habitat." Congress defined essential fish habitat for federally managed fish species as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity."

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3.11 Fire History and Management

The watershed assessment area as a whole is highly susceptible to wildland fire because of its Mediterranean climate and vegetation communities dominated by annual plants that dry completely in the summer, typically forming a dense layer of standing dry thatch. For this reason, fire has historically played an important role in the ecology of the assessment area. Mixed hardwood-conifer forests require fire for forest regeneration; fire clears dense understory shrubs and creates sunlit openings suitable for the germination and establishment of tree seedlings (Barbour and Billings 2000).

There is, however, evidence suggesting that humans have drastically influenced the fire patterns in some vegetation communities in the assessment area. An inventory of fire-scarred blue oak trees in the adjacent Sierra Nevada foothills revealed that the fire return period in this community prior to European settlement was 25 years but shortened to just 7 years after settlement (Barbour and Billings 2000). This decreased interval will affect how succession proceeds in blue oak woodlands and may be a factor in poor seedling recruitment in these habitats. In addition, the near-complete replacement of the native grassland flora by a Mediterranean annual grass flora following the Spanish settlement in California may have also altered fire ecology.

In addition to shaping plant communities in the assessment area, fire can have dramatic effects on other watershed functions, particularly water quality and sediment transport. Large, high-intensity fires leave behind bare soils that are highly susceptible to erosion when winter rains set in, particularly in hilly or steep terrain. These sediments are moved downslope into creeks and rivers, where they are transported downstream. The distance they are transported and their effect on water quality depend on a number of factors. Larger sediments will tend to settle more quickly, and finer sediments will be carried further downstream before settling. Sediments of all sizes will move farther with greater water velocities. Although sediment transport is a natural and important function of creeks and rivers, it is of increasing concern as human activities, such as overgrazing, land clearing, and removal of protective riparian vegetation, have increased erosion and sedimentation and impaired water quality.

Fire has historically played an important role in the ecology of the assessment area. In the northern portion, the closed-cone pine-cypress vegetation community requires fire to release seeds from the cones and to create the canopy openings needed for successful seedling establishment and growth. Mixed hardwood-conifer forests require fire for forest regeneration.

Development of urban centers within woodland environments (urban interface) results in the need to protect structures and populations from fire damage. As these areas grow and suburban developments push further into wildlands, the active suppression of fires becomes common practice. Approximately 17 percent of the assessment area is classified as urban/developed, with much of the remainder of the assessment area classified as rural residential (i.e., scattered rural homes and ranches). This section of the assessment summarizes the recent fire history of the assessment area; provides an overview of the characteristics of the assessment area that determine fire frequency and behavior; and discusses how

fire is currently managed and controlled in the assessment area.

3.11.1 Fire History

Most fires in the assessment area occur in the summer and fall when fuels are driest and ignition sources most frequent. Information on the history of fire in the assessment area was taken from the CDF's FRAP. The FRAP includes fires for which CDF was responsible that were 300 acres or larger and fires for which the USFS and BLM were responsible that were 10 acres or larger, although a few smaller fires are included. For this reason, the fire history reported here does not include all fires that have occurred in the assessment area; undoubtedly, there have been numerous small or unreported fires.

Since the 1950s, the assessment area has experienced approximately 14 wildland fires (Table 3.11-1) (California Department of Forestry and Fire Protection 2005a). The largest of these, the Jones fire, occurred in 1999 just east of Redding. This fire burned over 5,794 acres of primarily blue oak woodland habitat around Clough Creek, Salmon Creek, and the eastern tributaries to Stillwater Creek. The origin of the Jones fire is unknown. Since 2000, there have been six fires in the assessment area, ranging from 2 to 320 acres; most of these occurred in the northern portion of the assessment area north of the City of Shasta Lake.

In the Clikapudi watershed, which lies just northeast of the assessment area, it was noted that stream channel turbidity increased as a result of the Jones fire in 1999 (WSRCD 2004). This increase was limited to the first series of storms that occurred in December 1999 and January 2000 (WSRCD 2004). Topography in the Clikapudi watershed ranges from gentle to moderately sloped foothills. The part of the assessment area that was affected by the fire is predominantly flat to gently rolling, so it is expected that erosion and sedimentation into Clough, Salmon, and Stillwater creeks increased as a result of the fire but to a lesser degree than in the Clikapudi watershed.

The occurrence of fire in the assessment area is in part the result of the fire rotation class of the vegetation communities in the assessment area. The fire rotation interval is calculated from historic fires that occurred on land areas that are grouped into classes based on vegetation; fire environment conditions, including climate and elevation; and the agency responsible for protection in that area. The fire rotation interval is defined as the expected number of years it would take to burn an area equivalent to that of the entire class. The larger the fire rotation interval, the less frequently the area is expected to burn.

According to FRAP (California Department of Forestry and Fire Protection 2004), the fire rotation interval for the urban portions of the assessment area, including the cities of Redding and Shasta Lake, is undetermined. The eastern half of the assessment area, east of the cities of Redding and Shasta Lake, has been classified in the 100 to 300 years rotation interval, which means that every portion of that area is expected to burn at some time during a 100- to 300-year period. Vegetation in this portion of the assessment area is predominately blue oak and blue oak–foothill pine woodlands. The portion of the assessment area north of the City of Shasta Lake is in the greater than 300 years rotation interval. Vegetation in this portion of the assessment area is primarily montane hardwood–conifer forest. The longer burn interval in this area may be due in part to a lower density of understory annual forbs and grasses than in blue oak habitats.

Table 3.11-1
Historical Wildfires in the Stillwater–Churn Creek Watershed

Fire Name	Year	Responsible Agency	Cause	Acres Burned
G. Chatham	1951	CDF	Unknown	1,031
Prigmore Escape	1954	CDF	Unknown	676
Airport Fire	1954	CDF	Unknown	2,678
Loomis Corners	1958	CDF	Unknown	428
SPRR #14	1963	CDF	Unknown	725
Kittyhawk	1983	CDF	Unknown	263
Bear	1990	CDF	Lightning	618
Jones	1999	USFS	Unknown	5,794
Union	2000	CDF	Equipment use	320
Fawndale	2001	CDF	Vehicle	70
Shu Dersch	2001	BLM	Unknown	2
Wonder	2003	CDF	Vehicle	16
Lake	2004	CDF	Arson	119
Tierra	2004	CDF	Unknown	18
Total				**12,758**

3.11.2 Fire Hazard Severity Zones

Following a destructive fire season in 1980, legislation was introduced that required CDF to zone all State Responsibility Area lands in accordance with the degree of severity of the fire hazard (CDF 2001). State Responsibility Area lands are those lands for which CDF is responsible for protecting against fire. The purpose of the zoning was to identify measures that would slow the rate of fire spread and reduce the potential for uncontrolled fires. Each zone receives one of three ratings: moderate, high, or very high. The rating is based on fuel loading, slope, fire weather, and other landscape-specific factors (CDF 2001).

Within the assessment area, State Responsibility Area lands include all areas outside the jurisdiction of the City of Shasta Lake and the City of Redding (Figure 3.11-1 *Fire Protection Responsibility Boundaries and Fire Severity Ratings*.) They cover approximately one-half of the assessment area and include the entire eastern portion of the assessment area east of the City of

Shasta Lake and the city of Redding, the northern portion of the assessment area north of the City of Shasta Lake, and small portions in the west around Newtown and Buckeye creeks. State Responsibility Area lands in the southern portion of the assessment area south of Route 44 are designated High Fire Severity (Figure 3.11-1). Other State Responsibility Area lands designated as High Fire Severity are those areas immediately adjacent to the City of Shasta Lake. The remaining State Responsibility Area lands in the assessment area are designated as Very High Fire Severity. It is important to note that zoning is designed to give an average hazard rating for the area and does not define exact conditions for all areas within a given zone. Variation within a given zone will result from differences in fuels, slope, weather, aspect, elevation, and individual structures (CDF 2001).

3.11.3 Fuel Loads and Distributions

Surface fuels are vegetative materials near the ground through which fire will spread. These materials range from downed woody material such as leaf litter, dead branches, and logs to brush and grass. The amount, size, and moisture content of surface fuels determine how fast a fire spreads, how hot it burns, and how high its flames reach. Fuel ranking maps are used to identify and plan pre-fire projects that reduce fire hazard. Ranks are assigned based on expected fire behavior for each unique combination of cover type, vegetation type, fuel size, slope, aspect, elevation, and historical fire data for a given area.

Following the creation of the severity ratings maps developed for State Responsibility Areas back in 1980, CDF prepared an updated fuel ranking map that covers all of California, not just State Responsibility Areas, as part of its California Fire Plan. The existing fuel rankings map for the assessment area is provided in Figure 3.11-2, California Department of Forestry Fuel Ranks (CDF 2005b). According to this map, the assessment area includes areas ranked as moderate, high, and very high. A rank of very high classifies an area as very high priority for pre-fire projects that will help prevent catastrophic fire. Areas ranked as very high are scattered in very small areas throughout the assessment area. However, a majority of these areas occur in the very northern portion of the assessment area north of the City of Shasta Lake, and are likely associated with south-facing foothill slopes.

Approximately half of the assessment area is ranked as high priority for pre-fire projects, including most of the central and northern portions of the assessment area, except for the cities of Redding and Shasta Lake and the areas immediately adjacent to Stillwater and Churn creeks.

Approximately half of the assessment area is ranked as high priority for pre-fire projects, including most of the central and northern portions of the assessment area, except for the cities of Redding and Shasta Lake and the areas immediately adjacent to Stillwater and Churn creeks. This ranking means that areas adjacent to urban centers in the assessment area have a high priority for pre-fire projects and that these projects are necessary to prevent wildland fire damage. The remaining portion of the assessment area is ranked as moderate and includes Redding, the City of Shasta Lake, and areas immediately adjacent to Stillwater and Churn Creeks.

3.11.4 Fire Behavior

Fuel models are used to predict how fire will behave in a given area under a defined set of conditions. The ability to predict fire behavior, including flame length and the rate of spread, assists agencies in predicting the resources required to suppress a fire and provides increased safety to firefighters. In general, there are three key factors that influence fire behavior: fuel, weather, and topography. Fuel models are based on the dominant vegetation type present and the fuel loads associated with that vegetation type. There are three broad categories of fuel models, with each based on one of three vegetation types: grass, shrub, and conifer. Fire behavior varies among these models in intensity, rate of spread, flame height, and the height at which the fire is carried.

CDF uses fuel models for the assessment area based on Aids to Determining Fuel Models for Estimating Fire Behavior (Anderson 1982). These models are shown on Figure 3.11-3, Fire Behavior Prediction System Fuels Models. Approximately one-third of the assessment area falls under Fuel Model 1. Fuel Model 1 predicts fire behavior in areas dominated by short grasses (1 foot) (Anderson 1982) and includes the extreme eastern edge of the assessment area, most of the southern portion of the assessment area, parts of the cities of Redding and Shasta Lake, and the areas immediately adjacent to Stillwater and Churn creeks. It also includes the portions of the assessment area to the north and west of the City of Shasta Lake. Under Fuel Model 1, fire spread is governed by fine, very porous, and continuous herbaceous fuels that are dry or nearly dry. Fires are surface fires that move rapidly through dry grasses and associated material (Anderson 1982). Very few shrubs and very little timber is present, generally less than one-third of the area. Some of the vegetation communities in the assessment area that are included in Fuel Model 1 are blue oak woodland, blue oak–foothill pine woodland, annual grassland, mixed chaparral, urban, and montane hardwood. As stated above, the models are not based on the vegetation communities present, but on the predominant vegetation type, which determines how the fire will behave. Fires that occur in Fuel Model 1 areas in the assessment area, regardless of the vegetation community, are expected to behave like grassland fires.

Another third of the assessment area falls under Fuel Model 2. Fuel Model 2 predicts fire behavior in open shrub lands and pine stands or scrub oak stands where one-third to two-thirds of the area is covered (Anderson 1982). These areas include most of the central and the northeastern portion of the assessment area, including areas east of Redding and nearly all the areas to the south, east, and northeast of the City of Shasta Lake. Under Fuel Model 2, fire spread is primarily through fine herbaceous fuels, either drying or dead. These are surface fires in which the herbaceous material, in addition to litter and dead and downed stemwood from the open shrub or timber overstory, contributes to the fire intensity (Anderson 1982). Some stands may include clumps of fuels that generate higher intensities and that may produce firebrands. Because there are major population centers in Fuel Model 2 areas of the assessment area, there is a risk of significant damage under certain climatic conditions. Vegetation communities that occur in Fuel Model 2 areas include blue oak and blue oak–foothill pine woodlands, montane hardwood, annual grassland, and montane hardwood–conifer.

The remaining one-third of the assessment area is classified under 9 different fuel

models, the highest intensity of which is Fuel Model 10. Areas that fall under Fuel Model 10 occur in small areas of the extreme north-central portion of the assessment area and have the potential to support high-intensity fires. These areas likely correspond to south-facing slopes of the Klamath Mountains foothills. Fuel Model 10 predicts fire behavior in any area where heavy amounts of downed material is present, including insect- or disease-ridden stands, wind-thrown stands, over-mature stands with deadfall, and aged thinned or partially cut slash (Anderson 1982). In these areas, fire burns in the surface and ground fuels with greater intensity than predicted for other timber litter models. Dead and downed fuels include high quantities of 3-inch or larger limbwood resulting from over maturity or natural events that create a large load of dead material on the forest floor. Crowning out, spotting, and torching of individual trees are more frequent in this fuel situation, leading to potential difficulties in controlling fires. There are no major population centers in the Fuel Model 10 areas of the assessment area, so the risk of damage to structures is relatively low. Vegetation communities in Fuel Model 10 areas are primarily montane hardwood and montane hardwood–conifer.

According to CDF, the entire assessment area except for a very small portion of the city of Redding and a very small portion of forested land in the extreme northeastern corner of the assessment area is classified as Wildland Urban Interface. Because of this designation, prescribed fire, which is an effective tool for managing fuels, is generally not used in the assessment area.

3.11.5 Wildfire Relationships with Urban and Wildland Settings

The risk to areas of significant population density from wildfire is estimated by considering the residential housing unit density and the proximate fire threat. The resulting estimate provides a relative measure of potential loss of structures and the threats to public safety that could result from wildfire (California Department of Forestry and Fire Protection 2003a). Areas where these risks are high are classified as Wildland Urban Interface (WUI) areas. Areas designated as WUI are areas where pre-fire projects could be conducted to reduce the wildland fire threat to people. Therefore, these are priority areas for receiving funds to conduct pre-fire activities, such as thinning, brush clearing, and construction of firebreaks.

According to CDF (California Department of Forestry and Fire Protection 2003a), the entire assessment area except for a very small portion of the city of Redding and a very small portion of forested land in the extreme northeastern corner of the assessment area is classified as WUI. Because of this designation, prescribed fire, which is an effective tool for managing fuels, is generally not used in the assessment area; the proximity of wildland areas to population centers, in addition to the very high fire-severity hazard, creates too great a risk of harm and damage for this tool to be used. However, because of the risk that they face, such areas are priorities for other types of pre-fire projects that involve significant fuel modification and treatment.

3.11.6 Management Policies and Methods

Methods to prevent and control the spread of fire fall under two categories: prevention and

suppression. Fire prevention involves public education and awareness and the development and enforcement of fire codes. California Public Resource Code 4291 mandates a number of fire prevention activities that must be undertaken by property owners. The owner must:

- Maintain a 100-foot defensible space around homes and structures by removing all brush, flammable vegetation, or combustible growth. Grasses and other vegetation located more than 30 feet away that are less than 18 inches tall may be maintained where necessary to prevent erosion.
- Remove portions of trees that extend within 10 feet of the outlet of a chimney or stovepipe.
- Maintain any tree adjacent to or overhanging a building free of dead or dying wood.
- Maintain the roof of a structure free of dead vegetation.

This state code is implemented and enforced by municipalities within the assessment area, including the cities of Redding and Shasta Lake. The responsibility for protecting homes and lands within the assessment area from fire, and for managing fires when they do occur, is divided between local, county, and state jurisdictions. Municipalities, including the City of Redding, the City of Shasta Lake, and Mountain Gate, are responsible for activities within their boundaries. The remaining unincorporated portions of the assessment area fall under the jurisdiction of Shasta County or CDF.

It is important to understand what responsibility means in the context of fire protection within the assessment area. Although each municipality and agency is responsible for fire protection within a given area, there is a great deal of coordination among all responsible agencies. Therefore, the agency responding first to a fire is determined by proximity to the location of the fire and not by jurisdiction (Diehl pers. comm. 2005). For example, CDF may respond to a fire within the city of Redding because it has the closest fire station, but the Redding Fire Department will be the last to leave the scene and will be responsible for the subsequent investigation. This coordination and support among agencies is intended to decrease response time, loss of property, and potential injuries and fatalities.

The following briefly discusses plans and policies that guide fire management in the assessment area and the role of each of the various agencies responsible for fire protection.

Plans and Policies

National Fire Plan

Following a landmark wildland fire season, the National Fire Plan was developed in August 2000 with the intent of actively responding to severe wildland fires and their impacts to communities, while ensuring sufficient firefighting capacity for the future. The NFP is a nationwide program coordinated by the U.S. Department of the Interior and the USFS. The NFP addresses five key points: firefighting, rehabilitation, hazardous fuels reduction, community assistance, and accountability. The NFP supports four programs to assist communities in preventing and coping with wildfire:

- Firewise – This program supports an educational website for people who live in or vacation in fire-prone areas of the United States. It was designed to acquaint people with the challenges of living with wildland fire. The site includes interactive games and tutorials, along with a message board

and a Firewise Communities Workshop area.

- Rural Fire Assistance Program (RFA) – The RFA is a grant program designed to support the fire protection capabilities of rural and volunteer fire departments that typically fight fires near or on Department of the Interior lands. With an annual appropriated budget for the RFA program, the DOI offers awards of up to $20,000 to be dedicated to training, equipment purchases, and fire prevention work on a cost-shared basis.
- State Fire Assistance (SFA) – The SFA program assists state forestry agencies in wildfire response coordination and delivery, compliance with the national safety and training standards that ensure state and local crew deployment to fires and other emergency situations on federal lands, hazard assessments, fuels treatment projects, and public education efforts.
- Volunteer Fire Assistance (VFA) – The VFA program, formerly known as the Rural Community Fire Protection program, is administered by state forestry agencies through 50-50 cost-sharing grants to local fire departments in rural communities. The program's main goal is to provide federal financial, technical, and other assistance for the organization, training, and equipping of fire departments in rural areas with a population of 10,000 or less.

California Fire Plan

The California Fire Plan was initiated by the CDF as a pre-fire management initiative designed to reduce wildland fires and the associated costs of suppression. Through the systematic application of risk assessment, fire safety, fire prevention, and fire hazard reduction techniques, the initiative is aimed at protecting assets at risk through focused pre-fire management prescriptions and increased initial attack.

The California Fire Plan has five strategic objectives:

- Create wildfire protection zones that reduce the risks to citizens and firefighters.
- Assess all wildlands (not just state responsibility areas) to identify high-risk, high-value areas and analyze all wildland fire service providers (federal, state, local, and private) to determine who is responsible, who is responding, and who is paying for fire emergencies.
- Identify and analyze key policy issues and develop recommendations for changes in public policy.
- Develop a strong fiscal policy focus and monitor wildland fire protection in fiscal terms.
- Translate the analyses into public policies.

The assessment area is included under the Shasta County Fire Safe Council. The Council is actively involved in preparing grants for funding fire safe activities, which are carried out by local-level fire safe councils. These activities include the creation and maintenance of large fuel breaks and fuel reduction activities.

Fire Safe Councils

The California Fire Safe Council provides resources for establishing and maintaining local Fire Safe Councils. Its mission is to preserve and enhance California's manmade and natural resources by providing leadership and support that mobilize all Californians to protect their homes, communities, and environment from wildfires. The California Fire Safe Council distributes fire prevention education materials to industry leaders and their constituents, evaluates legislation

Site of one of the many structures lost during the Jones Fire in 1999. (Photo courtesy of the California Department of Forestry and Fire Protection.)

pertaining to fire safety, and empowers grassroots organizations to spearhead fire safety programs.

The assessment area is included under the Shasta County Fire Safe Council. The Council is actively involved in preparing grants for funding fire safe activities, which are carried out by local-level fire safe councils. These activities include the creation and maintenance of large fuel breaks and fuel reduction activities. The Council holds regular community meetings and special workshops on fire safe activities, such as the creation of defensible space around homes, and keeps community members abreast of legislative changes that affect homeowner responsibilities. It also provides community members with detailed information on creating fire safe zones and home evacuation plans, and provides a list of important fire defense tools that should be kept at hand in every home. The Council has applied for 501(c)(3) non-profit status to increase its funding opportunities.

Individuals in the City of Shasta Lake area are in the process of creating a Fire Safe Council. That Fire Safe Council will eventually be engaged in pre-fire activities in the assessment area near the City of Shasta Lake.

Responsible Agencies

California Department of Forestry and Fire Protection

Approximately half of the assessment area falls within the CDF Shasta-Trinity Unit, and wildland fire protection in these areas is administered by the CDF. The federal government is responsible for fire response on federal lands in California including those that fall under the USFS, NPS, BLM, and BIA (CDF 2006). CDF will assist when requested by the federal or local governments; the agency with jurisdiction is most commonly the lead for fire and emergency response. These areas include the entire eastern half of the assessment area, which lies outside the boundaries of the cities of Redding and Shasta Lake; STNF lands at the northern edge of the assessment area; and unincorporated land east of the City of Shasta Lake. There is one CDF fire station within the assessment area, Fire Station #43 on Airport Road. Because the Shasta-Trinity Unit covers such a large portion of Shasta County, its does not track response times; the responsibility area is too broad to make such a statistic meaningful (Diehl pers. comm. 2005). CDF maintains mutual-aid agreements with all other fire departments and districts within the assessment area. These agreements allow resources to be deployed more quickly, thereby decreasing property damage and potential harm to life.

Fire prevention and management activities carried out by CDF are guided by the Shasta-Trinity Unit Fire Plan (CDF 2003b), which was written in cooperation with a number of local stakeholders that have an interest in fire management within the Shasta-Trinity Unit. Watershed stakeholders involved with preparation of the plan include the USFS, BLM, CDFG, Shasta County, the Shasta County Fire Safe Council, the RWQCB, the WSRCD, the City of Redding, and the City of Shasta Lake. The plan documents the assessment of wildland fire potential within the Shasta-Trinity Unit, with the overall goal of reducing costs and losses due to wildfire through pre-fire management prescriptions and more successful suppression of fires once they start. According to the plan, strategies to prevent and suppress wildland fire within the assessment area include:

- Creating wildfire safety zones to reduce citizen and firefighter risk from future large wildfires
- Increasing initial attack success by understanding the level of service required to prevent damage from future fires.
- Identifying and protecting assets at risk from wildfire, including citizen and firefighter safety, watersheds and water, timber, wildlife and habitat, rural communities, structures, and other assets.
- Undertake effective pre-fire management to protect assets at risk, including fuels modification, fire-safe zoning, educational programs, improved road accessibility, suitable infrastructure including fire stations, and forest health.

An important component of the plan is measuring the potential for wildfire to occur and predicting the potential severity of the fire within all areas of the Shasta-Trinity Unit. This is done by considering the types of vegetation present, the existing fuel loads, slopes, and weather patterns over time, all of which affect fuel loads and fuel moisture.

Shasta County Fire Department

The Shasta County Fire Department has one fire station immediately adjacent to the assessment area in Palo Cedro that responds to fires that occur within the assessment area.

City of Redding

The Redding Fire Department provides emergency services to an area of approximately 75 square miles, including the city of Redding with a population of approximately 86,000, and the Buckeye Fire Protection District to the north with a population of approximately 8,000 (City of Redding 2005). The city currently has eight fire stations, including the new Fire Station #8 completed in 2005 that was built in order to reduce response times to the expanding northeastern portion of the city. Fire Station #8 is equipped with not only a structural firefighting engine, but also a wildland engine and a Shasta Cascade Hazardous Materials Response Team response vehicle (City of Redding 2005). With the addition of Fire Station #8, Redding currently has five fire stations that service the assessment area. The number of incidents that each station responded to in 2004 and their average response time are summarized in Table 3.11-2. Because Station #8 opened just prior to the preparation of this watershed assessment, there was no incident response information available for this station.

The Redding Fire Department maintains mutual/automatic aid agreements with the Shasta County Fire Department and CDF. Under this agreement, the Department responds automatically on a year-round basis to emergencies in Shasta County adjacent to the city of Redding, and to emergencies on county islands. These are vital agreements that enable both the Department and CDF to maximize resource utilization on wildland fire incidents within the city of Redding and the surrounding areas, and allows the Department to better address the significant potential for fire in the wildland-urban interface.

Because much of Redding is adjacent to areas designated as Very High Fire Hazard Severity, the City of Redding is actively involved in both fire prevention and fire suppression activities. Fire prevention involves public education and awareness of fire safety and the development and enforcement of fire codes. The Redding Fire Department in 2004 provided fire prevention education to approximately 5,000 elementary school children through presentations at 22 public and private elementary schools (City of Redding 2005). It

Table 3.11-2
City of Redding Fire Stations in the Stillwater–Churn Creek Watershed

Station #	Service Area	2004 Incident Responses	2004 Average Incident Response Time (minutes)
Station #1	Downtown, North Market, Hwy 299 East/College View	2,681	5
Station #5	Enterprise and East City	3,151	6
Station #6	North City	1,447	6
Station #7	Airport, Southeast City, new industrial	206	7
Station #8	Location on Churn Creek Rd., coverage area to be determined	N/A	N/A

N/A = not applicable.

was also involved in 58 fire and life safety presentations to other audiences, including older adults and occupants of apartment buildings. In addition, the Redding Fire Department is working with CDF to create a fuel reduction program in areas with the greatest fire hazard. This is a multi-year program that in 2004 was responsible for clearing 157 acres of greenbelt property within and around the assessment area. An additional 268 acres of downed materials were cleared using City funding approved by the City Council (City of Redding 2005).

City of Shasta Lake Fire Protection District

The City of Shasta Lake Fire Protection District consists of three stations, all of which service the assessment area. These stations are located in the City of Shasta Lake in areas previously designated as Project City (one station), Summit City (one station), and Central Valley (one station). The combined average response time of these fire stations is 4 minutes, 17 seconds (Smutz, personal communication). These stations are responsible for fire prevention and management activities within the City of Shasta Lake and an additional square mile that lies directly to the east of the city. The District also provides mutual aid to adjacent jurisdictions as needed.

Mountain Gate Fire District

The Mountain Gate Fire District has one fire station, Station #41. The District provides mutual aid to adjacent jurisdictions as needed.

Shasta Community College

Shasta Community College in northeastern Redding has a single fire station, #72. This fire station is managed by CDF and is funded by the College.

In addition to these fire stations, stations adjacent to the assessment area may respond to fires occurring in the assessment area. For example, Shasta County has two fire stations, #46 and #47, that are just south of the assessment area in Anderson. These stations would be mobilized for fires in the southern portion of the assessment area.

South Lake Shasta Fire Safe Council

The South Lake Shasta Fire Safe Council includes the communities of Shasta Lake, Mountain Gate, and Jones Valley, the most fire-prone area of the watershed. The Council was formed in October 2005 and has met monthly since this time on the fourth Tuesday of each month, rotating between the three communities. Currently, stakeholders in the Council are implementing a landowner assistance program to help five local landowners conduct fuel reduction projects on properties in the area. The Council is functioning under the umbrella of the Shasta County Fire Safe Council and has submitted several grant proposals to fund a Fuels Reduction Management Plan for the Council area.

3.11.7 References

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Chapter 4
Watershed Trends, Key Findings, and Key Questions

4.1 Introduction

This chapter presents a brief synthesis of trends occurring within the Stillwater-Churn Creek Watershed based on our review of the historic influences, land use trends, and current conditions of natural resources present in the assessment area. The findings of this analysis are presented at a level of resolution consistent with the detail of the available information discussed in previous chapters. One of the overall objectives of the watershed assessment process is to identify the dominant ecosystem components, natural processes, and human activities that influence the beneficial and reasonable uses of water resources. Therefore, the discussion in this chapter focuses on key findings concerning the relationship of the conditions of natural resources to the beneficial and reasonable uses of water resources in the assessment area. Key questions concerning these relationships have emerged through the process of this assessment and are presented as part of the findings in this chapter.

As referred to and analyzed in this chapter, uses of the water resources in the assessment area include those designated as beneficial uses for surface and ground waters of the region by the Central Valley Regional Water Quality Control Board and other reasonable uses. Thirteen beneficial uses of water, designated for the Sacramento River Basin in the Basin Plan, are described in Section 3.6, Water Quality. These designated beneficial uses extend to the waters of the assessment area under the "tributary rule," as described by the Basin Plan, and are evaluated in this chapter, where applicable, under three broad categories as follows:

WATER SUPPLY

Designated Beneficial Use

- Agricultural supply
- Municipal and domestic supply
- Industrial service supply
- Groundwater recharge
- Freshwater replenishment
- Navigation (not directly applicable to assessment area)
- Hydropower generation (not directly applicable to assessment area),

RECREATION

Designated Beneficial Use

- Water contact recreation
- Non-contact water recreation

AQUATIC HABITAT

Designated Beneficial Use

- Warm freshwater habitat
- Cold freshwater habitat
- Migration of aquatic organisms
- Spawning, reproduction, and/or early development.
- Wildlife habitat

Other reasonable uses considered as valued uses and functions provided by the water resources within the assessment area are also evaluated in this chapter and include:

- Wastewater discharge conveyance
- Water-dependent habitats (such as wetlands and riparian forests and those plant and wildlife resources supported by these habitats, including numerous special-status species and natural communities)
- Stormwater management and conveyance

Findings on the condition of the watershed and water resources within the assessment area are organized according to these broad categories of designated beneficial uses and other reasonable uses. Each finding is supported by a descriptive rating[1] of the quantity and quality of data and information available for this assessment and a synthesis and discussion of the supporting information and data found in Chapters 2 and 3.

4.2 Water Supply and Water Quality

FINDING 1

Water Supply

Surface water and groundwater supplies in the assessment area must be supplemented with diversions from the Sacramento River to generally meet existing and projected near-term future uses within the assessment area. However, deficiencies have occurred seasonally and during droughts in the past and are likely to continue to occur as a result of ongoing population growth, regulatory restrictions on use of Sacramento River surface water, and some limitations on groundwater quality and annual yield, especially in northern portions of the assessment area.

Data Quantity/Quality

Moderate to Good

Discussion

The surface water supply originating within the assessment area is highly seasonal and inadequate, without supplementation, to support the existing demands for beneficial uses of water and that of projected future growth in the area. Therefore, the primary water supplies for the assessment area rely on surface water diversions imported from the Sacramento River that are distributed by the cities of Redding and Shasta Lake, and several water districts, including BVWD, ACID, and Shasta County Water Agency. As described in Chapter 3.5, agricultural and urban development in much of the assessment area would not have been, or continue to be, possible without this water source. The Sacramento River surface water supply for local water purveyors is affected by regulatory requirements of the Central Valley Project Improvement Act, and thus can vary annually, which has resulted in water supply shortfalls in some years (Shasta County Water Agency, CH2M Hill, and California Department of Water Resources 1997).

Water supply shortfalls within the assessment area are most severe in critically dry years. Overall, these shortfalls are projected to more than triple (300 percent increase) within the cities of Anderson, Redding, and Shasta Lake over the next 25 years without development of alternative water supplies (County of Shasta 2004). Similarly, within unincorporated

[1] The descriptive rating system for data quantity/quality uses three levels: (1) "Low," when data quantity and/or quality is limited or lacking and insufficient to support management decisions without further investigation; (2) "Moderate," when data quantity and/or quality may be sufficient for management decisions, within an adaptive management framework, including focused investigation of issues and monitoring of actions; and (3) "Good," when data quantity and/or quality is sufficient for informed decision making and management actions, according to customary engineering and environmental standards.

portions of the assessment area, critically dry year water supply shortfalls are expected to increase by 20 to 30 percent (County of Shasta 2004).

Current use of the Sacramento River as the primary water supply for irrigation and domestic uses within the assessment area is thought to have stabilized or decreased surface water withdrawals from the principal streams of the watershed compared to historic water use. Runoff of irrigation and nuisance water to stream channels in the assessment area is also thought to currently result in greater amounts of stream flow and wetted channel reaches during the dry summer months than historically occurred in these streams. These conditions continue to support instream beneficial uses of water within the assessment area. However, localized land uses along watershed streams, including urbanization, channelization of streambeds, vegetation clearing, contaminated stormwater discharges from urban and agricultural areas, and invasive plant and animal species continue to have an impact on beneficial uses of instream water.

Groundwater supplies in the Redding Groundwater Basin aquifer are used to supplement the surface water supplies in the assessment area, especially during normal and dry years when surface water cutbacks can occur (Shasta County Water Agency, CH2M Hill, and California Department of Water Resources 1997). This aquifer is primarily recharged by infiltration of area stream flows, and secondarily by infiltration of irrigation water, which is dominated by the diverted Sacramento River supplies. Seasonally, this aquifer is subject to fluctuations of approximately 5 to 15 feet, with greater fluctuations during extended drought and recovery cycles (e.g., 1970s and 1990s climate conditions), but overall trends do not suggest any significant increase or decrease in groundwater levels (California Department of Water Resources Bulletin 118-03).

Reliance on groundwater for domestic, agricultural, and industrial purposes has increased, particularly in Enterprise and the unincorporated areas in the vicinity of Airport Road. The City of Redding, City of Anderson, and BVWD have increased development of groundwater sources in response to meet growing demands. In addition, continued development in unincorporated areas is reliant on individual and small community wells to further meet these increasing water demands. Groundwater supplies in the assessment area vary in terms of annual yield and quality. Groundwater in the northern portion of the assessment area has a lower water yield and is generally of lower quality than in the southern portion. While groundwater has historically accounted for 10 to 15 percent of annual water use in the assessment area, depending on the water year, new well fields being added by municipal and agricultural water purveyors in recent years are increasing the proportion of groundwater used. This trend is likely to continue in order to meet the water demand to support increasing urban growth. However, the effect of these new wells and increased groundwater drafting on the aquifer storage levels, on annual aquifer recharge efficiencies, and on area stream flows has not been fully analyzed.

Additionally, the use of detention and retention basins for managing stormwater runoff has increased within the assessment area in recent years to mitigate for the negative effects of ongoing urbanization on local stream hydrology (e.g., increases of impermeable ground surface due to roofs and street paving). The potential impermeable

surface area could exceed nearly 30 percent of the entire 77,762 acre assessment area at full build-out under the existing city and county general plans (Chapter 3.5). The effect of current stormwater management practices for reducing downstream flooding and maintaining groundwater recharge are thought to be an improvement over past practices; however, their efficacy for addressing impacts to both stream flows and groundwater recharge has not been evaluated, but monitoring is anticipated under the City of Redding's SWQIP (Chapters 3.5 and 3.6).

Key Questions

[Q 4-1] Where and to what degree are the local water supplies reliant on Sacramento River water? Are there contract limitations on the availability of this water (domestic/agricultural/industrial)? Are there limitations on development/growth in general terms, or in specific areas within the assessment boundary?

[Q 4-2] What is the location, quantity, and quality of irrigation runoff water during the dry summer months? How does this runoff affect beneficial uses of water in the watershed? Are there specific land use practices that should be considered in more detail with respect to this question?

[Q 4-3] What are the distribution and use of pumped groundwater in the watershed? What opportunities exist to expand these services? Are there any relationships between groundwater use and surface water?

[Q 4-4] Are detention basins functional in terms of reducing impacts to beneficial and reasonable uses of water? Are there any conflicts between these uses (e.g., retaining water in upslope areas versus recharge of floodplains/stream channels)?

FINDING 2

Water Quality

The quality of water in the assessment area, with a few exceptions, is generally good to excellent; and, although some stakeholders in the assessment area have reported localized deterioration of surface water quality, monitoring data remain too limited for definitive conclusions.

Data Quantity/Quality

Moderate

Discussion

Water quality of groundwater is generally considered very good to excellent in the southern portion of the assessment area; however, high TDS, especially sodium and boron salt levels, primarily from natural contaminate sources, in shallow wells north of about where Highway 44 bisects the assessment area, limits groundwater uses (California Department of Water Resources Bulletin 118-03). However, most municipal wells have been drilled in areas outside this region of poor groundwater quality.

Surface water quality is also generally considered to be very good within assessment area streams; however, as described in Chapter 3.6, comments received from stakeholders, natural resource professionals, and limited monitoring data obtained for this assessment suggest that some impairment of surface water quality can occur from excessive fine sediment and turbidity, high water temperature, nutrients, chemical pollutants, and pathogens.

Alteration of stormwater runoff patterns due to land development and associated infrastructure like roads, parking lots, and flood control structures; loss of native

vegetation due to land use conversions, invasive plants, and wildfire; and ground-disturbing construction activities are all implicated in the perceived increase in fine sediment and turbidity in assessment area streams during storm runoff.

While significant wildfires have occurred periodically within the assessment area and have resulted in transient increases in sediment runoff to streams, wildfire is not considered a significant, chronic threat to water quality in the watershed. However, localized fuel build-up in dense manzanita and live oak thickets, which occur in significant portions of the upper watersheds of assessment area streams, makes these areas especially prone to wildfire.

Ground-disturbing construction activities, particularly on steeper slopes in the upper watersheds, without properly employed erosion and sediment runoff prevention measures is considered to have a significant effect on the amount of sediment-laden runoff entering streams of the assessment area. Improperly managed increases in stormwater runoff from impermeable surfaces of developed areas is considered to pose the greatest single risk of chronic excessive sediment delivery to assessment area streams.

An invasive plant, the giant reed (Arundo), is also thought to have altered the sediment transport dynamics of assessment area streams (Western Shasta Resource Conservation District 2004) by colonizing freshly deposited fine sediments in stream channels and along stream banks, impeding stream flows, exacerbating silt deposition, and subsequently releasing large quantities of silt when the plants are washed away during high stream flows.

Historically, nutrient levels in Churn Creek were reported to be elevated and caused nuisance algae growth, which was primarily attributed to septic tank contamination of shallow aquifers and early operations of the Shasta Lake PUD wastewater treatment plant (Churn Creek Task Force 1991). Since the early 1990s, nutrient levels in Churn Creek have apparently decreased due to upgrades to the wastewater treatment plant and continuing expansion and improvement of sewer connection service throughout the upper Churn Creek watershed. However, nutrient levels and incidents of toxic pollutants do appear to remain somewhat higher in Churn Creek than in Stillwater Creek, based on limited monitoring data obtained for this assessment. This condition is a likely result of non-point sources of runoff from urban streets and landscaping, parks, and golf courses in the watershed, which can contribute nutrients and contaminant loads from fertilizers, pesticides, and petroleum-based materials. The available data are not sufficient to identify the relative duration and magnitude of these non-point source pollution events; however, spikes in pollutant concentrations in streams are widely known to occur during the runoff from first fall and winter storm events.

An additional source of sediment and nutrients in both Stillwater and Churn creeks may arise from irrigation tailwater discharges. While irrigated agricultural lands occupy only about 6 percent of the assessment area, most of this land is located on, immediately adjacent to, or otherwise in close proximity to floodplain terraces along the creeks. Flood irrigation is a principal method for applying irrigation to these lands within the assessment area. The tailwater from flood irrigation frequently drains to creek channels or distributaries that eventually drain to a creek. These tailwaters typically carry higher

concentrations of nutrients and sediments than the receiving streams.

Water temperatures of the assessment area streams vary seasonally and can become unsuitably warm during the summer to support coldwater fishes (U.S. Fish and Wildlife Service 1995). The limited seasonal stream temperature data obtained for this assessment suggest that Stillwater and Churn creeks show patterns consistent with natural thermal regimes of other regional streams. While no evidence was found of temperature impairment of assessment area streams, several stakeholders have voiced concern that alteration and removal of riparian vegetation along some portions of both Stillwater and Churn creeks over the course of time has resulted in warmer stream temperatures during the late spring months.

No reach-specific water quality data were available for analysis by this assessment. Such data would be useful for identifying the relative distribution, duration, and magnitude of various factors that affect the water quality of assessment area streams.

Key Questions

[Q 4-5] Where and to what degree is poor water quality affecting beneficial and other reasonable uses of water?

[Q 4-6] What are the relative contributions of sediment associated with various land uses and ecological processes? Some type of sediment budget may be used to assess the significance of these uses and processes.

[Q 4-7] Where does Arundo occur in the Churn Creek Watershed? Are there conditions that facilitate expansion of this species within the assessment area (e.g., channel gradient, available substrate, irrigation runoff during the summer)?

[Q 4-8] Are there critical areas where beneficial uses are subject to impacts from fires and/or fuel reduction projects?

[Q 4-9] Where and to what degree is water quality (i.e., nutrients) influencing the beneficial and other reasonable uses of water within the assessment area? Are these influences isolated, or widespread?

[Q 4-10] What is the relationship between irrigation practices and surface waters, particularly in terms of quantity and quality of water?

4.3 Recreation

FINDING 3

Detailed data describing historic recreational uses in the assessment area are not readily available. Increasing residential and commercial development suggests that dispersed recreational use activities like hunting and fishing may be stable or in decline, and activities like equestrian and off-road vehicle use may be on the increase. While some established dispersed recreational uses, such as for-fee hunting at the Hawes Ranch, will likely continue, informal observations and regional trends suggest that other forms of recreation are increasingly popular, including recreational experiences that are enhanced by proximity to water. Significant opportunities exist to increase water-enhanced recreational use in the forms of walking, biking, wildlife-viewing, and equestrian trails located adjacent to creeks and wetlands.

Data Quantity/Quality

Low

Discussion

Historic recreational use of the watershed area was dominated by dispersed activities (e.g., hunting, fishing, equestrian use and off-highway vehicle use). Although these historic activities still occur in rural portions of the assessment area, it is reasonable to assume that conversion from agricultural to urban land uses is increasing the demand for recreational opportunities in the assessment area that can be easily accessed by the diverse range of residents. Examples of easily accessible forms of recreation that have wide appeal include cycling, picnicking, walking, wildlife-viewing and nature-viewing. Lema Ranch, Enterprise Park, and the recently completed Clover Creek Preserve are examples of projects that provide venues for these kinds of recreation. For each of these projects, the recreational values are enhanced by proximity to water. Regarding future recreation, the City of Redding is planning a trail system along Churn Creek from the Churn Creek Road Bridge on Churn Creek Road north to the Gold Hills subdivision south of Oasis Road.

The success and popularity of Redding's Sacramento River trail system, the Clover Creek Preserve facilities, and McConnell Foundation's Lema Ranch continue to feed the public's interest in expanding and improving opportunities for local water-enhanced recreation and tying together local trail and open-space networks.

Contact and non-contact water recreational use historically has been limited due to the summertime low flow characteristics of the local creeks, concerns about water quality, limited public access, and because litter, aquatic weeds and algae diminished the recreational experience, particularly in Churn Creek. Detailed, long-term data for water quality are not available, but a short sampling program found surface water quality in Stillwater and Churn creeks to not be limiting for water-contact recreation. Decisions about enhancing and expanding opportunities for water-contact and non-contact water recreational use should be informed by a better understanding of water quality than currently exists.

Key Questions

[Q 4-11] Is there a collective vision among municipalities and other jurisdictions that directs recreational development in the assessment area? Does this vision acknowledge the value of water resources and associated habitats as important elements of the recreational experience?

[Q 4-12] Is there a public perception that surface water quality inhibits recreational experiences within the assessment area? Is there a need to initiate a water quality monitoring program that focuses on key water quality parameters (e.g., odor, nuisance algae, and fecal coliform) that influence the recreational experience?

4.4 Aquatic Habitat

FINDING 4

Although available information is limited, it is apparent that the overall quantity and quality of aquatic habitats, including wetlands and streams, has been modified compared to historic conditions. Habitat has been lost or modified in some areas and been created in other portions of the assessment area, although net losses of some habitats (i.e., wetlands) have occurred. The quality (functionality) of many aquatic habitats has and may continue to decline as a result of significant modification of stream channels and fragmentation of wetlands, increased erosion and sedimentation in stream

channels, historic gravel extraction, losses of riparian vegetation, introductions of non-native plant and animal species, urban rubbish accumulations in stream channels, and excess nutrients and toxic contamination in surface runoff.

Data Quantity/Quality

Low

Discussion

Very little quantitative data regarding historic conditions and changes in the quality of stream habitat and beneficial use of instream flows were found during investigations for this assessment. Data for other aquatic habitats, such as wetlands, were very limited. As a result, analysis and conclusions regarding the condition of aquatic habitat within the assessment area are necessarily qualitative and cursory (Chapters 3.8 to 3.10). Additional information on stream and wetland habitat quality and biological resources will likely be required for management planning purposes.

This assessment has identified that two factors have most affected the hydrology of stream flows and aquatic habitat within the assessment area: (1) increased stormwater runoff due to an increase of impermeable surfaces, with higher peak stormwater flows and consequent shorter seasons of sustained flow, and (2) diversion of Sacramento River water for supplying water to area residents, with irrigation runoff to local streams. These two factors have changed the availability of seasonal intermittent stream habitat. Irrigation runoff and residential drainage maintain water in certain drainage areas and stream channels throughout the summer and have created conditions suitable for establishment of riparian and wetland vegetation where it otherwise may not have existed. Although no reliable data are available to quantify the number of small impoundments on tributaries, the cumulative effect of these features may also be altering the seasonal hydrology of streams in the assessment area, while converting stream habitat to ponds and creating new aquatic habitat where none existed historically. Changes in the seasonal distribution of fish and other aquatic organisms in response to these physical habitat changes is not specifically known; however, these conditions are thought to have contributed to establishment of several non-native species to the area (e.g., non-native warm water fishes, bullfrog, giant reed) since native species are typically better adapted and more tolerant of periods of drought and seasonally dry streams. The effects of nuisance water and irrigation runoff on area stream channels and on native fish is not known, although it is commonly thought to be detrimental.

Non-native plant and animal species have been introduced to the assessment area for a number of purposes. Several of these species have been and continue to alter the landscape and aquatic habitats, and compete with, prey upon, and displace native species. The effects on native species and stream channels caused by the invasive giant reed (*Arundo donax),* are described in Chapters 3.5 and 3.8. Arundo is highly invasive and rapidly colonizes along stream channels and banks. It has been documented to be particularly abundant along Stillwater Creek from its upper forks to its confluence at the Sacramento River (Western Shasta Resource Conservation District 2004). Its prevalence is thought to be much less in Churn Creek than in Stillwater Creek, based on stakeholder comments received during this assessment.

The risks to beneficial uses of water affected by Arundo infestations include displacement of native plant and animal species, including

special-status species; consumption of ground and surface water due to very fast growth and transpiration rates; blockage of stream channels with excessive plant growth; alteration of the sediment-carrying capacity of streams; and introducing large pulses of accumulated sediment when plants are washed out by high stream flows. Because of these impacts, eradication and control of any future expansion by this invasive plant has been tentatively identified by stakeholders as a high management priority within the assessment area.

An additional concern is the illegal introduction of non-native aquatic plants and animals through the release or escape of aquarium and pond trade species to area streams. A number of non-native fish and aquatic weed species are known to inhabit the assessment area. Non-native sunfishes, carp, goldfish, and catfish, as well as occurrences of home aquarium fishes are common in area streams.

Interest in home aquariums and pond culture is at an all time high, as evidenced by the increasing retail trade throughout California, including in the assessment area. The number of pet stores, garden shops, and backyard-pond specialty stores supporting this activity is increasing within Shasta County. The release of plant and animals used in the aquarium trade to the environment is a growing problem and a risk to beneficial uses of water, particularly near urban centers, but throughout most waterways of the state. The documented impacts of invasive aquatic species on beneficial uses of water include clogging of water diversion by certain plants and shellfish, competition for food with native fishes, and predation of native fishes. Shasta County recognizes that this issue is a potential local problem, but the extents to which beneficial uses of water within the assessment area are affected remain unquantified (M. Pfeiffer, Shasta County Dept. of Agriculture, pers. comm.).

Impacts to water uses, particularly aquatic habitat, from non-point source pollution, primarily sedimentation from erosion, excessive nutrients, and other pollutants contained in surface runoff, remains of high concern within the assessment area. As described in Chapters 3.6 and 3.10, surface runoff carrying sediment to stream channels in the assessment area and associated impacts to salmon spawning habitat in local creeks and the Sacramento River is a major management issue for local watersheds. Fine sediment loads and turbidity during winter streams flows in the assessment area are naturally high, although casual observations documented for this assessment suggest that sediment levels appear to be higher in Stillwater Creek than in Churn Creek during recent years. Other pollutants in surface runoff are of concern in the assessment area, including plant nutrients from landscaped areas, golf courses, and land application of treated wastewater; petroleum-based compounds for roadways and illegal dumping in storm sewers; and pesticide residues from urban and agricultural areas. The limited water quality data for assessment area streams presented in Chapter 3.6 do not allow for evaluation of the distribution, duration, and magnitude of storm runoff sediment and other pollutant inputs; however, these data also do not suggest a significant impairment of stream habitat by plant nutrients and other chemical pollutants.

Considerable efforts are underway by local and state authorities to better control and reduce non-point source contributions of sediment and other pollutants to local streams. Several high-profile violations of stormwater discharge permits within the

assessment area have raised awareness of the importance of non-point source pollution management. Recent improvements in stormwater management and more consistent implementation of runoff control measures during ground-disturbing construction activities may alleviate this ecosystem stressor. The use of strategically located, multi-purpose detention basins, such as that at the Clover Creek Preserve, and use of stormwater biofilters as part of stormwater drainage systems, are examples of these types of improvements in the assessment area. However, monitoring data for evaluation of the performance and efficacy of these non-point source pollution control measures were not available for this assessment. The required monitoring included as part of the NPDES SWQIP (Phase II) implementation within the cities of Redding and Shasta Lake and monitoring required by the RWQCB's Conditional Waiver of Waste Discharge Requirements from Irrigated Lands Program described in Chapter 3.6 may provide such data for future evaluation.

Designation of critical habitat for federally listed species (i.e., winter-run Chinook salmon, spring-run Chinook salmon, steelhead, vernal pool branchiopods) within the assessment area necessitates special consideration of potential impacts to the stream channels of Stillwater and Churn creeks and to vernal pool habitats in areas of the Stillwater and Clover creek watersheds. Activities that may affect these habitats will require conservation measures to ensure their protection for the conservation and recovery of the listed species. Several sites within the critical habitat boundaries for the vernal pool species within the assessment area have been protected as habitat mitigation banks and vernal pool habitat preserves, as described in Chapters 3.8 and 3.9. However, the efficacy of these measures in contributing to recovery of the listed vernal pool species is not currently known.

Removal and isolation of seasonal wetlands are the dominant processes affecting changes to these aquatic habitats in the assessment area. Agricultural practices and urban development have caused fragmentation of riparian corridors and wetland complexes. However, the extent of change in distribution and loss of wetland habitats within the assessment area during the reference period cannot be fully calculated with the data compiled for this assessment.

Key Questions

[Q 4-13] Are there specific stream reaches where changes in the hydrologic regime (i.e., stormwater runoff, imported water sources) are evident? What is the nature and extent of the effects of hydrologic changes on stream and riparian habitats? What is the relationship between these changes in habitat and the beneficial and reasonable uses of water?

[Q 4-14] How many constructed impoundments (e.g., ponds, lakes, retention basins) exist within assessment area? What purpose do they serve and how do they influence beneficial and reasonable uses of water?

[Q 4-15] What is the current distribution of Arundo in Churn Creek and Clover Creek? Are there specific circumstances that may result in expanding the range of this species?

[Q 4-16] Are non-native and exotic organisms (e.g., plants, fish, mammals, reptiles) influencing beneficial uses within the assessment area?

[Q 4-17] How well are current Best Management Practices addressing impacts to beneficial uses?

[Q 4-18] Is there a need to prepare a systematic assessment to characterize the cumulative change (loss/conversion/ fragmentation) of seasonal wetlands and riparian corridors in order to prioritize future restoration/enhancement opportunities?

4.5 Wastewater Discharge Conveyance

FINDING 5

Discharge of treated wastewater effluent from the Shasta Lake Area Wastewater Treatment Plant is highly constrained with no opportunity for increased discharges at current treatment levels. Opportunities for discharge of treated wastewater effluent to Stillwater Creek are similarly limited by seasonal hydrology of the creek, so it is unlikely that point source discharges of this kind will be proposed in the future. Overall, the soils and other characteristics of the assessment area are poorly suited to the discharge of wastes, including discharge of primary treated effluent into conventional septic tank leach fields.

Data Quantity/Quality

Moderate to Good

Discussion

The ability to discharge treated wastewater effluent to Churn Creek has declined since construction of the Shasta Lake Area Wastewater Treatment Plant during the 1970s owing to the constraint imposed by the need for dilution capacity of the receiving waters. Unless a higher level of treatment is provided, there is no additional opportunity to increase effluent discharges to Churn Creek because the seasonal hydrology limits its use. The hydrology of Stillwater Creek imposes similar limitations on its ability to receive treated effluent from point sources, and there is little likelihood that such point source discharges will be proposed in the future.

On the other hand, the number of septic leach fields has increased in un-sewered parts of the assessment area. Monitoring of groundwater in the assessment area has yielded nitrate, a contaminant often associated with runoff from fertilizer and leaching from septic tanks, at concentrations approaching 50 percent of the maximum allowable loading. In parts of the assessment area, particularly portions of the Stillwater Creek drainage, current general planning and zoning would enable these types of wastewater discharges to continue to increase under controlled circumstances (e.g., limitations on development density, separation from wells, and requirement for alternative leach field designs).

Key Questions

[Q 4-19] What are the number and relative location of developments that rely on individual leach fields? Can the age and relative location of these fields be used to develop a systematic monitoring approach to assess potential impacts to beneficial uses?

4.6 Water-Dependent Habitat

FINDING 6

The quantity of water-dependent habitat (i.e., riparian forest, riparian marsh and wetlands) has been altered through time within the assessment area. Similar to the trend for aquatic habitats, these water-dependent habitats have also been lost in some areas and have been created in other portions of the assessment area, although a net loss of riparian forest habitat has generally occurred.

The quality of water-dependent habitat has generally declined throughout the assessment area.

Data Quantity/Quality

Low

Discussion

Water-dependent habitats are closely associated with water bodies, with riparian vegetation corridors and streamside marshes and wetlands being the most common within the assessment area. Riparian vegetation was historically cleared to create pasture and cropland. Associated riparian marsh and wetlands were drained and reclaimed for agricultural use and urban development. Irrigation runoff and residential drainage maintain water in certain drainage areas and stream channels throughout the summer, which has created conditions suitable for establishment of riparian and wetland vegetation where it otherwise may not have existed. Fire suppression and build up of fuels have altered the quantity of some water-dependent habitats, while other areas, especially along Stillwater Creek, have lost tracts of riparian forest to wildfire (e.g., Bear Fire). Agricultural practices and urban development have caused fragmentation of riparian corridors and wetland complexes. Erosion and sedimentation have gullied or filled and reduced the quality of certain water-dependent habitats within the assessment area.

The dense urban development along portions of Churn Creek tributaries where they course through the Dana Drive area has included removal of riparian vegetation, channelization, and culverting of entire channel segments. This has resulted in the direct loss of water-dependent streamside habitats and greatly affected the hydrology and flood patterns these habitats require.

The principal risks to water-dependent habitats in the assessment area are direct removal of vegetation and channelization caused by urban development and hydrologic impacts of urban development on streams and flood patterns. A level of protection to these resources is provided by city and county general plans, which include designated stream corridor greenways that consist of open space and riparian zones along portions of Churn Creek, Clover Creek, Stillwater Creek, and the Sacramento River in the assessment area. A little over 10 percent of the assessment area is zoned as open space, including riparian greenways, parks, and golf courses. City ordinances also currently require development setbacks and buffers of varying size to protect riparian habitat along assessment area streams. Additionally, Section 404 of the Clean Water Act requires the setting aside of wetlands that are avoided by development into conservation and preservation easements.

Key Questions

[Q 4-20] Where are the critical riparian areas (streams, wetlands) that should be protected, restored, or enhanced with respect to beneficial or reasonable uses? What factors should be considered to evaluate these riparian areas? How functional are they? What stressors exist that are influencing these areas?

[Q 4-21] Are there opportunities to restore specific reaches of Churn Creek in the vicinity of Dana Drive/Highway 44?

4.7 Stormwater Management

FINDING 7

The capacity of stream channels to convey high flows during storms has been reduced due to encroachment by development into floodplains. At the same time, peak storm runoff has increased, also due to increased urban development. Typically, storm flow detention basins are constructed to mitigate this condition (i.e., increased generation of runoff and decreased conveyance capacity in receiving waters), but data documenting the effectiveness of this approach are lacking.

Data Quantity/Quality

Moderate

Discussion

Land use practices and urban development patterns have allowed encroachment into riparian zones and floodplains constraining natural fluvial channel migration and adjustment. Increased urban development has resulted in increased impermeable surface area in the watershed creating greater peak runoff flows. Urban development practices have encouraged the use of storm flow detention basins to respond to these changes in natural stream channel conveyance capacity. While these improvements in stormwater management are thought to have a beneficial effect in alleviating stream channel conveyance problems, no data on the efficacy of these measures for assessment area streams are available.

Key Questions

[Q 4-22] Are there sensitive reaches/habitats that should be considered when siting future stormwater management facilities?

4.8 References

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County of Shasta. 2004. Shasta County General Plan, as amended September 2004. Department of Resources Management.

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U.S. Fish and Wildlife Service. 1995. Working paper: Habitat restoration actions to double natural production of anadromous fish in the Central Valley of California. May 9, 1995. Prepared for the U.S. Fish and Wildlife Service under the direction of the Anadromous Fish Restoration Program Core Group. Stockton, California.

Western Shasta Resource Conservation District. 2004. Stillwater Creek Watershed Noxious Weed Inventory. Anderson, California.

Chapter 5
Recommendations and Watershed Action Options

5.1 Development of Recommended Actions

This assessment was reviewed by the Technical Advisory Committee, who, jointly with the Western Shasta Resource Conservation District and North State Resources, Inc. (consultant), have developed a series of recommended actions that respond to the principal goals of this assessment:

1. Support the CALFED Bay-Delta Program goal of restoring the ecological health and improving the management of the Bay-Delta system by working with communities in the Sacramento/San Joaquin Basin at a watershed level;
2. Support the efforts of the Western Shasta Resource Conservation District in areas of environmental education and stakeholder outreach; and
3. Enhance collaboration and coordination between public agencies and non-governmental stakeholders.

An initially broad range of potential watershed actions were considered based on input received from stakeholders and the Technical Advisory Committee and on the information and analyses developed for this assessment. This list of potential actions was subjected to a screening process consisting of three criteria:

1. The recommended action is consistent with factual information and analyses provided in the watershed assessment;
2. The recommended action addresses known or suspected conditions that limit beneficial uses of water originating within the watershed and the ecosystem elements that it supports; and
3. In the absence of sufficient information for management decisions, the recommended action addresses information needed to enhance our current understanding of natural and water resources and the ongoing processes and conditions in the Stillwater, Churn, and Clover Creek watershed.

The resulting recommendations were compiled and consolidated, where similar, into 24 action options. These recommended action options are segregated into three categories;

1. Public Education and Awareness (6 actions),
2. Immediate Stewardship (6 actions), and
3. Assessments to Support Development of the Watershed Management Plan (12 actions).

No ranking or prioritization of these action options is implied by their position on the list provided in Table 5.1. Such prioritization should be made by the watershed coordinator with input from the Technical Advisory Committee and other stakeholders.

Specific criteria for prioritizing and funding recommended actions should be developed in a collaborative manner that links desires, interests, needs, and capabilities of as broad a section of the community as possible.

The recommended actions include options for continuation of successful ongoing programs and other stewardship actions that are improving watershed conditions and public awareness of watershed management issues. Other recommended actions include further detailed evaluation of habitat and stream bank and channel erosion conditions that will be needed to verify cause-and-effect relationships within the watershed and to identify specific treatment sites for restoration and enhancement activities.

5.2 Next Phase: Watershed Management Plan

The next phase of the Stillwater-Churn Creek Watershed planning process will be to prepare a watershed management plan, a framework to guide natural resource management and conservation decisions focused on protection and maintenance of the beneficial uses of water originating within the watershed. Accordingly, several of the recommended action options provide conceptual guidance for implementation of certain classes of actions and input for developing the watershed management plan.

Table 5.1
Action Options
Stillwater-Churn Creek Watershed Assessment

Action Options	Beneficial Use Category[1,2]
Public Education and Awareness Actions	
1. Continue public awareness and education program through periodic Watershed Alliance meetings that convey information contained in the Stillwater-Churn Creek Watershed Assessment. This program should be designed to offer flexibility that can meet the information and action needs of various stakeholders.	All
2. Engage schools within watershed boundaries in watershed education and management activities through Adopt-a-Watershed or similar program. This program could encourage schools in different areas of the watershed to share information about watershed resources in the areas where their schools are located.	All
3. Continue public awareness campaign and ongoing eradication and control efforts targeting noxious, invasive plants such as giant reed, tree-of-heaven, tamarisk, yellow starthistle, Scotch/Italian broom, and rattlebush.	3,8,9,10,11,12,B,C,D
4. Build upon the recent tremendously successful Churn Creek Clean-up effort to encourage and promote community volunteerism and public agency and municipality support for local creek protection and rehabilitation actions.	All
5. Facilitate public awareness and education on proper erosion and sediment control practices around homes, farms, businesses, and construction sites. This action may be coordinated with municipalities, Shasta Builder's Exchange, Shasta College, home building supply businesses, and regulatory agencies.	1,5,9,10,11,12,B,C
6. Continue to support public education campaign and South Lake Shasta Fire Safe Council projects to reduce catastrophic wildfire hazards. Successful implementation will protect hydrologic function; prevent excessive erosion and sediment delivery; and protect upland, riparian and aquatic habitat values.	1,3,5,9,10,11,12,B,C
Immediate Stewardship Actions	
7. Use the TAC to identify various agency institutional obligations and constraints to facilitate implementation of action options. Assign priorities, identify leadership opportunities, and analyze potential funding to implement programmatic and project level actions. This action should be coordinated with related actions from the Shasta West and Sulphur Creek Watershed Assessments.	All

Table 5.1
Action Options
Stillwater-Churn Creek Watershed Assessment

Action Options	Beneficial Use Category[1,2]
8. Continue to install signs at waterway road-crossings and label storm drains to promote public awareness of the presence and value of watershed streams.	All
9. Collaborate with the cities of Redding and Shasta Lake to promote and obtain funding for a community-based, volunteer program to monitor water quality (particularly plant nutrients, petroleum-based oils/greases, heavy metals, pesticides, dissolved oxygen, pH, turbidity, total settable solids, and urban refuse) in Churn Creek. This effort may be coordinated with and augment the cities' NPDES Phase II stormwater quality management requirements. Seek assistance of California DWR's Urban Streams Program for grant funding of effort.	3,4,7,9,10,12,B,C
10. Promote adoption of the draft countywide oak woodland management plan to conserve oak woodlands and the ecological communities that they support.	B
11. Identify suitable sites within the watershed for acquisition as well as financial issues, jurisdiction and socioeconomic considerations to conserve open space, natural resources, and watershed functions and that can be used to mitigate and offset land use impacts that will likely continue to occur throughout the watershed.	1,2,3,7,8,9,10,B,C
12. Investigate opportunities and promote creation of wetlands and widespread use of vegetated swales and buffers for storm water runoff management and water quality improvement.	3,9,10,11,12,D
Further Assessment Actions to Support Watershed Management Plan	
13. Map, inventory, and assess condition of stream and riparian habitat along Churn and Stillwater creeks, with Churn Creek as a first priority. Identify opportunities and constraints for habitat protection, rehabilitation, and restoration, particularly those that restore and enhance salmonid use. Approaches that use a combination of aerial imagery, remote sensing data, and field sampling/verification will be most cost-effective.	3,9,10,11,12,B
14. Map and inventory bank erosion sites and establish a baseline characterization of channel geomorphometry on Churn and Stillwater creeks. Identify opportunities and constraints for reducing excessive fine sediment inputs to protect/improve aquatic and riparian habitat, protect property, and protect/improve stream corridor, floodwater storage, and conveyance. Approaches that use a combination of aerial imagery, remote sensing data, and field sampling/verification will be most cost-effective.	3,5,9,10,11,12,B,C

Table 5.1
Action Options
Stillwater-Churn Creek Watershed Assessment

Action Options	Beneficial Use Category[1,2]
15. Develop a detailed, combined soils and slope map to identify areas of high erosive potential.	1,3,5,9,10,12,B
16. Reactivate or install stream flow gages in Churn and Stillwater creeks to better characterize current hydrologic patterns and monitor long-term trends that may affect aquatic and riparian habitat and flood damage potential. While Clover Creek may not be conducive to a traditional stream gaging, some approach should be developed to understand the relationship between stormwater runoff and flood flows, particularly downstream of Hartnell Avenue, Rancho Road, and Knighton Road. Bridges at these locations may be useful in estimating discharge during runoff periods.	1,2,3,4,,9,10,11,12,A,B,C,D
17. Inventory and assess hydraulic and ecologic performance of infrastructure features identified in the watershed assessment that may affect hydrologic and geomorphologic function, water quality, and animal migration in Churn, Stillwater, and Clover creeks. These include, but are not limited to, constructed impoundments, stormwater collection discharges, detention basins and discharges, culverts and road-crossings, utility crossings, and bank protections.	1,3,5,9,10,11,A,B,C,D
18. Expand water quality monitoring efforts (identified in Action Option #9) to include Stillwater and Clover creeks, in coordination with the Churn Creek efforts for cost-efficiency. Use results from this effort and that of Action Option #9 to inform identification of any point source and non-point source pollution problem areas.	3,4,7,9,10,12,B,C
19. Use stream and riparian habitat inventory and condition assessment to identify opportunities and constraints to maintain adequate wildlife migration and dispersal corridors within the watershed. Promote conservation and preservation of suitable wildlife habitat, habitat connectivity, open space, and an integrated trail system in community development planning.	7,8,B,C,D
20. Incorporate information and results of the Redding Groundwater Basin Management Plan (development is underway) when completed.	1,2,3
21. Further evaluate existing water rights and uses of surface water within the watershed, including water diverted from the Sacramento River, and opportunities and constraints to increase groundwater recharge and enhance stream flows in Churn and Stillwater creeks for aquatic habitat enhancement purposes.	1,2,3,4,7,8,9,10,11,12,A,B,C,D

Table 5.1
Action Options
Stillwater-Churn Creek Watershed Assessment

Action Options	Beneficial Use Category[1,2]
22. Enhance opportunities for contact and non-contact water recreational use focusing on better understanding the historic and future uses, particularly as future use may be limited by water quality; determining the adequacy of existing public access; and managing litter and aquatic vegetation to maintain a pleasing environment for recreation.	7,8,9,10,B,D
23. Expand and improve compatible open space and public use recreation, such as increasing and enabling public access for walking, biking, and nature-viewing, at some wildlife set-aside lands (where appropriate) and some portions of the proposed Stillwater Business Park that present significant opportunities for increasing water-enhanced recreation options.	8,D
24. Groundwater and surface water monitoring should be expanded in order to ensure that increasing discharge of septic tank effluent due to increased rural development in unsewered areas does not impair beneficial uses of surface waters and groundwater.	1,7,8,9,10,A,B,D

[1] Beneficial Use Categories
1. Municipal and domestic supply
2. Industrial service supply
3. Groundwater recharge
4. Freshwater replenishment
5. Navigation
6. Hydropower generation
7. Water contact recreation
8. Non-contact water recreation
9. Warm freshwater habitat
10. Cold freshwater habitat
11. Migration of aquatic organisms
12. Spawning, reproduction, and/or early development

[2] Other Reasonable Uses
A. Wastewater Discharge Conveyance
B. Water-Dependent Habitats (such as wetlands and riparian forests and those plant and wildlife resources supported by these habitats, including numerous special-status species and natural communities)
C. Stormwater Management and Conveyance
D. Water-Enhanced Recreation

Acronyms and Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
ACID	Anderson-Cottonwood Irrigation District
AFRP	Anadromous Fish Restoration Program
Alliance	Stillwater-Churn Creek Watershed Alliance
Basin Plan	Water Quality Control Plan for the Sacramento River Basin and San Joaquin River Basin, as revised September 2004
BIA	Bureau of Indian Affairs
BLM	U.S. Bureau of Land Management
BMP	best management practice
BVWD	Bella Vista Water District
Cal-IPC	California Invasive Plant Council
Caltrans	California Department of Transportation
CDF	California Department of Forestry and Fire Protection
CDFG	California Department of Fish and Game
CESA	California Endangered Species Act
cfs	cubic feet per second
CNDDB	California Natural Diversity Database
CNPS	California Native Plant Society
Corps	U.S. Army Corps of Engineers
CRS	Community Rating System
CVP	Central Valley Project
CWA	Clean Water Act of 1973
CWHR	California Wildlife-Habitat Relationships system
DHS	Department of Health Services
DOI	Department of the Interior
DWR	California Department of Water Resources
e.g.	for example
EFH	Essential Fish Habitat
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
ESU	evolutionarily significant unit
et al.	and others
FEMA	Federal Emergency Management Agency
GIS	geographic information system
I-5	Interstate 5
i.e.	that is
LCMMP	Land Cover Mapping and Monitoring Program

LRMP	Land and Resource Management Plan
mg	milligram
mgd	million gallons per day
ml	milliliters
mybp	million years before present
NFP	National Fire Plan
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRCS	Natural Resource Conservation Service
NRHP	National Register of Historic Places
NSR	North State Resources, Inc.
ppb	parts per billion
ppm	parts per million
Reclamation	U.S. Bureau of Reclamation
RFA	Rural Fire Assistance Program
RMP	Redding Resource Management Plan
RWQCB	Regional Water Quality Control Board
SFA	State Fire Assistance
SMARA	Surface Mining and Reclamation Act
SR	State Route
SRA	shaded riverine aquatic
STNF	Shasta-Trinity National Forest
SWQIP	Storm Water Quality Improvement Plan
SWRCB	State Water Resources Control Board
TAC	Technical Advisory Committee
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VFA	Volunteer Fire Assistance
WSRCD	Western Shasta Resource Conservation District
WUI	Wildland Urban Interface

Glossary

100-year flood: The flood having a 1 percent chance of being equaled or exceeded in magnitude in any given year. Contrary to popular belief, it is not a flood occurring once every 100 years.

100-year floodplain: The area adjoining a river, stream, or watercourse that would be covered by water during a 100-year flood.

abiotic conditions: Nonliving chemical and physical factors in the environment, including light, temperature, water, atmospheric gases, and wind as well as soil (edaphic) and physiographic (nature of land surface) factors.

aggradation: The build up of the land surface due to deposition of solid materials. Often applied to the deposition of sediment in a river, creating a braided stream channel.

aggregate: In building and construction, material used for mixing with cement, bitumen, lime, gypsum, or other adhesive to form concrete or mortar. Commonly used aggregates include sand, crushed or broken stone, and gravel (pebbles).

allelopathic chemicals: Allelopathy refers to the beneficial or harmful effects of one plant on another plant by the release of chemicals from plant parts by leaching, root exudation, volatilization, residue decomposition, and other processes in both natural and agricultural systems.

alluvium: A sedimentary formation composed of clay, sand, gravel, and other materials moved and deposited by running water.

anaerobic: Living, occurring, or existing in the absence of free oxygen.

andesite: Rock type common in most of the world's volcanic areas. Andesites occur mainly as surface deposits and, to a lesser extent, as dikes and small plugs.

anthropogenic: Originating from the activity of humans.

attenuation: A reduction in the volume and rate of runoff flow during flood events.

base flow: That part of a stream's discharge that is not attributable to direct runoff from precipitation or melting snow; base flow is usually sustained by groundwater.

bedload: Soil, rock particles, or other debris rolled along the bottom of a stream by the moving water.

berms: Man-made or naturally formed linear mounds of earth.

biotic conditions: Conditions pertaining to biological or ecological features in a given area.

brackish: Refers to water that is saltier than fresh water, but not as salty as seawater. Brackish water may result from the mixing of seawater with fresh water, as in estuaries, or as in brackish fossil aquifers.

braided channel: A channel that divides and reunites, with the divisions occurring at obstructions caused by sediment deposits. So-called because braided channels resemble the strands of a braid.

CALFED Bay-Delta Program: A collaboration among 25 state and federal agencies to improve water supplies in California and the health of the San Francisco Bay/Sacramento-San Joaquin River Delta.

carrying capacity: The population level of an organism that can be supported given the quantity of food, habitat, water, and other life requirements present.

census tract: Small, relatively permanent statistical subdivisions of a county.

chalcopyrite: Looks like and is easily confused with pyrite, FeS2. Chalcopyrite is one of the minerals referred to as “Fool's Gold” because of its bright golden color.

channel dynamics: Refers to the various natural and human-induced forces operating on a channel.

channel gradient: The ratio of drop in a stream per unit distance, usually expressed as feet per mile or as a percentage; often used interchangeably with “channel slope.”

channel meandering: Extreme curves in a stream, usually in a sequence resulting from variability of flow and sediment.

channel morphology: Encompasses several attributes used to describe features or processes associated with a specific reach of river or stream. These attributes include channel shape, size, slope, and discharge, and are used in channel classification systems.

channel sinuosity: An expression or measurement of channel meander patterns.

channel slope: The difference in elevation at the upstream and downstream ends of a stream segment, divided by the length of the segment.

chaparral: A vegetation habitat found primarily in California that is shaped by a Mediterranean climate (mild, wet winters and hot, dry summers) and wildfire. A typical chaparral plant community consists of densely growing evergreen scrub oaks and other drought-resistant shrubs.

cobbly: Containing appreciable quantities of cobblestones. The term is used to describe both soil and land.

conveyance capacity: The amount of water a channel can carry.

Cretaceous: One of the major divisions of the geologic timescale, reaching from the end of the Jurassic Period (i.e., from about 146 to 136 million years ago to the beginning of the Paleocene epoch of the Tertiary Period about 65.5 to 64 million years ago).

critical habitat: Areas essential for the conservation of a species listed under the federal Endangered Species Act as endangered or threatened.

culverts: There are two types of culverts, those used for stream crossings and those used to manage runoff. The first type of culvert is required where a roadway crosses a stream channel to allow water to pass downstream. The second type is strategically placed to manage and route roadway runoff along, under, and away from the roadway.

deadfall: A mass of fallen timber and tangled brush.

debitage: The collective term used by archaeologists to refer to the sharp-edged waste material left over when someone creates a stone tool.

dendritic drainage pattern: A branching stream pattern resembling the branching of certain trees, such as oaks and maples.

dessication: The drying process.

detention basin: An artificial flow control structure that provides protection for areas below it by containing flood water for a short period of time.

diatomite: A lightweight, white sedimentary rock formed by the accumulation of the highly porous shells of Diatoms.

dissolved oxygen: The amount of oxygen dissolved in water at a certain time.

downcutting: A geological process that deepens the channel of a stream or valley by removing material from the stream's bed or the valley's floor; also called erosional downcutting or downward erosion.

drift mining: A method of accessing valuable geological material by cutting into the side of the earth, rather than tunneling straight downwards.

ecosystem: A contraction of "ecological" and "system," ecosystem refers to the collection of components and processes that constitute, and govern the behavior of, some defined subset of the biosphere.

effluent: An outflowing of water from a natural body of water, or from a man-made structure.

essential fish habitat: Can consist of both the water column and the underlying surface of a particular area. Areas designated as essential fish habitat contain habitat essential to the long-term survival and health of fisheries.

evapotranspiration: The sum of evaporation and plant transpiration. Evaporation accounts for the movement of water to the air from sources such as the soil, leaf surfaces, and waterbodies. Transpiration accounts for the movement of water within a plant and the subsequent loss of water through its leaves.

exotic species: A plant or animal introduced accidentally or intentionally to an area to which it is not native.

extirpation: A process in which a species ceases to exist in the chosen area of study, but still exists elsewhere. This phenomenon is also known as local extinction.

feral: A feral animal or plant is one that has escaped from domestication and returned, partly or wholly, to its wild state.

fines: Fine-particled sediment.

floristic: Pertaining to flowers or a flora.

flow regime: Patterns of water discharge in streams and rivers over time.

fluvial: The word fluvial is used in geography and earth science to refer to all topics related to flowing water. Fluvial usually refers to rivers and streams.

flux: A silica material fed into a furnace with copper concentrate during the smelting process.

forbs: Herbaceous plants, usually small and seasonal.

fragmentation: Discontinuities in an organism's preferred environment.

fresh emergent wetlands: Fresh emergent wetlands occur in a variety of settings and landscapes. Positive field indicators include evidence of being frequently ponded and/or flooded for long duration or very long duration during the growing season, such as water marks, drift lines, and sediment deposits. Vegetation is typically dominated by perennial monocots, such as cattail, bulrush, and plantain (i.e., plants that make us say "marsh"); however, many other emergent species may occur. Fresh emergent wetlands frequently occur as a complex with riparian wetlands.

gage stations: Facilities used by hydrologists to automatically monitor streams, wells, lakes, canals, reservoirs, and other water bodies. Instruments at these stations collect information such as water height, discharge, water chemistry and water temperature.

geographic information system (GIS): A collection of computer hardware, software, and geographic data for capturing, managing, analyzing, and displaying all forms of geographically referenced information.

geologic substrate: A stratum of earth or rock lying immediately under another.

geomorphic: Of or pertaining to the form or surface features of the earth.

ghost dance: The ghost dance was a religious movement incorporated into numerous Native American belief systems. The traditional ritual used in the Ghost Dance, the circle dance, has been used by many Native Americans since pre-historic times.

grilse: A precociously maturing salmon that returns from the sea to fresh water.

hardpan: A general term for a dense layer of soil layer that is largely impervious to water, residing usually below the uppermost topsoil layer.

hydraulic: Of or powered by the mechanical properties of liquids.

hydric soil: A soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part.

hydrograph: A chart that measures the amount of water flowing past a point as a function of time.

hydrology: The study of the movement, distribution, and quality of water throughout the earth.

hydrophytic vegetation: Multi-celled plant life occurring in areas where permanent or periodic soil saturation is of sufficient duration to exert a controlling influence on the plant species present.

impermeable: Not permitting the passage of a fluid through the pores, interstices, etc.

impervious: Incapable of being penetrated.

impoundment: A body of water confined within an enclosure, as a reservoir.

indurated: hardened, as rock, tissue, etc.

intrusive rock: A rock that consolidated from magma beneath the surface of the earth.

lateral seepage: Leakage of water through the side of a ditch or canal.

limestone: A sedimentary rock composed largely of the mineral calcite (calcium carbonate: CaCO3). The source of the calcite in limestone is most commonly marine organisms. Limestone makes up about 10 percent of the total volume of all sedimentary rocks.

lithic artifacts: stone tools.

loam: A rich, friable soil, containing a relatively equal mixture of sand and silt and a somewhat smaller proportion of clay.

marsh: A type of wetland featuring grasses, rushes, reeds, typhas, sedges, cat tails, and other herbaceous plants in a context of shallow water. A marsh is different from a swamp, which is dominated by trees rather than grasses and low herbs. The water of a marsh can be fresh, brackish, or saline.

metamorphic rock: The result of the transformation of a pre-existing rock type, the protolith, in a process called metamorphism, which means "change in form." The protolith is subjected to heat (greater than 150 degrees Celsius) and extreme pressure, causing profound physical and/or chemical change.

midden: A dump for domestic waste. The word is used by archaeologists to describe any kind of feature containing waste products related to day-to-day human life. Middens may be convenient, single-use pits created by nomadic groups or long-term, designated dumps used by several generations.

mitigation bank: A wetland, stream, or other aquatic resource area that has been restored, established, enhanced, or preserved for the purpose of providing compensation for unavoidable impacts to aquatic resources permitted under Section 404 of the Clean Water Act or a similar state or local wetland regulation.

neotropical migrants: Birds that nest at North American sites but spend up to 6 winter months in warmer climates of the Americas, including Mexico and Central and South America.

non-point source pollution: Pollution from diffuse sources; in other words, pollution that is not from a specific point of origin. Agriculture is a common non-point source.

organic compound: An organic compound is any member of a large class of chemical compounds whose molecules contain carbon and hydrogen.

overstory trees: The overstory level of trees, called the canopy, is made up of the very tallest trees that stand over the rest of the plants.

percolation: The movement and filtering of fluids through porous materials.

perennial: Lasting or continuing throughout the entire year.

permeability: A measure of the ability of a material (typically, a rock or unconsolidated material) to transmit fluids.

petroglyphs: Images incised in rock, usually by prehistoric, especially Neolithic, peoples. They were an important form of pre-writing symbols, used in communication from approximately 10,000 B.C. to modern times, depending on culture and location.

phenotype: The phenotype of an individual organism is either its total physical appearance and constitution or a specific manifestation of a trait, such as size, eye color, or behavior, that varies between individuals.

pisciverous: Fish-eating; subsisting on fish.

Pleistocene: The Pleistocene epoch on the geologic timescale is the period from 1.8 million to 11,550 years Before Present.

point bars: Formed when alluvium is eroded from the outside bend (cut bank) and deposited on the inside bend of a meander.

point source pollution: Pollution from a single, identifiable, localized source. Point sources include industrial discharge of contaminated or heated water, sewage discharge, and leaks from underground storage tanks.

porosity: Describes the density of compaction of aggragates within a given soil.

pre-Columbian: Refers to the cultures of the Americas in the era before significant European influence.

recharge area: Where water from precipitation is transmitted downward to an aquifer.

retention basin: A type of constructed wetland that is used to contain stormwater or rain runoff.

riffle-pool sequences: In a naturally flowing river, areas of riffles and pools alternate in a predictable sequence and at predictable intervals which are related to the width of the stream. Riffles are where shallow water is rippling over rocks; pools are deeper and calmer areas.

rill erosion: Rill erosion is the removal of soil by concentrated water running through little streamlets, or headcuts.

riparian: The green, vegetated interface occurring naturally between land and a flowing surface water body.

riprap: Riprap (also known as rip rap, shot rock or rock armor) is rock or other material used to stabilize the shore. It reduces water erosion by resisting the hydraulic attack and dissipating the energy of flowing water or waves.

runoff: Water that flows over the land surface.

salmonid: Belonging or pertaining to the family Salmonidae, including the salmons, trouts, chars, and whitefishes.

seasonal wet meadows: Seasonal wet meadows typically consist of flat to gently rolling low-lying areas that exhibit positive field indicators of long-duration saturation during the growing season. These indicators include saturation and oxidized root channels within the upper 12 inches of the soil profile, and localized sediment deposits from short-duration ponding (i.e., immediately following precipitation events). Occasionally these features exhibit characteristics of frequent ponding or long-duration flooding. Depending on the site and/or specific feature(s), the floristic composition and density of seasonal wet meadows may be different from both vernal pools and vernal swales, or quite similar. Plant species occurring in this wetland type are typically adapted to saturated, but not inundated, environments. This wetland type may also occur on moderate or even steep slopes as seeps and/or springs.

sedentary: Applies to organisms and species that are not migratory but rather remain at a single location (permanently fixed or otherwise).

sediment: Any particulate matter that can be transported by fluid flow and that eventually is deposited as a layer of solid particles on the bed or bottom of a body of water or other liquid.

sediment flux: Description of the delivery, transport, and storage of sediment in a riverine environment.

senesce: To reach later maturity; grow old.

settling pond: A place where very fine particles are removed from water by means of gravity.

smelter: A factory for producing metal by the reduction of ore.

soil horizon: A discrete layer of soil, discernable by cross-section.

stakeholder: A person or organization that has a legitimate interest in a project or entity; everyone with an interest (or "stake") in what the entity does.

stewardship: Protecting the environment through recycling, conservation, regeneration, and restoration.

stormwater: Water that originates during precipitation events.

substrate: The material that rests at the bottom of a stream.

suspended solids: The amount of filterable solids in a water sample.

sympatric: One of three theoretical models for the phenomenon of speciation. In complete contrast to allopatry, species undergoing sympatric speciation are not geographically isolated by, for example, a mountain or a river. The speciating populations generally share the same territory.

tectonic terranes: Landscapes where topographic relief is related to some degree of tectonic uplift and is eroded over time.

tectonic uplift: A geological process that increases elevation; most often caused by plate tectonics.

terraces: Relatively flat, horizontal, or gently inclined surfaces, sometimes long and narrow, which are bounded by a steeper ascending slope on one side and by a steeper descending slope on the opposite side.

terrestrial: Consisting of or pertaining to the land.

thatch: A layer of living and dead organic matter that occurs between the green matter and the soil surface.

topography: The study of earth's surface features.

tribelets: Small, sub-tribal autonomous sociopolitical groups.

turbidity: A cloudiness or haziness of water (or other fluid) caused by individual particles (suspended solids) that are generally invisible to the naked eye. Measurement of turbidity is a key test of water quality.

understory: The area of a forest which grows in the shade of the forest canopy.

ungulates: Several groups of mammals, most of which use the tips of their toes, usually hoofed, to sustain their whole body weight while moving.

vascular plants: Plants in the kingdom Plantae that have specialized tissues for conducting water. Vascular plants include ferns, club mosses, horsetails, flowering plants, and conifers.

vernal pool: Vernal pools are generally described as variably shaped depressions that typically occur in landscapes characterized by a perched water table present due to an impermeable subsurface layer (e.g., hardpan). These features exhibit field indicators of being frequently ponded for a long duration or very long duration during the growing season and include, but are not limited to, watermarks, fine sediment deposits, and algal matting.

vernal swale: Vernal swales are similar to vernal pools and often occur as a complex with vernal pools. The primary distinction between vernal swales and vernal pools is that vernal swales are characterized as linear (or somewhat linear) drainage features, rather than as a "basin" feature, such as a vernal pool. Vernal swales often provide a hydrologic connection between vernal pools. Specific characteristics of vernal swales include the presence of field indicators of being frequently flooded for a long duration or very long duration during the growing season, including watermarks, fine sediment deposits, algal matting, drift lines, and drainage patterns indicating water conveyance.

volcanic arc: A chain of volcanic islands or mountains located near the edge of continents that are formed as the result of tectonic plate subduction.

volcanic cinders: Dark, glassy, vesicular fragments, produced by gas-rich eruptions.

water table: The surface where the water pressure is equal to atmospheric pressure.

watershed: A region of land where water from rain or snowmelt drains downhill into a body of water, such as a river, lake, reservoir, estuary, wetland, sea, or ocean. The watershed includes both the streams and rivers that convey the water as well as the land surfaces from which water drains into those waterbodies.

woody perennials: A plant that lives for more than 2 years and develops a woody base or root system from which the foliage and flower stems grow.

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