UPPER CLEAR CREEK WATERSHED ANALYSIS

Shasta County, California

Prepared for:

WESTERN SHASTA RESOURCE CONSERVATION DISTRICT

3179 Bechelli Lane, Suite 110
Redding, California 96002

November 1998

Tetra Tech, Inc.
180 Howard Street, Suite 250
San Francisco, California 94105-1617

TC# 1941-04

TC 1941-04

UPPER CLEAR CREEK WATERSHED ANALYSIS

December 29,1998

Prepared for:

Western Shasta Resource Conservation District
3179 Bechelli Lane, Suite 110
Redding, California 96002

Prepared by:

Tetra Tech, Inc.
180 Howard Street, Suite 250
San Francisco, California 94105-1617

TABLE OF CONTENTS

Section Page

1. CHARACTERIZATION OF WATERSHED 1-1

1.1 Introduction 1-1
1.1.1 Introduction to a Watershed Analysis 1-1
1.2 Ownership, Administration, and Special Land Allocations 1-6
1.2.1 Jurisdictional Boundaries and Special Land Allocations within the Range of the Northern Spotted Owl 1-6
1.2.2 Land Ownership and Administration 1-13
1.3 Watershed Characteristics 1-23
1.3.1 Location and Physical Setting 1-23
1.3.2 Geology and Soils 1-28
1.3.3 Erosion Hazards 1-30
1.3.4 Hydrology 1-30
1.3.5 Water Quality 1-31
1.3.6 Vegetation 1-35
1.3.7 Human Uses 1-38
1.3.8 Fire and Fuels 1-38

2. IDENTIFICATION OF KEY ISSUES, QUESTIONS, AND INDICATORS 2-1

2.1 Key Issues Most Relevant to Management Questions and Objectives, Human Values, or Resource Conditions 2-1
2.1.1 Key Issues of Concern in the Upper Clear Creek Watershed 2-1
2.1.2 Prioritization Process Used in Developing List of Key Questions and Indicators 2-3
2.1.3 List of Key Questions and Indicators 2-4

3. EXISTING CONDITIONS 3-1

3.1 Water Quantity and Water Quality 3-1
3.1.1 Issues 3-1
3.1.2 Existing Conditions – Water Quantity 3-2
3.1.3 Existing Conditions - Water Quality 3-14
3.2 Fuels and Fire 3-18
3.2.1 Issues 3-18
3.2.2 Existing Conditions 3-18
3.3 Habitat and Wildlife 3-27
3.3.1 Issues 3-27
3.3.2 Existing Conditions – Vegetation 3-27
3.3.3 Existing Conditions – Wildlife 3-34
3.3.4 Threatened, Endangered, and Sensitive Plant and Wildlife Species 3-38
3.3.5 Survey and Manage Species 3-42
3.4 Soils and Erosion 3-45
3.4.1 Issues 3-45
3.4.2 Existing Conditions – Geology 3-46
3.4.3 Existing Conditions – Soils 3-50
3.4.4 Existing Conditions – Soil Erosion 3-57
3.5 Human Uses 3-61
3.5.1 Issues 3-61
3.5.2 Existing Conditions 3-61

4. REFERENCE CONDITIONS 4-1

TABLE OF CONTENTS *(continued)*

Section | Page

	4.1	Water Quantity and Quality	4-1
	4.2	Fuels and Fire	4-4
	4.3	Vegetation and Wildlife	4-5
	4.4	Soils and Erosion	4-6
	4.5	Human Uses	4-9
5.	**COMPARISON OF EXISTING AND REFERENCE CONDITIONS**		**5-1**
	5.1	Water Quality and Quantity	5-1
	5.2	Fuels and Fire	5-4
	5.3	Vegetation and Wildlife	5-6
	5.4	Soils and Erosion	5-7
	5.5	Human Uses	5-8
6.	**RECOMMENDATIONS**		**6-1**
	6.1	Water Quality and Quantity	6-3
	6.2	Fuels and Fire	6-4
	6.3	Vegetation and Wildlife	6-6
	6.4	Soils and Erosion	6-8
	6.5	Human Uses	6-9
	6.6	Ecosystem / Watershed Management Framework	6-11
7.	**REFERENCES**		**7-1**

TABLE OF FIGURES

Figure		Page
1-1	Location Map of Upper Clear Creek Watershed	1-3
1-2	Land Ownership in the Upper Clear Creek Watershed	1-7
1-3	Special Land Allocations in the Upper Clear Creek Watershed	1-9
1-4	Resource Management Plans in the Upper Clear Creek Watershed	1-15
1-5	Elevation in the Upper Clear Creek Watershed	1-26
1-6	Annual Precipitation in the Upper Clear Creek Watershed	1-27
1-7	Geology of the Upper Clear Creek Watershed and Redding Area	1-29
1-8	Historic Monthly Average Flows (Clear Creek at French Gulch)	1-32
1-9	Water Quality Monitoring Stations in the Upper Clear Creek Watershed	1-34
1-10	Sightings of Species of Concern in the Upper Clear Creek Watershed	1-37
3-1	Watershed and Subwatershed Boundaries of the Upper Clear Creek Watershed	3-3
3-2	Stream Gradients in the Upper Clear Creek Watershed	3-4
3-3	Large Fires and Fire Starts in the Upper Clear Creek Watershed	3-21
3-4	Fuel Types in the Clear Creek LSR (from the FS Clear Creek LSR Assessment)	3-28
3-5	Vegetation Communities of the Upper Clear Creek Watershed	3-29
3-6	Seral Stage Descriptions Used for Wildlife Habitat Relationships	3-33
3-7	Active and Historic Mines in the Upper Clear Creek Watershed	3-48
3-8	General Soils Map for the Upper Clear Creek Watershed	3-52
3-9	Soil Erosion Potential in the Upper Clear Creek Watershed	3-59
3-10	Distribution of Slopes in the Upper Clear Creek Watershed	3-60
3-11	Roadways of the Upper Clear Creek Watershed	3-66
4-1	Historical Monthly Average Flows (Clear Creek at Igo Gage)	4-3
C-1	Daily Mean Discharge Values (Clear Creek at French Gulch)	C-2
C-2	Exceedance Probability for Mean Daily Flows (Clear Creek at French Gulch)	C-3
C-3	Maximum Annual Peak Discharge Values (Clear Creek at French Gulch)	C-4
C-4	Average Annual 7-Day Low Flow Minima (Clear Creek at French Gulch)	C-5
C-5	Log Pearson Type III Distribution of Peak Flows (Clear Creek at French Gulch)	C-7
C-6	Log Pearson Type III Distribution of Average Annual 7-Day Low Flows (Clear Creek at French Gulch)	C-9

TABLES

Table		Page
1-1	Beneficial Uses for Upper Clear Creek Waters Designated Under the Central Valley Regional Board Tributary Rule	1-33
3-1	Physical Characteristics of Stream System in the Upper Clear Creek Watershed	3-6
3-2	Mean Monthly Discharge and Annual Statistics for Normal, Dry, and Wet Years; Clear Creek at French Gulch (Station Number 11371000)	3-6
3-3	Highest Peak Discharge Events Measured During Period of Record 1951-1993 at French Gulch (Station Number 11371000)	3-8
3-4	Recurrence Interval and Discharge for Upper Clear Creek High Flow Events	3-10
3-5	Recurrence Interval and Discharge for Upper Clear Creek Low Flow Events	3-10
3-6	Inflows and Outflows through the Whiskeytown Reservoir	3-11
3-7	CVPIA Implementation Criteria for Whiskeytown Releases to Lower Clear Creek	3-14
3-8	Watershed Condition Classes	3-17
3-9	Watershed Condition for Upper Clear Creek Watershed	3-17
3-10	Incidence of Fires in the Upper Clear Creek Watershed	3-19
3-11	Cause of Recorded Fire Starts in the Upper Clear Creek Watershed	3-22
3-12	Fuel Models found in the Upper Clear Creek Watershed	3-23
3-13	Special Plant Species Known to Occur or Potentially Occur within the Upper Clear Creek Watershed	3-39
3-14	Special Status and Protected Wildlife Species Known to Occur or Potentially Occur within the Upper Clear Creek Watershed	3-41
3-15	Survey and Manage Species Known to Occur on Federal Lands within the Shasta-Trinity National Forest	3-43
3-16	Mineral Resources Mined in the Upper Clear Creek Watershed	3-50
3-17	Main Soil Types found in the Upper Clear Creek Watershed	3-53
3-18	Distribution and Length of Roads in Upper Clear Creek Watershed	3-67
4-1	Natural Fire Occurrence: Data Collected Near Upper Clear Creek Watershed	4-4
5-1	Adverse Impacts of Land Use Activities on Key Resources in the Upper Clear Creek Watershed	5-8

APPENDICES

Appendix	
A	Upper Clear Creek Technical Advisory Committee
B	Partial List of Laws Pertaining to Federal Land Management
C	Determination of Extreme Flows from Streamflow Data
D	Soil Mapping Units found in the Upper Clear Creek Watershed

LIST OF ACROYMNS

ACS	Aquatic Conservation Strategy
AGNA	Auburn-Goulding-Neuns association
ALIS	Alpine Land Information Services
BLM	Bureau of Land Management
BOR	Bureau of Reclamation
CAA	Clean Air Act
CalEPA	California Environmental Protection Agency
CalTrans	California Department of Transportation
CCA	Chaix-Corbett association
CDF	California Department of Forestry and Fire Protection
CDFG	California Department of Fish and Game
CDMG	California Department of Mines and Geology
CFR	Code of Federal Regulations
Cfs	Cubic Feet per Second
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CWA	Clean Water Act
DO	Dissolved Oxygen
DWR	California Department of Water Resources
EC	Electrical conductivity
EIS	environmental impact statements
EPA	US Environmental Protection Agency
ERA	equivalent road area
ESA	Endangered Species Act
FBPS	Fire Behavior Prediction System
FFRAP	Forestry and Fire Protection Resource Assessment Program
FIFRA	Federal Insecticide, Fungicide and Rodenticide Act
FPZ	fire protection zone
FRIs	Fire return intervals
FS	Forest Service
FWS	Fish and Wildlife Service
GIS	geographic information system
ISRMA	Interlakes Special Recreation Management Area
JMSA	Josephine-Marapa-Sheetiron association
LMP	land management plans
LS/OG	late-successional/old-growth
LSR	Late-successional Reserve
MSA	Maymen-Stonyford association
NCASI	National Council of the Paper Industry for Air and Stream Improvement, Inc.
NDKF	Neuns-Deadwood-Kindig families
NEPA	National Environmental Policy Act of 1969
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NTPZ	nontimber-production zone
PAC	Provincial Advisory Committee
PL	Public Law
$RI_{X<}$	recurrence interval
$RI_{X>}$	recurrence interval value

RMP	resource management plan
ROD	Record of Decision
RWQCB	California Regional Water Quality Control Board
SMA	Shasta Management Area
SPI	Sierra Pacific Industries
STATSGO	State Soil Geographic
STBC	Shasta-Tehama Bioregional Council
TAC	technical advisory committee
TOC	threshold of concern
TPZ	timber-production zone
US	United States
USC	United States Code
USDA	US Department of Agriculture
USDI	US Department of Interior
WFGMA	West of French Gulch Management Area
WHR	Wildlife Habitat Relationship
WSNA	Woodseye-Smokey-Nanny association
WSRCD	Western Shasta Resource Conservation District

1. Characterization of Watershed

SECTION 1
CHARACTERIZATION OF WATERSHED

1.1 INTRODUCTION

1.1.1 Introduction to a Watershed Analysis

Watershed analysis is a procedure used to characterize ecosystem elements within a watershed (Regional Interagency Executive Committee 1995). Ecosystem elements include the human, aquatic, riparian, and terrestrial features, conditions, processes, and interactions that occur within a watershed. With this in mind, watershed analysis can essentially be considered ecosystem analysis at the watershed scale. The watershed analysis process allows us to develop and document a scientifically-based understanding of the interactions and functions occurring within a watershed.

Watershed analysis is a required element of the President's Forest Plan for lands that lie within the range of the Northern Spotted Owl. They are intended to provide the watershed context for fishery protection, restoration, and enhancement efforts as required by the *Northwest Forest Plan Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Document within the Range of the Northern Spotted Owl* (US Department of Agriculture [USDA], US Department of Interior [USDI] 1994). Watershed analyses are generally intermediate in scale between management plans and projects and can be used to display landscape patterns of ecosystems and habitat types on larger regional scales.

Numerous agencies may be involved in the same watershed, each having different management strategies, jurisdictions, and mandates for the various natural resources they manage. Watershed analysis can be used to organize and synthesize data collected from these different sources, and to integrate the information for the entire watershed. A watershed analysis can also be used to describe existing resource management plans (RMPs) and objectives within the watershed. Through the use of the watershed analysis process, resource management agencies are changing their focus from species and sites to the ecosystems that support them in order to understand the consequences of management actions prior to implementation.

Watershed analyses can be used to accomplish the following:

- Verify the map accuracy of data layers (including vegetation type, soil type, and geology) used in management plans;
- Identify data gaps with respect to the current and historic condition of the watershed;
- Identify research needs and opportunities;
- Identify current and potential future cumulative effects operating in a watershed;
- Identify species, threatened and endangered species, and habitats that occur or would be expected to occur in the watershed;
- Identify current habitat patterns in the watershed;
- Identify natural disturbances and processes that have been operative in the watershed and that are expected to be important in the future (these can include fire and fuels buildup, erosion, ecologic impacts due to pest species, pathogens, and population distributions, and invasive plant species);
- Identify human caused disturbances that have occurred within the watershed;
- Identify special forest products in the watershed;
- Identify landowners and ownership patterns in watershed;
- Identify and locate special sensitive habitats, soil erosion, and archeological areas within the watershed; and
- Identify current and potential future problems within the watershed.

For resource management purposes, a watershed analysis should be used as an iterative examination of the landscape at the watershed scale and be added to as additional research and surveys are conducted.

The Upper Clear Creek Watershed Analysis

A watershed analysis has recently been completed on the lower Clear Creek watershed, covering the Clear Creek watershed from the Whiskeytown Dam to the confluence of Clear Creek and the Sacramento River (WSRCD 1996). Therefore, the upper Clear Creek Watershed Analysis is being conducted to cover the rest of the Clear Creek watershed upstream of the Whiskeytown Dam (Figure 1-1).

Location Map of the Upper Clear Creek Watershed
Figure 1-1

The upper Clear Creek watershed lies just east of the Trinity-Shasta County boundary and extends from the Whiskeytown Dam to the headwaters of Clear Creek near Slate Mountain (Figure 1-1). The Whiskeytown Dam was selected as the division between the upper and lower watersheds because it is the major hydrologic structure in the watershed, controlling upstream lake levels and downstream flows. Whiskeytown Dam is also familiar to many people because of the numerous recreational opportunities provided by Whiskeytown Lake and the Whiskeytown Unit of the Whiskeytown-Shasta-Trinity National Recreation Area. Although the upper and lower watersheds differ in the degree of residential and commercial development and associated land use activities, they share similar characteristics and concerns regarding fuel loads and fire protection, water quality and aquatic habitat conservation, soil erosion and sedimentation, and vegetation and wildlife management.

The upper Clear Creek Watershed Analysis is being performed by Tetra Tech, Inc., in coordination with the WSRCD and US Forest Service (FS). This watershed analysis is being guided by a technical advisory committee (TAC) team of approximately 15 individuals, including staff from the numerous resource management agencies, private industries and public stakeholders involved within the watershed. TAC representatives include staff members from the WSRCD, FS, Bureau of Land Management (BLM), National Park Service (NPS), California Department of Forestry and Fire Protection (CDF), California Department of Fish and Game (CDFG), California Department of Water Resources (DWR), Natural Resources Conservation Service (NRCS), California Regional Water Quality Control Board (RWQCB), Fish and Wildlife Service (FWS), Sierra Pacific Industries (SPI), and the Northwest Sacramento Provincial Advisory Committee (PAC). A list of TAC representatives and others who have been involved in developing the upper Clear Creek Watershed Analysis is included in Appendix A.

Alpine Land Information Services (ALIS), of Redding, California, were contracted by SPI to gather existing data during the initial feasibility of this watershed analysis. ALIS staff gathered written information and geographic information system (GIS) data from various sources, including the FS, BLM, NPS, SPI, California Department of Mines and Geology (CDMG), California Department of Transportation (CalTrans), and others. Additional data used for this study includes RMPs, land management plans (LMPs), environmental impact statements (EIS), survey data, field reports, and GIS layers produced by these agencies and obtained by WSRCD and Tetra Tech staff.

Mission Statement

The mission of the upper Clear Creek Watershed Analysis is to gather and integrate existing information regarding the condition of the physical and ecological environments within the watershed, and to gain a comprehensive understanding of natural and human disturbances in the watershed. The purpose of the upper Clear Creek Watershed Analysis is to inform interested individuals about the human, aquatic, riparian, and terrestrial features of the entire ecosystem, and to assist planning and decision-making.

Resource managers working in the upper Clear Creek watershed face numerous challenges involving natural and cultural resource management issues, including multiple jurisdictions across the watershed, multi-agency and public/private interests within the watershed, and management of ecological, commercial, and cultural activities throughout the watershed. The watershed analysis will provide a broad, landscape-scale description of the upper Clear Creek watershed that allows public, private, and government agencies to forecast future impacts from management actions. This watershed analysis will also provide information that represents project scale impacts, where such impacts effect valued resources in the watershed.

This watershed analysis can be considered one step of an iterative process for developing our knowledge about the physical, ecological and cultural conditions and processes that occur within the upper Clear Creek ecosystem. Existing conditions are compared with historic conditions to evaluate impacts, describe trends and infer the possible causes of change through time. This analysis should be amended in the future as new information from surveys, inventories, monitoring reports, and other analyses are made available. New information may describe impacts from natural events and/or management activities, and compare those impacts against baseline conditions described herein. In response to the new information and analyses, future additions to this watershed analysis will also enable adaptive management of watershed activities and conditions.

The upper Clear Creek Watershed Analysis follows the six-step process of analysis as described in the *Ecosystem Analysis at the Watershed Scale - Federal Guide for Watershed Analysis*, version 2.2 (Regional Interagency Executive Committee 1995). The six-step process ensures that the watershed analysis will include the following:

- A characterization of the watershed that identifies the dominant physical, biological, and human processes and features of the watershed that affect ecosystem functions and conditions;
- A description of issues and key questions regarding issues most relevant to natural resource management in the watershed;
- A description of the current range, distribution, and condition of ecosystem elements in the watershed;
- A description of how these ecosystem elements have changed through time as a result of human influence and natural disturbances;
- A synthesis and interpretation of information which compares existing and reference conditions of specific ecosystem elements and explains significant differences, similarities, trends and causes; and
- Management recommendations responsive to watershed processes identified in the analysis

Scope of the Analysis

Information and analyses provided in the upper Clear Creek Watershed Analysis are based on best available data for the upper Clear Creek area. Data have been provided by the following agencies: BLM, BOR, CDF, CDMG, CalTrans, CDFG, DWR, NPS, NRCS, RWQCB, Shasta County Planning Department, Shasta County Air Quality Management District, US Environmental Protection Agency (EPA), FS, and FWS. This report describes the main issues of concern, questions and indicators relevant to management objectives; details the existing and historic conditions; and discusses trends and potential future conditions of the upper Clear Creek watershed. It also provides descriptions of management opportunities and constraints, and makes recommendations for future information gathering, monitoring, and restoration projects.

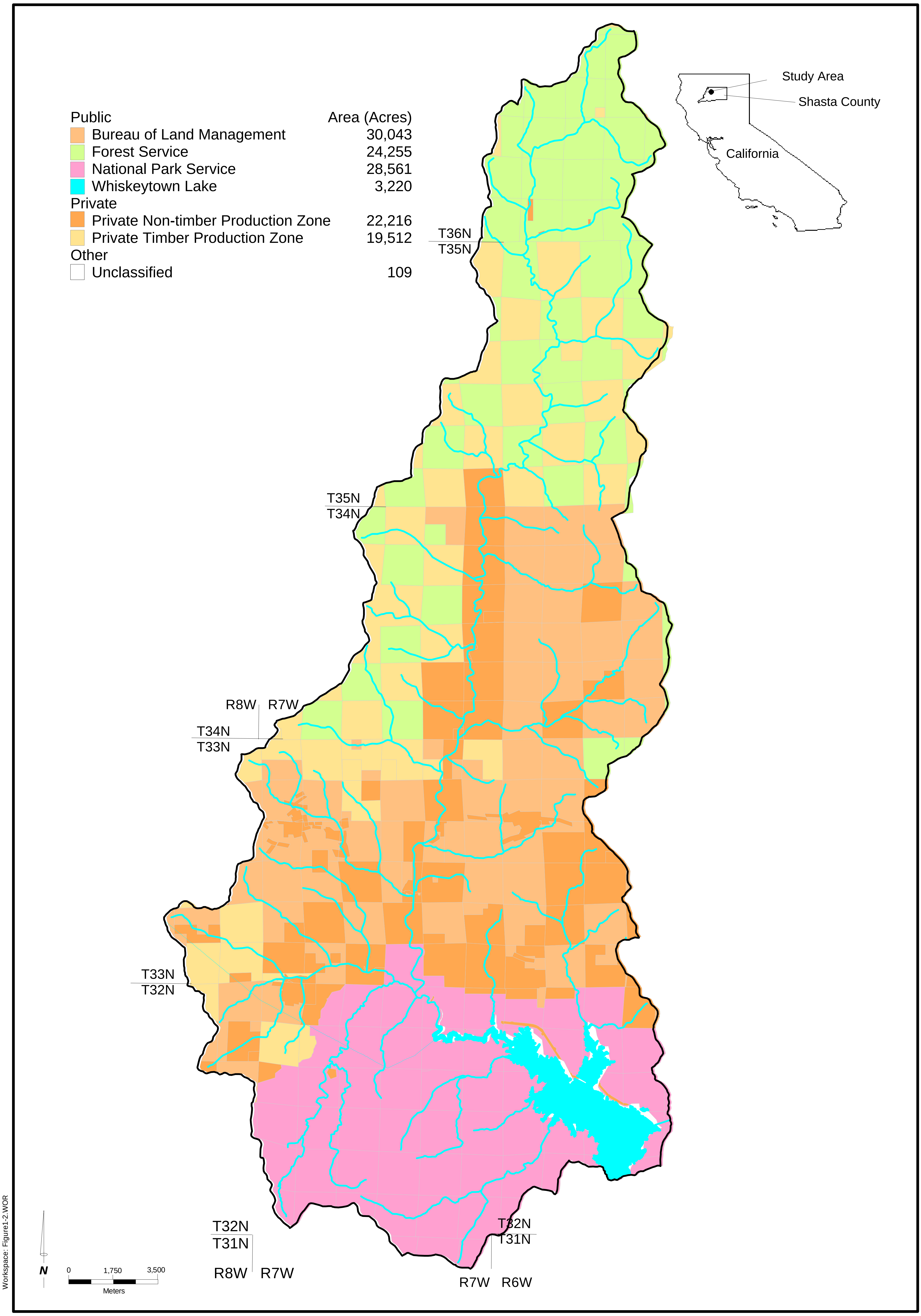
1.2 OWNERSHIP, ADMINISTRATION, AND SPECIAL LAND ALLOCATIONS

The upper Clear Creek watershed occupies nearly 200 square miles upstream of Whiskeytown Dam. The upper watershed consists of approximately 86,188 acres (67 percent) of publicly owned land and 41,728 acres (33 percent) of privately owned land (Figure 1-2). Publicly owned land is administered by three main federal agencies: the FS, the BLM, and the NPS. Privately owned land includes private timber-production zones (TPZs), managed by commercial timber production companies, and nontimber-production zones (NTPZs) that contain residential and other commercial lands.

Other agencies involved in the upper Clear Creek watershed include the BOR, CDFG, DWR, FWS, RWQCB, and EPA, which all have jurisdictional responsibilities over regions that include the upper Clear Creek watershed. Additionally, the NRCS is involved in watershed management and restoration throughout the country, and provides direct, technical assistance to private landowners regarding soil and watershed conservation resources and incentive programs.

1.2.1 Jurisdictional Boundaries and Special Land Allocations within the Range of the Northern Spotted Owl

The FS and BLM have developed and adopted a common management approach for federal forest land in the Pacific Northwest and Northern California in response to President Clinton's *Forest Plan for Sustainable Economy and Sustainable Environment*. This new ecosystem management strategy is detailed in the *Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl* (USDA, USDI 1994). The Record of Decision (ROD) establishes specific land allocations, and in conjunction with the Standards and Guidelines section included in the document,



Projection: UTM NAD 27, Zone 10
Source: SPI, DFG, NPS, and USFS
Date Created: 5/19/98
Draft: 11/12/98

Land Ownership in the Upper Clear Creek Watershed

Shasta County, California

Tetra Tech, Inc.

Figure 1-2

provides management strategies and requirements designed to protect old-growth related species while maintaining sustainable timber harvests on federally administered land in the range of the northern spotted owl.

Since the entire upper Clear Creek watershed lies within the range of the northern spotted owl, lands administered by the BLM and USFS within the upper Clear Creek watershed must follow the policies set forth in the ROD and Standards and Guidelines. Special land allocations within the upper Clear Creek watershed include Congressionally Reserved Areas, Late-successional Reserves (LSRs), Riparian Reserves, and Matrix Lands (Figure 1-3).

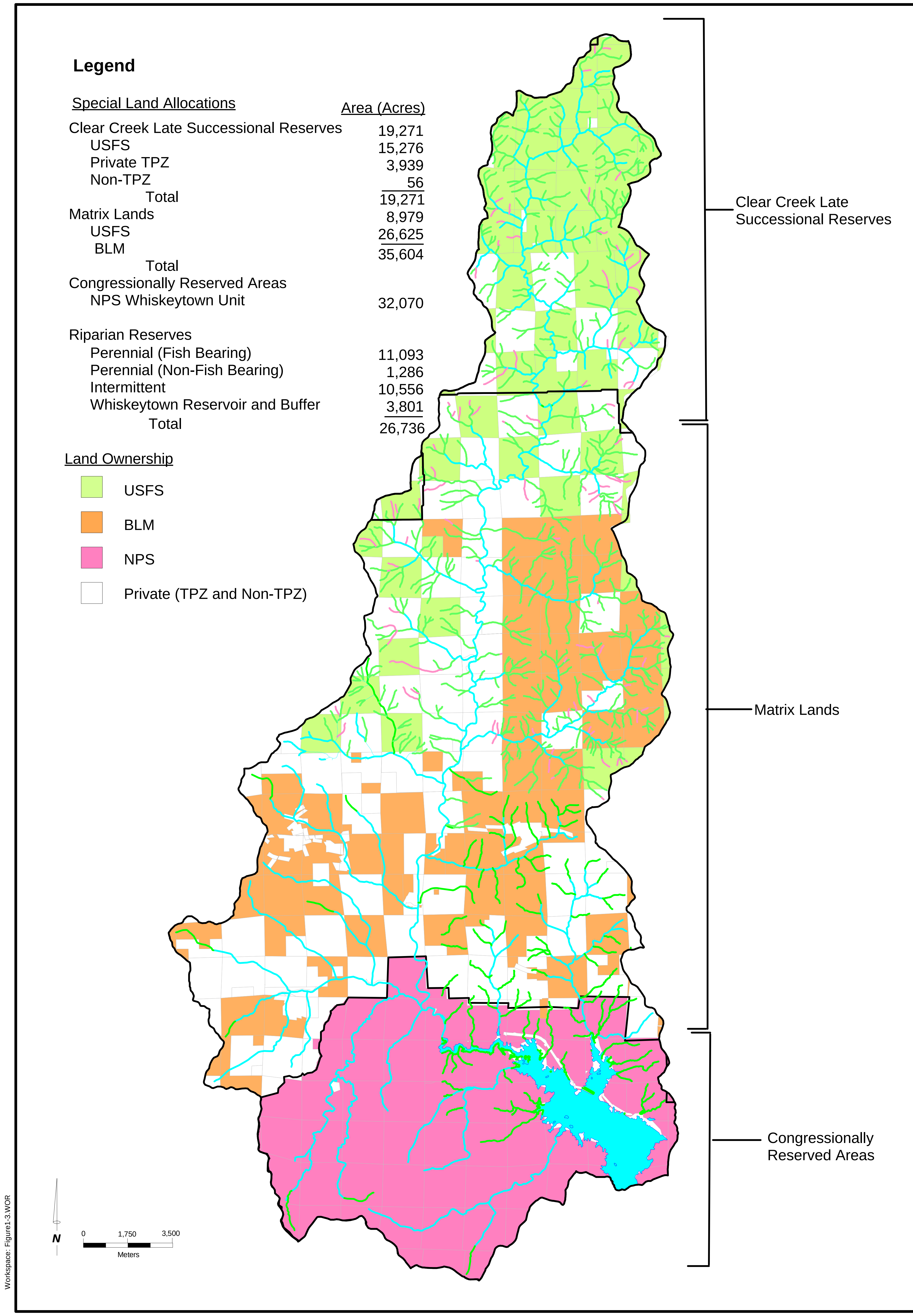
The total area occupied by each special land allocation was determined from GIS data provided by the FS, BLM and NPS. However, because of the difficulties involved with the various data sources and dividing each special allocation across public and private checkerboard ownership patterns, the acreages given are approximate and may over estimate the total acreage of each. For example, the total acreage given for congressionally reserved areas, LSRs and matrix lands also includes land allocated to riparian reserves. Similarly, the total area occupied by riparian reserves was calculated using interim widths across federally administered and private lands due to the difficulty of separating each layer across each ownership boundary.

Congressionally Reserved Areas

Congressionally reserved areas are lands that have been reserved by an act of Congress for specific land allocation purposes. Standards and guidelines for late-successional and old-growth (LS/OG) forest habitat apply if they are more restrictive and would not be contrary to intent of the legislative or regulatory language of these acts (USDA, USDI 1994). The Whiskeytown Unit of the Whiskeytown-Shasta-Trinity National Recreation Area is the only Congressionally Reserved area in the upper Clear Creek watershed. The Whiskeytown Unit covers 42,503 acres, of which 32,070 acres (including riparian reserves) are within the upper Clear Creek watershed. The Whiskeytown Unit is managed in accordance with the National Park Service Organic Act of 1916 and Public Law 89-336, the Congressional legislation which established Whiskeytown on Nov. 8, 1965.

Late-successional Reserves (LSRs)

LSRs are designed to provide habitat for species, including the northern spotted owl, that depend on LS/OG areas. Late-successional forests are those forest seral stages that include mature and old-growth age classes. They are managed to protect and enhance LS/OG forest ecosystems, and to protect them from loss due to large scale fire, insect and disease epidemics and major human impacts (USDA, USDI 1994). Programmed timber harvest is not allowed in the reserves. Only those practices that accelerate the development of LS/OG characteristics and that reduce the risk from severe impacts and loss of habitat are allowed. For example,



Projection: UTM NAD 27, Zone 10
Source: DFG and SPI
Date Created: 6/5/98
Draft:11/12/98

Special Land Allocations in the Upper Clear Creek Watershed

Shasta County, California

Tetra Tech, Inc.

Figure 1-3

thinning and other silvicultural activities are allowed in stands less than 80 years of age provided that the treatments are beneficial to the creation and maintenance of late-successional forest conditions. Similarly, non-silvicultural activities are allowed only if they are have no adverse impacts or are beneficial to the creation and maintenance of late-successional habitat.

Standards and guidelines for multiple-use activities other than silviculture have been developed for LSRs. Road construction in LSRs is generally not recommended unless potential benefits outweigh the costs of habitat degradation. Fuel wood collection is allowed only in existing cull decks, where trees are marked by silviculturists to thin. Mitigation measures are developed to minimize adverse impacts to late-successional habitat from mining. Developments that would adversely affect LSRs are not permitted or are designed to avoid degradation of habitat and impacts to late-successional species. Other guidelines address land exchange, habitat improvement projects, range management, fire suppression and prevention, special forest products, recreational uses, research rights-of-way, and nonnative species (USDA. USDI 1994).

LSR lands within the upper Clear Creek watershed are part of *Clear Creek Late-successional Reserve (RC-334) Management Assessment* (FS 1997). The Clear Creek LSR, which occupies a total area of 83,798 acres in both the Northern Interior Coast Range and the Shasta-McCloud subprovinces of the Klamath physiographic province (FS 1997), includes 19,271 acres in the northern end of the upper Clear Creek watershed. Approximately 15,276 acres (nearly 79 percent) of Clear Creek LSR land are managed by the FS and 3,995 acres (nearly 21 percent) of LSR land are in private holdings.

The Clear Creek LSR is an important link between the Northern Interior subprovince, which lies in the center of the northern spotted owl range, and the Shasta-McCloud subprovince, which lies at the southeastern extent of the owl's range. The geographic location and relatively unfragmented nature of the Northern Interior subprovince and resultant high owl densities make it one of the most important subprovinces in the state, while the Shasta-McCloud subprovince provides an important area of genetic exchange with the California spotted owl subspecies.

Riparian Reserves

Riparian reserves are one of four components of the Aquatic Conservation Strategy (ACS). The management objectives of the ACS are designed to maintain and restore the productivity and resiliency of riparian and aquatic ecosystems at the watershed and landscape scale by protecting habitat for fish and other riparian-dependant species and resources and by restoring currently degraded habitats.

Riparian reserves "help maintain and restore riparian structures and functions, benefit fish and riparian-dependent non-fish species, enhance habitat conservation for organisms dependent on the transition zone between upslope and riparian areas, improve travel and dispersal corridors for terrestrial animals and plants, and provide for greater connectivity of late-successional forest habitat" (USDA, USDI 1994). As a component of the ACS, riparian reserves are intended to benefit all species that make use of aquatic and riparian habitats, including fish, mollusks, amphibians, lichens, fungi, bryophytes, vascular plants, American marten, red tree voles, bats, marbled murrelets, and northern spotted owls.

Standards and guidelines for riparian reserves prohibit or regulate activities that may retard or prevent attainment of the ACS objectives. Therefore, they address timber management, roads management, grazing management, recreation management, minerals management, fire/fuels management, lands (in-stream flows needed to maintain riparian resources, channel conditions, and fish passage), general riparian area management, watershed and habitat restoration, fish and wildlife management, and research conducted within riparian reserves. Timber management, including fuelwood cutting, is prohibited in riparian reserves except under the following conditions: to allow salvage and fuelwood cutting to meet ACS objectives where catastrophic events such as fire, flooding, volcanic, wind, or insect damage result in degraded riparian conditions; to salvage trees only when watershed analysis determines that present and future coarse woody debris needs are met; and to control stocking, reestablish and manage stands, and acquire desired vegetation characteristics needed to attain ACS objectives. Accordingly, all of these activities must be conducted in compliance with ACS objectives (USDA, USDI 1994).

In order to meet ACS objectives, the Standards and Guidelines have prescribed interim widths for riparian reserves based on the following ecologic and geomorphic factors:

- Fish-bearing streams – the area on each side of the stream equal to the height of two site-potential trees, or 300 feet slope distance, whichever is greater;

- Permanently flowing nonfish-bearing streams – the area on each side of the stream equal to the height of one site-potential tree, or 150 feet slope distance, whichever is greater;

- Lakes and natural ponds – the body of water and the area to the outer edges of riparian vegetation, or to a distance equal to the height of two site-potential trees, or 300 feet slope distances, whichever is greater;

- Constructed ponds and reservoirs and wetlands greater than one acre – the area from the edge of the wetland or the maximum pool elevation to a distance equal to the height of one site-potential tree, or 150 feet slope distance, whichever is greater;

- Seasonally flowing or intermittent streams – the area on each side of the stream to a distance equal to the height of one site-potential tree or 100 feet slope distance, whichever is greater;

- Wetlands less than one acre and unstable and potentially unstable areas – the extent of unstable and potentially unstable areas, and wetlands less than one acre to the outer edges of the riparian vegetation (USDA, USDI 1994).

Using the interim widths established for fish bearing and non-fish bearing streams and wetlands, riparian reserves occupy approximately 26,736 acres (18 percent) of land in the upper Clear Creek watershed. Included in this number is the surface area of Whiskeytown Lake and a 150-foot buffer surrounding the lake, which may include riparian and wetland vegetation. Interim widths may later be refined after additional monitoring and analyses are conducted, to account for site specific features including the field determination of site specific tree height, unstable areas and wildlife dispersal corridors.

Additionally, it should be noted that because of the checkerboard ownership pattern of most federal lands within the upper Clear Creek watershed, the level of effort that would have been required to modify the existing GIS layers across federal and private boundaries was beyond the scope of this project. The acreage calculated for riparian reserves was determined over the entire watershed (including across public lands that are not necessarily managed under the federal standards and guidelines), and may, therefore, over-estimate the total amount of riparian reserves within the upper watershed. However, similar widths are used for watercourse and lake protection zones on private TPZ lands (which account for 47 percent of private lands), so it is expected that the over estimate is probably not significant at this level or watershed analysis.

Matrix Land

Matrix lands are considered to be those federally administered lands that are not within any other land allocation category. Matrix lands are managed for commercial timber production, mineral extraction, and recreational uses.

Standards and guidelines for timber harvest in matrix lands are designed to conserve ecosystems and protect habitat for sensitive species. The standards and guidelines emphasize ensuring that a renewable supply of large down logs is maintained, retaining at least 15 percent of the green trees on each regeneration harvest unit on National Forest land, and protecting the best 100 acres of late-successional habitat around owl activity centers known as of January 1, 1994. Prohibited timber harvest activities in riparian reserves are described above.

Additional topics covered under standards and guidelines for matrix lands include the following:

- Provide specified amounts of coarse woody debris in matrix management;
- Provide additional protection for caves, mines, and abandoned wooden bridges and buildings that are used as roost sites for bats;
- Modify site treatment practices, particularly the use of fire and pesticides, and modify harvest methods to minimize soil and litter disturbance;

- Provide for retention of old-growth fragments in watersheds where little remains;
- Provide protection buffers for sensitive species; and
- Coordinate fire and fuels management with local governments, agencies, and landowners (USDA, USDI 1994).

Matrix lands occupy approximately 35,604 acres within the upper Clear Creek watershed. The FS manages 8,979 acres (25 percent) of these lands, and BLM manages 26,625 (75 percent) of lands. Timber production and recreational activities are conducted on both FS and BLM matrix lands. Minerals mining is conducted on BLM matrix lands only. While, technically matrix lands are intended to represent federal lands that are not within any other land allocation category, the acreage calculated above does include riparian reserves due to the difficulty in modifying the GIS database across checkerboard ownership parcels and various buffer widths.

Survey and Manage Species

Additional standards and guidelines were developed specifically to protect amphibians, mammals, bryophytes, mollusks, vascular plants, fungi, mosses, lichens, and arthropod species that are known to exist on federal lands within the range of the northern spotted owl. The standards and guidelines divides these species into two groups, "Survey and Manage" and "Protection Buffer" species. Management requirements for these two groups apply to all special land allocations when "ground-disturbing" activities are planned on federal lands, and provide provisions for protecting the range and habitats that the species are known or suspected to occupy. Survey and manage species known to occur on National Forest lands in the upper Clear Creek are described in Section 3.

1.2.2 Land Ownership and Administration

National Forest Service

The FS administers approximately 24,255 acres (19 percent) of the upper watershed as part of the Shasta-Trinity National Forest. Approximately 14,744 acres (61 percent) of FS lands lie between township 33N and 36N in checkerboard parcels adjacent to private TPZs, private NTPZs, and BLM lands. Only 9,511 (39 percent) of FS lands exist as a single, mostly-contiguous parcel at the head of the watershed, in township 36N.

Forest Service lands are managed as part of the Weaverville/Lewiston Management Area of the Shasta-Trinity National Forest. Special land allocations for FS lands in the upper Clear Creek watershed include LSRs, riparian reserves and matrix lands (Figure 1-3). Approximately 15,276 acres (63 percent) of FS land lies within the Clear Creek LSR and 8,979 acres (37 percent) are considered matrix lands.

Management by the FS in the Clear Creek LSR (Figure 1-4) is to protect and enhance old-growth forest conditions. Management goals for these areas are intended to: maintain LS/OG habitat and ecosystems; maintain biological diversity associated with native species and ecosystems in accordance with laws and regulations; and protect

LS/OG ecosystems from loss due to large-scale fire, insect and disease epidemics, and major human impacts. Additionally, management recommendations for the LSR include developing, maintaining and enhancing conditions that are sustainable over periods long enough to allow natural processes to provide LS/OG conditions through time.

Management emphasis in FS riparian reserves is to maintain, improve and protect stream course, water quality, and wildlife habitat of riparian ecosystems. Riparian management zones, based on ROD standards and guidelines, are used to provide a buffer between riparian areas and forest management activities. Timber management within a riparian reserve is prohibited, except under specific conditions (e.g., repairing damaged riparian conditions due to extreme natural events; allowing salvage or fuelwood cutting to maintain ACS objectives).

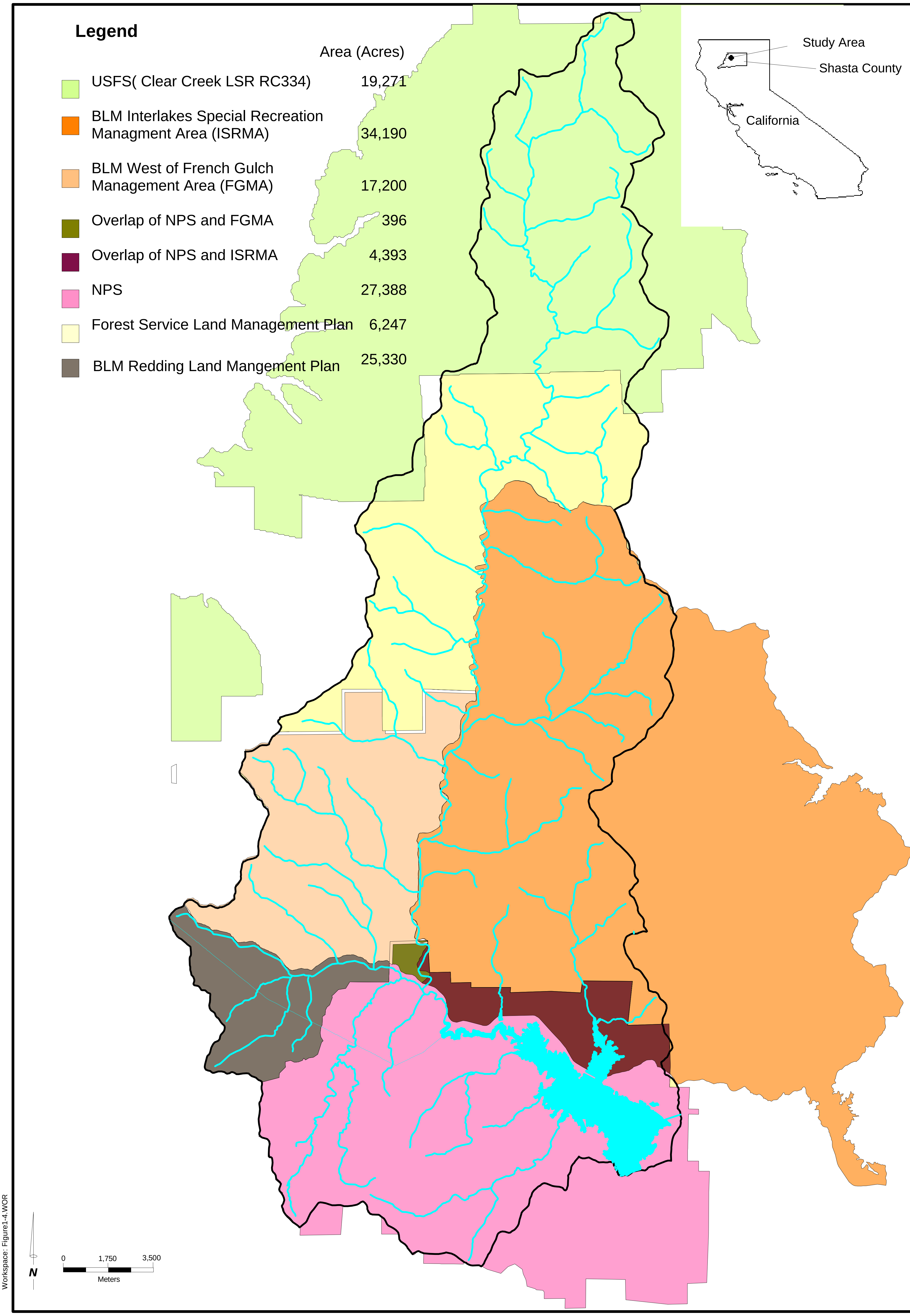
Management emphasis in FS matrix lands in the watershed includes wildlife habitat management and the production of commercial wood products.

Bureau of Land Management

The BLM administers approximately 30,043 acres (23 percent) of land in the upper watershed. Most BLM lands are noncontiguous parcels scattered throughout the central portion of the upper watershed, south of township 35N, and lie adjacent to both public lands and private TPZ and NTPZ lands.

Land managed by BLM includes public lands and federal mineral estate lands. Special land allocations for BLM lands in the upper Clear Creek watershed include congressionally reserved areas, riparian reserves, and matrix lands. Approximately 3,418 acres (11 percent) of BLM land lie within the congressionally reserved areas (i.e., within the administrative boundary of the Whiskeytown Unit), and 26,625 acres (89 percent) are managed as matrix lands.

The BLM manages lands in the upper Clear Creek watershed as part of the Shasta Management Area (SMA) in accordance to management strategies outlined in the Redding RMP (BLM 1993). Within the SMA are two special management areas that lie within, and/or across boundaries of the upper Clear Creek watershed (Figure 1-4). These two areas are known as the Interlakes Special Recreation



Projection: UTM NAD 27, Zone 10
Source: BLM, NPS, and USFS
Date Created: 5/19/98
Draft:11/12/98

Resource Mangement Plans of the Upper Clear Creek Watershed

Shasta County, California

Tetra Tech, Inc.

Figure 1-4

Management Area (ISRMA) and the West of French Gulch Management Area (WFGMA). The ISRMA extends east of Clear Creek, beyond the upper watershed boundary, and occupies a total area of 34,190 acres. The WFGMA lies fully within the upper Clear Creek watershed and encompasses a total of 17,200 acres west of Clear Creek. Within the upper Clear Creek watershed, approximately 20,052 acres (67 percent) of BLM lands in the SMA are managed as part of the ISRMA, and 7,502 acres (25 percent) are managed as the WFGMA. The remaining 2,489 acres (8 percent) of BLM lands are managed under the SMA.

BLM management objectives for matrix lands that lie within the upper Clear Creek watershed in the ISRMA are intended to accomplish the following:

- Provide motorized recreation opportunities;
- Maintain or improve the long-term sustained-yield of forest products from available commercial forest lands;
- Improve the long-term condition and protection of dear winter range habitat;
- Maintain special status species habitat;
- Maintain the existing scenic quality of the area; and
- Maintain opportunities to explore and develop freely available minerals on public lands.

BLM management objectives for matrix lands in the WFGMA are intended to accomplish the following:

- Maintain or improve the long-term sustained-yield of forest products from the available commercial forest lands;
- Improve the condition of deer winter range habitat;
- Protect significant historic elements of the French Gulch and Deadwood mining districts;
- Maintain opportunities to explore and develop freely available minerals on public lands; and
- Enhance existing semi-primitive motorized recreation opportunities.

BLM management objectives for matrix lands in the remaining portion of the SMA are intended to accomplish the following:

- Enhance the ability to acquire high value resource lands within the Redding Resource Area by disposal of public land interests within the SMA; and

- Enhance resource management efficiency and the public service mission of local, state and Federal agencies via transfer of jurisdiction of specific public lands from BLM.

Resource condition objectives, land use allocations, and management actions proposed for each of these management areas are further described in the Redding RMP (BLM 1993). Management actions specific to the ISRMA are further described in the ISRMA Final Plan and EIS (BLM 1997).

BLM management objectives within the upper Clear Creek focus on resolving four major planning issues, which include land tenure adjustment; recreation management; access; and forest management. To achieve these goals, the BLM is attempting to identify land that should be acquired through purchase, exchange, or donation to meet public needs, and to consolidate lands within BLM's scattered ownership pattern. BLM also wants to provide for recreation opportunities, while resolving conflicts among and between recreationists, other legitimate public land users, or resource values sensitive to certain types of recreational uses; determine where access rights should be acquired for the general public as well as for administrative purposes; and determine which land should be managed for commercial timber production and minerals mining and evaluate the management intensity on these lands.

National Park Service

The NPS administers approximately 31,781 acres (23 percent) of land in the upper Clear Creek watershed as part of the Whiskeytown Unit of the Whiskeytown-Shasta-Trinity National Recreation Area. This total acreage includes the Whiskeytown Lake, which was formed by impounding Clear Creek following construction of the Whiskeytown Dam in 1962. At full capacity, Whiskeytown Lake occupies 3,220 acres. The Whiskeytown Unit extends beyond the southern boundary of the upper Clear Creek watershed and covers a total area of 42,503 acres; 75 percent of the Whiskeytown Unit lies within the upper watershed, while 25 percent lies in the lower watershed. The northern boundary of NPS administered lands is adjacent to BLM and privately owned TPZ and NTPZ lands.

The entire Whiskeytown Unit, including Whiskeytown Lake, is considered a congressionally reserved area. Other special land allocations on NPS land include riparian reserves, which include Whiskeytown Lake and a 150 foot buffer around the lake.

As described in the Whiskeytown National Recreation Area Resources Management Plan, dated August 1997, the mandates of the NPS within the Whiskeytown Unit include:

> "... protection and conservation of natural and cultural resources. The mandate is derived from the National Park Service Organic Act of 1916 which outlines the fundamental purpose of the National Park Service. The mandate also directs the National Park Service to allow for public use and enjoyment of national parks, provided that the resources therein remain unimpaired for future generations. The conservation of resources takes primacy over the provisions of recreation. All resource management activities must be

> consistent with this dual mission of the National Park Service. The enabling legislation of Congress, which established Whiskeytown on Nov. 8, 1965 under Public Law 89-336, provided specific responsibilities beyond this mandate. The park was to " provide... for the public outdoor use and enjoyment" of the specified reservoirs and surrounding lands "by present and future generations, and for the conservation of scenic, scientific, historic, and other values contributing to public enjoyment of such land and water.""

The two other units of the Whiskeytown-Shasta-Trinity National Recreation Area include the Trinity Unit and the Shasta Unit. The reservoirs within each of these NRA units (Whiskeytown Lake, Trinity Lake, and Shasta Lake) are part of the Central Valley Project (CVP). Legislation that established the Whiskeytown-Shasta-Trinity National Recreation Area, mandates that administration of the Whiskeytown Unit be coordinated with other purposes of the CVP, including flood control, irrigation, and power generation (NPS 1997).

Bureau of Reclamation (BOR)

The BOR operates the Whiskeytown Dam and water supply for power generation, drinking water, and irrigation for the Central Valley. Much of the water of Clear Creek in the Whiskeytown Unit is also regulated by BOR (NPS 1997). Built as an element of the CVP, Whiskeytown Lake and Dam were primarily developed to protect the Central Valley from water shortages and potential floods. However, this multipurpose project also provides flood control, improves Sacramento River navigation, supplies domestic and industrial water, generates electric power, conserves fish and wildlife, creates opportunities for recreation, and enhances water quality (BOR 1998).

Other elements of the CVP include the Clear Creek Tunnel, Judge Francis Carr powerhouse, Spring Creek Tunnel and Spring Creek Powerhouse. The Clear Creek Tunnel is used to divert water from the Trinity River into the Whiskeytown Reservoir, thereby producing power at the Judge Francis Carr powerhouse, located at the end of the Clear Creek Tunnel. Water is then diverted from Whiskeytown Lake by the Spring Creek Tunnel, producing power at the Spring Creek Powerhouse prior to release into the Keswick Reservoir. The Trinity River diversion was authorized by Public Law 386, 84th Congress, First Session, and was approved August 12, 1955.

The mission of the BOR is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public (BOR 1998). The vision statement of the BOR is to "... protect local economies and preserve natural resources and ecosystems to the effective use of water." The BOR is involved in resource management activities that include environmental restoration, protection and water resources management.

BOR environmental restoration and protection management activities are intended to accomplish the following:

- Preserve wetlands and add to instream flows to increase migratory fish populations;

- Enhance fish and wildlife habitat, including endangered species;
- Champion environmental achievement on rivers; and
- Bring competing interests together to find consensus-based approaches to improve water quality.

BOR water resources management activities are intended to accomplish the following:

- Encourage water conservation and environmental restoration through partnerships, incentive programs, and challenge grants;
- meet increasing water demands of water reclamation, recycling, and reuse;
- support self-determination efforts of Native American tribes; and
- minimize impacts of extreme weather, by providing flood control benefits and route contingency planning.

The basic policies governing the BOR's power utilization activities are set forth in a large number of laws relating to electrical power activities. Some of these acts relate specifically to the BOR. The others serve equally to establish the general policy for all federal agencies. The most relevant acts with regard to BOR operations and other activities on federal lands within the upper Clear Creek Watershed are listed in Appendix B.

Private Timber-Production Zones

Approximately 19,512 acres (15 percent) of the upper Clear Creek watershed are occupied by private TPZs, which lie in checkerboard parcels between Township 32N and Township 36 N. SPI is the largest commercial timber company operating within the upper Clear Creek watershed, and is the only private timber production company that owns and manages lands within the Clear Creek LSR. Approximately 3,939 acres (20 percent) of private (SPI) TPZ lands lie in checkerboard parcels within the Clear Creek LSR adjacent to FS lands. The remaining 15,573 acres (80 percent) of private TPZ lands lie adjacent to FS, BLM and private NTPZ lands.

TPZ lands within the upper Clear Creek watershed are operated and managed by commercial timber companies, which are regulated by the California Forest Practice Rules in accordance with the Z'Berg-Nejedly Forest Practice Act of 1973. The intent of the Forest Practice Act is to "create and maintain an effective and comprehensive system of regulation and use of all timberlands so as to assure that: a) where feasible, the productivity of timberlands is restored, enhanced, and maintained; and b) the goal of maximum sustained production of high-quality timber products is achieved while giving consideration to values relating to recreation, watershed, wildlife, range and forage, fisheries, regional economic vitality, employment, and aesthetic enjoyment."

The CDF is the agency responsible for enforcing the Forest Practice Rules. The Forest Practice Rules include general limitations on timber operations near watercourse, lakes, meadows, and other wet areas. These limitations are focused on protecting water quality and habitat. They address removing slash, debris, or other materials; restricting road crossings, retaining vegetation - particularly large conifers, and felling trees away from watercourses. These rules establish widths of watercourse and lake protection zones that range from 50 to 150 feet, depending on the presence of fish and aquatic life and hill slope. Commercial timber harvest plans must ensure that activities planned within these areas (including mitigation measures) provide protection for water temperature control, streambed and flow modification by large woody debris, filtration of organic and inorganic material, upslope stability, bank and channel stabilization and vegetative structure diversity for fish and wildlife.

As defined by SPI, their mission is "... to conserve the productive basis of the land and associated resources by maintaining the integrity of biological and ecological processes while producing commodities and other services to the concept of sustainable forestry."

SPI currently has a no-take management plan agreement for TPZ lands within the Clear Creek LSR, through a letter of concurrence with the FWS.

The major elements of SPI's management objectives in the remaining commercial TPZs within the upper Clear Creek watershed include the following:

- Maintaining a sustainable timber resource in which the aggregate of tree species composition, age, and spatial arrangement are developed by planned application of specific forest management practices;
- Once an even age-class distribution is established (where poorly stocked and poorly growing stands are replaced with denser stands that exhibit better growth rates) ensuring total harvest will not exceed total forest growth for any ten-year period;
- Providing the greatest diversity of habitats and species within them, where the goal is to manage landscape for full complement of seral stages arranged in time and space while still maintaining a viable timber industry;
- Maintaining adequate amounts and careful distribution of riparian zones and late seral stage habitat in accordance with existing regulations for watercourse and lake protection zones;
- Protecting and enhancing water quality and providing habitat for dependent fish and wildlife species within designated watercourse and lake protection zones;
- Conserving soil resources and integrating soil protection techniques and soil erosion control methods throughout the forest landscape; and
- Participating in research projects that examine ecosystem requirements and distribution of components within them for species and habitat, and that focus on developing adaptive management techniques for sustainable forestry.

Private Non-Timber Production Zones

Private NTPZs occupy 22,216 acres (17percent) of land in the upper Clear Creek watershed. Private NTPZ lands include private residences, hotels, inns and shops in and around the town of French Gulch and the Whiskeytown Lake area. Private NTPZ lands also include private schools, abandoned and currently operating mine sites of the French Gulch historic mining district, and roadway easements along Highway 299 near Whiskeytown Lake. The community of French Gulch and surrounding rural residential areas occupy about 800 acres between French Gulch and Big Gulch. The 1990 US Census data show a total population of French Gulch of about 636 people.

Other Agency Objectives as Set Forth in Plans

California Department of Fish and Game (CDFG)

Management objectives of the CDFG within the upper Clear Creek watershed are to address the following:

- Protect fish and wildlife resources held in trust for the people of California;
- Protect and maintain fishery resource values; and
- Restore degraded fish and wildlife habitats.

California Department of Forestry and Fire Protection (CDF)

The mission of the CDF is to protect the people of California from fires, respond to emergencies, and protect and enhance forest, range and watershed values to provide social, economic and environmental benefits to rural and urban citizens.

CDF shares with the Board of Forestry the tasks of wildland fire protection planning for state responsibility area lands. In the upper Clear Creek watershed, CDF is the major wildland fire protection agency and has dispatching functions for NPS resources.

Working with the Board of Forestry, CDF developed the California Fire Plan, a proactive approach to managing resources to reduce wildfire losses and contribute to ecosystem health. The goal of the plan is to reduce the costs and losses associated with large, damaging wildfires. CDF works through community involvement, defining those assets at risk to wildfire, developing pre-fire management solutions, and then actively implementing those solutions. Pre-fire management solutions can include fuelbreaks, fire safe landscaping, removal of hazardous vegetation, and inspections for clearances around structures on wildland areas.

California Department of Water Resources (DWR)

DWR manages the water resources of California, in cooperation with other agencies, to benefit the state's people and to protect, restore, and enhance the natural and human environment. DWR has jurisdiction over all California waters and is responsible for ensuring that California's water needs are met. These needs include water-related recreation, fish and wildlife protection, hydroelectric power, prevention of damage and loss of life from floods, water related environmental enhancement, and DWR is responsible for ensuring that these needs are consistent with public desires and attitudes concerning environmental and social considerations (DWR 1998).

DWR interest in the upper Clear Creek watershed is focused on the following:

- Assuring that water quality is in line with water quality standards for aquatic species and human health (i.e., drinking water); and
- Relating water chemistry, temperature, and sediment sampling in the upper watershed to similar information collected in the lower watersheds.

USDA Natural Resources Conservation Service (NRCS)

The objectives of the NRCS are to provide leadership in a partnership effort to help people conserve, improve, and sustain natural resources. The NRCS works with resource conservation districts and private landowners to provide technical support in the conservation of natural resources on private lands.

NRCS objectives within the upper Clear Creek watershed include the following:

- Reducing fuel hazards;
- Controlling and preventing sediment erosion problems;
- Restoring habitat and vegetation in uplands and riparian corridors;
- Helping with reforestation and revegetation efforts following fires;
- Preventing water quality degradation; and
- Providing incentives-based soil and water conservation programs to private landowners.

Regional Water Quality Control Board (RWQCB)

The California legislature established the State Water Resources Control Board (State Board) and the nine RWQCBs in 1967. The State Board administers water quality, water pollution control, and water rights functions throughout California under the California Environmental Protection Agency (CalEPA). The mission of the RWQCBs is to develop and enforce water quality objectives and implementation plans, which will best protect the beneficial uses of the state's waters, recognizing local differences in climate, topography, geology, and hydrology. RWQCBs develop "basin plans" for their hydrologic areas, issue waste discharge requirements, take enforcement action against violators, and monitor water quality.

The RWQCB Region 5 branch office, in Redding, is responsible for enforcing water quality objectives in the upper Clear Creek watershed. Potential water quality concerns have been expressed in regards to bacteriological levels around the French Gulch area and the French Gulch Mobile Estates trailer park. Additionally, heavy rainfall events may cause septic systems to overflow around the Brandy Creek swimming area, Crystal

Creek, and Whiskey Creek swimming area. Acid mine drainage is not an issue in the French Gulch mining district because mines of this area are not massive sulfide mines, and thus are not acid producers. However, Willow Creek, a tributary in the southern portion of watershed, has been affected by acid mine drainage problems, so the potential for problems within Clear Creek below the Willow Creek confluence may exist. Additional issues of concern to the RWQCB, include the following:

- Fire and fuels management;
- Dispersed residential wastewater discharge; and
- Water quality conditions for aquatic species.

1.3 WATERSHED CHARACTERISTICS

1.3.1 Location and Physical Setting

The Clear Creek watershed is located in Shasta County, California, approximately six miles west of the town of Redding (Figure 1-1), and approximately 235 miles north of San Francisco. The watershed lies along the eastern flank of the Trinity Mountains, just east of the Trinity-Shasta county line. Clear Creek is part of the Upper Sacramento River Basin (Hydrologic Unit Code 18020112), and is an important tributary of the Sacramento River. The watershed has remained relatively undeveloped over time, in spite of it being within a one-hour drive of Redding which with a 1995 estimated population of over 78,000, houses nearly half of Shasta County residents (WSRCD 1996). The watershed also collects and provides a high quality water supply, which is distributed to CVP customers throughout the State and used for industrial, domestic and agricultural uses. Proper management and protection of the natural resources in the watershed can preserve and potentially increase the social, environmental, and economic value of the watershed and may help to protect the aquatic and terrestrial species that reside therein.

The Clear Creek watershed is approximately 35 miles long, ranges from five to 12 miles wide, and covers a total area of approximately 249 square miles, or 159,437 acres (NPS 1997; areas have been modified using recent GIS data). The mainstem Clear Creek flows generally southward from its headwaters near Slate Mountain to its confluence with the Sacramento River just south of Redding. The Whiskeytown and Saeltzer Dams regulate stream flows on Clear Creek. The reservoir formed by the Whiskeytown Dam, commonly referred to either as Whiskeytown Reservoir or Whiskeytown Lake, is the single largest hydrological feature in the watershed. Built by the BOR in 1962 as part of the CVP, Whiskeytown Lake stores approximately 240,000 acre-feet of water and has a surface area of approximately 3,220 acres.

The Whiskeytown Dam hydrologically divides the Clear Creek watershed into both upper and lower watershed areas. The upper watershed drains an area of approximately

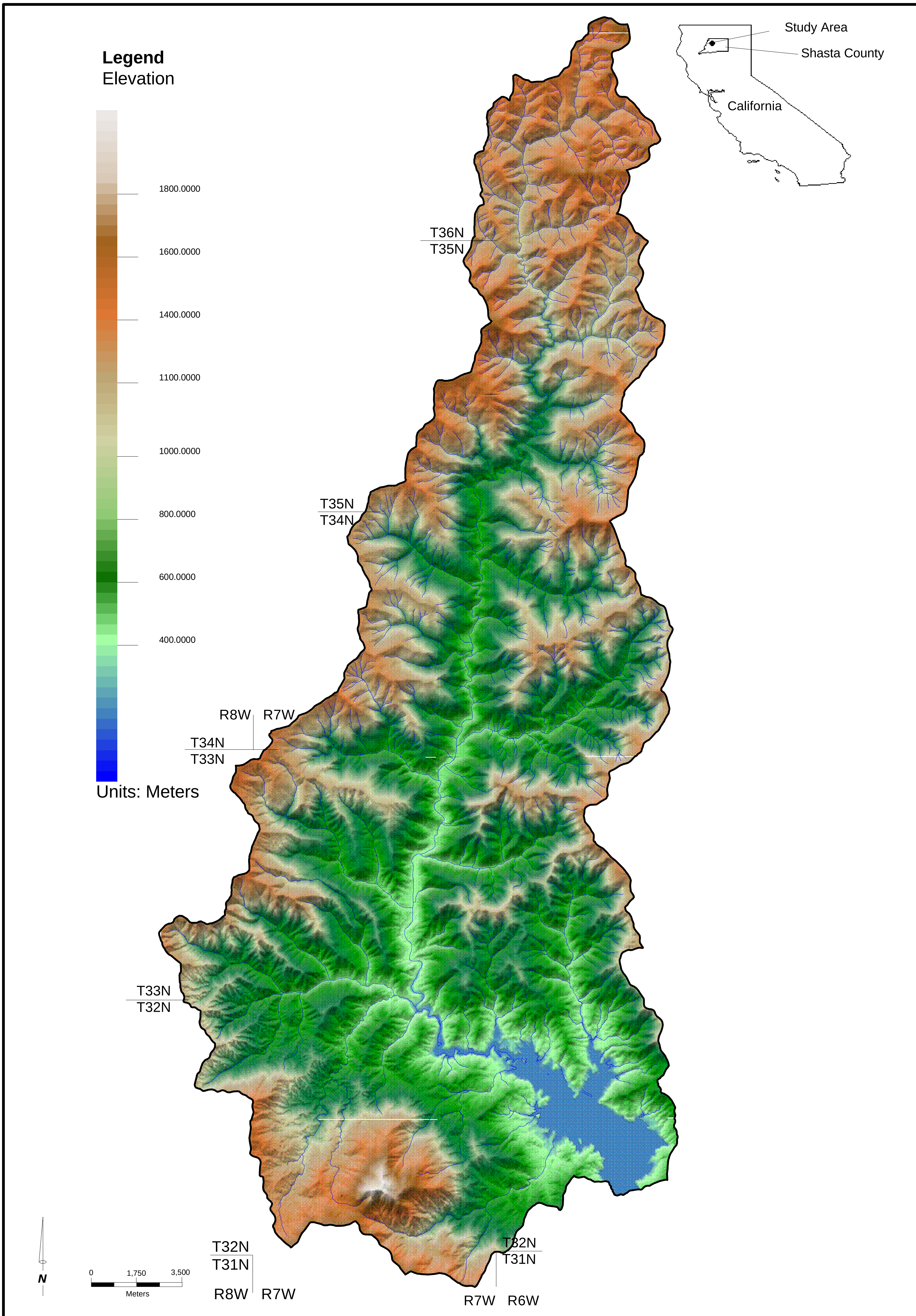
200 square miles, between Slate Mountain in the north and Whiskeytown Dam; the lower watershed drains approximately 49 square miles between Whiskeytown Dam and the Sacramento River. While the dam prevents the upstream migration of anadromous fish to historic spawning grounds located in the upper watershed, water quality and suspended sediments in releases from the dam can affect these and other aquatic resources upstream and downstream of the dam. Geologic, biologic and hydrologic characteristics upstream of the dam can also effect the storage potential in Whiskeytown Reservoir and hence the timing and magnitude of downstream flow releases, which have the potential to effect physical and biological conditions both upstream and downstream of the dam. Additionally, vegetation and wildlife, and fire protection and fuel management are issues of concern in both the upper and lower Clear Creek watersheds.

The following information is intended to characterize the upper Clear Creek watershed. Further description of the lower watershed is included in the Lower Clear Creek Watershed Analysis (WSRCD 1996).

Elevations in the upper watershed range from 6,209 feet at the top of Shasta Bally to approximately 369 feet at the Whiskeytown Dam spillway (Figures 1-1 and 1-5). Other peaks in the upper watershed include Slate Mountain, Blue Mountain, Trinity Mountain, and Iron Mountain. Climate in the watershed is seasonal and also varies with elevation; summers are hot and dry and winters are cool with moderate rainfall. Although no climate data centers exist near the head of the watershed, climate data has been collected at the Whiskeytown Reservoir (Western Region Climate Center Station #049621) for the last 38 years, over the period of record between April 1960 and February 1998. Mean monthly temperatures at Whiskeytown Reservoir range from 46 degrees in the winter to 77 degrees in the summer; the lowest monthly average temperatures of 36 degrees occur in December and January, while the highest average temperature of 95 degrees occur in July and August.

Average annual precipitation measured at Whiskeytown Reservoir is approximately 63 inches, with most rain falling in the winter and spring months. The isohyetal map (Figure 1-6) shows the pattern of annual precipitation across the upper Clear Creek watershed. Precipitation in the watershed is greatest in the mountain ranges flanking the watershed and is relatively lower in a band that somewhat follows the orientation of Clear Creek. Average annual precipitation amounts in the watershed range from 45 inches in the lower elevations near Whiskeytown Lake, to 85 inches near Cline Gulch along the eastern edge of the watershed. Average annual precipitation in the Trinity Mountains along the west-side of the watershed is approximately 65 to 75 inches. Snowfalls at Whiskeytown Reservoir have been measured during the months of November through March; annual average total snowfall at Whiskeytown Reservoir is 4.1 inches. Although no specific data exist on snowfalls in the higher elevations of the upper watershed, snowfalls certainly occur in the flanking ranges during the winter months and snow often remains on the uppermost peaks well into June (NPS 1997).

The upper Clear Creek watershed can be approached from both the east and west along State Route 299, which is the major two-lane highway connecting Weaverville and Redding. The Trinity Mountain Road is also an important transportation route for residents of French Gulch, as well as others traveling in the upper watershed. Starting at State Route 299 near Tower House, it follows the mainstem of Clear Creek before heading west to the crest of the Trinity Mountains, the ridge that divides the Trinity and Clear Creek watersheds. The Trinity Mountain Road follows along the ridgeline, which also defines the western edge of Shasta County, intersecting with Dog Creek Road, which leads across the northern end of the watershed east to Interstate Highway 5. Following Trinity Mountain Road northward leads out of the Clear Creek watershed near Jackass



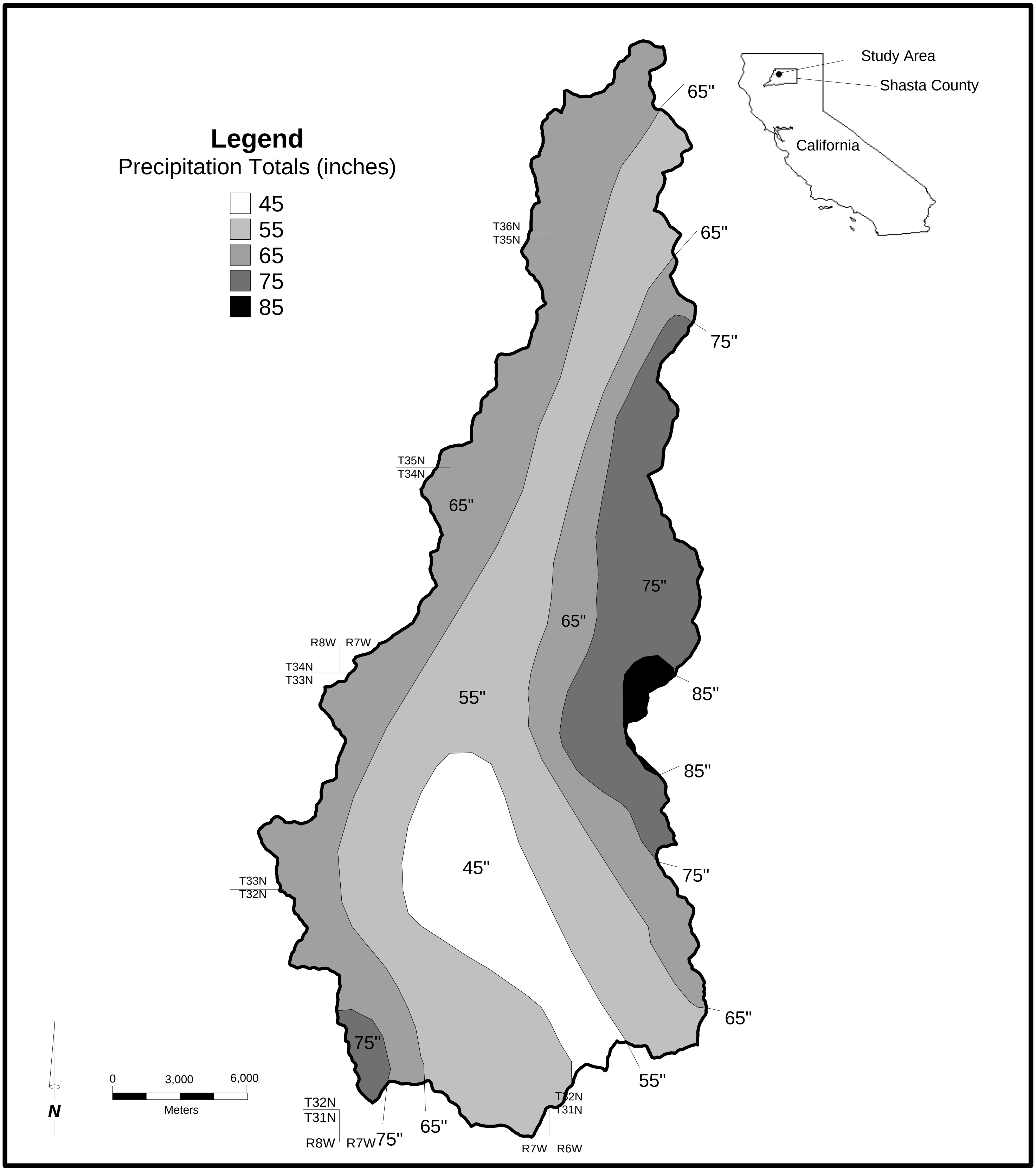
Projection: UTM NAD 27, Zone 10
Source:Tetra Tech and USGS
Date Created:7/11/98
Draft: 11/12/98

Elevation
in the Upper Clear Creek Watershed

Shasta County, California

Tetra Tech, Inc.

Figure 1-5



Projection: UTM NAD 27, Zone 10
Source: DFG
Date Created: 5/19/98
Draft: 11/12/98

Annual Rainfall in the Upper Clear Creek Watershed

Shasta County, California

Figure 1-6

Tetra Tech, Inc.

Peak and into the Trinity watershed along the eastern arm of Trinity Lake (formerly called Clair Engle Lake).

In addition to French Gulch residents, some of whom use the Trinity Mountain Road for local travel or to commute to Redding, this road is also used by recreationists, loggers, and resource managers. Clear Creek Campground, a FS campsite located at the confluence of Damnation Creek and Clear Creek, can be reached only via Dog Creek Road or Trinity Mountain Road. In some years, snowfall closes Trinity Mountain Road in the higher elevations for the winter season and snow removal equipment is used in the spring to clear the road.

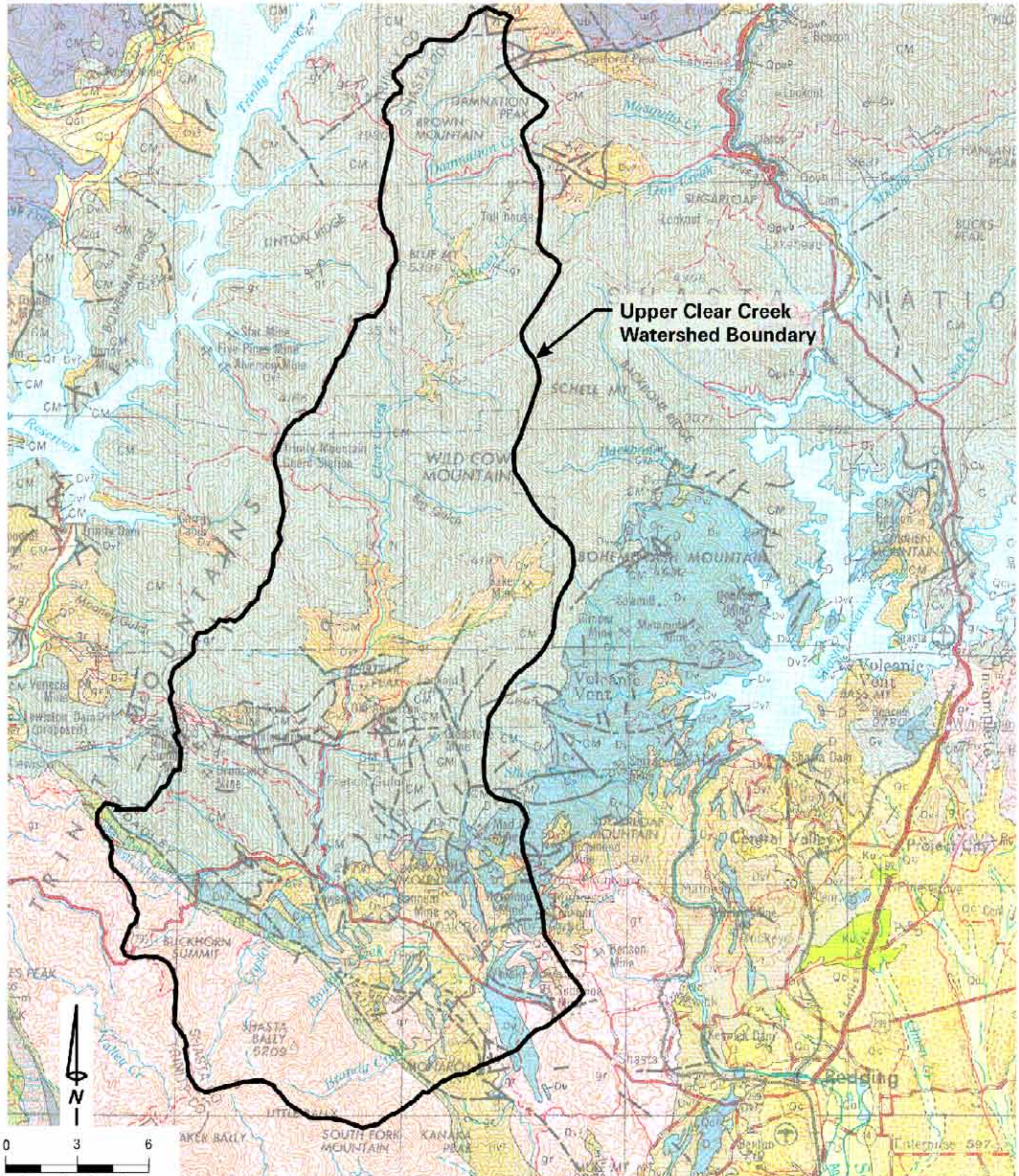
While the following sections are intended to provide a brief characterization of physical, biological and social watershed conditions; more detailed information on each of these subjects is provided in Chapter 3.

1.3.2 Geology and Soils

The upper Clear Creek watershed lies within the Klamath Mountains geological province, which is made up of a number of arcuate, concentric lithic belts separated by faults, and by linear ultra-mafic bodies, and granitic plutons (Irwin 1966). Irwin (1966), Davis (1966), Albers (1966), and others have described the geology of the Klamath Mountains province. The geologic map (Figure 1-7) was adapted from the geologic map of California, Redding sheet. Information used to develop the Redding sheet included the work of these authors as well as geologic mapping of the French Gulch quadrangle by Albers in 1964. The geologic formations found within the upper Clear Creek watershed include sedimentary, metasedimentary, and volcanic rocks that are Paleozoic in age and range from Middle Devonian to Mississippian. The Shasta Bally granitic batholith is Mesozoic in age and appears to have been emplaced during the Late Jurassic (Albers 1964).

Soils in the upper Clear Creek watershed have developed atop this bedrock geology over time due to physical, chemical, and biological factors that influence the parent rock material. Factors influencing soil formation include original parent rock mineralogy, topographic relief, climate, biological activity of vegetation and animals, and the amount of time that physical, chemical and biological forces have acted on a soil during its development. Soils in the upper watershed have been formed from the igneous, metamorphic, and sedimentary rock formations that underlie the area and soil characteristics are representative of these parent rock types and the variation in topographic relief found in the watershed. Shallow soils are found atop narrow ridges and steep hillsides where weathering and erosion processes are active, while deep soils are found in areas of lowlands and rolling hills, where soil formation and accumulation outpaces erosion.

The steep and rugged topography and the faulted and fractured condition of the metasedimentary and other metamorphic rocks that cover most of the area make



Source: Geologic Map of California - Redding Sheet. Compiled by R.G. Strand, 1962

n:\new\1941\02\Geology.cdr - 11/10/98 - BC

Legend - Geologic Formations in Upper Clear Creek Watershed

- Faults (dashed where inferred)
- Approximate boundary of Upper Clear Creek Watershed
- gr — Mesozoic granitic rocks (Shasta Bally & Mule Mountain Stock)
- Pre-cretaceous metamorphic rocks
- CM — Mississippian marine Bragdon & Kennet formations
- Dv
- Dv?

Geology of Upper Clear Creek Watershed

Shasta County, California

Figure 1-7

these soils more susceptible to erosion. Exposed granitic rock, such as that of the Shasta Bally batholith and Mule Mountain Stock, also decomposes relatively quickly due to lack of overburden pressures and relatively rapid weathering at surface temperatures and pressures.

1.3.3 Erosion Hazards

Soil erosion is dependent on a number of factors, including the soil characteristics (e.g., soil texture, structure, and degree of compaction), vegetative cover, amount and timing of precipitation, amount of disturbance, and surface gradient. Natural disturbances that impact the upper Clear Creek watershed include those caused by climatic extremes, fire, and physical instability (e.g., landslides and debris flows). Natural erosion and sedimentation problems are most severe in the Whiskeytown NRA due to the friable nature of the Shasta Bally batholith and erosion of the decomposed granitic soils. Other areas of high natural erosion can be found along the steep canyons of the upper watershed where mass wasting events such as landslides and rockfalls occur.

Anthropogenic (human-caused) disturbances result from certain land-use activities that remove vegetative cover, increase runoff, and steepen surface gradients. Land-use activities that disturb soil resources in the upper Clear Creek watershed include mining, timber harvesting, and recreational and rural development. Soil erosion potential is often increased where these land-use activities alter the physical and chemical composition of soils (e.g., soil depth, fertility, acidity, rate of water intake, and vegetative cover). Anthropogenic erosion hazards in the upper Clear Creek watershed include the removal of productive soils from the watershed, increasing gradients of hillslopes following road construction or grading, and changing stream channel gradients by scour or deposition due to increased runoff and sediment transport from denuded slopes.

Both natural and anthropogenic erosion hazards can impact the upper watershed by degrading water quality with increased turbidity from suspended sediments, burial or erosion of aquatic habitat, reduction of conveyance capacity of Clear Creek tributaries, and reduction of storage capacity of Whiskeytown Reservoir due to sedimentation.

1.3.4 Hydrology

Figure 1-1 shows the location of the stream gages and other hydrologic features located in the Clear Creek watershed. Flows in the upper Clear Creek watershed have been measured at two different stream gage locations: Clear Creek near French Gulch (Station 11371000) between 1950 and 1993; and Clear Creek near Shasta (Station 11371500) between 1911 and 1913. The “Clear Creek near Shasta” gage was located along Clear Creek near what is now the northern arm of Whiskeytown Lake. The town of Shasta, now a state historic landmark, was apparently chosen for a geographic reference point instead of the place name for the small mining town of Whiskeytown, to which the station is more closely located. Inflows from the Trinity River Diversion have been measured at the Judge Francis Carr Powerhouse near French Gulch (Station 11525430), and flows diverted from the Reservoir via the Spring Creek Tunnel are estimated based on power generated at the Spring Creek Powerplant. The only other stream gage on Clear Creek is the Clear Creek near Igo gage (Station 11372000), located downstream of the dam in the lower watershed.

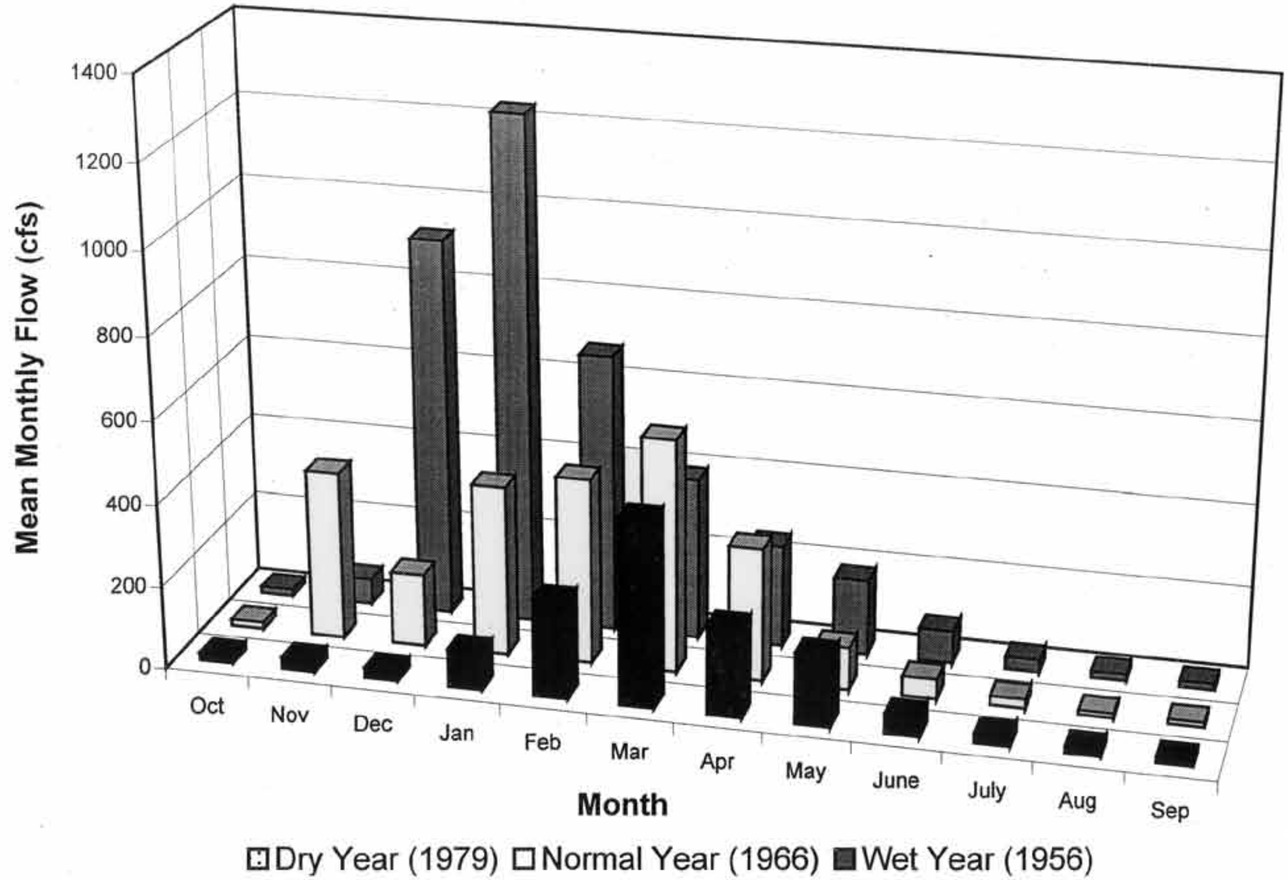
Streamflow in the upper watershed is characteristic of the Mediterranean climate of Northern California, with highest discharge during the wet, winter months and lower discharge during the summer and fall months. Mean monthly discharge for the French Gulch gage is shown in Figure 1-8 for normal, wet and dry years over the period of 1951 to 1992. Mean monthly discharge during a normal year does not get above 600 cubic feet per second (cfs). The highest peak discharge measured at the French Gulch gage over the forty-three year record was 14,600 cfs January, 1974. The gage was discontinued after 1993, so discharge data is not available for more recent peak events. The lowest minimum daily flow was 1.5 cfs, measured July 19-22, 1977.

1.3.5 Water Quality

Water quality in Clear Creek is regulated by the Clean Water Act, under the direction of the EPA and the California State Water Resources Control Board. The Central Valley Regional Board provides local regulation in Clear Creek. Water Quality Control Plans for the Central Valley Region contain Water quality Objectives (standards), Beneficial Uses and a "Statement of Policy With Respect to Maintaining High Quality Waters in California." The basin plans regulate water quality of the waters of the Shasta-Trinity National Forest just as they regulate all other waters of the respective river basins.

Beneficial uses specific to Clear Creek have not been designated. Therefore beneficial uses for Clear Creek are designated under the Regional Board's Basin Plan "tributary rule." The effect of the tributary rule is to apply the beneficial uses that have been designated for the nearest stream or river to all its tributaries. The Central Valley RWQCB has designated Beneficial Uses for many of the stream segments and reservoirs below upper Clear Creek. Therefore, the beneficial uses for the upper Sacramento River, Whiskeytown Reservoir and Clear Creek below Whiskeytown Reservoir apply to upper Clear Creek (Table 1-1). The upper Clear Creek has existing beneficial uses for 16 of the 21 categories used by the Central Valley RWQCB. No portion of the upper Clear Creek is included on the California Clean Water Act Section 303(d) list of impaired waters. This implies that all existing Beneficial Uses are currently supported in upper Clear Creek.

DWR has established five water quality monitoring stations along the upper Clear Creek and one station located in Whiskeytown Lake near Whiskeytown Dam (Figure 1-9). Water quality monitoring activities are being performed by DWR staff and funded through a grant from the Central Valley Project Improvement



Source: Tetra T

Historical Monthly Average Flows

Clear Creek at French

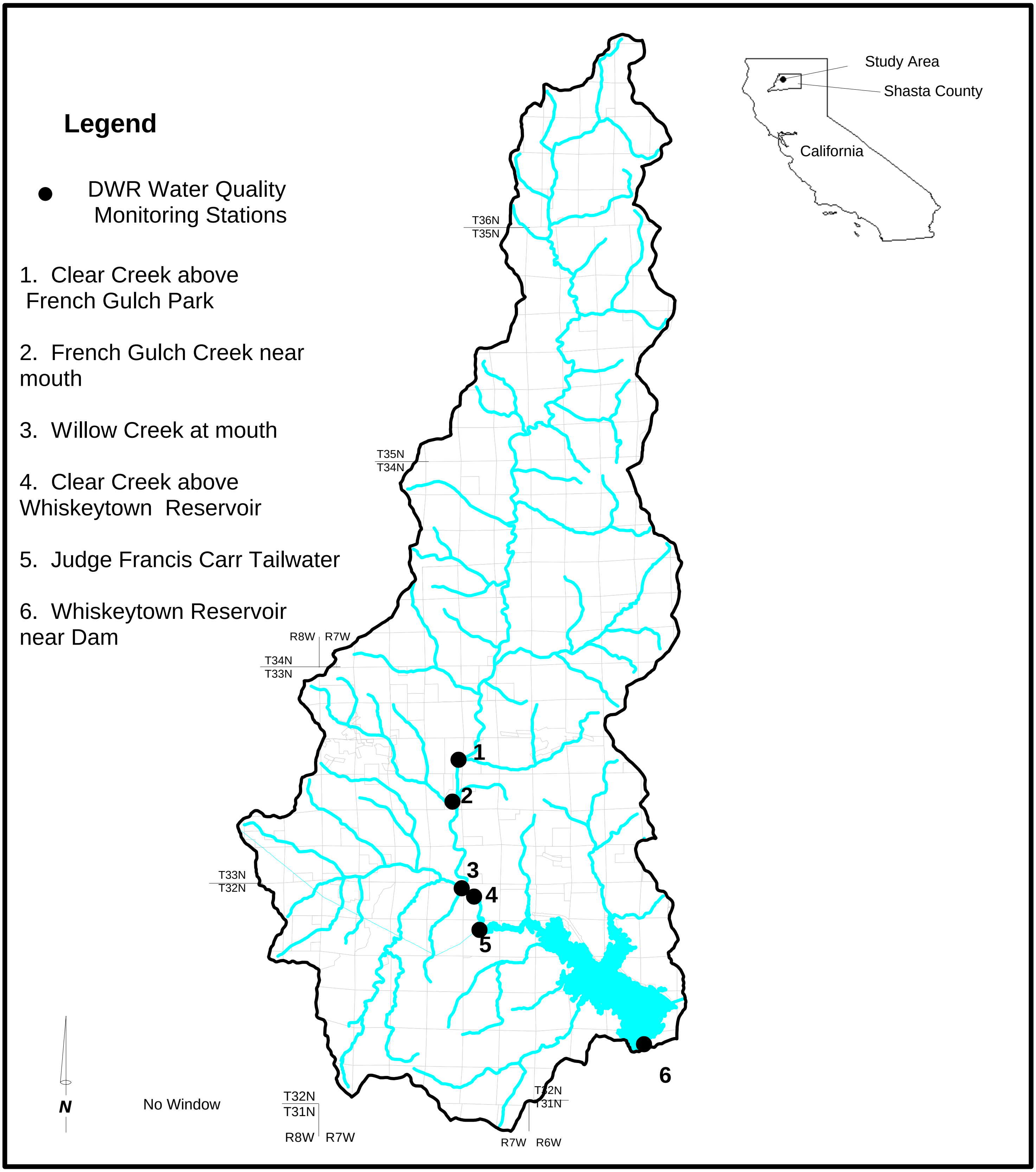
r:\new\1941\04\FGulch-Avg.cdr - 11/12/98 - BC

Tetra Tech, Inc.

Figure 1-8

Table 1-1
Beneficial Uses for Upper Clear Creek Waters Designated
Under the Central Valley Regional Board Tributary Rule

Water Designations	Beneficial Uses
Municipal Domestic Supply	Uses of water for community, military or individual water supply systems including, but not limited to drinking water supply.
Agriculture – Irrigation and Stock Watering	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.
Industry Service Supply	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.
Hydropower Generation	Uses of water for hydropower generation.
Water Contact Recreation	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.
Non-contact Water Recreation (Canoeing and Rafting)	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.
Commercial and Sport Fishing	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.
Warm Freshwater Habitat	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.
Cold Freshwater Habitat	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.
Wildlife Habitat	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.
Migration of Aquatic Organisms	Uses of water that support habitat necessary for migration or other temporary activities by aquatic organisms, such as anadromous fish.
Spawning, Reproduction, and/or Early Development	Uses of water that supports high quality aquatic habitats suitable for reproduction and early development of fish.



Projection: UTM NAD 27, Zone 10
Source: DFG, DWR, and SPI
Date Created: 5/19/98
Draft:7/12/98

Water Quality Monitoring Stations in the Clear Creek Watershed

Shasta County, California

Figure 1-9

Tetra Tech, Inc.

Act (CVPIA) and the DWR. The DWR stations became operational in October 1997 to provide additional information to characterize the water quality of upper Clear Creek in coordination with similar monitoring being conducted in the lower watershed. Water quality concerns in the upper Clear Creek watershed include coliform bacterial levels in waters downstream of septic systems used by residents of French Gulch and the Clear Creek Mobile Estates just downstream of French Gulch. Acid mine drainage is also of concern along a reach of Willow Creek due to drainage from the Greenhorn Mine west of the Tower House area.

NPS also conducts bacterialogical monitoring at the Whiskeytown Lake swimming area near Whiskey Creek, at a developed swimming area along Brandy Creek, and at the Boys Camp along Crystal Creek, where occasional problems associated with the septic systems in those locations have occurred.

1.3.6 Vegetation

Eight vegetation communities have been identified within the upper Clear Creek watershed. The categories include grasslands, chaparral, mixed conifer (which includes mixed conifer-hardwood communities), mixed fir, mixed hardwood (which includes mixed hardwood-conifer communities), mixed oak woodland, mixed pine, and wet meadow/marsh communities. Also mapped are areas covered only by soils and barren rock, gravel or pavement. The dominant vegetation communities in the upper watershed include mixed conifer (43 percent), mixed hardwood (25 percent), and grassland (15 percent).

Vegetation patterns develop based on vegetative species present and the natural conditions that affect vegetative growth, such as amount and distribution of precipitation, soil character, and surface characteristics (e.g., elevation, slope and aspect). Past management practices, such as commercial timber clear cutting, road construction, and mining, as well as natural disturbances, such as landslides and wildfire, also effect vegetation patterns. The amount and pattern of structural diversity in intermingled lands and lands being intensively managed is constantly being altered by wildfire, and forest management activities (FS 1994).

Various areas in the upper Clear Creek watershed are managed by different entities for different purposes and with different regulatory restrictions. The FS manages timber production on matrix lands within the Shasta-Trinity National Forest, BLM manages timber production on public lands outside of the Shasta-Trinity National Forest, and private timber companies manage timber production on private TPZ lands under the regulations of the California Forest Practice Rules. Restrictions regarding timber production on federal (FS and BLM) lands within LSRs and riparian reserves are described in Section 1.2. These different management activities consequently affect vegetation patterns across the landscape of the watershed. Special land allocations established for management of the northern spotted owl (i.e., LSRs) and other multiple land-use requirements established by the ROD (e.g., riparian reserves and congressionally reserved areas) have changed vegetation patterns by changing management practices regarding seral stage development and timber production.

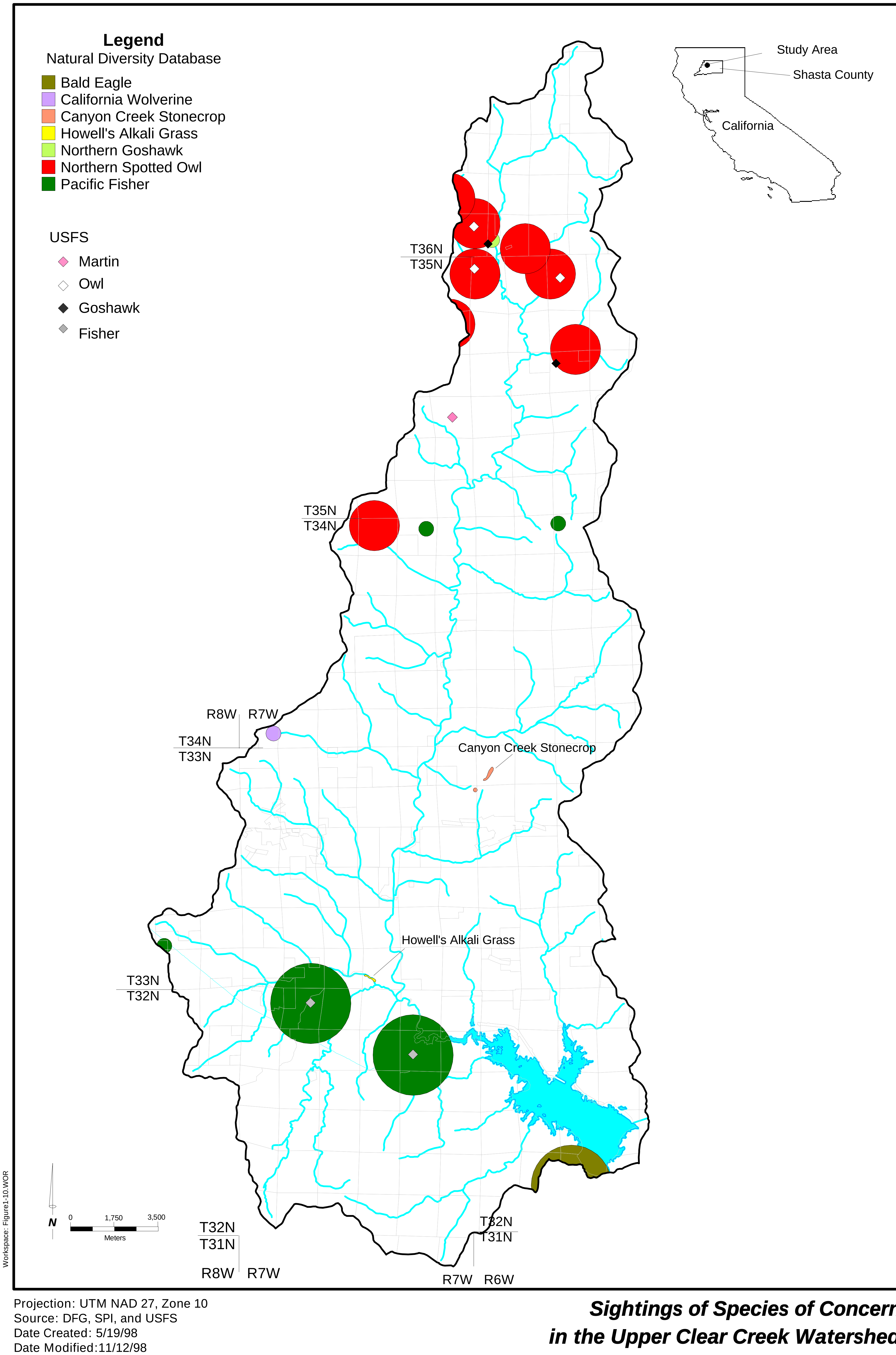
Wildlife

Wildlife and habitat are linked to each other and are key components of the upper Clear Creek watershed. Wildlife depends on specific habitats or a range of habitats for foraging, nesting, breeding, and thermal or protective cover. Habitats are often described using vegetation communities and/or location (e.g., oak woodland or perennial montane streams in mixed conifer-hardwood forests). A Wildlife Habitat Relationship (WHR) system is used by the Shasta Trinity National Forest to relate vegetation type with wildlife habitat types defined by seral stages. A similar WHR classification system has been used by BLM to list the wildlife types (amphibian, birds, mammals, and reptiles) associated with habitats found in their ISRMA. Vegetation types listed in the Shasta-Trinity National Forest WHR system include: Mixed Conifer, Douglas-fir, Red fir/White fir, Ponderosa Pine/Jeffrey Pine; Other Conifer Types; Hardwoods; Chaparral; and Grass. Habitat types listed in the BLM WHR system include: Mixed Chaparral; Mixed Conifer, Valley-Foothill Hardwood, Ponderosa Pine, Douglas-fir; Closed-Cone Pine-Cypress; Wet Meadows; Emergent Wetland; Lacustrine; and Riverine. Of the eight habitat types used by Shasta-Trinity National Forest, all can be found within the upper Clear Creek watershed. Of the ten different habitat types used by BLM, at least nine of the habitats (with the exception of Closed-Cone Pine-Cypress) can be found in the upper Clear Creek watershed.

The FS uses a classification of wildlife assemblages to discuss management of species and habitats. Wildlife assemblages used by the FS include: Late Seral Stage; Openings and Early Seral Stage; Multi-Habitat; Snag and Down Log; Riparian; Aquatic; Hardwood; Chaparral; and Cliffs, Caves, Talus, and Rock Outcrops (FS 1994).

Threatened, Endangered, and Sensitive Wildlife and Plant Species

Several threatened, endangered, and sensitive plant and wildlife species are found within the upper Clear Creek watershed (Figure 1-10). Two sensitive plant species have been found within the upper Clear Creek watershed: Howell's alkali grass (*Puccinellia howellii*) and Canyon Creek stonecrop (*Sedum paradisum*). Two federally listed species occur in the upper Clear Creek watershed: the northern spotted owl (*Strix occidentalis caurina*) and the bald eagle (*Haliaeetus leucocephalus*). The upper watershed also contains three federal species of concern wildlife species: the Pacific fisher (*Martes pennanti pacifica*), the northern goshawk (*Accipiter gentilis*), and California wolverine (*Gulo gulo*); and one Forest Service sensitive species: martin (*Martes americana*). The wolverine is also State listed as threatened and the Pacific fisher is a state species of special concern.



Projection: UTM NAD 27, Zone 10
Source: DFG, SPI, and USFS
Date Created: 5/19/98
Date Modified:11/12/98

Sightings of Species of Concern in the Upper Clear Creek Watershed

Shasta County, California

Figure 1-10

Tetra Tech, Inc.

1.3.7 Human Uses

The social aspect of the upper Clear Creek watershed includes residential, recreational and commercial (timber and minerals mining) land uses. Additionally, the Clear Creek watershed has developed a historic cultural identity from the Native American Wintun and early European mining communities that occupied parts of the watershed over different periods of history.

The town of French Gulch is a historic mining town that was named in 1856 after the French Canadians who mined gold in the area as early as 1849. Historic mining sites are scattered between the East Fork and Whiskeytown Lake in the historic mining region known as the French Gulch District. Five mine sites are also located north of Stacey Creek. Historically, ore, lode, and placer mining yielded large amounts of gold. Between 1900 and 1914, the average output for the district was between $300,000 and $500,000 worth of gold per year. Other minerals mined in the French Gulch District included chromite, copper, iron ore, and talc. The total mineral output from the district is valued at more than $30 million.

Approximately 650 residents currently live within the watershed, in and around the town of French Gulch. Some of the families that live in the area have ancestors that came into the area following the gold rush of 1849. The upper watershed is also a favorite of recreationists throughout the state. More than six million people live within a day's drive of the area. Recreational opportunities within the watershed include hiking, camping, fishing, boating, hunting, and nature watching, among others. Commercial land uses in the watershed include small service oriented businesses in the French Gulch area, and timber and minerals mining on public and private lands. Educational opportunities are also provided by programs associated with the French Gulch School, the NAWA environmental education boarding school, and NPS facilities located in the Whiskeytown Unit.

Adequate water supplies, transportation networks, fuel management and fire protection are required to support and protect the residents, recreationists, and employees who live, visit and work in the area.

1.3.8 Fire and Fuels

Historically, fire has been a natural influence on the landscape within the upper Clear Creek watershed. Before the influence of humans, wildfires started from lightning strikes or hot dry winds and spread across large tracts of land before burning out. Some conifer species (e.g., knobcone pines) require fire, heat or stress for seed germination. Such frequent, low intensity fires burn quickly through under brush, preserving large trees and maintaining diverse, multistory forests. Forest management practices over the past 70 years, however, have suppressed fire on many of the public lands and have profoundly affected the structure and composition of vegetation in low- to middle-elevation forests (Weatherspoon 1996). Conifer stands have become denser, mainly in small- and medium-size classes of shade-tolerant and fire-sensitive species. Additionally, dead and downed trees, due to drought, disease, or pest infestation, increase the amount of fuels on the forest floor. One consequences of these changes has been a large increase in the amount and continuity of both live and dead forest fuels, resulting in a substantial increase in the probability of large, severe wildfires (Weatherspoon and Skinner 1996). The conditions are now set for hot stand replacement type fires that consume underbrush, overstory trees and the duft layer. Stand replacement type fires burn hotter, longer and are usually more difficult to control. Fire size is predicted to increase with these conditions especially in the upper Clear Creek watershed which has steep, rugged topography and limited access.

2. IDENTIFICATION OF KEY ISSUES, QUESTIONS, AND INDICATORS

SECTION 2
IDENTIFICATION OF KEY ISSUES, QUESTIONS, AND INDICATORS

2.1 KEY ISSUES MOST RELEVANT TO MANAGEMENT QUESTIONS AND OBJECTIVES, HUMAN VALUES, OR RESOURCE CONDITIONS

2.1.1 Key Issues of Concern in the Upper Clear Creek Watershed

Issues of concern to management objectives, human values and resource conditions within the upper Clear Creek watershed include the following:

1) Fire protection and wildland fuel build-up;

2) Soils and erosion;

3) Water quality and quantity;

4) Vegetation and habitat; and

5) Human uses.

These five issues of concern affect and are affected by natural processes, land use practices, and management activities occurring within the upper Clear Creek watershed. These issues are also interrelated in that they can affect processes and patterns between each other. For example, soil erosion following catastrophic wildfire can degrade water quality conditions, thereby affecting the health of fish habitat in the watershed. Key questions have been developed for each of these issues and will be used to focus discussions regarding existing and historic reference conditions in the watershed. It is expected that subsequent analysis of each issue will enable an integrated understanding toward each of the core ecosystem elements, and will aid in predicting the impacts of future management activities within the upper Clear Creek watershed.

As described in Section 1.3, fire and fuel build-up relates to vegetation patterns and past land use and land management activities that have occurred within the upper Clear Creek watershed. Naturally caused fires relate to slope, aspect, elevation, and climatic extremes (such as lightning, heat, and wind), while fires caused intentionally or accidentally by humans relate to the location and number of roads, residential and recreation areas within the watershed, where such fires are most often started. Timing, location, and frequency of prescribed burns or other vegetation management controls can also relate to the amount of fuels built up within the watershed.

Erosion occurs naturally due to the structure and composition of the soils and underlying geology and the effects of natural hydrologic and geologic processes such as surface water runoff, channelized flow, freeze-thaw cycles, debris flows, and mass wasting (landslides, rockfalls, and slumps). Erosion can be accelerated, however, by particular land use practices that increase runoff, over-steepen slopes, or destabilize vegetation that would otherwise maintain a slope. Mining, timber production, road construction, and grazing are a few of the land use practices that can affect soil erosion. Soil erosion rates can also increase following fires if erosion prevention efforts are not carried out.

Water quality can be affected by both fires and soil erosion, which tend to increase temperature and turbidity by removing canopy cover of riparian vegetation and by increasing the amount of sediment delivered to the stream channel. Poorly maintained residential and recreational sewage and septic systems can effect water chemistry by increasing coliform and other bacteriological levels. Natural variations in precipitation and drought cycles can affect annual flows in Clear Creek. Most aquatic species are adaptable to these natural variations. However, the volume of water diverted annually from the creek can also affect water quantity in the upper Clear Creek watershed, unless minimum flow requirements for aquatic species are maintained.

Vegetation patterns within the upper Clear Creek watershed develop based on soil characteristics, slope/aspect, elevation, and associations with other vegetation types. Wildlife species are also connected to particular habitats, for feeding, nesting, breeding, and cover. Particular types of vegetation are more susceptible to fire, while other types of vegetation are rejuvenated following fires. Vegetative patterns then may be representative of historic occurrences of fire, as well as current vegetation control practices and land use practices, such as commercial timber production within the upper watershed. Habitat assemblages (which include wildlife species that are associated with particular vegetative types and habitats) may also be effected by these same issues, as well as by the consumptive-recreation activities of recreationists within the upper watershed, which include hunting and fishing. Motorized travel within the watershed also has impacts with regard to increasing deer mortality and decreasing deer birthrates within winter range areas, as well as increasing problems associated with increased access to hunting areas.

Human uses in the upper Clear Creek watershed, including rural residential, recreation, mining, commercial timber production, and natural habitat resource management, are involved in each of the key watershed issues because of the impacts that human activities have on these systems, as described above. Additional concerns regarding human uses within the upper Clear Creek watershed include public/private land access, regional transportation plans, human versus wild animal contacts, and domestic animals versus wild animal contacts.

2.1.2 Prioritization Process Used in Developing List of Key Questions and Indicators

A list of four issues regarding resource management in the upper Clear Creek watershed were first identified by a steering committee of the Northwest Sacramento PAC. The four main issues identified by the Northwest Sacramento PAC were listed in the original scope of work for the upper Clear Creek watershed analysis as water quality and quantity, fuels and fire, riparian habitat/wildlife, and soils/erosion. Individual and roundtable discussions of these and related topics were conducted with members of the upper Clear Creek TAC during an early phase of the project. In subsequent group discussions, it was recommended that habitat and wildlife include both upland and riparian species, and that a fifth issue relating to human uses of the upper watershed be added to the original list.

In addition to individual and roundtable discussions with TAC members, public comments and concerns were also obtained following an open house meeting for watershed residents, held at the French Gulch Elementary School on March 24, 1997. The meeting was attended by more than 50 public participants and included a general explanation describing the watershed analysis process, a question and answer period, and introductions of agency representatives and land managers involved in the analysis process. Then the public had the opportunity offer their own input while visiting with the various representatives at information stations related to fire and fuel management, soils and erosion, water quality and quantity, wildlife habitat, fish and streamside vegetation, timber management, and public uses. Comments collected at the March 24th public meeting were summarized by the WSRCD, and are available through their office.

Discussions with members of the TAC, and the summary of public comments were used to develop a matrix of concerns for each issue related to the upper Clear Creek watershed. The matrix was then used to prioritize concerns that have the most value to resource management in the upper watershed and to develop key questions and indicators for each issue. These key questions and indicators are listed below.

2.1.3 List of Key Questions and Indicators

- Key Questions
  - ➢ Indicators

Issue: Fire and Fuel Levels

- Fire hazard is related to the size, arrangement, quantity, quality and condition of fuels. What hazards are associated with the current fuel conditions in the upper watershed?
- Risk is related to the likelihood of ignition from some heat source – whether caused by natural lightning strikes or caused by human activity or human-related equipment.
  - ➢ Distribution of human and vegetation communities relative to past fires and fire starts.
  - ➢ Fuel models showing distribution and types of fuel hazards present.
- Can periodic fuel reduction methods (e.g., prescribed fire, biomass harvesting) be used to minimize the hazard and prevent large fires in the watershed?
  - ➢ Slope, presence or absence of roads and firebreaks, type and size of fuel present, and landowner willingness.
- How is fire protection and fire suppression efforts coordinated between FS, BLM, NPS and CDF?
- Are road networks adequate for assisting in fire suppression? Do they provide firebreaks? Where might additional firebreaks be needed?
  - ➢ Jurisdictional boundaries of different Fire Protection Zones (FPZs) and description of cooperative fire protection agreements
  - ➢ Number and location of existing fire breaks and controlled or prescribed burn areas
  - ➢ Pattern and distribution of roads (showing widths and surfacing) relative to potential fire areas
- What actions or cautionary measures should be taken to deal with invasive plant and pest species?
  - ➢ Landscape pattern of management activities and fire potential index (e.g., plantations, thinning, underbrush removal, etc.)
  - ➢ Pattern and distribution of invasive plants and pest species
- What areas are most at risk of soil erosion following fires? Are sediment inputs from burn areas impacting aquatic habitat and/or species? If so, where?
  - ➢ Erosion hazard potential (slope/aspect/vegetation cover) versus high-potential fire locations
  - ➢ Proximity of erosional feature to environmentally sensitive resources
  - ➢ Estimated measure of sediment delivery to stream channels in burn areas. Potential delivery rates in potential fire sites.
- Do management requirements in special land allocation areas conflict with vegetation control objectives and increase the risk of some areas to increased potential for fire?
  - ➢ Percent of watershed under land allocation management guidelines. Area of each land allocation.
- What T&E species are most at risk from the potential of fire?
- How would a high-intensity wildfire affect the health and habitat of upland, riparian, and aquatic species?
  - ➢ Plot occurrence of large fires and fire starts versus location of T&E species
  - ➢ Percent loss of habitat type following large fires

  - Marked change in hydrograph characteristics, water quality parameters, and sedimentation rates relative to pre-fire conditions
- What management techniques can be applied following fires to minimize the potential for establishment of invasive pest plant/animal/and insect/pathogen species? What pest species should be especially protected against? And why?
  - Pattern and distribution of invasive plants and pest species
  - Percent cover of invasive species following fire.
  - Proximity of existing invasive species to high potential fire areas
  - Extent of currently successful approaches to pest management being applied in the watershed
- How have historic timber management practices affected the reduction or build-up of fuels?
  - Pattern and distribution of fuels in TPZ areas
- Does a correlation exist between road networks and fire starts?
- What recreation areas may be at risk from fires? What recreation areas may be high fire start areas?
  - Number of fire starts in recreation areas
  - Proximity of recreation areas and road networks to location of fire starts

Issue: Soils and Erosion

- What areas of the watershed are currently experiencing accelerated erosion and what impacts are occurring? What human or natural disturbances are most likely to lead to accelerated erosion?
- What are the impacts of sediment erosion and sediment deposition on hydrologic and ecologic functions of watershed?
  - Location and distribution of erosional sites showing historic erosion rates
  - Proximity of erosion source to sensitive resources
  - Erosion hazard potential (slope/aspect/vegetation cover)
  - Estimated measure of sediment delivery to stream channels
  - Depositional zones/features
- How does vegetation type affect runoff characteristics and sediment transport?
  - Distribution and patterns of soil types versus vegetation patterns
  - Runoff characteristics based on vegetation and soil type
- Do soil type and soil erosion effect the success of revegetation and reforestation efforts?
  - Similarity between soil type, slope and aspect in un-impacted and impacted areas
  - Growth requirements of native species
  - Success criteria and outcome of previous revegetation methods
- In what areas are dg soils a concern, and why? Are areas of decomposed granite soils eroding at an accelerated rate compared to other soil types?
  - Location of granitic source areas
  - Location and distribution of erosional dg sites showing historic erosion rates
- Are sediment erosion and deposition degrading the health and habitat of threatened and endangered species, aquatic species, or of other wildlife species?
  - Turbidity levels at different sites in the watershed
  - WQ standards for levels of minor elements and nutrients (e.g., arsenic, cadmium, copper, ammonia)
- Does soil type, erosion or deposition affect the quantity or distribution of water flow? How does soil type and soil erosion effect runoff characteristics?
  - Location and type of depositional features in waterways

- Does the management of specific land allocations increase or decrease soil erosion?
  - Location and distribution of erosional sites in these areas showing historic erosion rates
- Does soil erosion increase the establishment of invasive pest plant/animal and insect/pathogen species?
  - Pattern of invasive plant/animal and insect/pathogen species relative to erosional sites and natural/human disturbances
  - Percent cover of invasive species in disturbed and undisturbed areas
- What do continued mining, abandoned mines, and timber management practices have on soil erosion? Do these land use practices increase soil erosion rates?
  - Location and distribution of erosional sites in these areas showing historic erosion rates and land use practices
  - Estimated measure of sediment delivery to streams and sensitive habitat areas
- What are soil and erosion conditions in vehicular and non-vehicular recreation areas? What measures can be used to minimize erosion associated with these sites?
  - Location and distribution of erosional sites in these areas showing historic erosion and sediment deposition rates
  - Estimated measure of sediment delivery to streams and sensitive habitat areas
- How much erosion and deposition can be attributed to roads in the watershed? What methods can be used to minimize erosion associated with roads and road-cuts?
  - Estimates of sediment yield from road cut erosion
  - Estimated measure of sediment delivery to streams and sensitive habitat areas in vicinity of roads

Issue: Water Quality and Water Quantity

- What impacts does fire have on timing and magnitude of peak flows?
  - Comparison of water temperature and turbidity in burn areas versus non-burn areas
  - Change in characteristics of hydrograph (e.g. timing and magnitude of peak flows) following burn
- How does existing water quality and quantity constrain vegetation control and management strategies?
  - Water requirements of vegetation communities
- How can revegetation and reforestation efforts improve water quality and water quantity in the watershed?
  - Comparison of habitat scores, channel stability, etc in vegetated versus non-vegetated areas
- To what extent are accelerated soil erosion and sedimentation affecting water quality and water quantity?
  - Location and distribution of erosional and depositional sites in the watershed with historic erosion and deposition rates
  - Estimated measure of sediment delivery to streams and sensitive habitat areas
  - Measure of sediment inputs (annual sediment delivery) versus sediment outputs (volume of annual bedload and suspended load)
  - WQ standards for levels of minor elements and nutrients (e.g., arsenic, cadmium, copper, ammonia)
  - Change in stream channel morphology (thalweg elevation; width/depth ratio; connection to floodplain)

- How can we assure adequate water quality for all beneficial uses (including human, aquatic, wildlife and vegetation)?
  - Water quality standards
  - Level of coliform and other bacteria
  - Physical measures (dissolved oxygen (DO), pH, electrical conductivity (EC), turbidity, alkalinity, nutrients)
- Is water quality or water quantity limiting the ecological function of the aquatic habitat?
  - Physical measures (DO, pH, EC, turbidity, alkalinity, nutrients)
  - Amount and distribution of appropriate fish habitat for feeding, spawning, and rearing
  - Presence or absence of rainbow and brown trout in main tributaries
- What impacts do continued mining, abandoned mines, and timber management practices have on water quality and water quantity? What activities have the potential to change hydrologic characteristics in the watershed?
  - Physical measures (DO, pH, EC, turbidity, alkalinity, nutrients)
  - Water column toxicity
  - Presence of acid mine drainage
  - Change in stream channel morphology (thalweg elevation; width/depth ratio; connection to floodplain)
  - Change in characteristics of hydrograph (timing and magnitude of peak discharge) following changes in land use patterns
- How does the use or presence of vehicular and non-vehicular recreation areas impact water quality and quantity?
  - Drainage patterns from roads and recreational sites
  - Level of coliform and other bacteria
- To what extent are existing roads and trails affecting water quality?
  - Proximity of roads to water features and sensitive habitats

Issue: Habitat and Wildlife

- What is habitat value of existing vegetation? What are desired future habitat and wildlife conditions?
- Can vegetation control and management strategies be coordinated throughout the watershed to sustain and improve habitat and wildlife? Where are revegetation efforts needed?
  - Status of vegetation community, habitats and associated wildlife (description of habitat and occurrence of species known or potentially present; desired assemblages)
  - Landscape pattern of management activities and fire potential index (e.g., plantations, thinning, underbrush removal, etc.) and habitat distribution
  - Location of unvegetated areas, and fire-sensitive areas
- How does water quality and quantity affect the health and habitat of threatened and endangered species, aquatic species, and other plant and wildlife species in the watershed.
- How healthy is the fishery in the upper watershed and in Whiskeytown lake?
  - Physical measures (DO, pH, EC, turbidity, alkalinity, nutrients)
  - Amount and distribution of appropriate fish habitat for feeding, spawning, and rearing
  - Predator prey relationships in tributaries and Whiskeytown Lake among existing fish species

- Do management requirements in special land allocation areas enhance and sustain habitat and wildlife, and provide for native species diversity?
  - Management guidelines and area of each land allocation
  - Number and range of each species of concern found in these management areas
  - Frequency of sightings, nesting success, age distribution of surviving members
- What T&E species are present in the watershed? What special requirements do these species have?
- What is status and trend of health and habitat of T&E species, aquatic species and other wildlife species?
  - List of plant and animal species present in watershed
  - Map of plant and animal species range and distribution
  - List of habitat condition and rating of how well habitat meets requirements
- What are risks to plant and animal species from potential invasive plant/animal and insect/pathogen species? How prevalent are these pest species?
  - Distribution and degree of damage of past pest species
  - Lost timber production due to pest species
  - List of lost habitat values due to pest species
- What are the impacts of continued mining, abandoned mines, and timber management practices on vegetation, habitat and wildlife?
  - Location and distribution of animal sightings relative to these sites and land-use practices
  - Loss or gain in use of these sites by animals
- Are vehicular and non-vehicular recreation areas being managed to enhance and sustain habitat values and ecological diversity? How does the use of these areas threaten the safety and sustainability of aquatic and upland habitat and wildlife?
  - Number and pattern of wildlife species in and around recreation areas
  - Interaction of recreationists with wildlife (observing, hunting, fishing, etc.) and daily take totals.
- Are roads inhibiting or enhancing habitat opportunities?
  - Location of roads versus location of animal sightings

Issue: Human Uses of Upper Clear Creek Watershed

- What features and functions within the watershed are of highest value to residents? What are perceptions of watershed health in the community?
  - Direct public input
- What are the most popular activities for residents and visitors in the watershed?
  - User days for various activities
- Is regional transportation network adequate for current population levels?
  - Traffic volume

3. Existing Conditions

SECTION 3
EXISTING CONDITIONS

3.1 WATER QUANTITY AND WATER QUALITY

3.1.1 Issues

Water quality and quantity can limit the ecological function of aquatic habitats in the upper Clear Creek watershed due to timing and magnitudes of flow (or discharge). Water quality and quantity also affect the function of aquatic and riparian habitats in the watershed by providing water and nutrients required by fish and riparian vegetation. Riparian and aquatic vegetation in turn provide food and shelter for many species and regulate temperatures of instream flows. The concentrations of certain metals (e.g., copper and lead) and anthropogenic contaminants (e.g., pesticides and oil) can have acute or chronic toxic effects on resident aquatic species. Elevated levels of contaminants can result from watershed disturbances (e.g., mining), from untreated discharge, or improper disposal of waste. Leachate from septic systems can be a source of biological contaminants (e.g., *E. coli*), can exacerbate biological oxygen demand problems, and can provide nutrients that, in sufficient quantities, can lead to excessive algae blooms. Untreated sewage can affect human uses (e.g., drinking water and recreational contact) and the ecological integrity of streams and reservoirs. The presence or absence of certain fish and riparian species are indicators of the health and proper function of aquatic and riparian habitats.

The amount and type of upland vegetation also affects water quality and quantity due to its ability to intercept rainfall and runoff, to draw moisture from soils, and to release water through evapotranspiration. Natural hazards, such as fire, landslides, and denudation of vegetation from such land use activities as timber harvest clear cuts and mining, can increase the magnitude of peak flows and reduce the time lag of rainfall-runoff events. Overland flows increase potential for soil erosion in disturbed areas and areas lacking vegetative cover. Resource managers are interested in determining to what degree each of these factors are affected by existing conditions in the upper Clear Creek watershed.

3.1.2 Existing Conditions – Water Quantity

Stream Channel Morphology

The upper Clear Creek watershed has been subdivided into 21 drainage basins, or subwatersheds, based on the main tributaries of the stream system. The Willow Creek drainage basin has been further subdivided into the Trail Gulch and Yankee Gulch sub-basins. Figure 3-1 displays the location and physical characteristics of each of the 21 drainage basins within the upper Clear Creek watershed.

Watershed drainage networks are characterized by stream order, based on the Strahler system of channel order (Strahler 1964). Channel order for a stream segment is determined by the number of times stream segments of similar order converge. First order streams are the lowest order, having no upstream tributaries; second order streams occur downstream of where two first order stream segments converge; third order streams occur downstream of where two second order stream segments converge; and so on. Channel width, depth, and drainage basin area generally increase with stream order. The upper Clear Creek watershed is a fifth-order system.

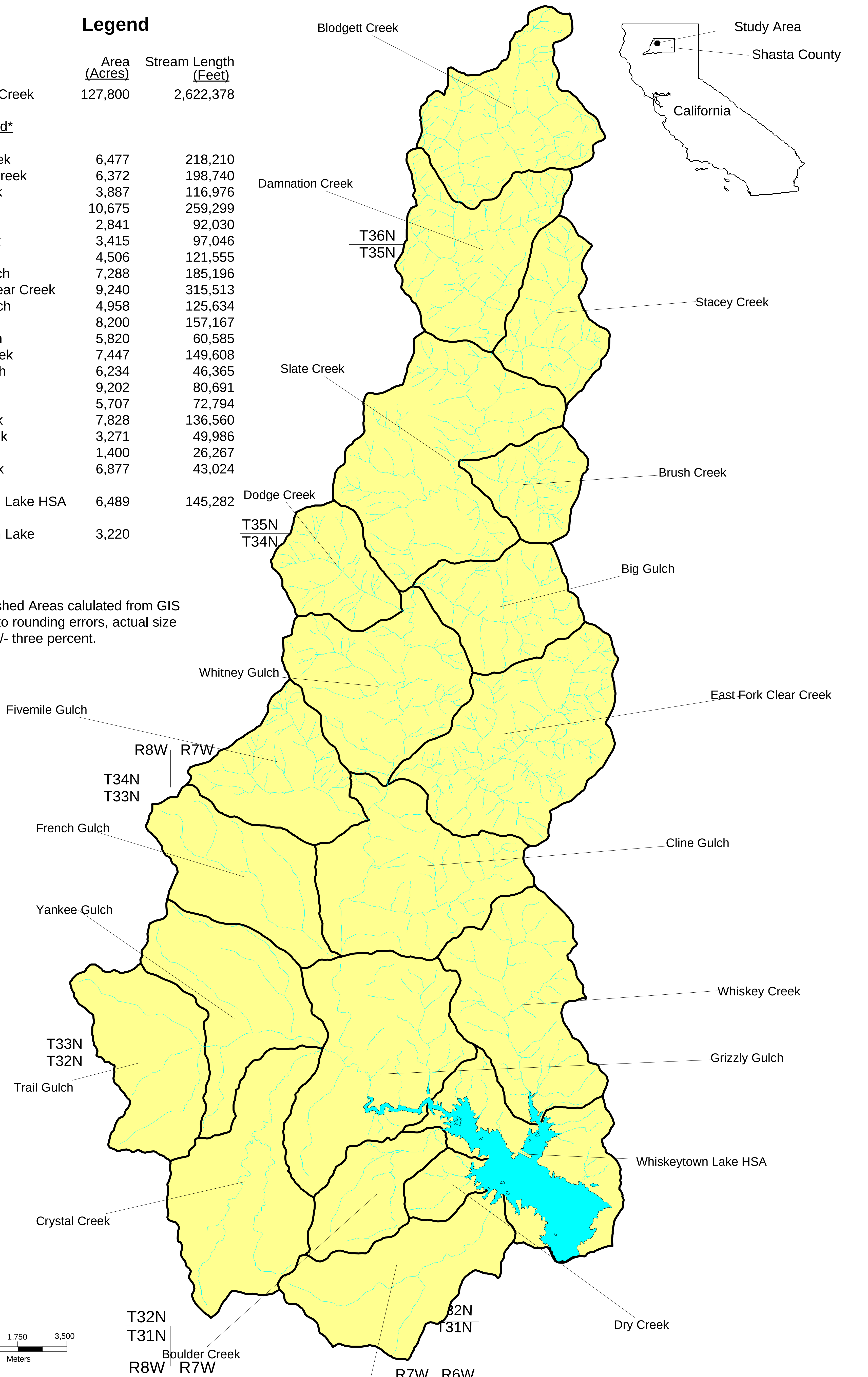
The drainage pattern north of French Gulch is dendritic (or tree-like), with numerous tributaries joining the mainstem of Clear Creek after exiting narrow mountain valleys. The main tributaries that flow directly into Clear Creek include Blodgett Creek, Damnation Creek, Stacey Creek, Slate Creek, Brush Creek, Big Gulch, Dodge Creek, Whitney Gulch, East Fork Clear Creek, Fivemile Gulch, Cline Gulch, French Gulch, Yankee Gulch, Trail Gulch, Willow Creek, Crystal Creek, and Grizzly Gulch. A more parallel drainage pattern exists south of French Gulch with several tributaries draining northward, off of Shasta Bally, and southward directly into Whiskeytown Lake. Whiskey Creek, Boulder Creek, Dry Creek and Brandy Creek are the main tributaries that flow directly into Whiskeytown Lake.

All of the tributaries in the watershed are characterized by steep v-shaped canyons that generally pass into more gentle slopes within a few hundred feet above the canyon bottoms (Albers 1964). Most stream reaches have gradients that range from 10 to 30 percent (Figure 3-2). Stream gradients may be greater than 50 percent in headwater reaches. Steep hillslopes have the potential to deliver sediment to the stream channels where denuded soils, fire or land use activities, such as timber harvest clear-cuts increase erosion. Stream gradient is high in the upper watershed tributaries and channels are fairly straight. Small meanders occur in the mainstem of Clear Creek where it is forced to flow around more resistant outcrops of the metamorphic and metasedimentary rocks. Much of the upper watershed area is underlain by shale and shaley rocks and is highly fractured and folded, and therefore easily erodible.

Legend

Watershed	Area (Acres)	Stream Length (Feet)
Upper Clear Creek	127,800	2,622,378
Subwatershed*		
Blodgett Creek	6,477	218,210
Damnation Creek	6,372	198,740
Stacey Creek	3,887	116,976
Slate Creek	10,675	259,299
Brush Creek	2,841	92,030
Dodge Creek	3,415	97,046
Big Gulch	4,506	121,555
Whitney Gulch	7,288	185,196
East Fork Clear Creek	9,240	315,513
Fivemile Gulch	4,958	125,634
Cline Gulch	8,200	157,167
French Gulch	5,820	60,585
Whiskey Creek	7,447	149,608
Yankee Gulch	6,234	46,365
Grizzly Gulch	9,202	80,691
Trail Gulch	5,707	72,794
Crystal Creek	7,828	136,560
Boulder Creek	3,271	49,986
Dry Creek	1,400	26,267
Brandy Creek	6,877	43,024
Whiskeytown Lake HSA	6,489	145,282
Whiskeytown Lake	3,220	

*Subwatershed Areas calulated from GIS files. Due to rounding errors, actual size may vary +/- three percent.



Workspace: Figure3-1.WOR

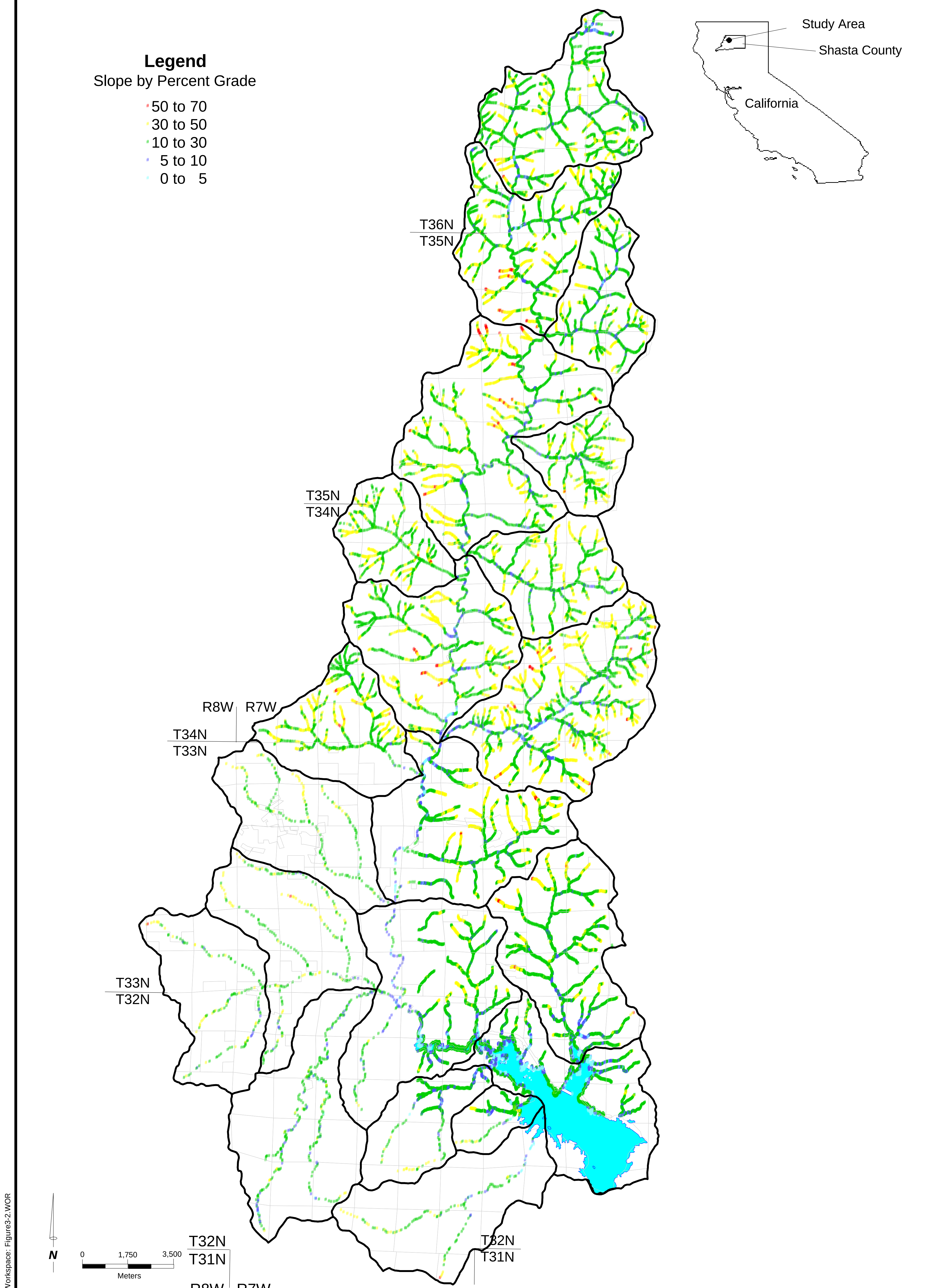
Projection: UTM NAD 27, Zone 10
Source: DFG, NPS, and USFS
Date Created: 5/19/98
Draft: 11/12/98

Watershed and Subwatershed Boundaries of the Upper Clear Creek Watershed

Shasta County, California

Tetra Tech, Inc.

Figure 3-1



Projection: UTM NAD 27, Zone 10
Source: DFG and SPI
Date Created:7/9/98
Draft:11/11/98

Stream Gradients in the Upper Clear Creek Watershed

Shasta County, California

Tetra Tech, Inc.

Figure 3-2

About 1.4 miles downstream of the East Fork of Clear Creek, the valley bottom broadens and floodplains 400 to 800 feet wide have developed along the canyon bottom. Between Big Gulch and French Gulch, Clear Creek flows swiftly within a channel that maintains a fairly constant width of about 50 feet. Between French Gulch and the Willow Creek confluence near the Tower House, the Clear Creek Channel remains about 50 to 60 feet wide.

Tailings piles lie along the banks of Clear Creek over a reach of about 10.4 miles, between the East Fork of Clear Creek and approximately 2.6 miles downstream of French Gulch. These tailings piles are the remains of historic instream placer mining carried out in the past.

The channel bottom in this reach is mostly gravel, though bedrock is exposed in some areas. Downstream of French Gulch, the mainstem of Clear Creek forms a more sinuous channel before flowing into Whiskeytown Lake near the Judge Carr Powerhouse. Gravel and sandy sediment line the banks along this reach and form alternate point bars at the meander bends.

Stream Flows

Upstream of the Whiskeytown Dam, flows are unregulated and are affected only by direct precipitation and runoff following rainfall and snowmelt, which in turn are affected by soil infiltration rates, interception storage from vegetation, detention storage from surface irregularities, and slope. Evapotranspiration and ground water recharge and discharge rates also affect streamflow between precipitation events. The upper Clear Creek watershed has numerous perennial, intermittent, and ephemeral tributaries. Perennial stream reaches carry stream flow all year long. In perennial streams, baseflow from soil moisture and groundwater discharge occur year long, and usually account for total discharge in the summer months. During the winter months and after summer thunderstorms, additional storm runoff adds to baseflow for brief periods. Intermittent streams carry water a considerable portion of the time but seasonally or occasionally cease to flow because bed seepage and evapotranspiration exceed available water supply. Ephemeral streams carry water only during and immediately after periods of rainfall or snowmelt.

The mainstem of Clear Creek is perennial nearly to its headwater reaches, as are most of the major second order tributaries that branch from the mainstem. Most first order streams in the upper watershed are ephemeral or intermittent. Table 3-1 shows the total length of perennial and intermittent tributaries in each sub-watershed. Streamlengths were determined from 1:100,000 scale hydrographic GIS coverage provided by CDFG. A total of approximately 497 miles of streams are mapped in the upper watershed. However, comparison of 1:100,000 scale maps and actual field mapping for watercourse determination by Registered Professional Foresters in similar areas has shown that 1:100,000 scale GIS coverage may only represent approximately 60 percent of the streams (Murphy 1998).

Table 3-1
Physical Characteristics of Stream System in the Upper Clear Creek Watershed

Watershed	Approximate Area (acres)	Total Stream Length (feet)	Perennial Streams (feet)	Intermittent Streams (feet)	Ephemeral Streams (feet)
Upper Clear Creek	128,135	2,622,377	1,027,988	1,456,464	137,925
Subwatershed					
Blodgett Creek	6,477	218,210	64,466	146,690	7,054
Damnation Creek	6,372	198,740	75,973	110,331	12,436
Stacey Creek	3,887	116,976	47,742	53,321	15,913
Slate Creek	10,675	259,299	69,494	161,887	27,918
Brush Creek	2,841	92,030	14,978	62,827	14,225
Dodge Creek	3,415	97,046	17,174	68,731	11,141
Big Gulch	4,506	121,555	21,223	99,877	455
Whitney Gulch	7,288	185,196	52,138	115,728	17,330
East Fork Clear Creek	9,240	315,513	68,123	219,484	27,906
Fivemile Gulch	4,958	125,634	30,877	91,210	3,547
Cline Gulch	8,200	157,167	57,415	99,752	0
French Gulch	5,820	60,585	53,033	7,552	0
Whiskey Creek	7,447	149,608	65,591	84,017	0
Yankee Gulch	6,234	80,691	77,079	3,612	0
Grizzly Gulch	9,202	136,560	63,814	72,746	0
Trail Gulch	5,707	46,365	38,063	8,302	0
Crystal Creek	7,828	72,794	62,324	10,470	0
Boulder Creek	3,271	49,986	40,206	9,780	0
Dry Creek	1,401	26,267	0	26,267	0
Brandy Creek	6,877	43,025	39,145	3,880	0
Whiskeytown Lake HAS	6489	69,130	69,130	0	0

Daily mean discharge values measured at the French Gulch station (Appendix D, Figure D-1) display the annual variation in discharge characteristic of Mediterranean climates. Average daily mean flows measured at the French Gulch gage over the period of record are 209 cfs. Median mean daily discharge values measured at French Gulch, however, reach only 64 cfs; meaning that 50 percent of the time flows are equal or below 64 cfs. Twenty percent of mean daily flows are less than 18 cfs, and only 27 percent of daily mean flows exceed 200 cfs. During drought years, minimum daily flows measured at French Gulch have been as low as 1.5 cfs. (Exceedance probability of daily mean flows is shown in Appendix D Figure D-2.)

Mean monthly discharge measured at the French Gulch gage during normal, wet, and dry years are shown in Table 3-2. The highest peak flows measured at the French Gulch gage over the period of record are shown in Table 3-3.

Table 3-2
Mean Monthly Discharge and Annual Statistics for Normal, Dry, and Wet Years; Clear Creek at French Gulch (Station Number 11371000)

Month	Mean Monthly Discharge (cfs) Normal* Year Water Year 1966	Dry* Year Water Year 1979	Wet* Year Water Year 1956
October	15.8	19.2	15.7
November	407	28.8	61.7
December	176	25.1	920
January	410	91.5	1233
February	448	236	673
March	563	452	390
April	322	216	247
May	103	171	182
June	48	47.4	78.3
July	22.4	23.1	30.1
August	10.4	16.4	16.5
Sepember	11.8	14.5	14.5
Water Year			
Mean	210	111	322
Minimum	8.5	11	10
Maximum	1550	2050	5690
Acre-feet	151700	80460	234000

Normal water year = median total discharge; Dry water year = 20th percentile; Wet water year = 90th percentile.

Factors that change vegetative cover and infiltration rates (such as denudation by fire or physical removal and compaction of soils for road building or other purposes) can affect the rate and magnitude of surface runoff (or overland flow) following precipitation events. In the upper Clear Creek watershed, such factors have included large fires, minor residential development, road construction, mining sites, and certain timber harvesting practices. The most recent large fires in the watershed include the 548-acre Yankee Gulch fire in 1980 and the 207-acre Kutras #2 fire in 1986. In areas of residential development, which has occurred on approximately 800 acres of the upper watershed, homes and other impervious surfaces usually cover about 20 to 30 percent of the area (160 to 240 acres). Even-aged cutting practices used by the FS lead to large clear-cut areas.

Terracing and replanting is often necessary to minimize runoff (and subsequent sediment erosion) in these areas. Paved roads and compacted dirt haul roads in the upper watershed also increase surface runoff, as do clearings for landings and mining operations. Most active and abandoned mines are located in the southern

Table 3-3
Highest Peak Discharge Events Measured During Period of Record 1951-1993 at French Gulch (Station Number 11371000)

Date	Peak Discharge (cfs)	Daily Mean Discharge (cfs)
1/16/74	14600	12000
1/26/83	10500	5620
1/14/78	9130	4090
12/22/64	7600	5770
12/22/55	7050	5690
2/14/86	6680	2840
2/17/80	6290	3380
2/19/58	5870	5230
12/19/81	5610	3620
3/10/89	5410	3620
1/23/70	4920	4030
3/8/75	4860	4390
2/24/57	4750	3940
12/11/83	4550	3100
2/1/52	4140	2880
4/14/63	3910	3100
1/16/71	3800	2690
2/12/92	3560	2810
10/29/50	3540	1860
1/28/81	3510	2220

portion of the upper watershed near French Gulch, Yankee Gulch, Cline Gulch, Grizzly Gulch and Whiskey Creek. Soil erosion and sediment transport are described in Section 3.4.

Flow Extremes

Extreme flows, both high and low, are important factors in determining the physical and biological characteristics of the watershed. Extreme high flows move large amounts of sediment, help determine channel morphology, and are an important constraint on the plant community in the riparian area. Extreme low flows are often a limiting factor on habitat suitability for aquatic animals. Low flows can exert stress directly, while also increasing the potential for temperature elevation and dissolved oxygen depression.

Extreme discharge events are characterized in terms of their probability of occurrence (the probability that an annual maximum is at or above a specified value) and their recurrence interval (the expected long-term average length of time between annual events of a given magnitude). The probability of occurrence is equal to the inverse of the return interval of a particular discharge event. To predict infrequent events with long recurrence intervals, a parametric fit to the data is often used. The Water Resources Council has established parametric analysis with the log Pearson Type III extreme value distribution as the official method for estimating flood frequencies and return periods

(Water Resources Council 1967; Water Resources Council 1977). The log Pearson Type III distribution uses historic discharge values to predict the magnitude of particular recurrence interval events. (A description of the process used for the analysis of extreme flow events is described in Appendix D.)

Streamflow maxima and minima measured at the French Gulch gage are discussed in Appendix D Both high and low extreme flows can be analyzed for the French Gulch gage for the period from 1951 to 1993 and used to predict the frequency and magnitude of extreme flows in Clear Creek.

High Flows

Instantaneous peak flows are available at French Gulch gage for water years 1951 to 1993. The annual maxima (highest flow observed in a year) range from a low of 101 cfs in 1977 to a high of 14,600 cfs in 1974 (Appendix D).

The program PEAKFRQ was used to fit a log Pearson Type III distribution to the annual maximum discharge values measured at the French Gulch gage; the graphical form of the distribution, which relates discharge to annual exceedance probability, is discussed in Appendix D.

The recurrence interval and discharge for several predicted high flow events are shown (with 95 percent confidence limits) in Table 3-4. Based on the log Pearson distribution of peak flows, the 1974 peak flow event is considered between a 100 to 200 year event (i.e., the event has the probability of being exceeded only once every 100 to 200 years). While very large flows are able to quickly transform channel configurations and transport tremendous amounts of sediment downstream, Dunne and Leopold (1978) note that lower flows occurring more often (i.e., those having a 1.5 to 2 year recurrence interval) are able to more effectively maintain channel configuration and sediment transport capacity due to the frequency of the discharge events. Predicted discharge values for a two-year recurrence interval event is 3,522 cfs.

Low Flows

Low flow events of various durations are of interest for evaluating potential effects on habitat, with the 1-day, 7-day, and 30-day average low flows most commonly evaluated. These estimates can also be extracted from the record of daily average flows available at the French Gulch gage for water years 1951-1993. (Appendix D, Figure D-4 shows the annual average 7-day low-flow minima.) The lowest observed flows at the French Gulch gage occurred during the summer of 1977, with a daily minimum of 1.5 cfs, 7-day minimum of 1.54 cfs, and 30-day minimum of 1.79 cfs. The recurrence interval and discharge for other predicted 1-day, 7-day, and 30-day low flow events were also determined using a log Pearson Type III distribution; predicted values are shown in Table 3-5. As shown in Table 3-5,

Table 3-4
Recurrence Interval and Discharge for Upper Clear Creek High Flow Events

Recurrence Interval (years)	Annual Exceedance Probability	Log Pearson Type III Estimate (cfs)	Lower 95 percent Confidence Limit	Upper 95 percent Confidence Limit
1.25	0.8	2163	1792	2528
2	0.5	3522	3041	4079
5	0.2	5703	4879	6886
10	0.1	7323	6141	9170
25	0.04	9544	7787	12500
50	0.02	11320	9051	15290
100	0.01	13180	10350	18340
200	0.005	15150	11680	21650
500	0.002	17920	13520	26480

Table 3-5
Recurrence Interval and Discharge for Upper Clear Creek Low Flow Events

Recurrence Interval (years)	1-day low flow (cfs)	7-day low flow (cfs)	30-day low flow (cfs)
1.25	12.5	13.3	16.5
2	9.6	10.4	12.7
5	6.4	7.0	8.3
10	4.8	5.2	6.2
25	3.4	3.6	4.3
50	2.6	2.7	3.2
100	2.0	2.0	2.4

these 1977 extreme low flows are estimated to have a recurrence period of greater than 100 years. The minimum two-year 7-day flows are predicted to be about 10 cfs.

Whiskeytown Inflows and Outflows

As the main hydrologic control between the upper and lower Clear Creek watersheds, Whiskeytown dam and reservoir affects water levels and storage in the lake as well as the magnitude and timing of flows to the lower Clear Creek and diversions to the Sacramento River via the Spring Creek tunnel.

Inflows to the Whiskeytown Reservoir include natural flows from Clear Creek and Trinity River diversion flows from the Judge Francis Carr Powerhouse (Station # 11525430) at the eastern end of the Clear Creek Tunnel. Outflows from the

Whiskeytown Reservoir include water diverted for use in the Whiskeytown NRA, releases from Whiskeytown Dam to Clear Creek, and Trinity River diversion flows taken through the Spring Creek Tunnel and Powerplant into the Sacramento River above the Keswick Dam. Additional inputs and outputs to the system include direct precipitation and evaporative losses and annual drawdown for flood control.

Total average annual inflow to Whiskeytown Reservoir is 1,242,287 acre-feet. Natural inflows from Clear Creek and Trinity River diversion flows through Judge Francis Carr Powerhouse account for 21 percent and 79 percent of the average annual inflow to Whiskeytown Lake, respectively (Table 3-6).

Table 3-6
Inflows and Outflows through the Whiskeytown Reservoir

Stream Gage or Diversion Facility	Station Number	Remarks	Average Annual Flow (acre-feet)		Percent of Total Whiskeytown Flows
INFLOWS			**1951-1963**	**1965-1997**	**1965-1997**
Clear Creek at French Gulch (58% of watershed)	11371000	stream gage discontinued after 9/93	158,359	151,557	12
Remaining portion of watershed (42% of watershed)	None	Estimated annual flows	114,673	109,748	9
Judge Francis Carr Powerhouse	11525430	Part of CVP Trinity Diversion	-	980,982	79
			Est. Total	**1,242,287**	**100**
OUTFLOWS			**1940-1963**	**1965-1997**	**1965-1997**
Whiskeytown Unit	None	Potable water use (9 mg/year)	-	10,085	1
Clear Creek at Igo	11372000	Post-Dam flows reduced to 35% of original flows	302,674	106,787	8
Spring Creek Powerhouse	11371600	Part of CVP Trinity Diversion	-	1,234,836	91
			Total	**1,351,708**	**100**

* Difference between inflows and outflows may be due to direct precipitation into Whiskeytown Reservoir, evaporative losses from the reservoir, additional inflow collected at the Igo gage in the lower watershed, and average annual drawdown for flood control.

Approximately 70 to 80 acre-feet of water are diverted annually from Clear Creek through a Shasta County Service Area facility located upstream of the County Park. This diversion, which supplies potable water to residents of French Gulch, is located upstream of the French Gulch gage and so is not measured as inflow to Whiskeytown Lake.

Natural annual average inflows to Whiskeytown Lake have been calculated based on the percent area drained upstream and downstream of the French Gulch gage. The drainage area upstream of the French Gulch gage is only 115 square miles, or 58 percent of the total drainage area (200 square miles) of the upper watershed. It was thus assumed that the average annual discharge (in acre-feet) measured at the French Gulch gage accounted for 58 percent of the total annual inflow to Whiskeytown Reservoir, leaving a 42 percent contribution of total discharge delivered from the drainage area downstream of the French Gulch gage. This assumption may not be completely valid since precipitation varies across the watershed. However, based on this assumption the total average annual discharge calculated for the period 1951 to 1963 is within 10 percent of the total annual flow measured at the Clear Creek at Igo gage over the same period. Therefore it is also reasonable to assume estimated values for the period 1965 to 1997 would also be within 10 percent of actual values. The average annual discharge measured at the French Gulch gage between 1965 and 1993 (following the filling of Whiskeytown Reservoir) is 151,557 acre-feet; the estimated average annual discharge from the watershed below the French Gulch gage was calculated to be 109,748. Combined, these two areas of the upper Clear Creek watershed yield an estimated total average annual natural inflow of 261,305 acre-feet to Whiskeytown Reservoir.

Average annual inflows from the Trinity River Diversion to Whiskeytown Reservoir measured at the Judge Francis Carr Powerhouse (Station # 11525430) over the period from 1963 to 1997 have been 980,982 acre-feet.

The BOR also developed synthesized natural inflow data for Clear Creek at Whiskeytown, for the period 1922 to 1991, as part of the CVP reservoir operations planning process (Rechtenwald 1998). These data, used in the Lower Clear Creek Watershed analysis, contained both synthetic and actual discharge values. While synthetic data were developed for the period prior to construction of Whiskeytown Dam in 1963, values from 1965 to 1991 were calculated based on monthly change in storage minus monthly inflows from Judge Francis Carr Powerhouse. The BOR has similarly amended the Whiskeytown natural inflow data to include additional discharge values for the years 1992 through 1997, for a total period of record of 1922 to 1997 (Fujitani1998). Using the BOR data, inflow contributions from Whiskeytown natural inflows and Judge Francis Carr Powerhouse flows between 1965 and 1997 account for 25 percent and 75 percent of total average annual flows, respectively. When comparing total average annual discharge values from synthetic BOR data against those measured at the Clear Creek at Igo gage for the period prior to 1963, the total average annual discharge from synthetic values is only within 30 percent of the total annual flow measured at the Clear Creek at Igo gage. Therefore, for this report, actual discharge measured at the Clear Creek at Igo gage 1940-1996 (rather than the BOR synthetic data) is used to describe historic outflows from the upper Clear Creek watershed and to describe the impact that construction of the Whiskeytown Dam has had on downstream flows.

Approximately 10,085 acre-feet of potable water are diverted annually for use in the Whiskeytown NRA. Releases from Whiskeytown Dam to Clear Creek are represented by discharge measurements collected at the Clear Creek at Igo gage (Station #11372000). Outflows for the Trinity River Diversion from Whiskeytown Lake at the Spring Creek Powerplant (Station #11371600; USGS 1996) have been calculated by the BOR based on powerplant output. Total average annual outflow from Whiskeytown Reservoir is 1,351,708 acre-feet. The Whiskeytown NRA diversion, Clear Creek at Igo discharge, and Trinity River diversion flows through the Spring Creek Powerhouse account for one percent, eight percent and 91 percent of total annual outflow, respectively (Table 3-6). The difference between inflow and outflow in Table 3-6 may be due to direct precipitation into Whiskeytown Reservoir, evaporative losses from the reservoir, additional inflow collected at the Igo gage in the lower watershed, and average annual drawdown for flood control.

Analysis of average total annual discharge measured at the Clear Creek at Igo gage indicates that total average annual discharge was reduced 65 percent following construction of Whiskeytown Dam. Current average total annual discharge is only 35 percent of pre-dam discharge (not 13 percent as previously described in the Lower Clear Creek Watershed Analysis).

Downstream Flows

Minimum monthly flows downstream of Whiskeytown Dam are regulated by the BOR as part of CVP reservoir operations. Past Whiskeytown release schedules are described in the Lower Clear Creek Watershed Analysis (WSRCD 1996). In general, the BOR has coordinated with the CDFG and FWS to provide minimum flows during certain months to satisfy downstream water rights, to allow for fish and wildlife purposes, and to enhance the recreational and fishery values of the Whiskeytown NRA. Since 1960, minimum flow releases have been made based on the schedule provided in the 1960 memorandum of understanding between CDFG and BOR (Table 2-2 in the Lower Clear Creek Watershed Analysis). According to this schedule, releases of 100 cfs were scheduled between November 1 and December 31, releases of 50 cfs were scheduled between January 1 and February 28/29, and releases below 50 cfs were allowed between March 1 and October 31.

More recently, changes have been made to the CVP operations and flow release schedules as part of the CVPIA, enacted in 1997. Under Section 3046(b)(2) of the CVPIA, 800,000 acre-feet of CVP water have been dedicated for the purpose making water use for fish and wildlife mitigation, protection, and restoration purposes equal in importance to irrigation and domestic water supply purposes (USDI 1997). In November 1997, the FWS and BOR established an implementation strategy for improving flows in CVP-controlled streams of Clear Creek, Sacramento, American and Stanislaus rivers. Under the CVPIA, flow releases from the Whiskeytown Reservoir are specifically intended to improve spawning and rearing habitat for salmon and steelhead and to improve survival of downstream migrating chinook salmon smolts, while providing water for other authorized purposes of the CVP.

Under the 1997 CVPIA schedule, minimum flow releases from Whiskeytown Reservoir will vary between 100 and 200 cfs from October through May, and between 150 and 100 cfs from June through September (Table 3-7), depending on storage levels in Trinity River Reservoir. According to BOR operations staff, adoption of these minimum flow rates have not been fully implemented yet. These minimum flow rates were proposed with the understanding that improvements to fish passage at the Saeltzer dam would be required. Currently, June through September minimum releases of 50 cfs are being used. October through May flows of 200 cfs may be implemented before fish passage improvements at Saeltzer Dam are completed if the need is justified by fishery agencies (Fujitani 1998).

3.1.3 Existing Conditions - Water Quality

There are only limited water quality monitoring data that can be used to determine existing condition. The consensus among TAC members that water quality in the upper Clear Creek watershed is generally excellent with a few potential problem areas in need of additional study.

The DWR Northern District water quality monitoring program is collecting information on 37 different parameters at six locations within the watershed. The data is organized into four categories: physical, mineral, nutrients, and minor elements. DWR began the monitoring program in November 1997 and collects samples once each month. The monitoring design and procedures have not been finalized and the data collected to date is not yet complete enough to conduct a comprehensive assessment. For example, information has not been collected during the critical low flow summer months. Also, DWR switched from standard methods to ultra-clean methods for metals after the second month of sampling. This change will provide more meaningful information for the minor element parameters. Therefore, the watershed analysis will include only a narrative summary of water quality for the six-month period of record.

The monitoring stations are in the bottom half of the watershed. However, stations one and two are located above and below the French Gulch community. The station at the mouth of Willow Creek, which has the largest known source of acid mine drainage located within the tributary (Greenhorn Mine on Crystal

Table 3-7
CVPIA Implementation Criteria for Whiskeytown Releases to Lower Clear Creek

Month	Trinity River Reservoir Storage Criteria*	Whiskeytown Releases to Lower Clear Creek (cfs)
October	End of Sep Storage >1.40MAF	200
	End of Sep Storage >0.75MAF	150
	End of Sep Storage <0.75MAF	100
November	End of Oct Storage >1.40MAF	200
	End of Oct Storage >0.70MAF	150
	End of Oct Storage <0.70MAF	100
December	End of Nov Storage >1.40MAF	200

	End of Nov Storage >0.80MAF	150
	End of Nov Storage <0.80MAF	100
January	End of Dec Storage >1.15MAF	200
	End of Dec Storage >0.85MAF	150
	End of Dec Storage <0.85MAF	100
February	End of Jan Storage >1.30MAF	200
	End of Jan Storage >0.90MAF	150
	End of Jan Storage <0.90MAF	100
March	End of Feb Storage >1.45MAF	200
	End of Feb Storage >1.00MAF	150
	End of Feb Storage <1.00MAF	100
April	End of Mar Storage >1.60MAF	200
	End of Mar Storage >1.20MAF	150
	End of Mar Storage <1.20MAF	100
May	End of Apr Storage >1.60MAF	200
	End of Apr Storage >1.20MAF	150
	End of Apr Storage <1.20MAF	100
June	End of May Storage >1.10MAF	150
	End of May Storage <1.10MAF	100
July	End of Jun Storage >1.00MAF	150
	End of Jun Storage <1.00MAF	100
August	End of Jul Storage >0.90MAF	150
	End of Jul Storage <0.90MAF	100
September	End of Aug Storage >0.80MAF	150
	End of Aug Storage <0.80MAF	100

* Stability criteria shall dictate that November and December flows equal or exceed October flows and that February through May flows equal or exceed January flows.

Creek). Station number four is below Willow Creek but above Carr Powerhouse Unit where the Clear Creek Tunnel delivers Trinity River water to the watershed. The fifth station is at the Carr Powerhouse Unit 1, which will provide information on the influence of transferred water on Clear Creek water quality. Station six is located at the Whiskeytown Reservoir near the dam. DWR uses a depth integrated sampling procedure at this site for physical parameters and collects bottom and surface samples for all other parameters. If the monitoring network is kept intact, it should allow integrated water quality to be assessed from the headwaters to the dam.

A review of the data across all sites for the period of record indicates occasional high concentration peaks for many of the metal parameters. Willow Creek in particular has several instances where metals, such as copper, zinc, iron, cadmium, lead and manganese, are in excess of the water quality objectives listed in the RWQCB Basin Plan. These values exceed both the chronic and acute criterion concentrations for these metals. The RWQCB conducted a study in 1984 to evaluate the effect of acid mine drainage from the Greenhorn Mine on water quality in Willow and Crystal creeks. The study identified highly acidic seeps that contributed significant amounts of cadmium, copper, iron, and zinc to the tributary. The study suggested that the acid mine drainage sources on Crystal Creek could have prevented repopulation of the tributary because of heavy metal toxicity in the acid mine drainage zone. Rainbow trout and several other species have been counted in tributaries above Willow Creek. However, the extent and impact of acid mine drainage on aquatic life in the upper Clear Creek watershed is largely unknown. It is also possible that some portion of the metals loading could be from machinery or automobiles that have been abandoned within the Willow Creek tributary (Babcock 1998).

The RWQCB conducted a single-day preliminary monitoring survey in 1996 to evaluate the possibility of contamination to Clear Creek from failing or faulty septic tanks. This data has been supplemented with a few samples from the DWR monitoring program. The RWQCB samples indicate a higher-than-background concentration of fecal coliform bacteria (maximum 170 MPN) at more than one location in the vicinity of French Gulch. The DWR network also has detected levels as high as 307/100 ml on Clear Creek above Whiskeytown Dam. The Water Quality Objectives of the 1994 Basin Plan designate that for contact recreation (REC-1, a beneficial use of upper Clear Creek) fecal coliform bacteria concentration based on a minimum of not less than 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. An instantaneous maximum concentration is not specified in the standard. The sampling regime used to date does not meet the minimum requirements to determine whether Clear Creek exceeds the objective. However, the preliminary results to date may suggest additional study to determine the extent and magnitude of bacterial contamination of upper Clear Creek and possible sources.

Additional watershed characterization information comes from the assessment of watershed conditions in the *Interlakes Special Recreation Management Area: Final Plan and Environmental Impact Statement* (BLM 1997). Watershed condition is a description of the health of a watershed, or portion thereof, in terms of the factors that affect hydrologic function and soil productivity. Hydrologic function controls the manner in which water travels through the watershed as surface and groundwater resources. Forest management activities influence the natural hydrologic function of watersheds in a number of ways.

Watershed condition can be classified by evaluating the cumulative watershed impacts. This method calculates soil disturbance and compaction from road and timber harvest activities in equivalent road areas (ERAs). Watershed sensitivity is evaluated and classified and a threshold of concern (TOC) value is assigned. This value is expressed in percent ERA, with lower sensitivity watersheds having a higher TOC than the highly sensitive watersheds. The TOC value is meant to indicate a point where, if approached or exceeded, the risk of watershed degradation is considered significant and mitigation measures should be implemented to lessen the hazard. Watershed condition classes are defined in terms of the level of ERAs for individual watersheds with respect to their TOC. Table 3-8 summarizes the typical characteristics of the three watershed condition classes.

The upper Clear Creek was classified based on a survey that included 4,642 acres of FS land out of a total of 24,255 acres of FS land in the upper Clear Creek watershed (which has a total area of 127,800 acres). Therefore the classification shown in Table 3-9 is not based on a comprehensive survey of the watershed.

Table 3-8
Watershed Condition Classes

Characteristics	Class 1	Class 2	Class 3
ERA levels as a percent of TOC	<40	40-80	>80
Stream Channel Conditions	Good to Excellent	Fair to Good	Fair to Poor
Soil Productivity	Maintained at Optimum Levels	Maintained at Lower Levels than Class 1	Maintained at Lower Levels than Classes 1 and 2
Water Quality	Exceeds Objectives	Meets Objectives	Meets or is Below Objectives
Potential for Degraded Water Quality or Soil Productivity	Low	Low to Moderate	Moderate to High

Table 3-9
Watershed Condition for Upper Clear Creek Watershed

Area of Upper Clear Creek Watershed used for Analysis (acres)	Threshold of Concern (Percent of ERA)	Existing Percent of ERA	Condition
4,642	16	3	Class 1

The water quality parameters that would be most likely to be affected by poor watershed condition would be turbidity (sedimentation), temperature, and dissolved oxygen. These would in turn affect one of the key indicators of water quality, the aquatic biological community.

Review of the DWR monitoring data for temperature and oxygen has no values outside the range specified by the water quality objectives. However, data for the most critical summer months has not been collected. Values for turbidity are consistently between 1 and 5, with a few intermediate peaks, and a single extreme value. These values are consistent with the Watershed Condition Class 1 rating given to upper Clear Creek. These values are also well within a range that provides suitable conditions for the resident fish assemblage. The occasional turbidity events suggests that there are some important watershed restoration (e.g., road improvements and channel stabilization) opportunities to be identified.

Freshwater fish have certain water quantity and quality requirements for spawning, rearing and holding. Fish found in the upper Clear Creek watershed include rainbow trout, riffle sculpin, Sacramento sucker, California sucker, and kokanee salmon. While the CDFG stocks Whiskeytown Lake and some upper Clear Creek tributaries with rainbow trout, some of these fish may have developed self-sustaining populations in the upper watershed (Healy 1998). Kokanee salmon, a landlocked variety of sockeye salmon, also have been stocked irregularly in Brandy Creek, Clear Creek, and Whiskeytown Lake, and are thought to have developed self-sustaining populations in some Clear Creek tributaries, including Whiskey Creek, Brandy Creek, and possibly even

Boulder Creek. Rainbow trout have been found in many of the perennial reaches of Clear Creek tributaries, including Brandy Creek, Boulder Creek, Crystal Creek, French Gulch, Whiskey Creek, and the East Fork Clear Creek and have been found as far north as the lower and middle sections of Slate Creek (Healy 1998). There is no fish survey data available north of Slate Creek. The water quality objectives from the 1994 Basin Plan for temperature, dissolved oxygen, and turbidity were determined to satisfy the requirements for the most sensitive species and life stages of the fish species found in upper Clear Creek. The status of the fish populations within upper Clear Creek also is dependent on habitat conditions. The fish surveys conducted for upper Clear Creek have not included habitat suitability ratings. Information on habitat status should be gathered to better determine stream restoration priorities, if any.

3.2 FUELS AND FIRE

3.2.1 Issues

The buildup of extensive brush and ladder fuels throughout the upper Clear Creek watershed increases the potential of catastrophic wildfires, with both human and natural resources at risk. Vegetation management plans and fire suppression efforts must be used within the upper Clear Creek watershed and coordinated among the three FPZs in the watershed, managed by the CDF, the FS, and the NPS.

3.2.2 Existing Conditions

Fire Protection and Fire Occurrence

Currently, fire protection in the upper Clear Creek watershed is managed by three different agencies, each responsible for different areas of the watershed. Two of these agencies include the FS, which is responsible for fire protection north of Brush Creek, and the NPS, which manages fire protection within the Whiskeytown Unit. The CDF also has a cooperative statewide fire protection agreement with the BLM, FS and NPS for sharing fire protection resources and jointly managing fires that threaten lands on more than one jurisdiction (Soho 1998).

Over the past 70 years, a regime aimed at total fire suppression has been in operation on forestlands in the upper watershed. While the purpose of a full-suppression regime is to protect resources and structures valued by resource managers and residents of the area, it has also lead to the build up of underbrush and ladder fuels that increase the hazard for catastrophic wildfires in the area. With the increased development of roads, and use of residential and recreational areas in the upper watershed, the incidence of fire starts has also increased over time, as shown in Table 3-10.

Table 3-10
Incidence of Fires in the Upper Clear Creek Watershed (from FS and CDF data)

Decade	Recorded Number of Fire Starts	Recorded Number of Large Fires	Total Acres Burned
1910	11	-	-
1920	6	2	352
1930	17	2	1,990
1940	23	2	138
1950	32	1	3,545
1960	6	3	7,377
1970	13	-	-
1980	58	1	548
1990	59	2	323
Total	225	13	14,273

The CDF and FS maintain databases on large fires and fire starts within and around their FPZs. The CDF database also includes fires recorded within the NPS FPZ. Both databases include year of fire start and large fire, but cause of fire is included only on CDF fire start data and FS large fire data. The FS Weaverville and Hayfork Ranger District offices also have data, which includes both year and cause of fire for all fire starts that have occurred within the Clear Creek LSR. This data was obtained directly from the Hayfork Ranger District office to enable us to differentiate between natural (lightning) and human causes for most of the recorded fires that have occurred within the upper watershed.

Because historic records of fire occurrence are incomplete, one caveat should be noted: the fire history represented by these databases probably under represents the actual number of large fires and fire starts that have occurred in the upper watershed. According to descriptions of fire history in the Clear Creek LSR (FS 1997), FS records were made only of those fires that received some type of fire suppression action; fires that had no suppression activity or that went out due to natural causes were not recorded. Fire records collected at the Shasta and Trinity National Forests prior to the mid-1950s may also have been lost during consolidation of the two forests and the division of ranger districts into different administration units (FS 1997). The CDF database is also historically incomplete because it does not record large fires less than 300 acres and because it does not contain fire starts prior to 1985. (Fire start data was collected by the FS within areas of the CDF FPZ prior to 1985.)

The FS and CDF recorded at least 13 large fires and 219 fire starts in the upper Clear Creek watershed between 1918 and 1997 (Table 3-10). The date and location of these fires and fire starts is shown in Figure 3-3. Most of the locations mapped as fire starts were small burns of less than 50 acres. However, large wildfires have burned a total of 14,273 acres, or 11 percent, of the watershed area. The largest of these wildfires burned 3,545 acres in the French Gulch area in 1955. Humans were reported to have caused five of the six large fires recorded by the FS.

Of the 219 fire starts mapped within the upper Clear Creek watershed, 72 fires were caused by lightning strikes, 62 were caused by human activities (including at least 14 by arson), and 85 had unidentified causes (Table 3-11). Although road density in the watershed is fairly low (averaging about 16 feet of road per acre of watershed), most fire starts in the watershed were located in close proximity of roads. Many of the fire starts with unidentified causes are likely to have human causes based on their distribution near roads and riparian corridors where human access and use is high. The available road network, however, limits the access for land-based fire suppression activities in remote areas of the watershed. Fire suppression is also extremely difficult throughout much of the watershed because of very steep slopes and rugged terrain.

Fuels Conditions

The Fire Behavior Prediction System (FBPS), developed by Rothermel (1972) and Albini (1976), uses thirteen standard fuel models to predict the general expected behavior of a fire based on the types and amounts of available fuels. These thirteen models represent the variation in type, size, and cover of vegetative species present, and so are important factors in determining the fire behavior potential for a given site (Anderson 1982; FS 1997). CDF has conducted fuel modeling for the entire state, including the upper Clear Creek watershed, to assist

Legend

Large Fires

	Data Source	Area (Acres)	Name	Year	Cause
1	USFS	557		1934	Unknown
2	USFS	1,433		1931	Human
3	USFS	198		1991	Human
4	CDF	5,156	East Fork	1962	Wildfire
5	USFS	41		1948	Human
6	USFS	97		1945	Human
7	USFS	214		1924	Human
8	USFS	138		1922	Human
9	CDF	385	Bowdish	1961	Wildfire
10	CDF	3,545	French Gulch	1955	Wildfire
11	CDF	1,836	Towerhouse	1961	Wildfire
12	CDF	548	Yankee Gulch	1980	Wildfire

Prescribed Fires (NPS)

- 1997 (1,055 Acres) (NPS)
- 1996 (227 Acres) (NPS)
- 1995 (178 Acres) (NPS)
- 1994 (65 Acres) (NPS)
- 1986 (207 Acres) (CDF Kutras #2)
- 1983 (245 Acres) (CDF Kutras)

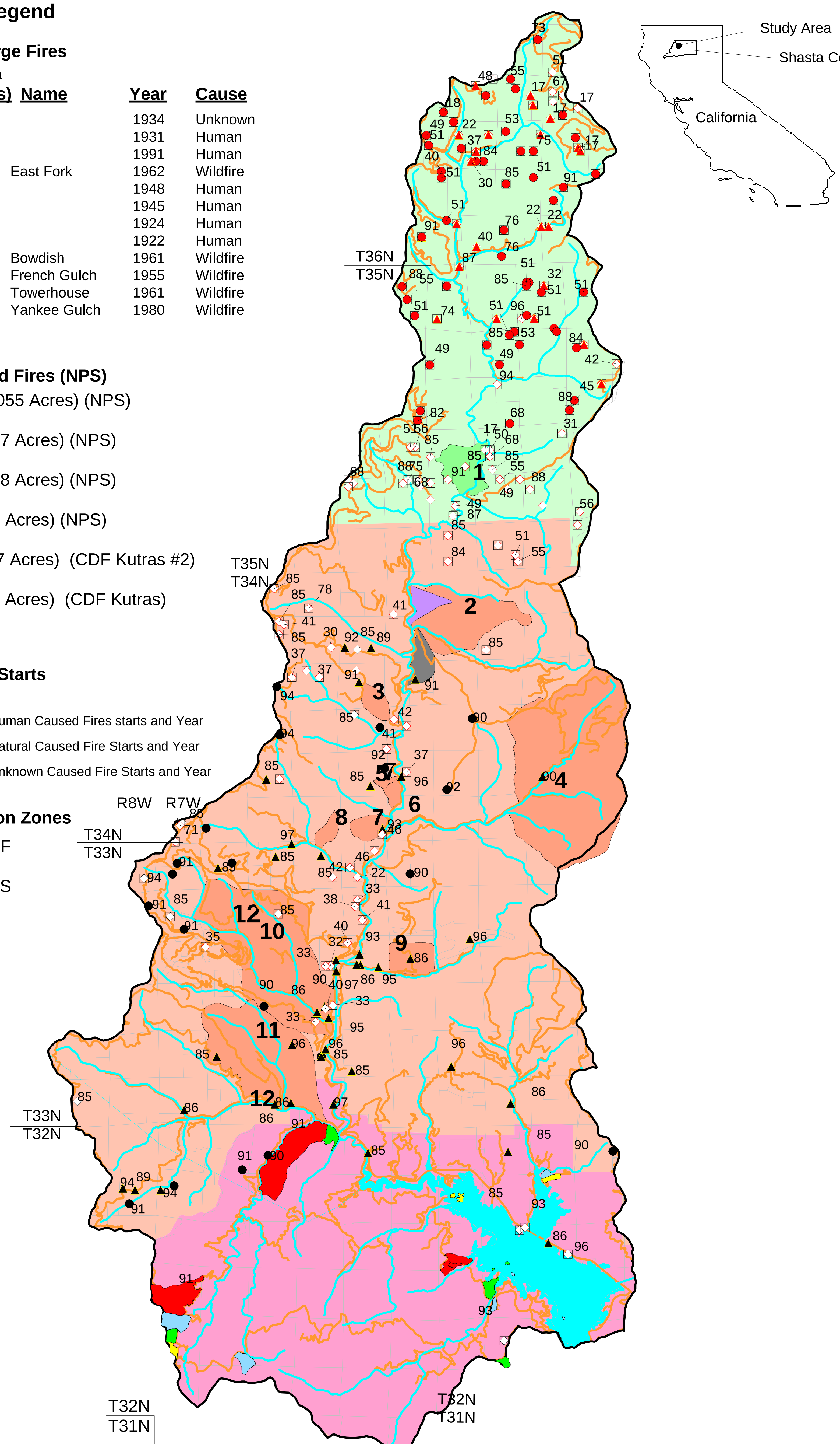
Fire Starts

USFS CDF

- Human Caused Fires starts and Year
- Natural Caused Fire Starts and Year
- Unknown Caused Fire Starts and Year

Fire Protection Zones

- CDF
- NF
- NPS



Workspace: Figure3-3.WOR

Projection: UTM NAD 27, Zone 10
Source: CDF, DFG, SPI, and USFS
Date Created: 5/19/98
Date Modified: 11/12/98

Large Fires and Fire Starts in the Upper Clear Creek Watershed

Shasta County, California

Tetra Tech, Inc.

Figure 3-3

Table 3-11
Cause of Recorded Fire Starts
in the Upper Clear Creek Watershed (from FS and CDF data)

Decade	CDF Fire Protection Zone	NPS Fire Protection Zone	FS Fire Protection Zone	Total number of Fire Starts in Upper Watershed
Natural	18	3	51	72
Human	37	3	22	62
Unknown	46	4	35	85
Total	101	10	108	219

with developing the state fire protection plan. Digital fuel model information is available from the CDF Forestry and Fire Protection Resource Assessment Program (FFRAP) from their large fuels model database. The FS Weaverville and Hayfork Districts have also conducted fuel modeling in the watershed as part of the Clear Creek Late-successional Reserve Management Assessment (FS 1997). Fuel modeling is based on vegetation data which must sometimes be obtained from multiple data sets, each of which may have different spatial resolution and accuracy. FFRAP and FS vegetation data come from various sources with different spatial resolution, including LandSat high-resolution data (with 30-meter resolution), 2.5-acre polygon data, and various forest inventory data

Both the FFRAP and FS fuel model data have been mapped within the upper Clear Creek watershed. While ground truthing of the vegetation data should probably be conducted throughout the watershed to determine the accuracy of the mapping and to refine the vegetation and fuel model classifications, it is probably sufficient for describing fuel loading and potential fire behavior conditions at this scale of watershed analysis.

FFRAP data cover most of the watershed except for the areas within the Clear Creek LSR, which uses fuel model classifications established by FS fire specialists. The FFRAP mapping found eight of the 13 standard fuel models in the upper Clear Creek watershed, while the FS found that five of the 13 standard fuel models best represented fuel loads present in the Clear Creek LSR. Table 3-12 describes the fuel models and general fire behavior that can be expected in the upper Clear Creek watershed based on the vegetation conditions present.

Table 3-12
Fuel Models found in the Upper Clear Creek Watershed (Modified from Anderson, 1982 and FS 199

Model[1]	FBPS[2] Classification	General Description	Vegetation Types or Size Canopy[3,4]	General Ex
1	Grass	Open grasslands and savanna with shrub or timber, if present, on less than one-third of the area.	Annual and perennial grasses.	Surface fires move reac associated material; fire very porous, and contir dead or curing.
2	Pine/ Grass	Timber, open grassy understory; shrub or tree cover is approximately one-third to two-thirds of the area.	Young plantations, burned forest, grass, herbaceous, foothill pine, Oregon white oak, and commercial conifer 2S/P	Surface fires can spreac herbaceous fuels, either that generate higher he firebrands.
4	Tall Chaparral	Stands of mature shrubs, six or more feet high.	Older plantations, chaparral, montane shrub, and commercial conifer 2N/G	Very high to extreme r efforts difficult; fire int involve the foliage and material in the crowns overstory
5	Brush	Regeneration shrub lands that formed after fire or other disturbances; short, green shrub fields within timber stands or without overstory; almost totally cover the area	Young, green stands with little deadwood; litter cast from shrubs and grasses or forbs in understory	Surface fire, generally n fuel loads are light, shru material; poor burning vegetation

Table 3-12
Fuel Models found in the Upper Clear Creek Watershed (Modified from Anderson, 1982 and FS 1997) ***(co***

Model[1]	FBPS[2] Classification	General Description	Vegetation Types or Size Canopy[3,4]	General Ex
6	Dormant Brush	Older, intermediate stands or shrubs less than six feet high.	Chamise and chaparral; shrub-size hardwood and commercial conifer 3&4S/P; can also have considerable hardwood slash component	Fire carries through the winds, but drops to the openings in the stand.
8	Hardwood/ Lodgepole Pine	Closed canopy stands of short-needle conifers or hardwoods with little undergrowth	Commercial conifer (White pine, lodgepole pine and fir) without understory	Slow burning ground fi can flare up where occa concentrations; fire ma layer
9	Mixed Conifer – Light	Closed canopy relatively healthy conifer stands; hardwood stands and hardwood/sparse conifer stands.	Knobcone pine, black oak, mixed hardwood, live oak and commercial conifer 3&4N/G	Fires run through the s out trees, spot, and cro dead & down materials
10	Mixed Conifer – Medium	Any forest types if heavy down materials are present; often from insect or disease; wind throw, or competition induced tree mortality.	Commercial conifer ≥4N/G	Torching of individual frequent and fire intens or 9; potential fire cont

1. All fuel models used by CDF regional mapping. Models 2, 4, 6, 9, and 10 also used by Shasta-Trinity National Forest in Clear Creek LSR.
2. FBPS fuel model classifications based on Anderson, 1982.
3. Crown Size Classes: 1 = 0-5 ft crown diameter, seedling sapling; stand establishment stage; includes most contemporary plantations; 2 = (poles; growth and maturation with little or no natural thinning; includes minor acreages of contemporary plantations; 3 = 13-24 foot crown dia timber; continued growth and maturation and beginning natural thinning (possible current LS); 4 = >24 foot crown diameter, large sawtimber; current LS/OG). Based on FS, 1997.
4. Canopy Closure: S = <20%; P = 20-39%; N = 40-69% ; G = > or = to 70%. Based on FS, 1997.

The following are additional notes taken from the *Clear Creek Late-successional Reserve (RC-334) Management Assessment* (FS 1997) regarding the general vegetation types and fuel models that occur in the Clear Creek LSR. These comments may also apply to other regions of the watershed as well:

1. Poorer timber sites (Forest Service Survey Site Class 6 and higher) are not as great a fire concern due to the lack of large fuel buildups. Fires will burn in these areas but would generally be confined to the ground level allowing direct attack by suppression forces. Hardwoods may be killed but will readily sprout after a fire has passed. These areas support foothill pine, shrub, grass, herb, and hardwood vegetation types **(Models 2 & 4)**.

2. Unthinned plantations on any slope or aspect are a concern. The closed nature of plantations creates a continuous fuel condition with the dense tightly packed crowns. The crown density and associated shrub layer increases the likelihood of a crown fire and stand-replacing event **(Model 4)**.

3. Sparse conifer stands can be a concern if they contain large amounts of decadent brush in the understory. This is the case for many of the areas with S or P canopy closure **(Model 6)**.

4. Densely stocked pole and mature stands contain high amounts of dead fuels on the ground along with the dense canopies. Thus these stands are at an increased hazard of carrying through and reaching the crowns. Stand replacing events are more of a concern on south and west aspects and steep slopes **(Model 9)**.

5. Dense late-successional conifer stands often contain high amounts of dead fuel and a considerable amount of understory vegetation. A wildfire carried by these fuels would be intense enough to cause crowning, spotting, and rapid rates of spread. This type of fire would be beyond the ability of suppression forces to control using direct attach methods and large stand replacing fires could occur. Stands on south and west facing aspects or those on slopes over 65 percent are at increased hazard **(Model 10)**.

Fire Hazard Potential

The FS is the only agency that has mapped fire hazard (or fire behavior) potential in the upper watershed. Fire hazard potential has been mapped only within the Clear Creek LSR in coordination with the *Clear Creek Late-successional Reserve (RC-334) Management Assessment* (FS 1997). Although fuel models have been developed for the rest of the upper Clear Creek watershed, fire hazard potential has not yet been conducted for the entire upper watershed.

The FS assessment of fire hazard potential for the Clear Creek LSR incorporated the total number of starts over a given period of time for a specific landscape, with fuel models, early summer and worst case (90 percentile) weather scenarios, and slope data. The purpose of fire hazard potential modeling was to portray how resistant to control an area would be if ignited to fire under given weather conditions. Fire hazard potentials have been divided into low, medium high, nonflammable, and private. Private lands in the Clear Creek LSR are considered to have high fire hazard potential because of human occupancy and resource value. Areas of moderate and high fire behavior potential are difficult to control due to their associated flame lengths and rates of spread (FS 1997). Timely and appropriate fire suppression response is required to contain these fires and to keep them from getting out of control. Fire hazard potential modeling should be conducted in the rest of the upper watershed to identify areas of high risk.

The amount, type and distribution of live vegetation and fuels can be manipulated using vegetation management programs to reduce the potential hazard of large, catastrophic fires. Because of the inherent risk from natural and human caused fires, vegetation management programs are an essential resource management component for reducing fuel loads in the upper Clear Creek watershed. Vegetation control methods currently being used by NPS, BLM, and the FS include prescribed burning, manual and mechanical removal, and wildfire suppression. The first two methods are especially useful in areas where fire suppression capabilities are relatively poor or limited by access and rough topography

The FS has also recommended prescribed treatments and management actions to reestablish and maintain conditions representative of frequent, low-intensity fire regime conditions and LS/OG habitat conditions in the Clear Creek LSR (FS 1997). Recommended vegetation management prescriptions for the Clear Creek LSR include the following actions:

1. Intermediate thinning of overstocked young to mature conifer stands in 150 to 200 acre blocks to limit the possibility of large stand replacing fires;

2. Conducting plantation thinning to make stands more resistant to large-scale disturbances (such as insect, disease and fire); and

3. Conducting post-thinning prescribed burns where manual or mechanical fuel reduction efforts cannot completely reduce the fuel-loading situation.

Prescribed burns have been conducted in the Whiskeytown Unit annually since 1994, burning a total of 1,438 acres (Figure 3-3). The CDF has also conducted prescribed burns as part of vegetation management programs. Two prescribed burns (Kutras, and Kutras #2) were conducted by the CDF in 1983 and 1986, burning a total of 452 acres along Clear Creek near Big Gulch. A notable wildfire was the Trinity fire. The NPS plans to conduct additional prescribed burns on 5,717 acres of land within the Whiskeytown Unit. As shown in Figure 3-3, these prescribed burns are planned for the Crystal Creek, Grizzly Gulch, Dry Creek, Brandy Creek and Boulder Creek watersheds, and areas adjacent to Whiskeytown Lake. The NPS has also constructed approximately 32,158 feet (or 6.1 miles) of fuel breaks along ridges within the Whiskeytown HSA area, between South Fork Mountain and Whiskeytown Dam, and near Monarch Mountain south of Whiskeytown Lake. Fuels types are shown on Figure 3-4.

3.3 HABITAT AND WILDLIFE

3.3.1 Issues

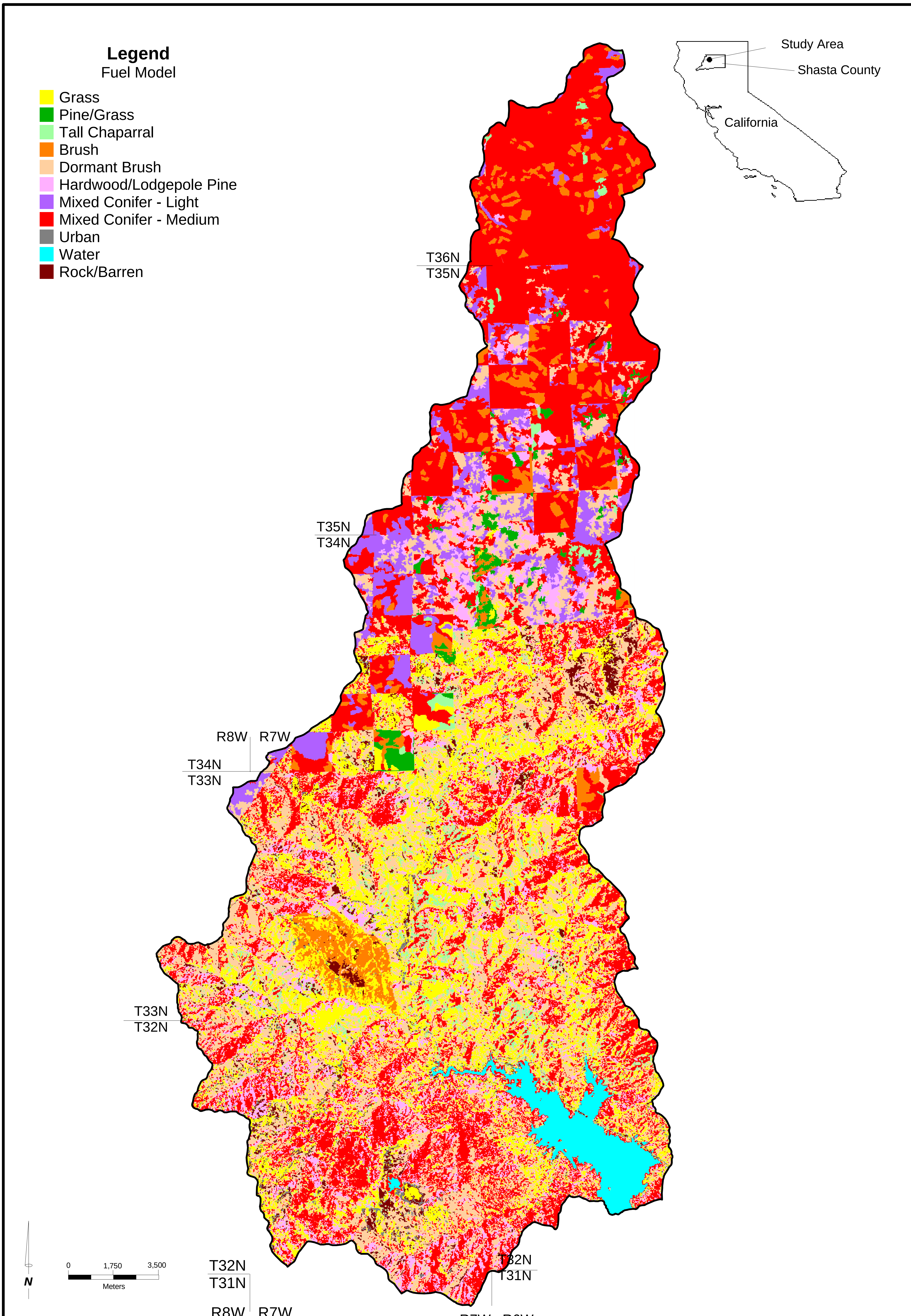
The amount, type, and condition of vegetation communities determine the availability of habitat for wildlife. Wildlife depends on specific habitats or a range of habitats for foraging, nesting, breeding, and thermal or protective cover. Recovery of threatened and endangered plant and animal species depends on providing the right quantity and quality of habitat to sustain viable populations.

Land use activities or practices, such as timber harvest, fire suppression, and mining, can alter the amounts of available and suitable habitats. Vegetation patterns have been changed and exotic species have invaded many communities. People in vehicular and non-vehicular recreation areas may disturb habitat and plants and animals in the area. Roads can fragment habitat, cutting off wildlife corridors.

3.3.2 Existing Conditions – Vegetation

Vegetation communities within the upper Clear Creek watershed have been mapped using LandSat data from the Klamath Bioregional Assessment Project (HSU 1997). The classification system is based on a modified version of the California's WHR Classification System (Mayer and Laudenslayer 1988). To simplify the numerous types of vegetation communities observed in the LandSat data, eight broad vegetation communities have been established based on the dominant plant species present. The categories include grasslands and chaparral, mixed conifer (which includes mixed conifer-hardwood communities), mixed fir, mixed hardwood (which includes mixed hardwood-conifer communities), mixed oak woodland, mixed pine, and wet meadow/marsh communities. Also mapped are areas covered only by soils and barren rock, gravel or pavement. Figure 3-5 shows the distribution and acreage associated with each community or ecosystem.

The dominant vegetation communities in the upper watershed include mixed conifer (43 percent), mixed hardwood (25 percent), and grassland (15 percent). Other smaller vegetation communities within the upper watershed include mixed oak woodland (7 percent), chaparral (4 percent), mixed fir (2 percent), mixed pine (1 percent) and wet meadow/marsh (<1 percent). Nonvegetated areas include soils and barren rock, gravel or pavement, and water features, such as Whiskeytown Lake, which together cover 0.5 percent of the upper watershed. Approximately 1.5 percent of the upper watershed is unclassified.



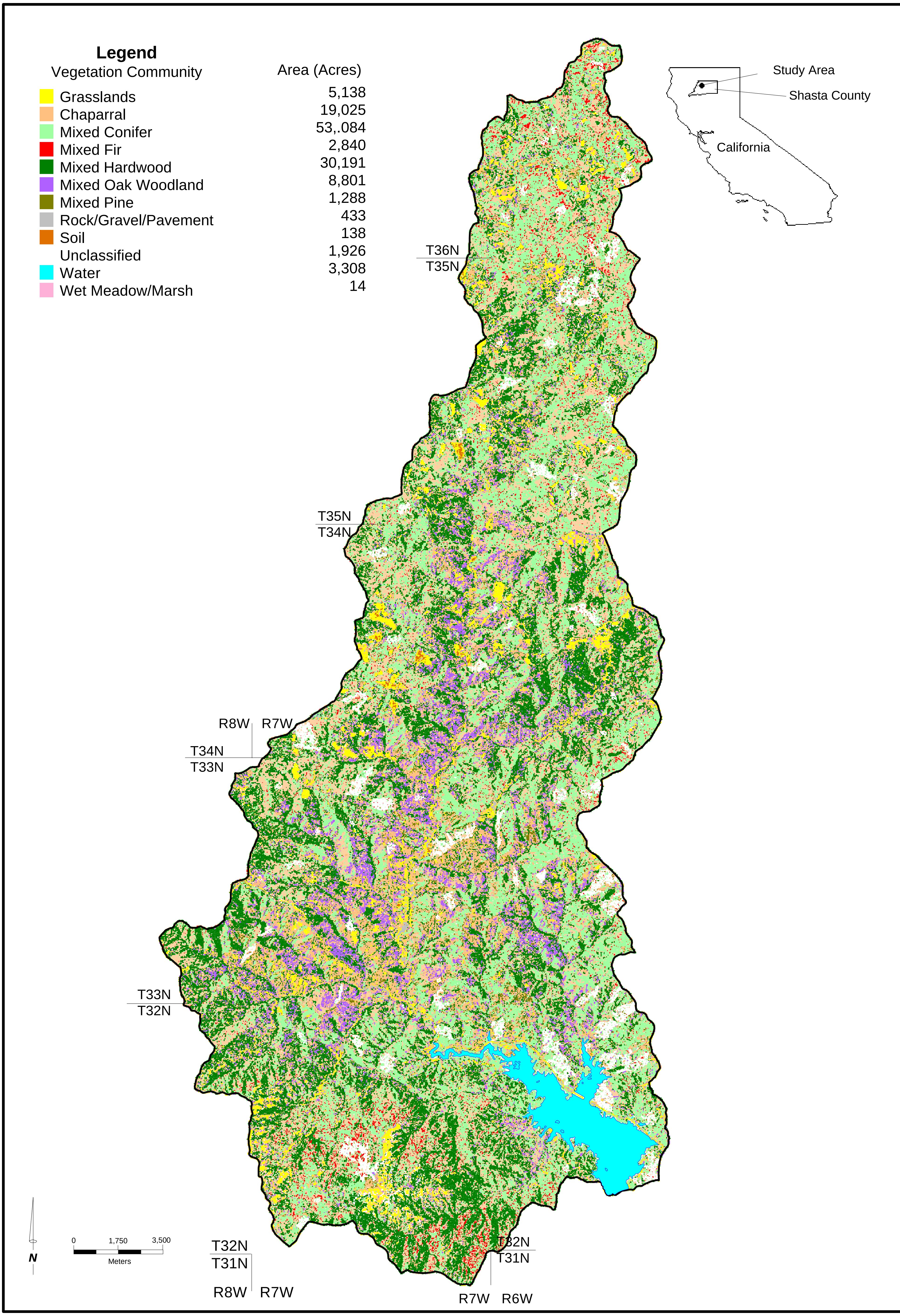
Projection: UTM NAD 27, Zone 10
Source: USFS
Date Created: 5/19/98
Draft: 11/12/98

Fuel Types in the Upper Clear Creek Watershed

Shasta County, California

Figure 3-4

Tetra Tech, Inc.



Projection: UTM NAD 27, Zone 10
Source: DFG
Date Created: 5/19/98
Draft:11/13/98

Vegetation Communities
of the Upper Clear Creek Watershed
Shasta County, California

Tetra Tech, Inc.

Figure 3-5

Mixed conifer communities dominate the mid-elevation zone and contain various mixtures of ponderosa pine (*Pinus ponederosa*), Jeffrey pine (*Pinus jeffreyi*), Douglas fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), sugar pine (*Pinus lambertiana*), and incense cedar (*Calocedrus decurrens*) (FS 1994). Mixed conifer, Douglas fir, ponderosa pine, and red fir are the four major vegetative communities of value for commercial timber harvesting. Mixed conifer communities occupy 53,084 acres (43 percent) within the upper watershed. Mixed fir communities occupy 2,840 acres at higher elevations and include pure stands of red fir, mixed with Douglas-fir, white fir, and lodgepole pine. Red fir grows generally above 6,000 feet.

Mixed hardwood communities occur at lower elevations and include species such as black oak (*Quercus kelloggii*), madrone (*Arbutus menziesii*), tanbark oak (*Lithocarpus densiflora*), canyon live oak (*Quercus chysolepis*), and big leaf maple (*Acer macrophyllum*). The most predominant hardwood varieties include black oak and live oak. Hardwoods are not a commercially valuable timber resource other than for firewood and biomass for energy producing wood-burning plants (FS 1994). Mixed hardwood communities occupy 30,191 acres of the upper watershed (25 percent), and are an important ecosystem element because they increase soil productivity and provide wildlife and habitat diversity. Hardwoods are also common components of riparian woodlands, which grow in the vicinity of perennial and intermittent streams.

Mixed oak woodland communities occupy 8,801 acres south of Big Gulch, in lower elevation hillsides, along creek drainages, and where large fires and mining practices have cleared other larger vegetation.

Chaparral communities are a mosaic of shrub communities that are adapted to extremes of temperature and precipitation and periodic fire (NPS 1997). These communities help stabilize soils and increase water yields. Chaparral species commonly include numerous ceanothus species, such as wedgeleaf (*Ceanothus cuneatus*), lemon ceanothus (*C. lemmonii*), snowbrush (*C. velutinus*), deerbrush (*C. intergerrimus*), whitethorn (*C. cordulatus*), or mahala mat (*C. prostratus*), as well as other species such as manzanitas (*Arctostaphylos* spp.), bittercherry (*Prunus emarginata*), silk tassel (*Garrya fremontii*), Brewer's oak (*Quercus garryana* var. *breweri*), dwarf tanbark oak (*lithocarpus densiflora* var. *echinoides*), chinquapin (*Castanopsis sempervirens*), chamise (*Adenostoma fasciculatum*), mountain mahogany (*Ceracarpus betuloides*), serviceberry (*Amelanchier alniflora*), and bitterbrush (*Purshia tridentata*). Chaparral communities cover about 5,338 acres, concentrated between the French Gulch area and Cline Gulch.

Grasslands occupy about 18,734 acres and provide foraging and transitional zones between other ecosystems. Together, grasslands and chaparral areas occupy 24,163 acres (19 percent) in the upper watershed, and are of concern to resource managers because of the potential of fuel buildup and ignition from lightning strikes or unintentional fire starts, which could lead to the possibility of large fires within the watershed.

Only 14 acres of wet meadow/marsh areas are mapped within the upper watershed, occurring along low floodplains and meadows in tributary drainages. Wetlands do not commonly exist along the shoreline of Whiskeytown Lake because the annual drawdown in water surface elevation during winter months for increased flood storage does not allow establishment of wetland vegetation. Alkali seeps are found within the Whiskeytown Unit, between State Route 299 and Willow Creek, near the Crystal Creek confluence. Dominant native species associated with these seeps are dwarf alkali grass (*Puccinellia pumila*), seaside arrow grass (*Triglochin maritima*), saltgrass (*Distichlis spicata*), rush (*Juncus balticus*), toad rush (*J. bufonius*), and sand sperry (*Spergularia marina*).

Riparian communities depend on a high water table and grow in areas adjacent to tributaries in steep canyons and along broader floodplains. Within the Whiskeytown Unit in the southern portion of the upper watershed, riparian communities consist primarily of grey pine (*Pinus sabiniana*), willow (*Salix* spp.), white alder (*Alnus rhombifolia*), dogwood (*Cornus* spp.), Oregon ash (*Fraxinus latifolia*), bigleaf maple (*Acer macrophyllum*), and Fremont and black cottonwood (*Populus fremontii and P. trichocarpa*). Wild grape (*Vitus californica*) is very common, and common riparian shrubs include snowberry (*Symphoricarpos rivularis*), California blackberry (*Rubus vitifolius*), toyon (*Heteromeles arbutifolia*), buckeye (*Aesculus californica*), and button willow (*Cephalanthus occidentalis*). The riparian understory is made up of flowering herbaceous plants, cattails, sedges, rushes, and ferns (NPS 1997).

Vegetation patterns develop based on vegetative species present and the natural conditions that affect vegetative growth, such as amount and distribution of precipitation, soil character, and surface characteristics (e.g., elevation, slope and aspect). Past management practices, such as commercial timber clear cutting, road construction, and mining, as well as natural disturbances, such as landslides and wildfire, also affect vegetation patterns. The amount and pattern of structural diversity in intermingled lands and lands being intensively managed is constantly being altered by wildfire and forest management activities (FS 1994).

Special land allocations established for management of the northern spotted owl (i.e., LSRs) and other multiple land-use requirements established by the ROD (e.g., riparian reserves and congressionally reserved areas) have changed vegetation patterns on federally administered lands by changing management practices regarding seral stage development and timber production. The Clear Creek LSR occupies approximately 19,340 acres of land in the northern portion of the upper watershed. Riparian areas occupy approximately 26,736 acres of land as connected bands (of various widths) that follow drainage patterns of perennial and intermittent tributaries within the watershed. The Whiskeytown Unit of the Whiskeytown-Shasta-Trinity National Recreational Area is the only congressionally reserved area within the upper watershed, occupying 28,561 acres. Matrix lands which occupy 35,604 acres are the only public lands on which timber harvesting is allowed.

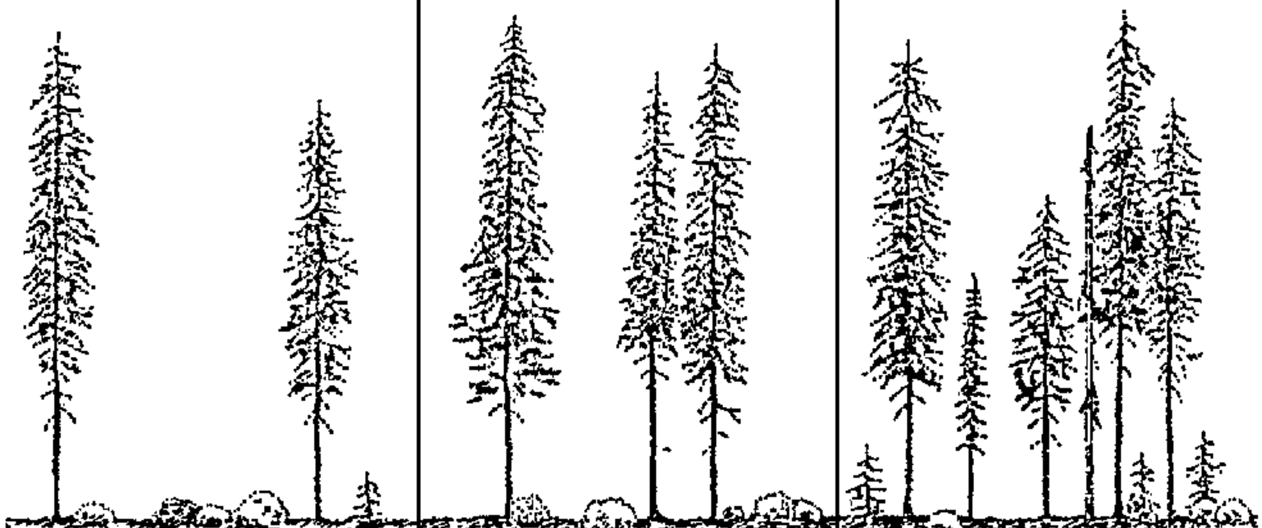
Timber production on the Shasta-Trinity National Forest is managed by the FS, Weaverville Ranger District. Timber production is not allowed on land within LSRs or riparian reserves. Somewhat less than 4,900 acres (20 percent) of FS land in the upper Clear Creek watershed is suitable for timber production; the remaining 80 percent of FS land is unstable, in riparian reserves or within the Clear Creek LSR. As described in the *Clear Creek Late-successional Reserve (RC-334) Management Assessment* (FS 1997), the overall objective of FS management of the Clear Creek LSR is to "... protect and enhance conditions of late-successional and old-growth (LS/OG) ecosystems, which serve as habitat for LS/OG related species including the northern spotted owl."

Within the suitable timber producing FS lands, selected even-aged management is used as a means of harvesting timber (FS 1994). Even-aged management systems include clear cutting, seed-step and overstory removal step of shelterwood cutting, and intermediate commercial true thinning. Between 1984 and 1990, about 49 percent of the acres harvested on forest lands in the Shasta-Trinity National Forest were harvested using clear cutting. Other lands within the Shasta-Trinity National Forest that are non-productive, non-regenerable, unstable, or unavailable are classified as unsuitable for timber production.

Approximately 19,512 acres of land in the upper Clear Creek watershed are within private timber production zones. Somewhat more than 20 percent of private TPZ land lies within the Clear Creek LSR; leaving somewhat less than 80 percent available for timber harvesting (excluding those TPZ lands within watercourse and lake protection zones). While the purpose of commercial forestry practices is to yield economic benefit, consideration is also taken to reduce or avoid significant adverse impacts of timber harvesting plans and methods in order to maintain sustainable timber resources. Silvicultural practices in commercial timber production zones are regulated by the CDF, for the purpose of substantially minimizing adverse effects on the environment from timber harvesting activities. One of the objectives of these management directives is to recruit and maintain diverse seral stage components of forest lands to provide healthy and naturally diverse forests (CDF 1996). Seral stages represent an ecologic successional time period for vegetative growth and habitat. Seral stages are often based on the age of a tree, represented by the diameter of its trunk measured at breast height, its height, the amount of canopy provided, and the presence of additional understory species. Figure 3-6 shows illustrations and definitions of seral stage descriptions used by the FS for WHRs.

Management of existing and desired vegetation communities is intended to sustain and enhance the biological diversity of native plant species throughout the watershed. Pest plant species, which can include both undesirable native and invasive nonnative species, often become established following fire and other land disturbances. These species tend to provide less valuable habitat because they reduce habitat diversity. Species of special concern include the following:

1. Grass/Forb Stage	2. Shrub/Seedling/Sapling Stage	3. Pole/Medium Tree Stage	4. Large Tree Stage



A. Less than 40 percent (3A or 4A)	B. 40 to 69 percent (3B or 4B)	C. 70 to 100 percent (3C, 4C or 4C-Older)

1	Grass-Forb Stage	**3c**	Pole/Medium Tree Stage, <70% Canopy Closure	**4c**	Large Tree Stage, >70% Canopy Closure
2	Shrub/Seedling/Sapling Stages	**4a**	Large Tree Stage, <40% Canopy Closure	**4c-Older**	Old growth, same as 4c large tree stage, but exhibiting obvious signs of decadence.
3a	Pole/Medium Tree Stage, <40% Canopy Closure	**4b**	Large Tree Stage, 40 to 70% Canopy Closure		
3b	Pole/Medium Tree Stage, 40 to 70% Canopy Closure				

Source: FEIS for Shasta-Trinity National Forest, USFS 1994

Seral Stage Descriptions Used for Wildlife Habitat Relationships

Shasta County, California

Tetra Tech, Inc.

Figure 3-6

- ❖ Mediterranean annual grasses and forbs. Introduced as livestock forage in the area, these species have eradicated most native grasses in the region. One exotic that does particularly well in the watershed is medusa-head grass.

- ❖ Yellow star thistle. Eurasia species introduced with the grasses. Reproduces rapidly in grasslands and barren areas.

- ❖ Himalayan blackberries. Introduced in the latter half of the nineteenth century. The plant has long runners and grows rapidly, spreading over large areas. Out competes native vegetation by shading them. Tends to favor moist soil in riparian areas.

Management opportunities for maintaining and enhancing biological diversity are presented in Chapter 6.

3.3.3 Existing Conditions – Wildlife

The WHR of the upper Clear Creek watershed determine the diversity and abundance of species. Wildlife depends on specific habitats or a range of habitats for foraging, nesting, breeding, and thermal or protective cover. Habitats are often described using vegetation communities and/or location (e.g., oak woodland or perennial montane streams in mixed conifer-hardwood forests). The Shasta-Trinity National Forest uses WHRs to relate vegetation type with wildlife habitat types defined by seral stages. A similar WHR classification system has been used by BLM to list the wildlife types (amphibian, birds, mammals, and reptiles) associated with habitats found in the ISRMA. Vegetation types listed in the Shasta-Trinity National Forest WHR system include: Mixed Conifer; Douglas-fir; Red Fir/White fir; Ponderosa Pine/Jeffrey Pine; Other Conifer Types; Hardwoods; Chaparral; and Grass. Habitat types listed in the BLM WHR system include: Mixed Chaparral; Mixed Conifer, Valley-Foothill Hardwood, Ponderosa Pine, Douglas-fir; Closed-Cone Pine-Cypress; Wet Meadows; Emergent Wetland; Lacustrine; and Riverine. Of the eight habitat types used by Shasta-Trinity National Forest, all can be found within the upper Clear Creek watershed. Of the 10 different habitat types used by BLM to describe the ISRMA, which extends east of Clear Creek to the Shasta Dam and Sacramento River, at least nine of the habitats (with the exception of Closed-Cone Pine-Cypress) can be found in the upper Clear Creek watershed. These classifications also relate fairly well to the vegetative communities described above.

The FS uses a classification of wildlife assemblages to discuss management of species and habitats. As described in the Final EIS, Shasta-Trinity National Forests Land and RMP (FS 1994), "... assemblages or groups of wildlife associated with vegetative communities or key habitat components have been identified and selected as management indicators ... [and] were chosen because (a) they represent the vegetation types, seral stages, and special habitat elements necessary to provide for all wildlife species on the forests, and (b) their population changes are believed to indicate the effects of management activities on other wildlife populations." Wildlife assemblages used by the FS include: Late Seral Stage; Openings and Early Seral Stage; Multi-Habitat; Snag and Down Log; Riparian; Aquatic; Hardwood; Chaparral; and Cliffs, Caves, Talus, and Rock Outcrops. These assemblages are described below (FS 1994).

Late Seral Stage Wildlife Assemblage. Species found in this assemblage include northern spotted owl (*Strix occiodentalis*), goshawk (*Accipiter gentilis*), fisher (*Martes pennanti*), marten (*Martes americana*), Trowbridge's shrew (*Sorex trowbridgii*), and northern flying squirrel (*Glaucimys sabrinus*). These species use later seral stage trees and older over-mature habitat for cover, and nesting. The average age of these older forest stages is greater than 110 years. These forests have large diameter trees that are at least 21 inches. Tree cover and density range from fairly open canopies to dense canopies of multiple layers of trees. These seral stages are important to wildlife because they provide protective and thermal cover, large trees for nesting, large snags and down logs, vertical diversity, and older over-mature habitat.

Forested habitats are managed on Shasta-Trinity National Forest lands indirectly through application of standards and guidelines for such features as snags, hardwoods, and seral stages. Current management policy is to retain sufficient seral stage diversity to maintain viability of the wildlife species dependent on these later stage habitats

Openings and Early Seral Stage Wildlife Assemblage. Species that are characteristic of openings and the early seral state wildlife assemblage include the racer (*Culber constrictor*), western meadowlark (*Sturnella neglecta*), California quail (*Callipepla californica*), song sparrow (*Melospiza melodia*), western harvest mouse (*Reithrodontomys megalotis*), brush mouse (*Peromyscus boylii*), brush rabbit (*Sylyilagus bachmani*), California vole (*Microtus californicus*), and mule deer (*Odocoileus hemionus*).These species use natural and temporary openings for forage and habitat. Grasslands, shrublands, and early forest seral stages provide diversity within the forest landscape, and forage areas for some big game species and habitat for small birds and mammals, which in turn become prey species for larger carnivores.

Natural openings are maintained to provide wildlife habitat. Early forests seral stages are created through even-aged timber management activities. These openings are temporary as they grow into older conifer plantations. Other openings are created in a mosaic pattern over the forest landscape.

Multi-Habitat Wildlife Assemblage. Species that occur in this assemblage include black bear (*Ursus americanus*), mule deer, and elk (*Cervus elaphus*), which depend on a variety of vegetated habitats, seral stages, and special habitat components for foraging, resting, and breeding. Black bear is a big game species found throughout the watershed. Black bear require a diversity of habitats to provide for their diet and hibernation needs. Oaks and berry-producing shrublands are especially important to the bear. Bear hunting is regulated by the state. Black bear are extremely vulnerable to hunting and poaching in areas with a well-developed road system. Encounters between bear and people are significantly greater during years of drought when forage becomes scarce. The problem is being partially resolved through better trash management and education of the visiting public.

Deer are found throughout the watershed, where suitable range and habitat is available for the entire deer population. Historically, elk were native to this area but by the 1800s were no longer believed to be present on the forests. Rocky Mountain elk were reintroduced in 1916 near the east-side of Shasta Lake, and a small herd of Roosevelt elk was reintroduced onto the Klamath National Forest north of the Trinity Alps in 1990. Currently elk occupy about 150,000 acres of habitat mostly on the Shasta Lake District.

Deer are managed directly and indirectly. Direct management consists of water development and fencing riparian areas, prescribed burning of chaparral, road closures, and imposing administrative vehicle control areas during hunting seasons. Browse improvements on winter range habitat also occur. Indirect habitat improvement occurs through coordination with other resource programs. Over time, coordinated resource planning results in the management of key habitat elements for deer. Direction is provided for hardwood retention and seral stage diversity to benefit deer.

Snag and Down Log Wildlife Assemblage. Species found in this assemblage include long-toed salamander (*Ambystoma macrodactylum*), rubber boa (*Charina bottae*), pileated wood-pecker (*Dryocopus pileatus*), black bear, western screech owl (*Otus kennicottii*), northern pygmy owl (*Glaucidium gnoma*), northern saw-whet owl (*Aegolius acadicus*), and tree swallow (*Tachycineata bicolor*). These species depend on tree cavities. Snags and down logs are diversity requirements for many wildlife species.

Timber management practices are limiting to the large portion of this resource. The current management practice on Shasta-Trinity National Forest land is to maintain sufficient large snags and logs for the wildlife species requiring the habitat component.

Riparian Wildlife Assemblage. Species typically found in riparian areas include California red legged frog, black salamander, yellow warbler, willow flycatcher, and fisher. Riparian vegetation depends on a high water table. The dense canopy of riparian vegetation provides cover, shade, and cooler temperatures, allowing riparian forests to serve as corridors, connective habitat, and migration routes.

Timber and range management activities can impact riparian areas by changing in plant species composition. Riparian habitat can also be affected by the removal of surrounding canopy, thereby increasing air and water temperatures. Roads, trails, and campgrounds within riparian area can also alter this habitat. Current management direction on the Shasta-Trinity National Forest is to provide riparian reserve areas, ranging from 150 to over 300 feet in width for each side, depending on site conditions for all streams, lakes, ponds, reservoirs, and wet areas. In addition, the use of best management practices provides water quality protection.

Aquatic Wildlife Assemblage. Species present in the aquatic wildlife assemblage may include tailed frogs (*Ascaphus truei*), western pond turtle (*Clemmys marmorata*), bald eagle

(*Haliaeetus leucocephalus*), river otter (*Lutra canadensis*), and water shrew (*Sorex palustris*). These species rely on good water quality, adequate water quantity, riparian and forest cover, fish or aquatic insects, and large woody debris for food and habitat.

Current management direction is to manage riparian reserves of a minimum 150 feet along all perennial streams and lakes, a minimum 300 feet along all perennial fish-bearing streams, and a minimum 100 feet along all seasonally flowing or intermittent streams, wetlands less than one acre, and unstable and potentially unstable areas. The use of best management practices also helps provide for water quality protection. Aquatic systems are managed to meet the goals and objectives of the ACS of the *Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl.*

Hardwood Wildlife Assemblage. Acorn woodpecker (*Melanerpes formicivorus*), scrub jay (*Aphelocoma coerulescens*), evening grosbeak (*Coccothraustes vespertinus*), white-breasted nuthatch (*Sitta carolinensis*), and Hutton's vireo (*Vireo huttoni*) use hardwoods for forage, nesting, and shelter. Acorns are an important food source.

Hardwoods are found throughout the watershed either in pure stands or as individual trees in conifer forest types. Because many hardwood species are found on sites that are not suitable for forest management activities, there is little likelihood they will be significantly altered by timber management practices. However, some hardwoods, such as black oak, may be found on sites suitable for timber production.

Chaparral Wildlife Assemblage. Chaparral is the general name given to a diverse combination of shrubs that provide habitat for many wildlife species, including green-tailed towhee (*Pipilo chlorurus*), wrentit (*Chamaea fasciata*), brush mouse (*Peromyscus parvus*), and mountain lion (*Felis concolor*). Many rodents inhabit chaparral, and deer and other herbivores find forage here. Chaparral is found at a variety of elevations and can provide winter and summer range, escape cover, and fawning areas for deer. The flowers, seeds, and leaves from the shrubs provide food, cover, and nest sites for birds. Chaparral is also included within the early seral stage category. Prescribed burning of selected shrublands is the major form of chaparral management on Shasta-Trinity National Forest lands. The burning is done primarily to enhance forage for deer, but it also creates a mosaic that benefits many other species inhabiting the chaparral community.

The dominant habitat on BLM lands in the watershed is mixed chaparral (BLM 1997). The Whiskeytown deer herd (black-tailed deer), which is a subunit of the Weaverville deer herd, occupies territory east of Clear Creek and north of Whiskeytown Lake as wintering range. Deer use south- and west-facing slopes within this territory during their gestation period. The mixed chaparral vegetative community provides forage and protective cover for the Whiskeytown deer. Although ceanothus and black oak have the greatest nutritional value for the deer, past and present land management activities have limited the amounts of ceanothus and black oak (acorns) available for the deer (BLM 1997). Other threats to the Whiskeytown deer herd described in the ISRMA Final Plan include fire suppression practices which have reduced the number and quality of ceanothus in the area, with subsequent increases in less nutritional species, such as chamise and manzanita, and stresses to the deer from increased motorized travel over the network of roads and trails that traverse the area.

Cliffs, Caves, Talus, and Rock Outcrops Wildlife Assemblage. Shasta salamander (*Hydromantes shastae*), cliff swallow (*Hirundo pyrrhonota*), peregrine falcon (*Falco peregrinus*), and Townsend's big eared bat (*Plecotus townsendii*) use cliffs, caves, talus, and rock outcroppings for nesting, denning, and shelter.

Because of rough, broken terrain and less vegetation, these features are usually undisturbed. For example, cliffs and talus are usually not affected by construction activities, although adjacent areas may be. Some of these areas are considered as special features because they provide unique habitat for wildlife and are managed for their protection.

Habitats and vegetation communities found within the Whiskeytown Unit include mixed chaparral, mixed pine forests, mixed conifer forests, riparian communities, blue oak grasslands, black oak woodlands, and knobcone pine forests.

3.3.4 Threatened, Endangered, and Sensitive Plant and Wildlife Species

Several threatened, endangered, and sensitive plant and wildlife species are found within the upper Clear Creek watershed (refer to Figure 1-10). No federally listed plant species have been observed within the upper Clear Creek watershed. Two federally listed birds (one endangered and one threatened), one federal candidate and four federal species of concern are known to live within the upper Clear Creek watershed.

Two sensitive plant species have been found within the upper Clear Creek watershed: Howell's alkali grass (*Puccinellia howellii*) and Canyon Creek stonecrop (*Sedum paradisum*). Howell's alkali grass is a federal candidate species, which means that its listing is supported by the FWS. The only known location of alkali grass is in the Whiskeytown Unit (NPS 1997). Canyon Creek stonecrop is located on north- and west-facing slopes on outcrops of exposed bedrock within the ISRMA (BLM 1997); these sites are located in the Cline Gulch and East Fork Clear Creek subwatersheds. Canyon Creek stonecrop is listed as a federal species of concern. Although other special status plant species have not been found within the upper Clear Creek watershed, species that have the potential to be located within the watershed are also listed in Table 3-13.

Two federally listed wildlife species occur in the upper Clear Creek watershed (Table 3-14): the northern spotted owl (*Strix occidentalis caurina*) and the bald eagle (*Haliaeetus leucocephalus*). The spotted owl was listed as a threatened species by the FWS on July 23, 1990. The bald eagle is currently listed as federally threatened and state endangered and is on the state protected species list but will likely be reclassified as threatened in the next year (NPS 1997). The northern spotted owl prefer dense stands of mature, mixed conifer and Douglas fir (FS 1994); however, there may be some variance in their habitat preferences. Recent studies funded by the National Council of the Paper Industry for

Air and Stream Improvement, Inc. (NCASI) have observed northern spotted owls using second-growth forests in areas where old-growth forests don't exist (California Forest Products Commission 1998). Numerous spotted owl locations exist in the Damnation Creek, Stacey Creek, and Dodge Creek subwatersheds, all of which are within the Clear Creek LSR. Bald eagles depend on large lakes, reservoirs, and/or river systems (FS 1994). Two pairs of bald eagles have nesting sites in the Whiskeytown Unit, south of Whiskeytown Lake. Substantial wintering populations have also been documented in this area (NPS 1997).

The upper watershed also contains three federal species of concern wildlife species: the Pacific fisher (*Martes pennanti pacifica*), the northern goshawk (*Accipiter gentilis*), and California wolverine (*Gulo gulo*); and one FS Sensitive species: marten (*Martes americana*). The wolverine is also state listed threatened and the Pacific fisher is state species of special concern.

Pacific fishers are commonly found in riparian, deciduous, and dense stands of many coniferous types (FS 1994). The fishers prefer large, contiguous tracts of mature and older over-mature mixed conifer, Douglas-fir, red fir, and in some areas, lodgepole pine forests. Five sightings of the Pacific fisher have been documented in the upper watershed: two in the Whiskeytown Unit, one in the Trail Creek sub-watershed, one in the Dodge Creek sub-watershed, and one along the divide between Big Gulch and Brush Creek. The Pacific fisher is also classified by the Shasta-Trinity National Forest as a "sensitive" species (see below).

Goshawks can be found in late and other successional stages of most conifer timber types (FS 1994). One northern goshawk sighting has been documented in the upper watershed within the Shasta-Trinity National Forest in the Damnation Creek subwatershed, which is within the Clear Creek LSR.

Table 3-13
Special Plant Species Known to Occur or Potentially Occur within the Upper Clear Creek Watershed

Common Name	Scientific Name	Status Fed/State/CNPS		Occurrence
Sanborn's onion	*Allium sanbornii* ssp. *sanbornii*	-	-, CNPS 4	P
Three-bracted onion	*Allium tribracteatum*	FSC	-, CNPS 1B	P
Klamath manzanita	*Arctostaphylos Klamathensis*	FSC	-, CNPS 1B	P
Shasta County arnica	*Arnica venosa*	-	-, CNPS 4	P
Wilkins harebell	*Campanula wilkinsiana*	FSC	-, CNPS 1B	P
Mildred's clarkia	*Clarkia mildrediae*	-	-, CNPS 4	P
Sierra Clarkia	*Clarkia virgata*	-	-, CNPS 4	P
Silky cryptantha	*Cryptantha crinita*	FSC	-, CNPS 1B	P
Clustered lady's slipper	*Cyprepedium fasciculatum*	FSC	-, CNPS 4	P
Small spikerush	*Eleocharis parvula*	-	-, CNPS 4	P
Trinity buckwheat	*Erigonum alpinum*	FSC	E, CNPS 1B	P
Scott Mountain fawn lily	*Erythronium citrinum* var. *roderickii*	-	-, CNPS 1B	P
Scott Mountain bedstraw	*Galium serpenticum ssp. Scoticum*	-	-, CNPS 1B	P
Pickering's ivesia	*Ivesia pickeringii*	FSC	-, CNPS 1B	P

Common Name	Scientific Name	Status Fed/State/CNPS		Occurrence
Red-anthered rush	*Juncus marginatus* var. *marginatus*	-	-, CNPS 2	P
Heckner's lewisia	*Lewisia cotyledon* var. *howellii*	FSC	-, CNPS 3	P
Rattan's linanthus	*Linanthus rattanii*	-	-, CNPS 4	P
Tehama navarretia	*Navarretia heterandra*	-	-, CNPS 4	P
Shasta snow-wreath	*Neviusia cliftonii*	-	-, CNPS 1B	P
Thread-leaved beardtongue	*Penstemon filformis*	FSC	-, CNPS 1B	P
Snowmountain beard tongue	*Penstemon purpusii*	-	-, CNPS 4	P
Tracy's beardtongue	*Penstemon tracyi*	-	-, CNPS 1B	P
Scott Mountain phacelia	*Phacelia dalesiana*	FSC	-, CNPS 1B	P
Scott Valley phacelia	*Phacelia greenei*	FSC	-, CNPS 1B	P
Howell's alkali-grass	*Puccinellia howellii*	FSC	-, CNPS 1B	K
Showy raillardella	*Raillardella pringlei*	FSC	-, CNPS 1B	P
Sanford's arrowhead	*Sagittaria sanfordii*	FSC	-, CNPS 1B	P
Canyon Creek stonecrop	*Sedum paradisum*	FSC	-, CNPS 1B	K
Short-petaled campion	*Silene invisa*	-	-, CNPS 4	P
Salmon Mountains Wakerobin	*Trillium ovatum* ssp. *oettingeri*	-	-, CNPS 4	P
Yellow triteleia	*Triteleia crocea* var. *crocea*	-	-, CNPS 4	P

Status Definitions: FE = Federally Endangered; FT = Federally Threatened; FSC = Federal Species of Concern; SE = State Endangered; ST = State Threatened; SSC = State Special Concern; CNPS 1B= List 1B, Plants rare and endangered in California and elsewhere; CNPS 2 = List 2, Plants rare, threatened, or endangered in California, but more common elsewhere; CNPS 3= Plants about which we need more information – a review list; CNPS 4 = Plants of limited distribution – a watch list; FS = Forest Service Sensitive; STE = Shasta-Trinity National Forest Emphasis

Occurrence: K = Known; P = Potential

Source: Adapted from (a) BLM 1997; (b) NPS 1997; (c) FS 1994.
Status verified from CDFG 1998a, 1998b, 1998c, 1998d; FWS 1995a, 1995b, 1996

Table 3-14
Special Status and Protected Wildlife Species Known to Occur or Potentially Occur within the Upper Clear Creek Watershed

Common Name	Scientific Name	Status Fed/State		Occurrence
Invertebrates				
Trinity bristle snail	*Monadenia setosa*	STE	-	
Klamath Mountains ground beetle	*Nebria gebleri siskiyousensis*	FSC	-	
Franklin's bumble bee	*Bombus franklini*	FSC	-	
Amphibians				
Shasta salamander	*Hydromantes shastae*	FSC	ST	P
Western spadefoot	*Scaphiopus hammondii*	FSC	-	P
California red-legged frog	*Rana aurora draytonii*	FT	SSC	P
Cascades frog	*Rana cascadae*	-	SSC	P
Foothill yellow-legged frog	*Rana boylii*	FSC	SSC	P
Reptile				
Northwestern pond turtle	*Clemmys marmorata marmorata*	FSC	SSC	P
Birds				
Common loon	*Gavia immer*	-	SSC	P
Double-crested comorant	*Phalacrocorax auritus*	-	SSC	P
Barrow's goldeneye	*Bucephala islandica*	-	SSC	P
Osprey	*Pandion haliaetus*	-	SSC	P
Bald eagle	*Haliaeetus leucocephalus*	FE	SE, SP	K
Northern harrier	*Circus cyaneus*	-	SSC	P
Sharp-shinned hawk	*Accipiter striatus*	-	SSC	P
Cooper's hawk	*Accipiter cooperii*	-	SSC	P
Goshawk	*Accipiter gentilis*	FS	-	P
Swainson's hawk	*Buteo swansonii*	-	ST	P
Ferruginous hawk	*Buteo regalis*	FSC	-	P
Golden eagle	*Aquila chrysaetos*	-	SP	P
Merlin	*Falco columbarius*	-	SSC	P
Peregrine falcon	*Falco peregrinus*	FE	SE, SP	P
Prairie falcon	*Falco mexicanus*	-	SSC	P
Blue grouse	*Dendragapus obsurus*	-	SSC	P
Sandhill crane	*Grus canadensis*	-	ST	P
Black tern	*Chilidonias niger*	-	SSC	P
Northern spotted owl	*Strix occidentalis caurina*	FT	-	K
Long-eared owl	*Asio otus*	-	SSC	P
Black swift	*Cypseloides niger*	-	SSC	P
Vaux's swift	*Chaetura vauxi*	-	SSC	P
Willow flycatcher	*Empidonax traillii*	FS	SE	P
Purple martin	*Progne subis*	-	SSC	P
Bank swallow	*Riparia riparia*	-	ST	P
Yellow warbler	*Dendroica petechia*	-	SSC	P
Yellow-brested chat	*Icteria virens*	-	SSC	P
Tricolored blackbird	*Agelaius tricolor*	FSC	SSC	P

Table 3-14
Special Status and Protected Wildlife Species Known or Potentially Occurring within the Upper Clear Creek Watershed *(continued)*

Common Name	Scientific Name	Status Fed	Status State	Occurrence
Mammals				
Pacific western big-eared bat	*Plecotus townsendii*	FSC	-	P
Pallid bat	*Antrozous pallidus*	-	SSC	P
Ringtail	*Bassariscus astutus*	-	SP	P
Marten	*Martes americana*	FS	-	P
Pacific fisher	*Martes pennanti*	FSC	SSC	K
California wolverine	*Gulo gulo*	FSC	ST	K
White-footed vole	*Arborimus albipes*	FSC	-	P

Status Definitions: FE = Federally Endangered; FT = Federally Threatened; FSC = Federal Species of Concern; SE = State Endangered; SP = State Protected; ST = State Threatened; SSC = State Special Concern; FS = Forest Service Sensitive; STE = Shasta-Trinity National Forest Emphasis
Occurrence: K = Known; P = Potential

Source: Adapted from (a) BLM 1997; (b) NPS 1997; (c) FS 1994
Status verified from CDFG 1998a, 1998b, 1998c, 1998d; FWS 1995a, 1995b, 1996

The California wolverine uses caves, logs, or burrows for cover and den in high elevation habitats and can travel long distances to hunt in open areas. A California wolverine was sighted in the Fivemile Gulch sub-watershed, near the drainage divide, or ridgeline between the upper Clear Creek and the Trinity watersheds.

The FS Pacific Southwest Region (Region 5) has designated certain animal and plant species as "sensitive" (FS 1994), indicating that these species require special management considerations due to low or unknown population numbers and/or the potential for their habitats to be degraded (FS 1994). Sensitive wildlife species in the Shasta-Trinity National Forest include the goshawk, marten, pacific fisher, and willow flycatcher. Goshawk and Pacific fisher sightings have been described above. One marten sighting has been documented on the Shasta-Trinity National Forest in the Slate Creek sub-watershed south of the Clear Creek LSR. The marten is a close relative of the Pacific fisher and is generally found on large, contiguous tracts of mature and over-mature mixed conifer, Douglas-fir, red fir and lodgepole pine above 4,000 feet (FS 1994).

3.3.5 Survey and Manage Species

Survey and manage species include specific uncommon and endemic amphibians, mammals, bryophytes, mollusks, vascular plants, mosses, fungi, lichens, and arthropods that are known to occur on forested lands within the range of the northern spotted owl. Table C-3 in the Standards and Guidelines (USDA, USDI 1994) has identified 408 species that are known to occur on federal lands within the range of the northern spotted owl. Based on distributions published in 1994 (USDA, USDI 1994), at least 78 of these species are known or suspected to ccur on lands within the Shasta-Trinity National Forest's boundaries (Table 3-15). It is unknown whether these species actually occur in the Upper Clear Creek Watershed.

Table 3-15
Survey and Manage Species Known or Suspected to Occur on Federal Lands within the Shasta-Trinity National Forest

Survey and Manage Species	Management Category			
	1	2	3	4
FUNGI				
Mycorrhizal Fungi				
Boletes, low elevation				
Boletus piperatus			X	
Tylopilus pseudoscaber	X		X	
Rare Boletes				
Boletus haematinus	X		X	
Boletus pulcherrimus	X		X	
False Truffles				
Nivatagastrium nubigenum	X		X	
Rhizopogon truncatus			X	
Rare False Truffles				
Arcanegeliella lactarioides	X		X	
Chanterelles – Gomphus				
Gomphus bonarii			X	
Gomphus clavatus			X	
Gomphus floccosus			X	
Gomphus kauffmanii			X	
Rare Chantrelle				
Chantrelle cantharellus	*X*		*X*	
Rare Gilled Mushrooms				
Cortinarius verrucisporus	X		X	
Uncommon Ecto-Polypores				
Albatrellus ellisii			X	
Albatrellus flettii			X	
Rare Ecto-Polypores				
Albatrellus avellaneus	X		X	
Tooth Fungi				
Hydnum repandum			X	
Hydnum umbilicatum			X	
Phellodon atratum			X	
Sarcodon fuscoindicum			X	
Sarcodon imbricatus			X	
Saprobes (Decomposers)				
Rare Gilled Mushrooms				
Clitocybe subditopoda	X		X	
Clitocybe senilis	X		X	
Rhodocybe nitida	X		X	
Bondarzewia Polypore				
Bondarzewia montana	X	X	X	
Rare Cup Fungi				
Aleuria rhenana	X		X	
Helvella compressa	X		X	
Helvella crassitunicata	X		X	
Helvella elastica	X		X	
Helvella maculata	X		X	

Table 3-15
Survey and Manage Species Known or Suspected to Occur on Federal Lands within the Shasta-Trinity National Forest *(continued)*

Survey and Manage Species	Management Category			
	1	2	3	4
Branched Coral Fungi				
Clavulina cinerea			X	X
Clavulina cristata			X	X
Clavulina ornatipes			X	X
Mushroom Lichen				
Phytoconis ericetorum			X	X
Cauliflower Mushroom				
Sparassis crispa			X	
Moss Dwelling Mushrooms				
Cyphellostereum laeve			X	
Galerina atkinsoniana			X	
Galerin cerina			X	
Galerina heterocystis			X	
Galerina sphagnicola			X	
Galerina vittaeformis			X	
Richenella setipes			X	
LICHENS				
Rare Nitrogen-Fixing Lichens				
Lobaria hallii	X		X	
Riparian Lichens				
Ramalina thausta				X
Usnea longissima				X
Rare Oceanic Influenced Lichens				
Bryoria spiralifera	X		X	
Bryoria subcana	X		X	
Niebla cephalota	X		X	
BRYOPHYTES				
Antitrichia curtipendula				X
Douinia ovata				X
Kurzia makinoana	X	X		
Ptilidium californicum	X	X		
Scouleria marginata				X
AMPHIBIANS				
Shasta salamander	X	X		
MAMMALS				
Red tree vole (P. longicaudus)		X		
MOLLUSKS				
Helminthoglypta hertleini	X	X		
Monadenia chaceana	X	X		
Monadenia churchi	X	X		
Monadenia troglodytes troglodytes	X	X		
Monadenia troglodytes wintu	X	X		
Trilobspsis roperi	X	X		
Trilobopsis tehamana	X	X		
Vespericola pressleyi	X	X		
Vespericola shasta	X	X		
Prophysaon dubium	X	X		
Fluminicola n. sp. 14	X	X		

Table 3-15
Survey and Manage Species Known or Suspected to Occur on Federal Lands within the Shasta-Trinity National Forest *(continued)*

Survey and Manage Species	Management Category			
	1	2	3	4
Fluminicola n. sp. 15	X	X		
Fluminicola n. sp. 16	X	X		
Fluminicola n. sp. 17	X	X		
Fluminicola n. sp. 18	X	X		
Fluminicola seminalis	X	X		
Juga (O.) n. sp. 3	X	X		
Lyogyrus n. sp. 3	X	X		
Vorticifex n. sp. 1	X	X		
VASCULAR PLANTS				
Allotropa virgata	X	X		
Arceuthobium tsugense	X	X		
Botrychium montanum	X	X		
Clintonia andrewsiana	X	X		

1. Adapted from Table C-3 in Standards and Guidelines (USDA, USDI 1994) and Table 1 in Foster-Wheeler report to California Forestry Association (Foster-Wheeler 1995).
2. Information regarding the location of survey and manage species may be found in Appendix J2 (Results of Additional Species Analysis) of the *Final Supplemental Environmental Impact Statement on Management of Habitat for Late-Successional and Old-Growth Forest related Species within the Range of the Northern Spotted Owl* (USDA, USDI 1994).

Management requirements are based on four categories. Management for category 1 species requires that activities implemented during or after 1995 must include identification and provisions (which, in most cases include protection zones) for all known locations of survey and manage species. Category 2 species require the development of survey protocols, site-specific surveys using survey protocol, and implementation of management prescriptions defined prior to any ground-disturbing activity. Category 3 species require extensive regional surveys (rather than site-specific surveys) on a routine basis to locate and provide protection zones for high priority sites. Similarly, category 4 species require regional surveys (rather than site-specific surveys) on a routine basis to gather additional information that can further refine management standards and guidelines. The level of compliance with these management requirements for survey and manage species is unknown at this time; results of compliance status should be compiled from FS, and BLM management staff.

3.4 SOILS AND EROSION

3.4.1 Issues

Soil erosion is a function of the structure and lithology of the underlying geology, composition and texture of soil type, natural processes of gravity, weathering and runoff, and the amount of natural or human-induced disturbance. Accelerated erosion can occur in areas where bedrock and soils are structurally weak and where natural events and land use activities have disturbed land, changed surface slopes, and denuded soils of vegetation. Resource managers are interested in examining the distribution, lithology, and structure of underlying geology and soils in the upper Clear Creek watershed, and in determining the location and causes of accelerated erosion. They are also interested in determining the impacts of sediment deposition on the hydrologic and ecologic functions of the watershed.

3.4.2 Existing Conditions – Geology

Bedrock and Surficial Geology

The geologic formations found within the upper Clear Creek watershed include sedimentary, metasedimentary, and volcanic rocks. The five major geologic formations found in the area include the Copley greenstone, Balakala rhyolite, metasedimentary Kennett Formation, sedimentary Bragdon Formation, and granitic Shasta Bally batholith (see Figure 1-7).

The Copley greenstone is the oldest formation found in the upper watershed and is believed to be Middle Devonian. It is composed of mafic volcanic material (consisting of pillow lavas, massive flows, flow breccia, coarse- and fine-grained pyroclastic material, minor tuffaceous shale, and shale), which crops out in a belt one to two miles wide between Shasta Bally, a granitic batholith on the west, and the Mule Mountain stock on the east (Albers 1964). It is best exposed in the Grizzly Gulch area north of the Oak Bottom Campground.

The Balakala rhyolite both overlies and intertongues with the Copley greenstone. It consists of light-colored extrusive and intrusive siliceous lava flows, flow breccia, and pyroclastic rocks. Outcroppings of the Balakala rhyolite can be found in the area of Whiskey Creek near the Mad Ox mine and in the area between Boulder Creek and Trail Gulch. In the upper watershed, the Balakala rhyolite is overlain in some areas by the Kennett formation in other areas by the Bragdon formation.

The Kennett formation consists of grey to black cherty shale, with beds one to two inches thick that include poorly preserved Radiolarian fossils and that easily cleave along parting planes. The Kennett formation is very highly fractured and contorted, with quartz commonly found infilling fractures. The Kennett formation lies as a discontinuous belt between the Balakala rhyolite and shale rocks of the Bragdon formation. Repetition of beds by folding and faulting increase the apparent thickness of this formation to 400 feet; however, the actual thickness of this formation is probably much less. Small outcrops of the Kennett formation are exposed between Mad Mule Mountain and Shirttail Peak.

The majority of the upper watershed is underlain by fine- and coarse-grained rocks of the Bragdon formation, which is Mississippian in age. The Bragdon formation is greater than 6,000 feet thick, with a lower section, approximately 4,500 feet thick, consisting mainly at shale, mudstone, and siltstone, with lesser amounts of sandstone, conglomerates, and mafic tuff. The upper section of the Bragdon formation is approximately 1,500 feet thick and consists of coarse clastic material, including sandstone, grit, and conglomerate. Intrusive rocks, quartz veins and sheared and faulted contacts are found in places where the Bragdon formation directly overlies the Copley greenstone, indicative of the deformation and mineralization caused by the intrusion of the Copley greenstone formation.

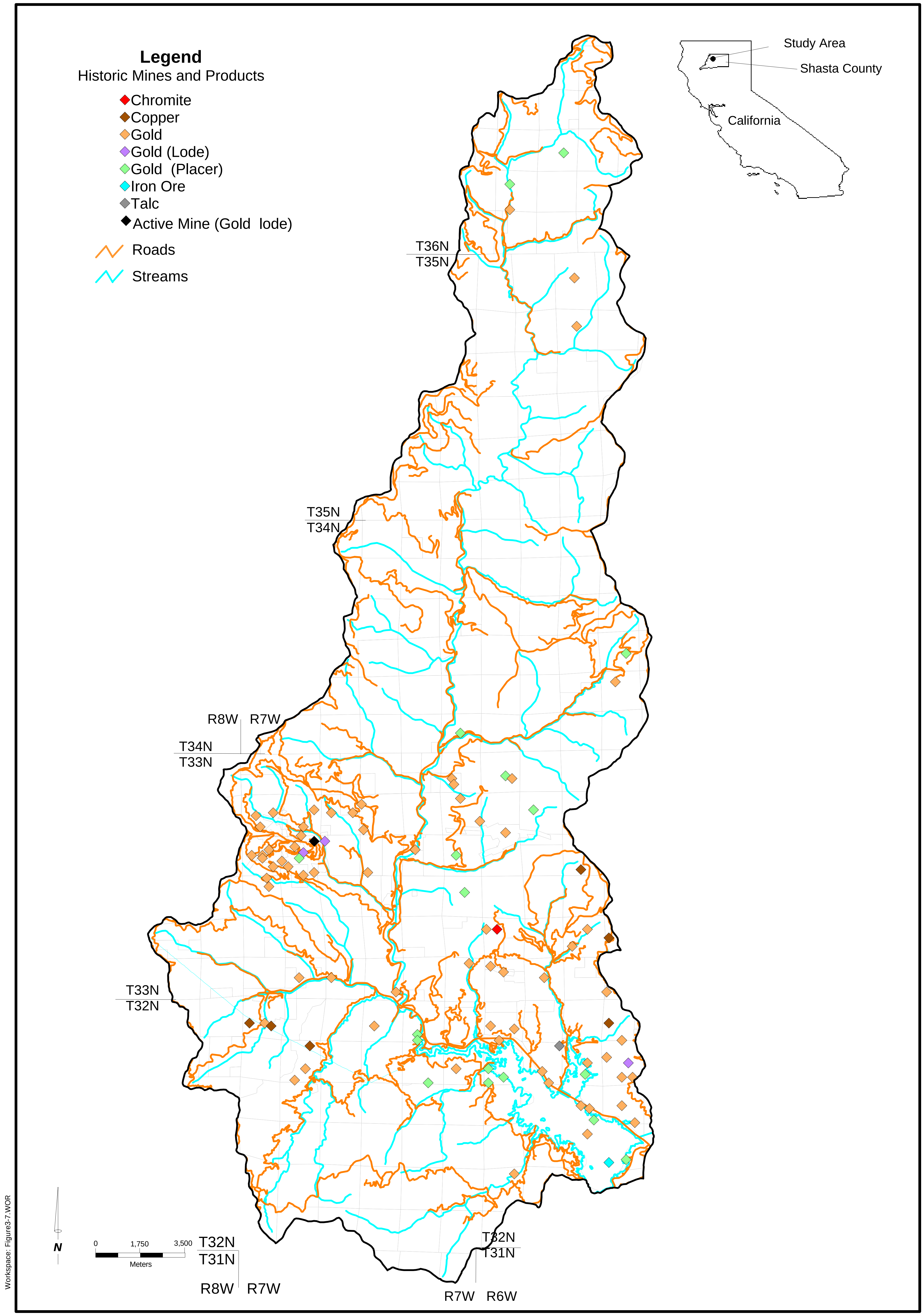
Shasta Bally is the most prominent mountain in the upper watershed, with a peak elevation of 6,209 feet. It is underlain by the Shasta Bally batholith, which is composed of light-colored granitic rock (consisting of quartz diorite and granodiorite). A narrow band of fine-grained amphibolite and banded gneiss, formed from contact metamorphism with rocks of the Copley greenstone, Balakala rhyolite, and Bragdon formation, exist along the northeast side of the batholith. Shasta Bally lies in the southeastern portion of the Whiskeytown unit, approximately two miles from the south shore of Whiskeytown Lake. It is deeply weathered along minor ridges and hillslopes, and soils made from the decomposed granite are easily erodible.

A number of normal faults occur in the lower half of the upper Clear Creek watershed. These faults are common in all rocks other than the Shasta Bally batholith. Major faults include the Hoadley fault, Shirttail fault, and the French Gulch fault. The French Gulch fault is one of the system of east- and northeast-trending faults that apparently controls the distribution of gold quartz veins in the French Gulch mining district (Albers 1964). A small number of faults are also found north of Damnation Peak, at the very northern end of the upper watershed.

Mineral Resources

Mineral resources in the upper watershed include chromite, copper, gold, talc, and iron ore. Gold was the dominant mineral resource mined in the area, producing over 30 million dollars between its discovery in 1848 and 1942, when most mining operations ceased. Although absolute boundaries do not exist, mine sites in the upper watershed are considered to be part of the French Gulch Mining District. According to the CDMG database, as many as 97 historic mine sites were operated in the past (Figure 3-7). Most of the mine sites in the upper watershed exist in the French Gulch, Cline Gulch, Grizzly Gulch, and Whiskeytown Lake HSA watersheds.

Historically, gold placer deposits were dredged from the Clear Creek and East Fork Clear Creek channels and adjacent terrace deposits. Gold lode deposits were mined from underground and pit mines that traversed gold-bearing quartz veins, formed between contacts with Copley greenstone and rocks of the Bragdon Formation. These veins commonly ranged from a few inches to several feet thick. Other lode and ore deposits were mined from underground or pit mines located throughout the watershed.



Projection: UTM NAD 27, Zone 10
Source: SPI, DFG, and DMG
Date Created:6/6/98
Draft:11/11/98

Active and Historic Mines in the Upper Clear Creek Watershed

Shasta County, California

Tetra Tech, Inc.

Figure 3-7

Commercial dredge and placer mining no longer occur in the upper Clear Creek watershed. Dredge tailings, however, cover a 10.4-mile reach along the mainstem Clear Creek and along a portion of the East Fork Clear Creek and contain large quantities of gravel. Mineral resources of the watershed are shown on Table 3-6.

Gold mining is currently conducted within the upper watershed at only one location: the Washington Mine (Figure 3-7). The Washington Mine is located on a prominent ridge on the west side of French Gulch across from the Milkmaid and Franklin Mines. The Washington Mine, discovered in 1852, is one of the oldest mines in the state and has produced over 2.5 million dollars worth of gold ore (Ferguson 1914; Albers 1965). The Washington Mine was developed by about six principal levels that extended through a vertical distance of about 450 feet, and by numerous pits and trenches (Albers 1965). The Washington-Niagra Group out of Rib Lake, Wisconsin, are the current operators of the Washington Mine.

The remaining open pit and underground mining sites that exist in the upper watershed have since been abandoned, and some of them pose a hazard to personal safety, soil erosion, and water quality because of their degraded physical condition. Many of the mines have been sealed or are in the process of hazard abatement evaluation. While most mines generally provide poor value as potential habitat, some bats, including Townsends big-eared bats (*Plecotus townsendii*), a species of special concern, and other small mammals and reptiles have been found using some of the mines. Most of the abandoned mines occur on lands managed by the NPS (in the Whikeytown Unit) and by BLM (in the ISRMA and WFGMA).

NPS staff members, C. Harvey and G. Ring, surveyed a representative group of 22 abandoned mining sites in the Whiskeytown Unit in June and July of 1993 in order to assess impacts of mine hazard abatement on biological resources in the area. Abandoned mine sites in the Whiskeytown Unit include those found in the Crystal Creek, Grizzly Gulch, Boulder Creek, Brandy Creek, Whiskey Creek, and Whiskeytown Lake HAS watersheds. All of the mines in the unit are considered dangerous and a hazard to the visiting public (Harvey and Ring 1993).

While most of the sites showed signs of "greatly degraded natural and constructed watercourses related to mine operations," Harvey and Ring suggest that little erosion danger currently exists because they are already "blown out" and no longer provide a significant source of sediment. However, the NPS Whiskeytown Mines General Report/database contains notes that additional slumping and rockfall at some sites was observed during surveys conducted in 1994, indicating that some of these mine sites may continue to be erosion hazards.

Townsends big-eared bats (*Plecotus townsendii*) were positively identified at one mine adit (Ganim #2), and other bats, tentatively identified as *Myotis* species (probably *Myotis lucifugus*), were observed in the main adit of the Northstar Mine. Abatement methods described to the reduce safety and erosion hazard of these mine sites include signing and fencing off the hazard areas, and using polyurethane foam plugs, permanent concrete bulkheads or backfill to seal the mines. Additionally, mine hazard abatement methods include installing bat gates or grates where bats have been observed, or have the potential to exist, as mitigation for threatened and endangered bat species.

Abandoned mine land surveys were also conducted for at least 20 abandoned mines found on BLM lands in the upper watershed. The main hazards that are found at these sites include adit and shaft tunnels, tailings, and waste/ore piles. Many of the adits are partially blocked (30 to 90 percent) by shale and unconsolidated rubble. Bats were observed at the Franklin Mine (located up French Gulch), and bear tracks were observed near the Old American Mine (located in Cline Gulch). Use by other large mammals was suggested at a mine site located near Centennial Gulch. Water found near many of these mine sites was described as slightly acidic to weakly alkaline (pH 6 to 8; based on litmus tests).

Table 3-16
Mineral Resources Mined in the Upper Clear Creek Watershed

Watershed	Chromite Mines	Copper Mines	Gold Mines	Iron Ore Mines	Talc Mines
Blodgett Creek	-	-	1 lode 2 placer	-	-
Damnation Creek	-	-	-	-	-
Stacey Creek	-	-	2 lode mines	-	-
Slate Creek	-	-	-	-	-
Brush Creek	-	-	-	-	-
Dodge Creek	-	-	-	-	-
Big Gulch	-	-	-	-	-
Whitney Gulch	-	-	-	-	-
East Fork Clear Creek	-	-	2 lode mines 3 placer mines	-	-
Fivemile Gulch	-	-	-	-	-
Cline Gulch	-	-	6 lode mines 3 placer mines	-	-
French Gulch	-	-	23 lode mines 1 active lode mine 1 placer mine	-	-
Whiskey Creek	-	3 mines	5 lode mines	-	1 mine
Yankee Creek	-	-	4 lode mines	-	-
Grizzly Gulch	1 mine	-	5 lode mines 3 placer mines	-	-
Trail Gulch	-	2 mines	1 lode mine	-	-
Crystal Creek	-	1 mine	2 lode mines	-	-
Boulder Creek	-	-	2 placer mines	-	-
Dry Creek	-	-	-	-	-
Brandy Creek	-	-	1 lode mine	-	-
Whiskeytown Lake HAS	-	-	14 lode mines 5 placer mines	1 mine	-

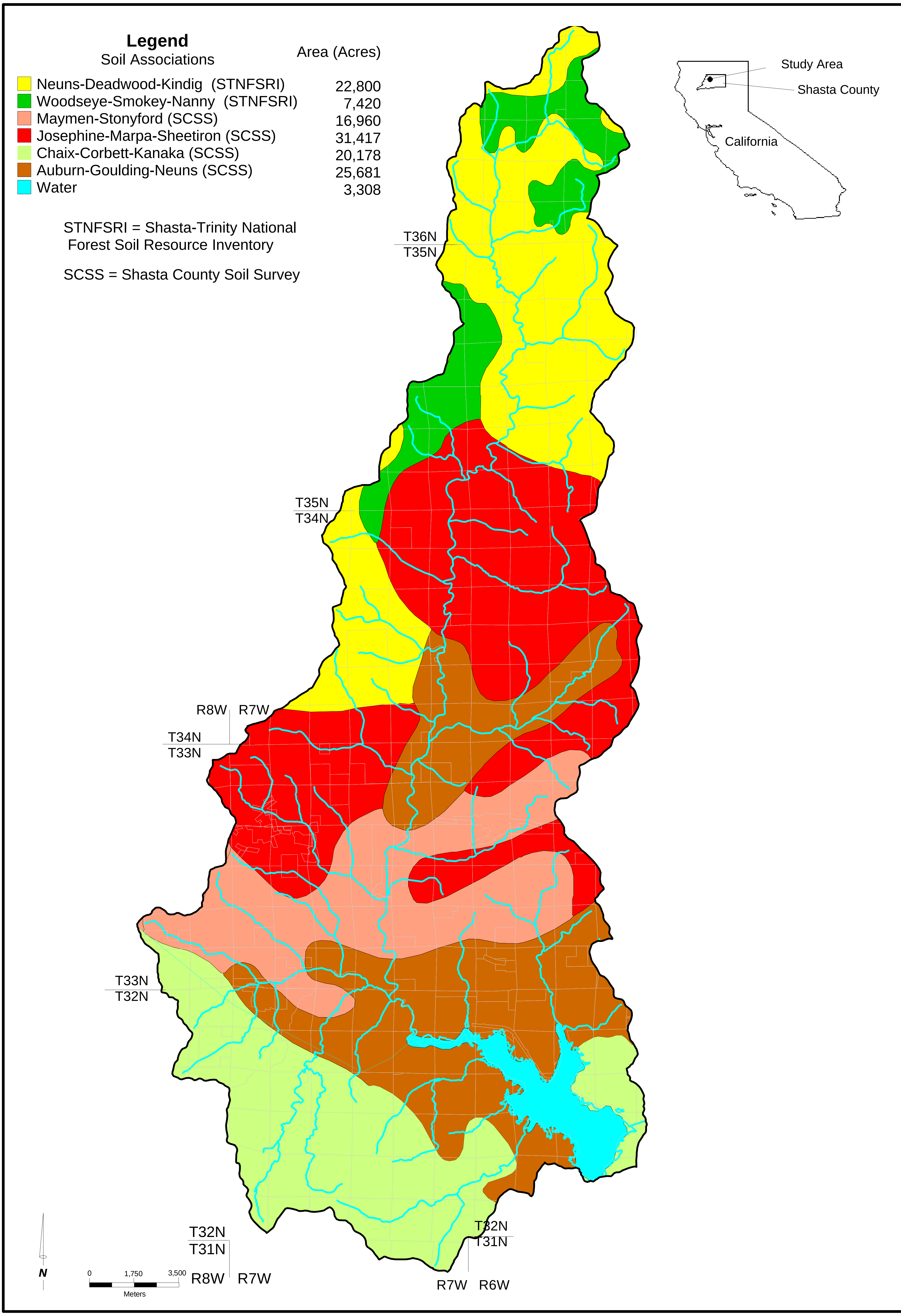
3.4.3 Existing Conditions – Soils

Information on the soils found in the upper Clear Creek watershed have been gathered from the Shasta County Soil Survey (USDA, Soil Conservation Service 1974), FS Soil Resource Inventory Report for the Shasta-Trinity National Forest (FS 1982), the FS report *Soils and Vegetation of the French Gulch Quadrangle* (Mallory et al. 1973), and GIS data obtained from the State Soil Geographic (STATSGO) database developed by the National Cooperative Soil Survey (USDA, NRCS). The Shasta County Soil Survey describes soils found within the Whiskeytown National Recreation Area, administered by the NPS, and the ISRMA and WFGMA, administered by BLM. The USDA FS Soil Resource Inventory describes soils found with the Shasta-Trinity National Forest, administered by the FS. Soils and vegetation associations described by Mallory et al. (1973) cover only the lower half of the upper watershed south of Highland Ridge (near Fivemile Gulch) and Shirttail Peak (near East Fork Clear Creek), and so are used to further describe soils and vegetation associations found within BLM and NPS lands.

A general soil map for the upper Clear Creek watershed is shown in Figure 3-8, based on STATSGO GIS data, which uses soil associations described by the Shasta County Soil Survey and the FS Soil Resource Inventory. Soil associations are based on groupings of one or two major (and usually one minor) soil series that are commonly found in distinctive proportions over landscapes having similar physiographic features. Soil series included in soil associations usually share similar soil characteristics, such as lithology, slope, and erosion hazard. Soil associations have been grouped as mountain soils, foothill soils and terrace soils based on differences in physiographic features and parent rock material. Mountain soils in the upper watershed include the Josephine-Marpa-Sheetiron association (JSMA), Chaix-Corbett association (CCA), Maymen-Stonyford associaiton (MSA), Neuns-Deadwood-Kindig families (NDKF), and Woodseye-Smokey-Nanny association (WSNA). Foothill soils in the upper watershed are represented by the Auburn-Goulding-Neuns soil association. Churn soils are the main terrace soils in the watershed. Table 3-17 shows the physical characteristics of the main soil series found in these soil associations.

In some areas of the upper watershed soils have not had time to form or accumulate due to natural or anthropogenic disturbances or high rates of erosion. These miscellaneous land types include cobbly alluvial land, colluvial land, gravel pits, landslides, river wash, rockland and rock outcrops, and tailings and placer diggings.

The soil associations and miscellaneous land types found in the upper Clear Creek watershed are described below (and listed in Appendix C with the map unit classification and soil survey reference).



Projection: UTM NAD 27, Zone 10
Source: DFG and SPI
Date Created: 5/19/98
Draft:11/11/98

General Soils Map for the Upper Clear Creek Watershed

Shasta County, California

Tetra Tech, Inc.

Figure 3-8

Table 3-17
Main Soil Types found in the Upper Clear Creek Watershed

Soil Series	Percent Slope	Parent Material	Depth to Bedrock (inches)	Drainage	Permeability	Soil K Factor	Erosion Hazard
Mountain Soils							
Auberry	3-70	Gr	30-60	G	M		H-VHS
Chaix (and Chawanakee)	8-70+	Gr	18-60	G-E	MR		H-VH
Corbett	0-70+	Gr	24-60+	E	R		VH
Holland	0-70+	Gr	24-72+	G	M		H
Josephine	0-70	SS/SH	30-60+	G	M		M
Kanaka	0-70	Gr	20-40+	E	MR		H-VHS
Marpa	0-70+	SH/SS	20-40	G	M		M
Maymen	0-70+	SS/SH	4-20	E	M-R		M-HS
Stonyford	8-70	Mi/s	12-28	G-E	M-S		M-H
Sheetiron	30-70	Ms	21-42	G-E	M		M
Sites	0-70	Ms	36-60+	G	M		M
Skalan	40-60	M	40				L
Hugo	40-60	Mi/s	68				M
Deadwood	40-60	M	17				L
Etsel	40-80	SH	12				M
Skymor	40-80	Mi	17-19				L
Foothill Soils							
Auburn	8-70	Sch/Mi/s	10-28	G	M		M
Boomer	0-70	Mi	30-56	G-E	M-MR		M-HS
Goulding	8-70+	Mi	8-25	G-E	M		M-HS
Kidd	30-70+	Rhy	5-18	G-E	M-R		H-VHS
Neuns	0-70+	Mi	20-40	G-E	M		M-H
Terrace Soils							
Churn	0-30	Al	60+	G-MG	S-M		L-M

Parent Material: Gr: granitic; M: metamorphic; i: igneous; s: sedimentary; SS: sandstone; SH: shale; Sch: schistose; Rhy: rhyolitic; Al: alluvium
Drainage: G: good; E: excessive; M: moderate; MG: moderately good
Permeability: M: moderate; MR: moderately rapid; R: rapid; S: slow
Erosion Hazard: L: low; M: moderate; H: high; VH: very high; S: on slopes over 50 percent.

Mountain Soils

Mountain soils are found on nearly 124,450 acres, or 77 percent, of the upper Clear Creek watershed. Mountain soils include well-drained to excessively well- drained sandy loams, gravelly loams, and gravelly clay loams, formed from granitic and metamorphic rocks. Weathering of metamorphic and sedimentary rocks occurs along fractures and cleavage planes of structurally weak and less resistant clay layers. Weathering of these rocks leads to highly erosive tallus slopes and fine-grained sediment with a high clay content. Weathering of granitic rocks in the current climate regime of the area produces coarse textured particles with low clay content. These soils are friable and crumble easily, creating loose, unconsolidated sediment susceptible to erosion by wind and water. Mountain soils are generally found on moderate to steep to very steep slopes at elevations that range from 800 to 5,000 feet. Fire control on mountain soils is difficult because soils are steep and slopes are irregular. Weathered granite soils are found in the area of Shasta Bally and the Mule Mountain Stock in the southern end of the upper water-watershed, while the other mountain soil associations are found mainly north and west of the Willow Creek confluence.

The following gives a brief description of the different mountain soil associations found in the upper Clear Creek watershed (unless otherwise noted, descriptions have been taken from the Shasta County Soil Survey):

The Josephine-Marapa-Sheetiron association (JMSA)
JMSA is characterized by moderate to steep slopes, well-drained and somewhat excessively drained gravelly and very gravelly loams and clay loams underlain by sedimentary and metamorphic rocks of sandstone, shale and slate. The JMSA is made up of 30 percent Josephine, 25 percent Marpa, 15 percent Sheetiron, and 30 percent other (including Maymen and Sites) soils. JMSA soils are generally 18 to 60 inches deep, are found on hilly to very steep terrain, and have moderate erosion potential. These soils are mainly used for timber production; vegetation includes conifer-hardwood communities (including Douglas-fir, pine, oak and shrubs). Other uses include mining, recreation, wildlife habitat, and watershed.

Chaix-Corbett association (CCA)
The CCA is characterized by gently sloping to very steep, well-drained to excessively drained sandy loams and loamy coarse sands underlain by granitic rocks. The CCA is made up of 45 percent Chaix, 25 percent Corbett, and 30 percent other (including Holland and Kanaka) soils. CCA soils are generally 18 to 40 inches deep, are found on rough terrain in narrow valleys and ridgetops, and have high to very high erosion potential. These soils are generally used for timber production, wildlife habitat, and watershed; vegetation on these soils is mainly trees (including Ponderosa pine, Douglas-fir, white fir, and oak) with an understory of shrubs and a sparse cover of brush or grass.

Maymen-Stonyford association (MSA)
The MSA is characterized by steep and very steep, somewhat excessively drained and well-drained gravelly loams and gravelly clay loams underlain by sedimentary, metamorphic, and metamorphosed basic rocks of sandstone, shale, conglomerate, schist, and greenstone. The MSA is made up of 50 percent Maymen, 35 percent Stonyford, and 15 percent other (including Rockland, Boomer, Neuns, and Goulding) soils. MSA soils are generally 6 to 20 inches deep, are found on the sides of steep and very steep, entrenched valleys and narrow ridgetops, and have a moderate to high erosion potential. MSA soils are vegetated with chaparral made up of brush, a sparse understory of grass, and shrubs dominated by chamise and ceanothus, which when burned readily regenerate from subaerial root systems and cover the surface within a few years. These soils provide only a small amount of forage for livestock and so are generally used for watershed.

Neuns-Deadwood-Kindig families (NDKF)
The NDKF (as described in the FS Soil Resource Inventory) is characterized by gentle to steep slopes, well-drained gravelly loams and gravelly clay loams formed from metamorphosed shale. The NDKF is made up of 50 percent Neuns, 25 percent Deadwood, and 25 percent other (including Kindig and

Marpa) soils. NDKF soils are generally 17 to 40 inches deep, are found on simple, steep to very steep, moderately to highly dissected mountain side slopes with sharp ridges, and have a low to moderate soil erosion potential. These soils are generally used for timber production, wildlife habitat and watershed; typical vegetation on NDKF soils includes Douglas-fir-Pine mixed conifer forest and mixed conifer-Canyon Oak forest.

Woodseye-Smokey-Nanny association (WSNA)
Neither the Woodseye nor Smokey soil series is described in the Shasta County Soil Survey or the FS Soil Resource Inventory. The Nanny soil series is described in the FS Soil Resource Inventory (1982) and is characterized by moderate slopes, fine-grained sandy loams to gravelly and cobbly sandy loams that are underlain by slightly acid gravels and cobbles. These soils are generally 20 to 60 inches deep, are found on the lower slopes of simple, shallowly dissected, steep to very steep mountainsides and along steep to very steep, rough to craggy ridges, and have a low erosion potential. Typical vegetation found on these soils includes mixed coniferous forest, white fir forest and upper montane mixed chaparral.

Foothill Soils

Foothill soils cover 25,681 acres, or 20 percent, of the upper watershed. Within the upper watershed, foothill soils of the Auburn-Goulding-Neuns association (AGNA) are found on rolling to steep hillsides at elevations generally below 3,000 feet. They occupy about 18,390 acres north, south and west of Whiskeytown Reservoir, and 7,291 acres along the mainstem Clear Creek (between French Gulch and Whitney Gulch), and the East Fork Clear Creek. The following is a brief description of the foothill soils found in the upper Clear Creek watershed:

Auburn-Goulding-Neuns association (AGNA)
The AGNA is characterized by flat to very steep, well-drained gravelly loams, clay loams, and very gravelly silty clay loams underlain by partly metamorphosed volcanic rocks and fractured greenstone. The AGNA is made up of 30 percent Auburn, 30 percent Goulding, 15 percent Neuns and 25 percent other (including Boomer, Diamond Springs) soils. AGNA soils are generally 12 to 40 inches deep, are found on sides of narrow valleys in upper elevations and broad valleys in lower elevations, and have moderate to high soil erosion potential.

Terrace Soils

Terrace soils make up a minor portion of the upper Clear Creek watershed. They are found along the mainstem Clear Creek between Big Gulch and the Willow Creek confluence. Terrace soils found in the upper watershed include Anderson, Churn, Newton, Red Bluff, and Redding soil series. Anderson and Churn soils are moderately well-drained to somewhat excessively drained gravelly sandy loams and gravelly loams. They occur on low terraces between the alluvial floodplain and high terraces and were formed from recent alluvium of mixed sources. Newton, Red Bluff and Redding soils are well-drained and moderately well-drained gravelly and stony loams formed from older alluvium of mixed sources. Newton soils are found on moderately sloping to steep sides of terraces, Red Bluff soils are found along terrace tops, and Redding soils, which have a hardpan of indurated gravel about 13 inches below the surface, are found on high hummocky terraces.

Miscellaneous Land Types

Tailings and Placer Diggings

This land type occurs in areas that have been mined for gold by placer mining or dredging. Within the upper watershed, tailings and placer diggings occur along the East Fork Clear Creek tributary and the mainstem Clear Creek between the East Fork and the Willow Creek confluence. Dredge tailings occur on floodplains and low terraces, while placer diggings occur on high terraces. Dredge tailings are usually long, parallel steep ridges of cobbles and gravels separated by narrow troughs that may fill with water in the winter. Ridges are often bare, but troughs may contain sparse stands of cottonwood and willow. Placer diggings are irregular, random piles of cobbles and gravelly alluvium generally three to eight feet high. The height of the diggings and alluvial banks can become very steep and can reach 15 to 60 feet high. Vegetation on placer diggings is usually dense and can include manzanita, poison oak, ceanothus, interior live oak, and Grey pine.

Colluvial Land

This land type consists of gravels and cobbles that accumulate at the base of steep slopes from the draw of gravity. Within the upper watershed, colluvial land is found in long narrow tracts along the canyon bottoms of most of the Clear Creek tributaries (including Big Gulch, Dodge Creek, Fivemile Gulch, East Fork, French Gulch, Cline Gulch, Trail Gulch, Sawpit Gulch, Willow Creek, Grizzly Gulch, Boulder Creek and Crystal Creek). Colluvial soils occur in the stream channels and adjacent areas of most of the perennial and intermittent tributaries and are subject to continuous or frequent flooding, depending on the flow conditions. Colluvium can consist of granite, metamorphic, and sedimentary rock, depending on the bedrock source. Colluvial lands are usually unstable and the surface is subject to movement from gravity and streamflow. Colluvial deposits range from shallow to very deep and often overlie bedrock or compacted colluvium. These unconsolidated sediments are excessively well-drained, generally have rapid runoff and have high erosion potential. Vegetation that does grow on these lands is similar to that on adjacent soils, but may have more canyon live oak and Douglas-fir.

Riverwash

This land type consists of nearly level or gently sloping sands and gravels that occur in stream channels and adjacent areas, subject to continuous or frequent flooding. Within the upper watershed, riverwash is found along the mainstem Clear Creek from just upstream of the Willow Creek confluence, downstream to the Mill Creek confluence near the Tower House area. Riverwash lands are excessively drained, have rapid permeability, and very high erosion potential.

Cobbly Alluvial Land

This land type consists of very gravelly, very cobbly, or very stony coarse textured alluvium that occurs in or adjacent to stream channels. Within the upper watershed, cobbly alluvial land occurs along the mainstem Clear Creek, north of Fivemile Gulch, and along a portion of the East Fork Clear Creek, between the First South Fork and the Third South Fork tributaries. This land type, which is frequently flooded, occurs as a somewhat continuous band of alluvium that is found between areas of rockland and bedrock outcrops. Runoff is vey slow, and erosion potential is moderate.

Rockland and Rock Outcrops

This land type consists of exposed bedrock outcrops and shallow soils that occur in nearly level to very steep uplands in the mountainous parts of the upper watershed. It also occurs in some areas along steep hillslopes adjacent to the mainstem Clear Creek and in tributary canyons. This land type can consist of granitic, metamorphic, and sedimentary rocks, depending on the location and underlying geology. Rockland may support vegetation similar to that of adjacent soils but with less grass and more drought resistant plant species, such as canyon live oak, manzanita, toyon, buckeye, and yerba santa. It may also support riparian vegetation, where it occurs adjacent to stream channels.

Landslides

Landslides consist of rock fragments, soil and rubble that have moved down slopes in geologically recent times due to physical processes that act upon a mass of material. Within the upper watershed this land type is found along the steep hillslopes of the East Fork Clear Creek and near Monarch Mountain, southwest of Whiskeytown lake. Landslides are mainly found near areas underlain by Josephine, Behemotosh, and Sites soils, where slopes are moderately steep to very steep. This land type, typically composed of a gravelly to stony mixture of soil and broken bedrock, is well-drained and has high erosion potential.

3.4.4 Existing Conditions – Soil Erosion

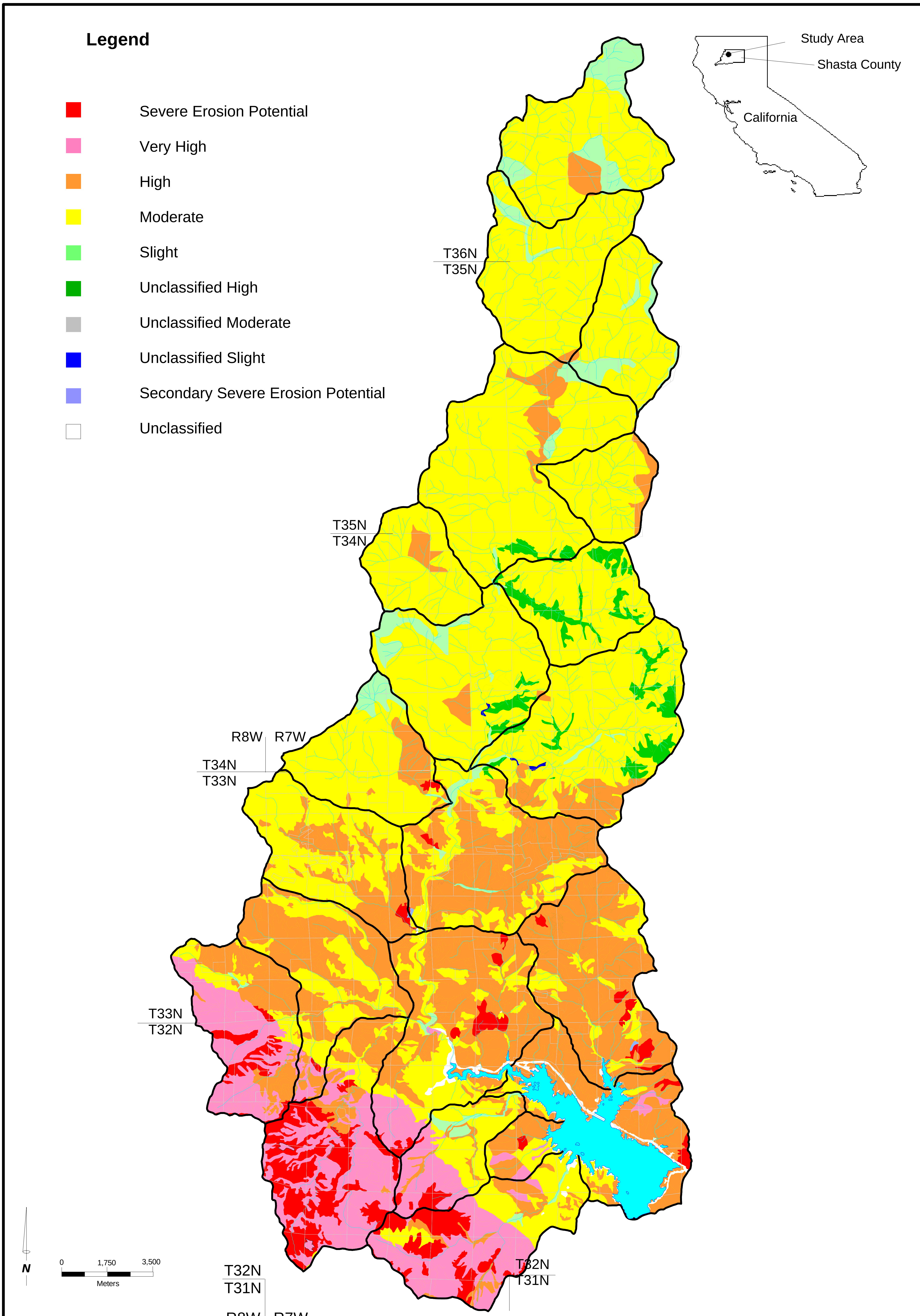
Soil erosion potential has been mapped within the upper Clear Creek watershed by the FS, the BLM, and the NPS, based on soil type or association, vegetative cover, and percent slope (Figure 3-9). Sources used by these agencies include the Shasta County Soil Survey (USDA, NRCS 1974) and the Soil Resource Inventory of the Shasta-Trinity Forest Area (FS 1982). BLM also used the FS report *Soils and Vegetation of the French Gulch Quadrangle* (Mallory et al. 1973) to determine erosion hazards in the ISRMA.

Erosion hazard is defined as the probable susceptibility of a soil to surface erosion on a 30 to 50 percent slope when all vegetation cover is removed (BLM 1997). Slopes in the upper watershed range from 0 to over 70 percent (Figure 3-10). The FS used a classification of high, medium, and low erosion potential. The BLM classified soil erosion potentials in the ISRMA into slight, moderate, high, and very high erosion potential; and the NPS used a classification of severity, noting areas of severe erosion potential and secondary severe erosion potential.

As described in the ISRMA Final Plan and EIS (BLM 1997), soils with high erosion hazard ratings include "colluvial and alluvial material found in narrow tracts along streams, drainages, and slopes. Colluvial soils range from shallow to very deep overlying rock or compacted colluvium. These soils are excessively drained and have moderate permeability. Other soils with a high erosion hazard rating are located on steep slopes with excessive drainage and rapid permeability." Soils with moderate erosion hazard ratings "occur mostly on slopes adjoining streams. They are normally well-drained to excessively drained, have moderate to rapid permeability, and slow to moderate runoff." Soils with slight erosion hazard ratings "…are normally located along streams and ridgetops" and "…are generally deep (greater than 36 inches) and have a high infiltration rate and a high rate of water transmission through the soil profile. They occur on slopes of less than 15 percent and are well-drained."

Areas of high erosion potential found on FS lands have been mapped west of Damnation Peak in the Blodgett Creek watershed, in the area surrounding the Clear Creek mainstem within the Slate Creek watershed, along the upper hillslopes at the eastern boundary of the Brush Creek watershed, in the Dodge Creek watershed south of Highland Ridge, and in an area at the base of Fivemile Gulch.

Soils with high erosion ratings have not been mapped within BLM lands in the upper Clear Creek watershed. Soils with moderate erosion hazard ratings on BLM lands in the ISRMA are found along the midslopes of the Big Gulch, East Fork, Cline Gulch, Grizzly Creek and Whiskey Creek subwatersheds. Soils with slight erosion hazard ratings are found within the Whiskey Creek subwatershed.



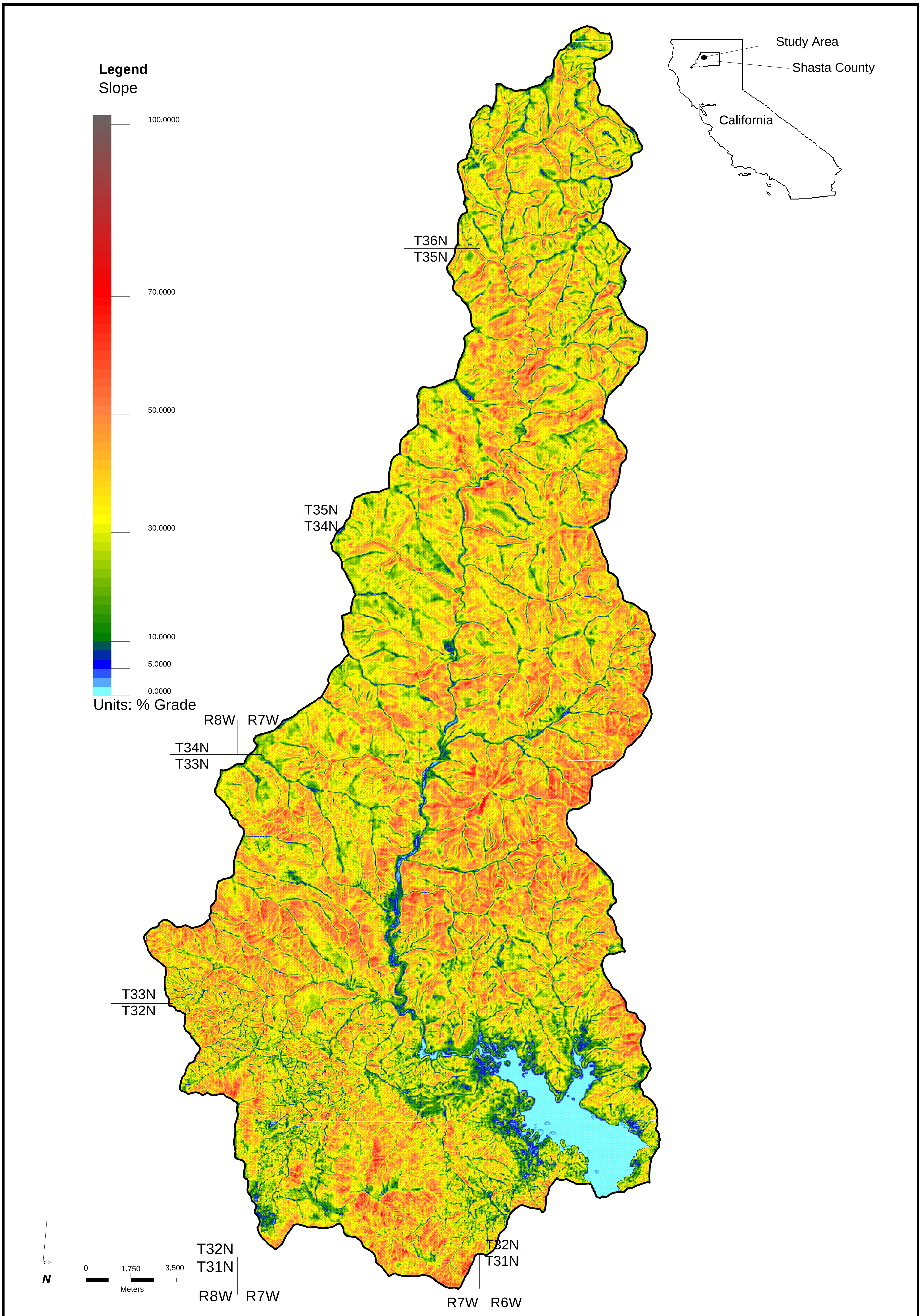
Projection: UTM NAD 27, Zone 10
Source: BLM, DFG, NPS, SPI, and USFS
Date Created:7/11/98
Draft:11/11/98

Soil Erosion Potential in the Upper Clear Creek Watershed

Shasta County, California

Tetra Tech, Inc.

Figure 3-9



Projection: UTM NAD 27, Zone 10
Source:Tetra Tech
Date Created: 5/19/98
Draft: 7/11/98

Distribution of Slope in the Upper Clear Creek Watershed

Shasta County, California

Figure 3-10

Tetra Tech, Inc.

Most areas of severe erosion potential on NPS lands in the Whiskeytown Unit are associated with decomposed granitic soils of the Shasta Bally batholith along the southwestern boundary. Two small areas of secondary severe erosion also occur along the southwestern boundary of the Whiskeytown Unit. Other areas of severe erosion potential (and small areas of secondary severe erosion potential) are located north of State Route 299 on the west side of South Fork Mountain Road, between South Fork Mountain and the Sunshine Mine.

Whiskeytown Reservoir is the final depositional zone for sediment within the upper watershed due to Whiskeytown Dam, which blocks further transport of bedload sediment downstream. No data exists, however, to show current sedimentation rates in Whiskeytown Reservoir (BOR 1998). The only measurements of sediment delivery in the upper watershed are suspended sediment discharge (in tons/day) measured at the French Gulch gage November 1962 to April 1963 and November 1963 to March 1964.

Suspended sediment discharge measured between November 1962 and April 1963 totaled 18,758 tons. Based on flow frequency analyses (described in section 3.1.2), 1963 is considered a normal water year, with a total average annual discharge of 155,200 acre-feet. Mean flows that year were 214 cfs, while peak flows reached 3,100 cfs. If we assume the suspended load measured at the French Gulch gage represents 58 percent of the total contribution from the watershed based on drainage area above the gage, the total annual contribution of suspended sediment to the Whiskeytown Reservoir during water year 1963 is estimated to have been 32,341 tons. If we assume this to be the average annual suspended load, we can calculate that a total suspended load of 1,099,594 tons have been transported to Whiskeytown Reservoir in the past 34 years. We can only assume that a significant amount of bedload sediment has likely been deposited in Whiskeytown Reservoir.

3.5 HUMAN USES

3.5.1 Issues

Various elements of the upper Clear Creek watershed hold some social value by the people who reside, work, and visit the area. These include residential, commercial, recreational, cultural and natural components of the watershed valued by humans for their utility, sense of history, enjoyment and aesthetic sense. Additionally, natural resource management in the watershed is intended to provide for future generations as well. It is therefore important to determine what features and functions of the watershed are of highest importance to residents and others who make use of the area. Land use zones, demographics and cultural heritage, water supplies, recreational opportunities, fuels management and fire protection, and transportation networks are important components of the human values and concerns regarding the upper Clear Creek watershed.

3.5.2 Existing Conditions

The Shasta County Planning Department maintains records of land use zoning for most (but not all) of the private lands (and some of the public lands) in the upper Clear Creek watershed as part of their French Gulch Planning Area. The dominant land use zones in the upper watershed/French Gulch Planning Area include rural residential, recreation, mining, commercial timber production, and natural habitat resource management.

The NPS, BLM, and FS administer public lands within the upper watershed, as described in Section 1.2. Public lands administered by the NPS are zoned as part of the National Recreation Area Whiskeytown Unit District. Special building district areas and special recreation districts are also found within the NRA Whiskeytown Unit District. Service buildings associated with the NPS are also located in Whiskeytown, at the Whiskeytown Dam overlook and along the southwest shore of Whiskeytown Lake. Public lands administered by the BLM include those zoned as timberland, mineral resource, mining district, agricultural forest district, and upland conservation district. The only land use zone shown for FS lands is agricultural forest. The remaining public lands in the upper watershed are managed to sustain and enhance ecosystem condition for vegetation and wildlife species. Non-consumptive uses of public lands include wildlife viewing, hiking, and nature photography.

Private lands in and around the town of French Gulch are zoned as part of the North and South Rural Community Center Plans and include lands zoned for rural residential, public facilities, rural recreation, trailer districts, open space, habitat reserve, and multiple use. Rural residential lands are found along the mainstem of Clear Creek between the town of French Gulch and the East Fork of Clear Creek, in some of the hill country immediately east of French Gulch, and along a small area on the East Fork Clear Creek. An open space zone has been defined along a 100-foot corridor on either side of the centerline of Clear Creek upstream of French Gulch Creek. Private lands throughout the rest of the upper watershed are zoned as timberland, mineral resource, agricultural grazing and natural habitat resource lands. Agricultural grazing lands are found adjacent to Clear Creek between Big Gulch and Slate Creek. The dominant land use on private lands outside of the French Gulch area is for commercial timber production.

The town of French Gulch supports a post office, school, and several service-oriented businesses. A county park is located along Clear Creek between French Gulch and Cline Creek, and an academic and outdoor wilderness adventure school, called the NAWA Academy, is located on Trinity Mountain Road near the Dodge Creek confluence.

The 1990 census showed the population of French Gulch and surrounding rural residential areas to total 636 residents. Census data showed that the population was made up of 383 (60 percent) males and 253 (40 percent) females. Median annual household income in 1989 was a little less than $20,000. The median age of the population was between 25 and 34 years old, but the largest number of people were those 30 to 34 years old. Eleven percent of the population at that time was under six years old, and thirteen percent of the population was older than 65. Race among residents was 98 percent white (with four percent having Hispanic origin) and two percent Native American. Ancestries of non-native origin residents included Danish, Dutch, English, Finnish, French, German, Greek, Irish, Italian, Polish, Portugese, Scottish, Swedish and Swiss. Of those over 18 years old, nearly 40 percent had received a High School diploma (or equivalency), 20 percent had some college experience, four percent had received an Associate Degree and nine percent had received a Bachelors Degree. Of those over 16 years, 35 percent were employed in the following industries: mining (25 percent), construction (7 percent), manufacturing of non-durable goods (6 percent), manufacturing of durable goods (8 percent), retail trade (6 percent), business and repair (2 percent), personal services (10 percent), entertainment and recreation services (5 percent), health services (13 percent), educational services (2 percent), and other professional and related services (16 percent). Travel time for those who commuted singly (74 percent) and those who carpooled (23 percent) ranged from less than five minutes up to 90 minutes, however, fifty five percent had commutes of less than a half hour.

In addition to the residential population, nearly six million people live within a day's drive of the upper Clear Creek watershed. The largest population centers within a 30-mile radius of the watershed include the towns of Redding (population 70,000), Anderson (population 20,309), and Weaverville (population 3,188). The NPS also employs full time and seasonal employees who work in and around the Whiskeytown Unit.

Cultural and historic sites within the upper Clear Creek watershed include the mining sites, structures and ruins, that remain from the gold rush days. Some of the buildings in French Gulch, Whiskeytown and the Towerhouse area were originally built during the heydays of the mid-1800s. Also, place names and sites of religious or spiritual significance to the Wintun peoples remain within the upper watershed. Native Wintu that have survived to the present day conduct programs and annual ceremonies to help maintain their religion and cultural heritage. Consultations with local Wintu should continue to identify sites having traditional or historical significance.

Water quality in Clear Creek is important to the human occupants and visitors of the watershed for water supply and water related sports and recreation. Domestic and irrigation water is supplied to the residents of French Gulch and surrounding areas from a Shasta County Service Area diversion on Clear Creek, located upstream of the county park. Approximately nine million gallons per year of potable water is supplied to the Whiskeytown Unit from Whiskeytown Lake through several water rights issued to the NPS.

Remnants of historic mining activities include placer mining tailings along the banks of Clear Creek and East Fork Clear Creek, and scattered mine shafts and tailings piles in the hills east and west of French Gulch. These unconsolidated materials, which are easily eroded and transported to nearby tributaries, lead to concerns regarding water quality (turbidity, toxicity, and bacteria) conditions for drinking water and water-contact recreation. Reports of acid mine drainage problems are associated with Willow Creek upstream of the Clear Creek confluence. Bacteriological levels in exceedance of clean water standards are health threats to swimmers and others involved in water contact activities. Septic systems in and around French Gulch, the Clear Creek Mobile Estates (trailer park), and Whiskeytown Lake may leak during periods of extreme flows or high water levels, contaminating the water for some time afterward. Warning signs and closure of some swimming areas and other areas where water contact may occur are necessary for maintaining human safety until coliform levels are reduced. NPS staff has occasionally had to post such warnings at developed swimming areas along Whiskey Creek, Brandy Creek and at Oak Bottom Beach when bacterial loads in the waters have exceeded water quality limits.

The diversity of natural and cultural resources within the upper Clear Creek watershed makes it a popular location for recreationists. Clear Creek and Whiskeytown Lake are features that draw people interested in water based recreation, while the surrounding mountains provide access for hiking and camping. Numerous recreation sites exist within the upper watershed and include campsites, trails, parks, and picnic grounds. The FS maintains one primitive campground in the northern portion of the upper watershed. The FS Clear Creek campground is located along Clear Creek at Dog Creek Road. The Whiskeytown Unit also has about 11 campsites, and three established picnic sites around Whiskeytown Lake. Hunting and fishing is allowed within the Whiskeytown Unit. Permits are used to manage hunting of big game, small mammals and birds. Sportfishing is one of the most popular recreational activities in the Whiskeytown Unit. Sailing and kayaking are also popular water sports in the Whiskeytown Unit and paddle boaters often use the reach between the Tower House and the Oak Bottom campground for kayaking or canoeing. Both sailboats and motorboats use the lake, via the boat ramp at the Oak Bottom marina. Activities in and around Whiskeytown Lake are regulated by the NPS.

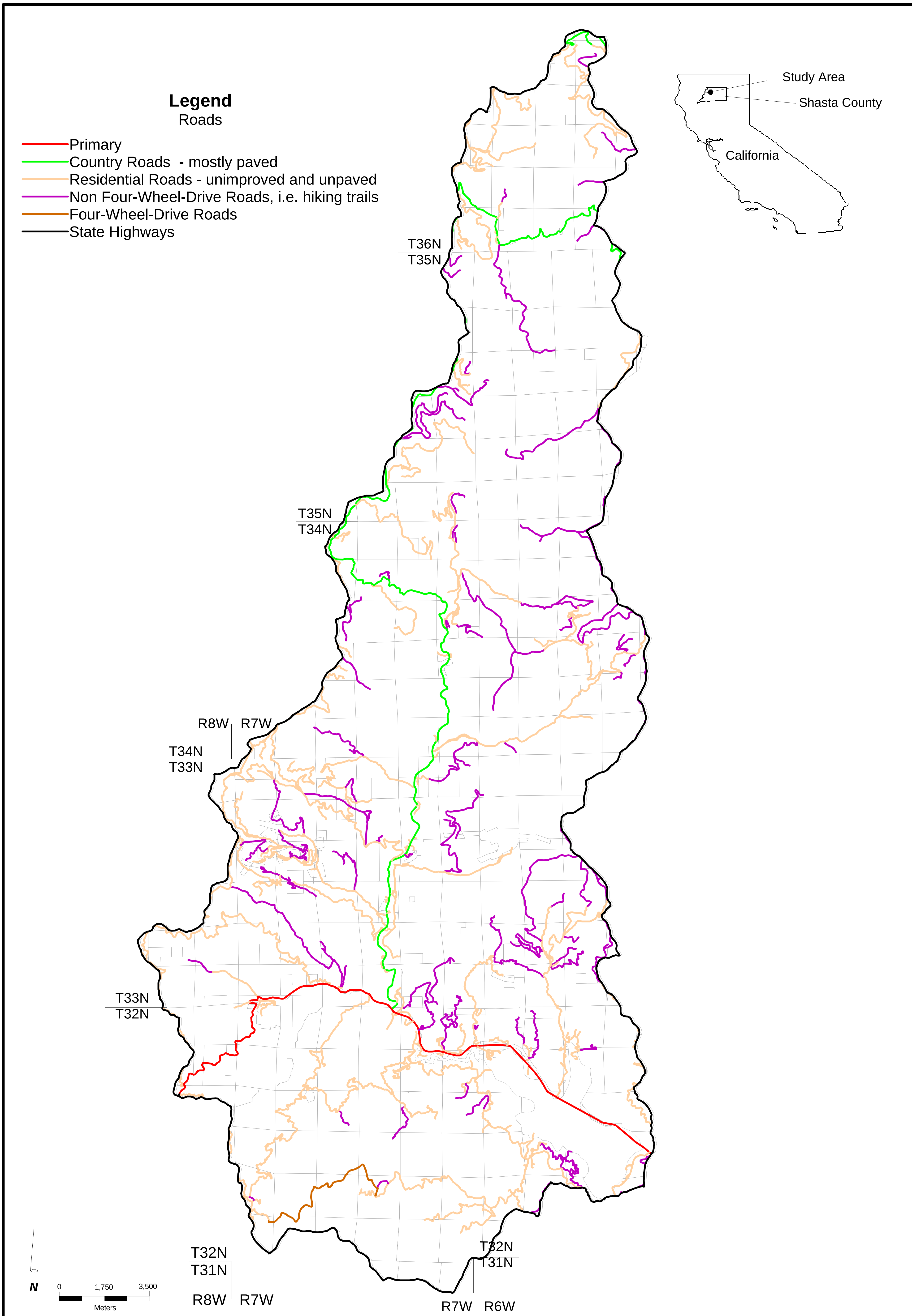
A network of both paved and unpaved roads traverses the upper watershed through both public, and private lands. Road conditions vary depending on location, purpose, and maintenance authority. Some of these roads traverse nesting and breeding areas of the black-tailed mule deer, as well as other species, and motorized traffic on these roads has caused deer fatalities and may impact birthrate survival of some species. Additionally, the condition and location of roads within the upper watershed directly relates to the ability of fire suppression ground forces to protect property and life from the threat of wildfires.

Figure 3-11 shows the major road networks found in the upper watershed. This data was digitized off 1:100,000 scale maps and so does not show all roads that may be present (e.g., forest service road that can be picked up from maps of finer resolution). Digital data from FS GIS coverage does show that a greater density of roads exists in FS lands. As shown in Table 3-18, the total length of roads found on forested lands may be as much as 16 times greater than the 1:100,000 scale data represent. Unfortunately, digital data provided by the FS does not cover the entire watershed, so in order to look at the watershed as a whole, we must rely on the 1:100,000 scale data.

The existing road network is made up of five different road types: 1) primary roads, 2) county roads, 3) residential roads, 4) four-wheel drive roads, and 5) non four-wheel drive roads. Primary roads are generally State Highways and are paved along their entire length. They may be undivided or divided by centerline and may have opposing traffic lanes physically separated from each other. County roads are mostly paved, generally wide enough for two way traffic, and may or may not be divided by a centerline. Residential roads are generally unpaved and unimproved by county transportation districts. Four wheel drive roads are generally dirt roads, which may traverse steep grades. Non four-wheel drive roads are generally made up of hiking trails and other trails not wide enough for vehicular traffic. Table 3-18 shows the distribution and length of each road type found in the upper watershed.

The main roads in the watershed are Highway 299 and Trinity Mountain Road. Highway 299 is a primary road that traverses east/west between Redding and Weaverville. Primary roads make up only four percent (16 miles) of the road network in the upper watershed. Trinity Mountain Road is a county road that runs mostly north/south between Highway 299 and through the northern end of the watershed. It runs parallel to Clear Creek for some distance before winding its way up to the ridgeline that divides the Clear Creek and Trinity River watersheds. It then follows the ridgeline toward Brown Mountain where it begins to descend into the Trinity River watershed. The only other county road in the upper watershed is Dog Creek Road (County Road 21), which traverses east/west across the northern tip of the upper watershed and intersects with Interstate 5 near Delta. County roads account for approximately eight percent (29 miles) of the total road network in the upper watershed.

Residential roads are the most common type of road in the upper watershed. Approximately 226 miles of residential roads traverse the upper Clear Creek watershed, accounting for approximately 60 percent of the road network. Most residential roads either parallel the main tributaries in the upper watershed or traverse hillsides to approach ridgeline roads or mining sites in the surrounding hills. Non four-wheel drive roads account for 30 percent (118 miles) of the road network. Most of these are actually trails that traverse hillsides or ridgelines. Four-wheel drive roads account for only one percent (almost five miles) of the road network, and only exist along the southwest flank of the Shasta Bally area.



Projection: UTM NAD 27, Zone 10
Source: SPI, DFG, NPS, and USFS
Date Created:11/12/98
Draft:11/12/98

Roads
in the Upper Clear Creek Watershed
Shasta County, California

Tetra Tech, Inc.

Figure 3-11

Table 3-18
Distribution and Length of Roads in Upper Clear Creek Watershed (measured using 1:100,000 scal
GIS roads layer).

Watershed	Area (acres)	Road Length (in feet)					To I (	
		Primary Roads (State Route 299)	County Roads (mostly paved)	Residential Roads (unimproved and unpaved)	Hiking Trails	Four-Wheel Drive Roads		
Blodgett Creek	6,477	-	8,621	94,250	16,273	-		
Damnation Creek	6,372	-	32,890	26,470	26,609	-		
Stacey Creek	3,887	-	3,827	3,159	5,091	-		
Slate Creek	10,675	-	16,744	82,461	70,750	-		
Brush Creek	2,841	-	-	-	10,771	-		
Dodge Creek	3,415	-	34,348	32,356	2,550	-		
Big Gulch	4,506	-	-	26,590	53,484	-		
Whitney Gulch	7,288	-	19,561	28,485	35,258	-		
East Fork Clear Creek	9,240	-	-	61,041	45,410	-		
Fivemile Gulch	4,958	-	3,921	91,745	22,535	-		
Cline Gulch	8,200	-	19,843	52,549	53,912	-		
French Gulch	5,820	-	1,517	148,709	63,256	-		
Whiskey Creek	7,447	-	-	70,896	71,187	-		
Yankee Gulch	6,234	15,396	-	66,584	29,494	-		
Grizzly Gulch	9,202	21,669	14,227	116,079	61,759	-		
Trail Gulch	5,707	22,863*	-	37,818	3,529	-		
Crystal Creek	7,828	-	-	82,538	666	10,580		
Boulder Creek	3,271	-	-	41,890	13,092	12,999		
Dry Creek	1,401	-	-	10,330	3,607	-		
Brandy Creek	6,877	-	-	60,924	4,495	46		
Whiskeytown Lake HAS	6,489	23,376	-	56,786	30,831	-		
TOTAL	128,135	83,304	155,499	1,191,660	624,559	23,625	:	

*Trail Gulch primary roads include 211 feet of State Highway at western boundary of watershed.

No road conditions inventory exists for the upper Clear Creek watershed, so it is not possible to determine the ability of the road network to meet regional transportation requirements or to provide adequate ground access for fire fighting equipment. However, we do know that while road density in the upper watershed is about 16 feet of road for every acre of land, only 11 percent of the road network is paved. The Highway 299 grade near Buckhorn summit has experienced numerous erosional problems because of its steep ascent through highly erosional areas of decomposed granitic soils from Shasta Bally (Ivey 1998). The NPS has determined that roads often alter the natural hydrology. Instability of slopes leading to mass wasting originated at road locations in the Whiskeytown NRA in 1997. Other erosion problems associated with road cuts and roadway surfaces in the watershed should be determined. The greatest erosional problems associated with roads are usually located where roads intercept and accelerate storm water runoff, and where road crossings and culverts have been placed across tributary drainages.

While fire fighting equipment can probably make use of some residential and four-wheel drive roads in the watershed, some of the roads may not be wide enough or maintained well enough for fire fighting vehicles to use. Additionally, most of the residential roads are not located along ridgelines where they could provide access to remote areas of the watershed, or function as firebreaks. Existing ridgeline trails are likely too narrow to work as firebreaks. A full inventory of the road network (including road width, surface conditions, and any associated erosional or maintenance problems) should be conducted to further understand the network's components and capabilities. Service roads in FS and private TPZ lands should also be evaluated to determine if appropriate erosion control measures are being adequately applied.

4. REFERENCE CONDITIONS

SECTION 4
REFERENCE CONDITIONS

4.1 WATER QUANTITY AND QUALITY

Pre-European Settlement

Stream flows in the watershed prior to European settlement were unregulated and flowed in response to the natural cycles of seasonal precipitation and snowmelt. In the Mediterranean climate of Northern California, precipitation events generally occur annually between November and March, except during periods of drought. Cycles of drought and extreme precipitation occurred historically such that stream channels likely experienced both floods and dry conditions. Overbank flows provided sediment to build the floodplains that occur in the lower gradient reach of Clear Creek, below the East Fork Clear Creek confluence.

Factors affecting streamflow prior to European settlement are similar to those that affect it today (described in Section 3.1.2), except that vegetation cover and land use practices were likely quite different then. Natural occurrences of fire from lightning strikes and manipulation of fire by Native Americans denuded the forest floor of brush cover. These fires, having short recurrence intervals, were likely not high intensity stand-replacing fires that would have significantly changed soil infiltration rates for long periods.

1850 to Federal Ownership (1905)

Following the gold rush of the mid-1800s, the upper Clear Creek watershed became one of the state's richest gold producing areas. Placer and vein deposits were mined in the area known as the French Gulch District, which developed around the town of French Gulch. Flows in the mainstem channel were affected by placer mining activities, which dredged large quantities of sediment out of the creek and deposited them along the banks between East Fork and the confluence with Willow Creek. These activities removed much of the spawning gravel that previously would have been transported downstream by bankfull flows occurring every one and a half to two years; much of this material remains along the banks of the creek, unable to be transported by instream flows. At the height of the gold rush, the population of French Gulch reached nearly 1,000 and logging began in the upper watershed to provide timber for housing and mining shafts in the area.

Logging continued following the decline of the mining industry, and has since become the dominant commercial industry in the upper watershed. Skid trail, haul roads, and landings likely increased runoff into the tributaries of Clear Creek, while clear cuts removed much of the timber from forested hillsides surrounding the French Gulch area, changing the dominant vegetation to chaparral and increasing the runoff characteristics of the area.

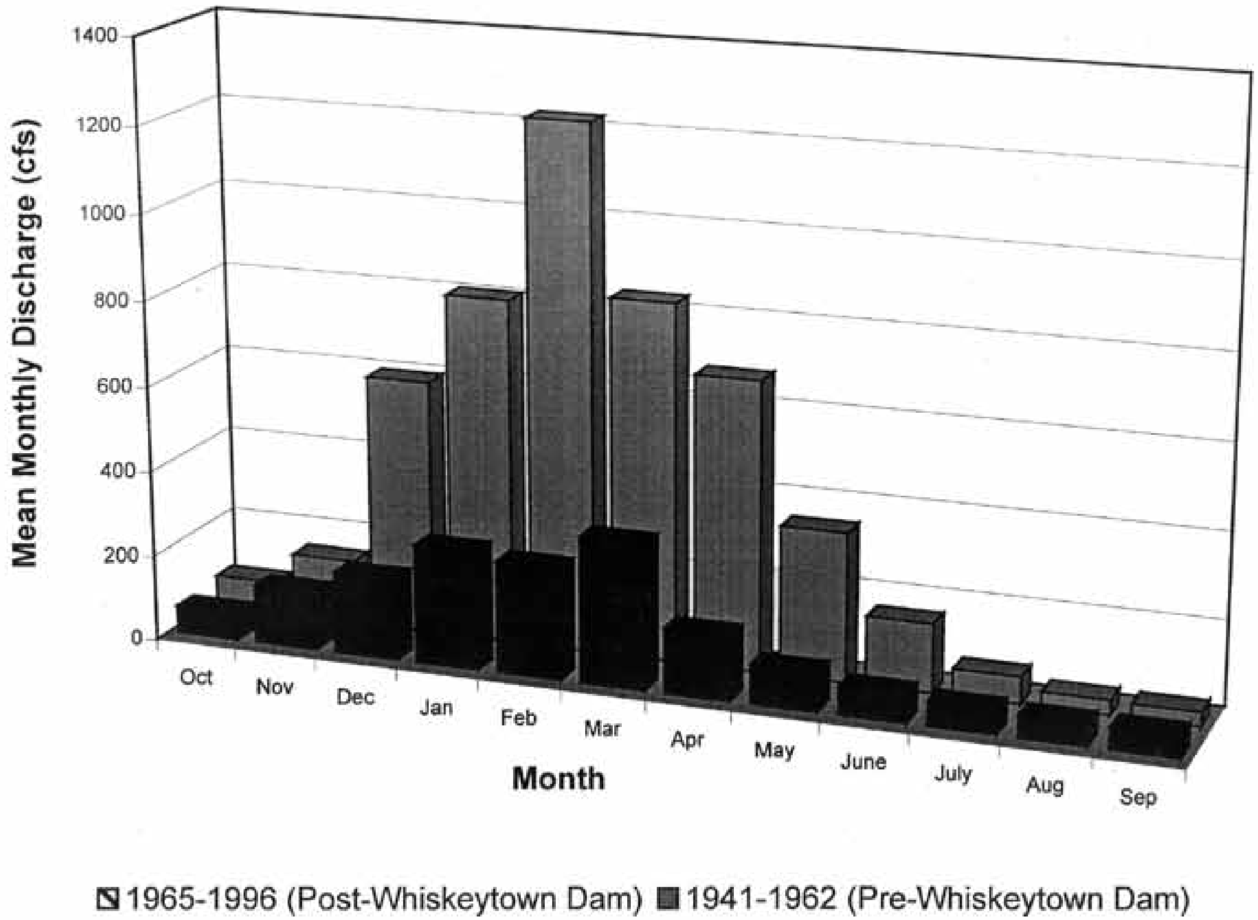
1905 to Filling of Whiskeytown Lake (1963)

Federal administration of lands in the upper Clear Creek watershed began in 1905 when the Shasta National Forest was established by proclamation of President Theodore Roosevelt. The Trinity National Forest was established in 1907, and in 1954 the two forests were combined into one administrative unit. A total of 24,255 acres of land in the upper Clear Creek watershed are administered as part of the Shasta-Trinity National Forest. Commercial timber production remained the leading commercial industry on suitable lands managed by the FS.

1963 to Present

Since the construction of Whiskeytown Dam, flows on Clear Creek have been impounded at the southern end of the upper watershed in Whiskeytown Lake. Flows upstream of the Judge Francis Carr Powerhouse remain unregulated with a flow regime similar to that described under existing conditions (Section 3.1.1). However, with the establishment of the President's Forest Plan, zones along stream channels have been established as riparian reserves. Riparian reserves have specific restrictions on land use activities in order to protect the health and function of aquatic habitats and to reduce the effects of nonpoint source pollution by providing a buffer between the upland and stream system.

Flow measurements in the lower Clear Creek watershed have been collected at the Clear Creek at Igo gage (Station #11372000) between 1940 and 1996. Data collected at this gage, located downstream of Whiskeytown Dam, are the only actual records of flows that could be considered representative of the southern portion of the upper Clear Creek watershed before filling of Whiskeytown Reservoir. Mean monthly flows measured at the Igo gage before and after the construction of Whiskeytown Dam are shown in Figure 4-1. Since construction of Whiskeytown Dam, average mean monthly flows downstream of the dam have been reduced as much as 79 percent during winter months (October to March), and have increased as much as 58 percent during summer months (May to September).



Source: Tetra T

r:\View\1941\04\lgo-Avg.cdr - 11/12/98 - BC

Historical Monthly Average Flows

Clear Creek

Tetra Tech, Inc.

Figure 4-1

4.2 FUELS AND FIRE

Pre-European Settlement

Natural and human-caused fires have been a source of disturbance to vegetation for thousands of years, influencing the development of plant characteristics and vegetative patterns on the landscape (FS 1997). Fires started naturally by lightning strikes and spread by hot dry winds could quickly burn large tracts of land. Naturally caused fires occurred frequently due to annual weather patterns and seasonal climatic extremes and would have kept the accumulation of woody debris and brush to a minimum. Frequent, low-intensity fires burn out quickly, preserving large trees, and maintaining diverse, multi-story forests (Weatherspoon 1996). Mixed conifer forests are typical of short-interval, low-intensity surface fires (Chang 1996). Prior to European settlement, Native Americans of the Wintu Tribe also lived in the area and used fire to increase the amount of grasslands and particular plant species favored as sources of food, building, or trade.

Evidence of past fires can be detected from tree rings of large trees that have lived a century or more. Fire scars on the stumps of trees that remain in previously logged areas record the occurrence of fires throughout the history of the tree. Evidence of fires recorded in tree rings provides the most accurate long-term record of fires that occurred before the twentieth century (Skinner 1997b).

Fire occurrence histories were determined from sites located in the Northwest Sacramento Province by fire specialist Carl Skinner (FS Pacific Southwest Research Station). This data, collected in 1997, contain measurements taken from large tree stumps in the vicinity of the upper Clear Creek watershed near the Clear Creek LSR. Sampling sites nearest the upper Clear Creek watershed include those located along the Mosquito Creek Ridge and French Ridge, both of which lie just east of watershed divide near Damnation Peak. Table 4.1 shows data collected at these sites (the complete data set for the Clear Creek LSR and Northwest Sacramento Province are located in Appendix D. Fire return intervals (FRIs) calculated from these data range from three to 34 years, with the median FRI of 11 years. These FRI values represent recurrence intervals for fire occurrence under natural, nonsuppression conditions.

Table 4-1
Natural Fire Occurrence:
Data Collected Near Upper Clear Creek Watershed

Site	N Samples	Earliest Scar	Last Scar	Years Record	Median FRI	Min Interval	Max Interval	Med.Prob Interval	LEI	UEI
MosquitoA	5	1784	1916	132	13.0	3	17	9.6	4	16
MosquitoB	8	1729	1909	180	9.5	3	27	13.2	3	37
French Ridge	6	1724	1931	207	11.0	4	34	13.3	5	26

1850 to Federal Ownership (1905)

Prior to the 1900s, coordinated, large-scale fire suppression efforts did not generally exist. Fires that started by lightning strikes or by human activities were often allowed to burn unabated until they were put out naturally or until they burned themselves out.

1905 to Filling of Whiskeytown Lake (1963)

Following the establishment of both the Shasta and Trinity National Forests in the early 1900s, fire was considered detrimental to growing trees, and fire suppression was considered important for protecting the timber resources on forestlands. However, in the early years of the Forest Service, rangers were spread thin, fire suppression conflicted with local interests, and many fires were allowed to burn unchecked (FS 1997). It wasn't until after World War I that more personnel were made available to fight fires. Following the 1920s, fire suppression forces grew, and as fire prevention policies and fire suppression methods improved, attempts were made to suppress all fires.

1963 to Present

The fire suppression capabilities of local resources increased between the 1960s and late 1970s (FS 1997), enabling local fire protection managers to attempt to suppress all fires occurring within the upper Clear Creek watershed. With these efforts in force, a regime aimed at total fire suppression has been in operation on forestlands in the upper watershed over the last 70 years. Effective fire suppression has shifted the fire regime within the upper Clear Creek watershed, increasing the potential for partial to complete stand-replacing fires within mature conifer and hardwood stands (FS 1997; Agee 1993).

4.3 VEGETATION AND WILDLIFE

Pre-European Settlement

There are few records of what were the "natural" conditions of upper Clear Creek prior to 1850. Vegetation patterns may have been altered prior to European settlement by natural and human-induced events. Manipulation of fire by Native Americans probably was used to promote grasses and shrubs for wildlife forage. This activity plus natural lightening caused fires probably kept the floor of the watershed populated with grasses and chaparral. Native grasses were likely more abundant in each of the habitat types (BLM 1996), but more recently have been out-competed by exotic annuals.

1850 to Federal Ownership (1905)

Logging and mining activities affected vegetation patterns between 1850 and 1905. Roads to support logging and mining fragmented habitat. Mining affected water quality for wildlife. Mine tailings caused changes in composition of plant species. Clear cuts caused a shift in vegetation to more chaparral species and even-aged stands. Annual burning associated with sheep grazing had heavy impacts on the east central portion of the Clear Creek LSR from the mid to late 1800s until the mid 1900s. These fires primarily affected south- to southwest-facing slopes and generally did not reach the north- or northeast-facing slopes or into the riparian areas. The burned slopes consisted primarily of grasses and shrubs with widely spaced conifers (FS 1997).

1905 to Filling of Whiskeytown Lake (1963)

The FS began managing forestlands during this time period for multiple use purposes, with commercial timber production being the primary commercial industry on suitable lands. Between 1920 and 1940 timber harvesting occurred on approximately 1,000 acres of Shasta-Trinity National Forest land per year (throughout the entire Shasta-Trinity National Forest). The rate of harvesting increased by one and a half to five times per year during the 1940s and 50s (FS 1994).

A management assessment for the Clear Creek LSR compared aerial photographs from 1944 with 1995 conditions. Fire suppression in the 1940s increased fuel loading of both live and dead material. Stands were more open, with tree crowns separated, and dense conifer overstory were mostly limited to the north and east aspects. Riparian vegetation was less affected by fire than the surrounding uplands (FS 1997).

1963 to Present

Vegetation in what is now Whiskeytown Lake was flooded when the Whiskeytown Dam was installed. With the establishment of the President's Forest Plan, buffer zones along stream channels, called riparian reserves, now have specific restrictions on land use activities in order to protect the health and function of aquatic habitats.

Logging since 1963 affects more than twice as many acres annually than were logged in the 1940s and 1950s (FS 1994). Most of this logging has been clearcutting. Because herbicides are no longer used extensively, many younger plantations in the Clear Creek LSR are experiencing intense competition from shrubs and hardwoods. Older plantations are overstocked and experiencing intense intertree competition (FS 1997).

4.4 SOILS AND EROSION

Pre-European Settlement

Prior to European settlement, soil development and soil erosion occurred under natural conditions, affected only by the processes of weathering, runoff, and land instabilities (such as landslides and earthquakes). The steep mountainsides and narrow canyons of the watershed formed over geologic time in response to the processes of structural uplift and erosion. Vegetative cover in the watershed, consisting of mixed conifer, mixed hardwood, and chaparral, protected the soils from excessive runoff and erosion, except for some geologically short period of time following fires. Regeneration of vegetative species over time reduced erosion rates and led to vegetation communities that were well adapted to the landscapes and soils in which they evolved.

Steep mountainsides and sheared and fractured zones near faults were probably areas that experienced the most erosion over time. Erosion of the Shasta Bally batholith due to mineralogic weathering and decomposition of the exposed granitic body also occurred as a continual process under natural conditions. Under the natural hydrologic cycle, streamflows transported these sediments downstream, creating graded gravel and sand deposits that were used by the aquatic species in the watershed, including anadramous salmon and steelhead that spawned in the lower reaches of the upper watershed.

1850 to Federal Ownership (1905)

While the rate of natural erosion has likely remained the same through time in response to the cyclic and episodic patterns of climate and fire, land disturbances have increased over time due to development and consumptive land use activities by human occupants. Following the discovery of gold in the gravels of Clear Creek in 1848, dredge mining and, later, underground and pit mining for gold lode and other minerals changed the landscape and population base in the upper Clear Creek watershed. Commercial logging operations also increased in response to the mining boom as construction and housing needs in the watershed and surrounding areas grew.

The periods of greatest gold mining activity were during the early 1850s soon after the discovery of placer and lode gold in the watershed, from 1900 to 1914, when lode gold mining was stimulated by the needs of the copper smelters for siliceous flux, and during the depression of the 1930's, when many unemployed people resorted to mining gold for a livelihood (Albers 1965). Historic maps have been made of mine site locations present in the Whiskeytown Unit between the periods 1850 to 1880, 1880 to 1896, 1896 to 1914, 1915 to 1941, and 1941 to 1960. At least 50 mining sites were located in the upper Clear Creek portion of the Whiskeytown Unit between 1850 and 1880, 17 sites between 1880 and 1896, and 27 sites between 1896 and 1914. These maps also show that ditches and flumes had been constructed along portions of Boulder Creek, Brandy Creek, Whiskey Creek, and most of Clear Creek downstream of the Tower House between 1850 and 1880. (By 1896, flumes and ditches appear on these maps only along creeks in the lower Clear Creek watershed.) While start-stop dates are unknown for many of the historic mines in the upper watershed, as many as 41 mines were located in the French Gulch, Cline Gulch, and East Fork Clear Creek watersheds.

Mining activities and the construction of structures associated with development of the area (including dirt trails, wagon roads, homes, and other commercial buildings) cleared land of vegetation, changed the grade of hillside and streamside areas, and increased the amount of disturbed land, and hence soil erosion, in the watershed. Evidence of past mining activities still remain today as open pit mines, adits, tailings piles and ruins on hillslopes in the upper watershed, and dredge tailings and placer diggings along the terraces of the Clear Creek and East Clear Creek channels.

1905 to Filling of Whiskeytown Lake (1963)

Mining operations continued until the start of World War II in 1942, when virtually all mining was suspended due to the war effort. Historic maps of mining sites in Whiskeytown Unit over this time frame illustrate this decline, showing about 20 locations between 1915 and 1941, and eight locations between 1941 and 1960. When operations at the mine sites ended, many of the sites were merely abandoned, leaving ruins of old structures and unconsolidated tailings. While active land disturbance due to mining ceased following shutdown of operations, soil erosion in these areas likely remained high relative to other, undisturbed lands.

Timber harvesting in the forested lands of the upper watershed began in the early 1900s (FS 1994). Early timber harvesting practices were not concerned with sustainable yield and were quite efficient at removing most vegetation on the rolling hilly terrain of the upper watershed in areas where access was relatively easy. Clear cutting and skid trails were used to get trees down slopes and into the bottom of drainages where they could then be dragged by donkey or transported by the watercourse. Such practices created a great deal of disturbance and generated steep slopes with very high erosion potential due to the lack of vegetative cover and increased amount of loose soil and woody debris. Skid trails, haul roads, and landings were likely sites of greatest erosion. Riparian vegetation and habitat were also lost, and water quality was affected by the removal of vegetation and sedimentation in these areas.

1963 to Present

Following construction of Whiskeytown Dam, approximately 3,220 acres of canyon land was filled by the impoundment of Clear Creek in Whiskeytown Lake. The lake also inundated several old mine sites along with approximately 12 miles of stream channel. Construction of the dam virtually eliminated the transport of bedload sediments, primarily gravel and sand) downstream of the dam. Sediment deposition rates in Whiskeytown Lake have not been measured. The bathymetry (or depth) of the lake would need to be surveyed and compared with pre-dam conditions to accurately determine the storage volume that has been lost since 1963.

The distribution of soil types and soil erosion potential was mapped in 1974 for the Shasta County Soil Survey (USDA, Soil Conservation Service 1974). As conditions have not changed significantly since then, this survey was also used to describe existing conditions in the previous chapter.

Soil erosion hazards continue to be high at sites where current and historic land-use activities affect vegetative cover and change the grade of hillside and streamside areas. The number of paved and dirt roads, landings, and impermeable surfaces in the watershed increase runoff potential and can divert runoff following precipitation events to areas that are less resistant (e.g., areas of less compacted roadfill or sidecast materials beside compacted roadbeds). Such activities can accelerate erosion and induce landslides in areas where soils become waterlogged or where slopes are over-steepened. Landslides are episodic events that move massive amounts of sediment in short periods. They occur over time due to gravity or relatively quickly in response to heavy runoff or earth shaking events.

Following the 1997 New Years storm, which delivered 19 inches of rain on top of an already rapidly melting snow pack, landslides occurred in at least three areas of the Whiskeytown NRA. David Steensen, of the National Park Service Geologic Resources Division, conducted a reconnaissance of these slides February 1997, and described their cause and effect in his trip report to the Superintendent of Whiskeytown NRA, dated April 18, 1997. One of these events occurred in the upper Clear Creek watershed: a debris flow that originated in the upper Brandy Creek watershed south of Whiskeytown Reservoir. The other two landslides, a debris flow in Paige Boulder Creek and a debris avalanche immediately below Trinity River Reservoir, occurred in the lower Clear Creek watershed.

Both the Paige Boulder Creek and Brandy Creek debris flow were described to have "begun as small-scale (pickup truck sized) failures originating in headwater swales – precisely at the intersection of abandoned timber skid roads," with the head of the slide area in weathered granitic rocks of the Shasta Bally batholith. As it moved downslope, the Brandy Creek debris flows scoured colluvial material from the hillside until it ran into Rich Gulch, approximately one mile above the mainstem of Brandy Creek. After converging into the larger stream channel, which was carrying additional storm runoff, the debris flow converted into a debris torrent. The debris torrent moved down the channel like a flood wave, carrying a significant load of organic debris and scouring the main channel of Brandy Creek all the way to Whiskeytown Lake. The trip report notes that virtually all of the riparian vegetation along Brandy Creek had been removed, and an estimated 500,000 cubic yards of coarse sediment was delivered to the lake. The debris torrent also removed the Sheep Camp Bridge, rerouted the creek channel and modified the Brandy Creek beach at the lakeshore.

Though the cause of the slides could not be determined absolutely, the debris flows apparently progressed from small side-cast fill failures associated with the timber skid roads. Field reconnaissance determined that no landslides occurred in other undisturbed areas of the Whiskeytown Unit during this storm. However, it is likely that additional unreported landslides occurred in other portions of the upper Clear Creek watershed. The most likely places for landslides include areas underlain by Josephine, Behemotosh, and Sites soils, where slopes are moderately steep to very steep. Such episode events continue to be potential sources of erosion and sedimentation problems due to the folded and faulted nature of the regional geology.

4.5 HUMAN USES

Pre-European Settlement

Human use of the upper Clear Creek watershed area extends over nearly 7,000 years. Pre-historic sites exist in the Whiskeytown Unit and provide evidence of early occupation by small, highly mobile groups of hunter-gatherers (NPS 1997). These small bands or family groups followed the annual cycles of animal migrations and plant maturation, travelling between low elevation river terraces and high mountain ridges (Dubois 1935; BLM 1992). Artifacts found from these peoples include tools such as atlatls (dart throwing devices), obsidian dart tips, stone knives and scrapers. Later peoples developed settlements at lower elevations along larger streams during part of the year and traveled into the upper elevations during the spring and summer for seasonally available resources (NPS 1997).

By the time Europeans arrived in the area, the Wintu, or Northern Wintun, were widespread inhabitants of the area (BLM 1997). Their territory stretched from Cottonwood Creek on the south, north past LaMoine and west to Hayfork Valley and Weaverville (La Rena 1978). They are thought to have migrated from southwestern

Oregon and to have settled peacefully amidst earlier inhabitants (BLM 1992). Archaeological data suggest that Wintun peoples occupied the area for as much as 1,000 to 1,200 years. Different subgroups of Wintu have been recognized on the basis of geographic range. Wintu subgroups listed as inhabiting or utilizing resources within the upper Clear Creek watershed include the Dau-nom Wintu, found in the plains and hills west of Redding (BLM 1997), and the Keswick and French Gulch Wintu (NPS 1997), found in the area now managed as the Whiskeytown Unit.

The Wintu located their villages along rivers and major tributaries, where they found a variety of plants and animal life to support their daily needs (BLM 1992). Salmon and other fish were important food sources that could also be dried and stored for later use. Other sources of meat included deer, rabbit, squirrel, duck and geese. The most important plant food was acorns, which after processing could be made into a meal for soup or bread. Other plants gathered for food included buckeye balls, berries, nuts, tubers, and bulbs. The Wintu used the abundant natural resources found in the area to make shelters, tools, baskets and other essential items used for cooking, hunting, and ceremonial activities.

Wintu religion and mythology is intricately bound to the landscape of the area. Many rocks or rock outcrops, springs, pools, caves, and mountain peaks are considered to possess spiritual qualities by Wintu people, and so were sanctified or considered holy. Although no specific sites have been mapped, various locations throughout the upper Clear Creek watershed have been identified as Wintu places, and include place names, resource gathering areas, spiritual sites and habitation sites.

1850 to Federal Ownership (1905)

Like other California Indian groups, the Wintu suffered severely from contact with European-Americans who came in large numbers to the area following the discovery of gold in 1848. Epidemics, depravation, and massive land alterations severely changed many parts of Wintu life, especially economic and settlement patterns (BLM 1992).

Following the Gold Rush of the 1850s, placer, dredge and lode mining became the major land use activities, changing the land use ethic of the area from one of reverence to one of utility. Mining sites polluted many of the local fish streams while using the Wintu as laborers and introducing them to western diseases. The result was a mass decrease in the Wintu population. It is estimated that by 1852, the Wintu population had decreased from 14,250 to 3,500 (La Pena 1978).

Boomtowns such as Shasta, Whiskeytown and French Gulch grew quickly as large numbers of miners arrived in the area in the early 1850s (NPS 1997). Emigrant Chinese laborers were used to help build the elaborate system of flumes and ditches required for carrying water to mining sites, and later mined many of the abandoned claims left by others. At the peak of the gold rush, as many as 1,000 people lived in the areas surrounding French Gulch, which in its prime supported four saloons, two hotels, a post office, two mercantile stores, an assayers office and various livery stables and blacksmith shops. Dirt wagon and haul roads were also developed as travel in and through the French Gulch and Whiskeytown Mining Districts increased.

By 1896 copper replaced gold as the number one mineral produced in Shasta County (BLM 1997). Peak copper mining activities occurred from 1897 to 1919 and again from 1924 to 1925. Smelters used for refining copper ore were located in Kennett, Coram and Keswick. Timber cruiser reports from 1910 indicate that fumes from copper smelting operations had already caused severe environmental damage, killing trees throughout most of the eastern side of the upper watershed in townships 31N, 32N, and 33N. Total value of injured and dead trees in these three townships was estimated in 1910 at $51,288.

The earliest records of commercial logging are from these timber cruiser reports, which provide information on topographic relief and vegetation in areas considered for logging in the early 1900s. The 1910 reports noted that much of the area west of the Clear Creek/Sacramento River divide was very mountainous with steep slopes making it very difficult to log. Reference was made to sawmills located outside of the Clear Creek watershed on Dog Creek and Slate Creek, indicating that these may have been the nearest sawmills available to logging efforts carried out in the northern region of the upper watershed. Cut logs could be hauled to these sawmills north and east of the area, and then flumed to Delta or LaMoine where the cut wood could be put onto rail cars of the Southern Pacific Railroad. Although no historic railroad lines ever traversed the area, mention was made about the possibility of bringing in a logging railroad across the western divide south of Damnation Pass to take logged wood down to LaMoine. These reports also mention floating small timber down Clear Creek to mining companies to use in mine shafts.

1905 to Filling of Whiskeytown Lake (1963)

Following the inclusion of much of the upper watershed area into the Shasta and Trinity National Forests, federal administration of forested lands began, but with no long-term management objectives (FS 1994). With the decline in gold and development of western cities, activity in the watershed began to shift to logging. Numerous roads were built into remote areas to gain access and remove high value pine and Douglas-fir trees from the area. By the mid-1900, logging became the predominant industry. The largest volume of logging in the watershed was conducted in the 1950s, as was typical of the entire state. Although not as intensive, logging remained the dominant activity in the watershed during the 1960s.

1963 to Present

During the mid-1960s to the present day, human use of the watershed has slowly changed from extractive uses to non-consumptive uses, such as recreation and wildlife management. Construction of the Whiskeytown Reservoir provided an opportunity for water based recreation. San Francisco and other northern California towns were growing, and residents increasingly began to use the Clear Creek watershed for hiking, fishing, hunting, and off-highway vehicle use. Seasonal second home development increased, along with service industries.

5. COMPARISON OF EXISTING AND REFERENCE CONDITIONS

SECTION 5
COMPARISON OF EXISTING AND REFERENCE CONDITIONS

5.1 WATER QUALITY AND QUANTITY

Prior to 1963 and the construction of Whiskeytown Dam, flows in the entire Clear Creek watershed were unregulated. Flows in Clear Creek varied based on the Mediterranean climate of northern California with annual dry periods. Clear Creek and tributaries had perennial flows, with ephemeral and intermittent reaches in the headwaters of each tributary.

Climatic cycles of wet and drought years continue to occur as they have in the past, though global warming may change future climatic trends. Peak runoff during normal years occurs in late winter and early spring following precipitation events and annual snowmelt. Low flows occur during the months of July through September. Historically, flows in Clear Creek have been diverted through pipes for domestic water supply and irrigation and through flumes for mining and sawmill operations. Clear Creek, however, typically has had flows throughout the summer months that are sufficient to maintain a cold water fishery.

Since 1963, the Whiskeytown Dam has regulated downstream flows. The Whiskeytown Reservoir formed by the dam has inundated up to 12 miles of stream channel and impounds Clear Creek at a water level of 369 feet spillway elevation. The Trinity River water diversions to Whiskeytown Reservoir through the Clear Creek tunnel have been used to produce power at the Judge Francis Carr powerhouse. Additional power is generated as water leaves Whiskeytown Reservoir through the Spring Creek tunnel and powerhouse. Water diverted through the Spring Creek tunnel bypasses lower Clear Creek and is transported directly to the Sacramento River below Redding. The amount of water diverted from Whiskeytown Reservoir through the Spring Creek tunnel (outflow) is greater than the amount of water diverted through the Clear Creek tunnel (inflow). This imbalance between inflow/outflow and dam operations has significantly altered the natural flow regime in lower Clear Creek below Whiskeytown Dam.

The Trinity River diversion through the Clear Creek tunnel delivers an average annual inflow of 980,982 acre-feet into Whiskeytown Reservoir. Upper Clear Creek delivers an estimated average annual inflow to Whiskeytown Reservoir of 261,305 acre-feet. The total average annual inflows to Whiskeytown Reservoir, combining the Trinity River diversion and the natural input from the upper Clear Creek watershed, is estimated to be 1,242,287 acre-feet. Thus runoff from the upper Clear Creek watershed is 21 percent of the average annual inflow to Whiskeytown Reservoir. The Trinity River diversion accounts for the remaining 79 percent of the inflows to the reservoir. In spite of the increased inflows from the Trinity River diversion, average annual flow below the dam in lower Clear Creek has been reduced since 1963 from an average annual flow of 302,647 acre-feet to 106,787 acre-feet from 1965 through 1997. The 65 percent reduction of flow in lower Clear Creek is a result of 1,234,836 acre-feet of water diverted through the Spring Creek powerhouse and tunnel.

Dam operations controlling the timing of the release of the remaining water (106,787 acre-feet) have reduced peak flows downstream of Whiskeytown Reservoir and have extended the summer flows. Since construction of Whiskeytown Dam, monthly mean flows downstream of the dam have been reduced as much as 79 percent during the winter (October through May) and have increased as much as 58 percent during the summer (May to September).

Flow release schedules at Whiskeytown Dam are being revised to meet CVPIA regulations. These regulations are intended to maintain flows of between 100 and 200 cfs from October through May and between 150 and 100 cfs from June through September. These flow regulations are being implemented but have not yet been obtained. In 1998 the high flow was 200 cfs and the low flow was 50cfs. The purpose of these release schedules is to improve aquatic habitat conditions in the lower watershed. However, discharge in the upper watershed above Whiskeytown Dam remains unregulated.

Soil compaction from construction of roads, rural residential developments, and historic timber production over time have increased the amount of impervious area, thereby decreasing infiltration and increasing runoff and erosion rates to some degree. However, there is insufficient historical stream flow data or sediment core analysis in Whiskeytown Reservoir to confirm or characterize these anticipated hydrological changes within the watershed.

Very little information is available on the historical and present condition of aquatic habitats. Construction of Whiskeytown Dam has created a barrier to anadromous fish that used historical spawning grounds in the upper watershed. However, kokanee salmon (a land-locked species) and other freshwater fish inhabit the watershed as far north as Slate Creek. A functional level of aquatic habitat must exist in the watershed because many of these species appear to have developed self-sustaining populations.

DWR has collected fish tissue and aquatic invertebrates, which are being tested to determine bioaccumulation levels and to get a measure of the health of the aquatic ecosystem.

While local water quality problems exist in the upper watershed, water quality is no doubt better now, relative to the mid-1800s, when contamination from septic systems (or the lack thereof) and in-stream placer mining were probably at their peak. Fumes from copper smelting during the early 1900s killed trees throughout the eastern side of the watershed and likely affected water quality as well.

A review of existing water quality monitoring data indicates that on several occasions at various sampling stations in the lower portion of the watershed, levels of minor elements (such as aluminum, cadmium, copper, iron, lead, manganese, and zinc) exceeded drinking water quality criteria limits maximum contaminant levels and/or the California Toxics Rule and Rule 9150—Aquatic Water Quality Criteria for freshwater aquatic life. All of the minor elements are commonly found in the minerals that compose igneous and metamorphic rocks prevalent throughout the watershed and in the tailings of past mining operations. While most of the source rock areas cannot be contained, erosion control efforts or sediment traps in and around abandoned mine sites and tailing piles can reduce sediment input from such rock types. Current rehabilitation efforts at Greenhorn and Washington mines provide a good example of efforts to control erosion and minor element transport.

Assessment of the impacts of bacterial contaminants on water quality in upper Clear Creek and Whiskeytown Reservoir is based on a small number of samples. Beneficial uses potentially affected by bacterial contamination include water contact recreation (REC-1) and municipal and domestic supply (MUN). The Basin Plan water quality objectives for these two beneficial uses require several samples taken over a month. The existing monitoring program does not meet the minimum sampling requirements to evaluate if conditions violate the established objectives. Residents in the watershed use Clear Creek as a drinking water supply; however, the applicable standard for this beneficial use is that no more than five percent of samples in a month (total of 40 samples) will contain any fecal coliform colonies. The water quality objective for REC-1 is that the fecal coliform concentration shall not exceed a geometric mean of 200/100 ml, nor shall more than ten percent of the total number of samples taken during a 30-day period exceed 400/100 ml. Fecal coliform above natural background levels have been detected in the vicinity of French Gulch (maximum 170 MPN) and in Clear Creek just above Whiskeytown Dam (307/100 ml). However, the extent or magnitude of the impact or the potential source of bacterial contamination cannot be determined based on the existing information. Additional information is needed to determine if any beneficial uses in Clear Creek are affected by bacterial contamination and whether appropriate control measures should be applied to upgrade faulty septic systems.

With the increase in population throughout Shasta County and increased use of Highway 299 to transport materials through the watershed, there is an increased potential for accidents or hazardous material spills, and emergency actions may be necessary and planned for in case such accidents occur. Shasta County does not have an established emergency response team, and it is unknown if emergency response strategies have been developed and coordinated among the NPS, Caltrans, CDF, CDFG, CalEPA, and the county sheriff's department.

5.2 FUELS AND FIRE

The probability of a large fire occurring at any particular location depends on the fire hazard within the watershed. Fire hazard is composed of fire risk, fuel conditions, weather, and topography within the watershed. Each is discussed below.

- Fire risk is associated with ignition sources, such as lightning or campfires, and the proximity of ignition sources to fuel. Backcountry roads and trails are examples of access routes that may increase the fire risk from human activity. Approximately 90 percent of wildland fires occurring on land protected by CDF are human-caused, the remaining ten percent being started by lightning.

- Fuel condition is a combination of fuel size, quantity, arrangement, and dead/live ration. Fuel conditions make up fuel hazard (not to be confused with fire risk) and are a major component of how wildfires burn (e.g., from low intensity grass fires to high intensity crown fires). Fuel size is measured by the number of hours it takes for the fuel to reach equilibrium with the changes in the relative humidity in the air. Generally, the larger the debris, the slower the fuel adapts to seasonal changes. Fuel quantity is the amount of all fuel sizes located on an area of land. Fuel arrangement refers to density and compactness of fuel. Generally, the denser the fuel load, the slower moving the fire will be. Ladder fuels are important in assessing fuel hazard because they provide the means for ground fires to become crown fires, thereby having a higher potential for generating destructive fires. Another factor related to ladder fuels is the dead to live material ratio. The higher the ratio, the faster the rate of spread of a wildfire. This factor is especially important in areas areas with large amounts of standing brush or where groves of trees have a significant amount of dead lower branches extending to the ground.

- Although humans have no control over weather, it is a large factor in wildfires. Temperature, humidity, lightning, and wind are the major components affecting wildfires.

- Topography is the lay of the land, such as flat, hilly, or mountainous. Canyons and valleys and how they face the cardinal directions influence fire spread. Rugged topography allows fire going uphill to preheat fuels ahead of the fire, causing explosive burning conditions. Fires generally move uphill faster than downhill or on flat terrain under the same weather conditions.

Work by Skinner and others has determined that the occurrence and severity of naturally occurring fires in the southern Klamath Mountains of northern California and southern Oregon has been greatest in the upper slopes, ridge tops, and south- and west-facing slopes (Skinner 1998). Such fire occurrence patterns can affect the distribution and structure of late successional forests in these areas. Regional climatology, such as mean temperature, average humidity in summer, and wind patterns, also affect the rate and occurrence of large fires (Sapsis et al. 1996). Studies of fire probability in the Sierra Nevada mountains found that fire occurrence is predominantly a function of interactions between fuel and ignition sources. The fire risk tended to increase in lower elevations and along river corridors where human use was concentrated (Sapsis et al. 1996). The probability of a fire start in these areas was increased in places where there was also a fire hazard from fuel loading. Similarly, based on the occurrence of fire starts and large fires in the upper Clear Creek watershed, it appears that the fire risk is highest in areas along roads and riparian corridors, where human access and use are greatest.

The occurrence of wildfires in the upper watershed has changed over time due to the accidental and intentional ignition by inhabitants and visitors and by fire suppression efforts of resource managers. The actual number of fires caused by human activity over time cannot be accurately assessed due to lack of historic data. It is likely that fire risk was high during the mining years because fire was used for lighting, cooking, and heating. These ignition sources tended to be concentrated within townsites. Today, common ignition sources include campfires, equipment, and cigarettes. As access into the watershed has improved with the construction of roads, the geographical extent of fire risk has increased. This is evident by an increase in human-caused fires throughout the watershed.

To protect and preserve private residences, public lands, and natural resources in the watershed, a fire suppression policy was implemented about 70 years ago. This fire suppression regime has decreased the recurrence of frequent, low intensity fires, resulting in a buildup of underbrush and ladder fuels. Therefore, the fire suppression policy has increased the probability of high intensity stand replacing fires.

Natural historic FRIs for the area range from nine to 13 years (median return interval of 11 years). However, since the fire suppression policy has been carried out in the upper watershed for the past 70 years, at least six or seven fire frequency cycles have been missed. Therefore, unnatural amounts of downed woody debris and undergrowth has accumulated over this period that has altered the vegetative structure. Fire intensity is highest in mixed conifer forests where heavy downed materials are present due to insects, disease, wind throw, or mortality from increased competition. The steep and rugged terrain of the watershed makes fire fighting extremely difficult. Fire in stands of tall chaparral also can be difficult to control because of the extremely fast spread rate and spotting.

While the CDF has cooperative agreements with the BLM, FS, and NPS for sharing fire protection resources, each agency independently conducts vegetation management programs to reduce the hazard of potential wildfires. Vegetation control methods currently used by NPS, BLM, FS, and industry (TPZ lands) include prescribed burning, manual and mechanical removal, and wildfire suppression. Intermediate thinning of stands, trimming of lower limbs, and staggered cutting of plantations to allow five-year adjacency of ages, as required by law, are also methods used to minimize the potential for stand replacing fires. SPI provides a more intensive regime by allowing a 10-year adjacency of ages. By controlling the understory and minimizing the ability of flame lengths to reach lower tree limbs, resource managers and private property owners can reduce the possibility of ground fire from becoming a more catastrophic crown fire. Vegetation management also is practiced by private landowners that clear brush and fuel wood from around their properties and away from residential structures and potential ignition sources. By managing the amount and types of vegetation, brush, and downed woody debris, fire hazard potential can be decreased.

Because of the steep and rugged topography of much of the watershed, access is quite difficult in many places. Control of wild fires once they have begun is very difficult in the watershed. Few firebreaks exist; the BLM is constructing a break in Big Gulch, but the remainder are in the Whiskeytown Unit (constructed by the NPS). Vegetation management is a preventative measure that can be taken without adding additional erosion problems commonly associated with roads. More roads could be constructed to improve distribution of fire protection forces. Roads built on ridges would provide an added benefit as fire breaks if constructed properly. However, constructing roads may increase the fire risk by providing additional access for human ignition sources. Limiting public access or roadways can control this.

5.3 VEGETATION AND WILDLIFE

Vegetation patterns have changed over time due to fire and past and present land use activities. Of those recorded, large fires have burned approximately 14,273 acres (11 percent) in the watershed. Land use activities that have changed vegetative composition include mining, grazing, and logging. Mining areas often were burned or otherwise cleared of vegetation in order to access and work a site. Native Americans also burned grasslands to encourage specific grasses and other preferred vegetation. Commercial timber products between the mid-1800s and 1900s also have changed patterns by clear cutting structurally complex, mixed-age stands and selectively replacing them with less diverse even-aged stands of more commercially desirable species.

Special land allocations provided by the *Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl* (USDA, USDI 1994) established management requirements, which affect vegetation patterns by providing for species diversity and ecosystem health. Late succession reserves and riparian reserves have been established to protect and preserve LS/OG species and habitats. Timber production is restricted in these areas to protect and enhance conditions that enable native plant and animal species to develop.

Information is not available on the historical representation of wildlife assemblages, so it is unknown if they have changed through time. It is reasonable to assume that as vegetation patterns changed, so have the spatial distribution of habitats. For example, large catastrophic fires that destroy or reduce chaparral lands that offer feeding and thermal cover have affected the Whiskeytown deer herd, which occupies parts of the southeastern portion of the watershed. The diversity of chaparral species also has been reduced by past fire suppression efforts, which have increased the percentage of less nutritive species. Further, as more roads have been constructed on private and public lands, wildlife habitat has been affected to varying degrees, and the increase in vehicular traffic has led to increased stress and mortality.

Further surveys of wildlife populations, dispersal, and habitat relationships should be conducted to determine the health and distribution of wildlife in the upper watershed. Riparian reserves and the Clear Creek LSR are intended to improve habitat conditions for both aquatic and terrestrial species that live and forage in these areas, as well as to benefit those species that may transit these lands.

5.4 SOILS AND EROSION

Land disturbing activities and consumption and exploitation of natural resources have changed the natural resources in the watershed. Land uses that have caused the greatest amount of disturbance to soils include mining, logging, and developing roads and skid trails to move materials out of the watershed. Although no historical records exist for soil erosion rates, the highest amount of erosion and sedimentation likely occurred during two periods when resource extraction was dominant. The first period was the mining boom during the mid- to late-1800s . Constructing and operating mining sites resulted in large-scale soil disturbance. Likewise, constructing towns resulted in harvesting and transporting trees as building materials and firewood. This probably caused extensive but localized soil compaction and erosion. Soil erosion probably continued into the second notable period of high erosion in the mid-1900s when lumber extraction was at its highest level. Erosion rates have since decreased following the decline in mining and increase in erosion control practices. While most mining sites have since been abandoned (only one mine remains in operation within the upper watershed), many mine sites continue to experience erosion associated with remnant tailings and unconsolidated debris at the mouths of mine shafts. Gravity weathering and runoff continue to erode these materials and transport them downslope.

Erosion rates with regard to decomposed granite have likely remained the same over the last century in the Shasta Bally area, where weathering processes have acted on the granitic batholith. Construction of Highway 299, operation of the Greenhorn Mine, and historic logging activities exacerbated erosion problems in the area of decomposed granitic soils near Buckhorn Summit, where the road steeply climbs through areas of exposed granite.

Erosion prevention efforts can be used to protect erosion areas and to lower the amount of sediment transported into Clear Creek and its tributaries. Revegetating and maintaining vegetative cover in logged and fire burn areas help to minimize erosion caused by runoff.

Without sediment erosion control efforts, severe erosion will continue, and sediment will continue to be transported to Clear Creek and its tributaries. Without such efforts, the cumulative effect to these sediment erosion sources will continue to degrade water quality and aquatic habitats in the watershed and will continue to fill in the Whiskeytown Reservoir, reducing its capacity.

5.5 HUMAN USES

Human occupation and use of the upper Clear Creek watershed during the past 150 years has influenced the ecosystem of the region. The effect of human use in the watershed has varied from nonconsumptive uses, such as hiking, wildlife viewing, and photography, to consumptive uses that have altered the ecology and landscape over time. Human occupation and uses of the upper watershed have varied over time. Historically, people were drawn to the watershed to capitalize on natural resources. During the mid- to late-1800s the French Gulch area was a popular town site for miners and their families; in 1860, approximately 350 people lived in French Gulch. Their life style was simple, and they relied on timber for housing and heat, wildlife and limited agriculture for food, and minerals for income. As mining activity decreased in the late-1800s, so did the population. The next period of notable human activity was in the mid-1950s when logging in the watershed reached its peak. More recently, human activity has become more diversified. While logging still takes place, along with limited mining, recreation-based uses have increased. Vacation homes now occupy French Gulch, while the watershed provides opportunities for hiking, fishing, hunting, and off-highway vehicle use. Much of the recreation is concentrated around Whiskeytown. Table 5-1 summarizes the predominant land use activities in the upper Clear Creek watershed and provides a qualitative ranking of their impact on key resources.

Table 5-1
Adverse Impacts of Land Use Activities
on Key Resources in the Upper Clear Creek Watershed

Human Activity & Land Use	Water Quality	Water Quantity	Fire Risk	Fire Hazard	Soil Erosion[1]	Riparian Vegetation	Upland Vegetation	Aquatic Habitat/ Wildlife	Terrestrial Habitat/ Wildlife
Logging	M	M	M	L	H	L	H	M	H
Housing/ Ranchettes	M	L	M	M	H	L	M	L	M
Roads	M	L	M	L	H	L	M	L	H
Trails (Off road vehicles/ horse/bike/ foot)	M	L	M	L	M	L	M	L	M
Recreation (hunting, fishing, hiking, camping)	L	L	M	L	L	L	L	M	M
Mining (current)	L	L	L	L	L	L	L	L	L
Mining (closed)	H	L	L	L	M	L	L	M	L
Fire Suppression Policy	L	L	L	H	M	H	H	M	H
LSR Management and Policy[2]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

H= High M = Medium L = Low

[1] Granite soils would be high for all activities that result in land disturbance. Subsequently, it would have indirect effects on water quality.

[2] N/A = not available at this time. Policy for managing LSR areas is still being developed. Different management tools may have differing impacts on the key resources.

Human use in the Clear Creek watershed is expected to continue. Projections made by the State of California Department of Finance estimate that the population of Shasta County will double by 2030 to 302,000 people. Much of this growth will occur in Redding; however, local growth is anticipated, along with an increase in seasonal populations (such as seasonal workers and summer homeowners). This growth will increase housing demand, possibly raising the demand for vacation or second homes within the watershed.

Although no local data is available, advancements in technology (e.g., telecommuting) are expected to result in a migration of people from urban areas to more rural communities in search of small-town values, recreational opportunities, scenic views, open space, and improved quality of life. Likewise, as larger urban areas expand, there is an increased demand for recreational opportunities outside the city. Based on trends in other similar rural regions, employment is expected to shift from agriculture and extractive industries to service industries.

Current trends suggest that recreation, housing and land development, and ecosystem preservation will increase, while extractive uses will decrease. Logging on timberlands is expected to continue to be regulated by state laws. Opportunities for logging and mining on federal lands will remain regulated by federal laws.

An increase in recreation and seasonal residents could increase adverse impacts on the ecosystem. Examples include soil erosion from developments and off-highway vehicle use, wildlife habituation, and increased fire risk from an increased number and wider distribution of people in the watershed.

6. RECOMMENDATIONS

SECTION 6
RECOMMENDATIONS

The purpose of Section 6 is to provide recommendations based on the topic areas addressed in the watershed analysis, including water quality and quantity, soils erosion and sedimentation, fire and fuels, vegetation and wildlife, and human uses. An ecosystem watershed management framework has been added as a sixth topic area for recommendations. It will not be possible to implement the recommendations made in the first five topic areas without the capability to coordinate activities across ownership/management boundaries. The sixth topic area addresses this capability. The main issues associated with water quality and quantity, soils erosion and sedimentation, fire and fuels, vegetation and wildlife, and human uses have been outlined in Chapter 2 and are further described in chapters 3 and 5. Recommendations for projects to improve or solve resource management issues in the upper watershed are made below, based on the findings of this watershed analysis.

This watershed analysis could be used as the foundation for a coordinated ecosystem watershed management plan that would be the culmination of a large-scale watershed evaluation and planning process. It is evident that human activity in the watershed over the last 150 years has altered the natural processes and ecosystem, yet there is a lack of basic natural resources data and an insufficient understanding of the ecosystem. By providing a baseline of existing data, an evaluation of trends, identification of key issues, and management recommendations, this watershed analysis is the first step in better understanding the watershed. The next steps in the process include collecting and interpreting supplemental data and developing resource-specific management plans.

The ecosystem management plan for the upper Clear Creek watershed should integrate resource specific management plans. The following RMPs would need to be developed for incorporation into the ecosystem management plan:

- Vegetation and Wildlife Management Plan—Inventories and remote sensing would be used to further refine data on vegetation within the watershed. Management parameters would be established and would include management tools, such as thinning, prescribed burns, and biomass removal. To protect vegetation from an epidemic scale insect or disease outbreak, an integrated pest management program should be included in the plan. Vegetation types would be correlated to wildlife species to characterize habitat quality. As part of the wildlife assessment, effects of hunting would be documented and a hunting management program would be developed.

- Fire Management Plan—A fire atlas of the watershed would be developed and incorporated with fire potential modeling and vegetation maps. Inventories from the vegetation management plan would be used to refine fire hazard models. Management policies would include locations for fuel breaks and access needs and fuel reduction programs, such as salvage sales and biomass harvesting.

- Recreation Management Plan—This plan would establish use projections, would evaluate and monitor recreational impacts to the ecosystem, would delineate recreational areas by type of activity and geographic area to minimize impacts, and would provide a coordinated approach to meet user needs in the watershed. Data would be collected and would include surveys of users to establish use patterns and the willingness of users to pay recreational fees. Primitive, semiprimitive, nonmotorized, and motorized recreation would be evaluated.

- Comprehensive Transportation Plan—Evaluates needed road and trail systems and projects that could illustrate restored hydrologic functions. Part of the process would evaluate options for roadway decommissioning, drainage control, maintenance, and improvements. Vehicular use and impacts to the ecosystem would be assessed and addressed by management programs, such as loop trails and roadway rehabilitation.

- Strategic Monitoring Plan—A long-term strategic monitoring plan needs to be developed to track the health of ecosystems over time. Coordinated efforts among land administrators will be required to minimize duplication, to share costs, and to ensure consistency in training staff and implementing survey and monitoring efforts. Data management tools discussed above (e.g., GIS and reference libraries) would facilitate the monitoring efforts.

Given that these stand-alone plans are interrelated (e.g., vegetation management influences fire management), it would be the objective of the watershed management plan to integrate these plans using a criteria of ecosystem principles to resolve management conflicts. Further, it would be the objective of the ecosystem/watershed management framework to ensure that these plans were developed and implemented together, coordinating across ownership boundaries.

The following sections summarize the findings of this watershed analysis, provide management objectives of key issues, and list recommended projects. These projects, if implemented, would provide the required data for informed management decisions in the watershed to improve, preserve, and protect existing ecosystems.

6.1 WATER QUALITY AND QUANTITY

FINDINGS:

- There are limited records on water quality monitoring data for the upper Clear Creek watershed; however, consensus among participants in the Watershed Analysis Ecosystem Elements interviews is that water quality in the upper watershed is generally excellent, with a few problem issues.

- Historic construction of roads, rural residential developments, timber harvesting, and changes in vegetative cover increased the amount of impervious area, thereby decreasing infiltration and increasing erosion and runoff. While still present, these conditions are not as evident today due to erosion control measures, improved logging practices, and better roadway engineering.

- There is preliminary data that suggests that water quality in Clear Creek is adversely affected by sedimentation, minor elements (such as aluminum, cadmium, copper, iron, lead, manganese, and zinc), and bacteriological contaminants (primarily fecal coliform from overloaded septic systems).

- A data gap in the erosion, hydrology, and water quality analysis is the lack of a reasonable sediment budget for the watershed. Professional judgment suggests that without sediment erosion control efforts, severe erosion will continue and sediment will continue to be transported to Clear Creek and its tributaries. Without such efforts, the cumulative effect to these sediment erosion sources will continue to degrade water quality and aquatic habitats in the watershed and will reduce Whiskeytown Reservoir capacity.

- Increase in population and human use of the Clear Creek watershed will increase demand for water resource-based recreation (e.g., swimming and fishing). Meeting these demands will require reliable supplies (currently subject to climatic conditions) and maintaining water quality levels for aquatic species production, while posing no risk to human health.

- Increasing the use of Highway 299 to transport materials through the watershed increases the risk for accidents and hazardous materials spills.

GOALS:

- Record and document water quality to better assess current conditions and to forecast future trends.

- Control source, timing, transport rates, and storage of sediment, minor elements, and anthropogenic pollutants in riparian zones.

RECOMMENDATIONS:

(1) Continue a water quality sampling program to ensure that water quality goals are met and to determine where and when water quality limits are exceeded. Develop mitigation measures to implement when water quality limits are exceeded. Determine what improvements can be made to septic systems in residential and other high use areas of the Whiskeytown Unit. Specific areas include in and around the town of French Gulch (e.g., rural residential septic systems of French Gulch, including Clear Creek Mobile Estate Trails Park) and Whiskey Creek, Brandy Creek, and Crystal Creek swimming areas.

(2) Reestablish a stream gage site (or two) within the upper watershed to collect stream flow measurements. The health of the aquatic and riparian habitats is associated with seasonal and long-term variation in flow. Flow in and through Whiskeytown Reservoir affects water levels, thereby affecting the aquatic habitats around the perimeter of the lake. Two gauges had been established along upper Clear Creek at French Gulch and near Whiskey Creek. Reestablish the French Gulch gauge at the confluence of French Gulch and Clear Creek. If funds provide for a second gauge, it could be placed downstream of the Willow Creek/Clear Creek confluence to measure the flow contribution of Willow Creek.

Comment: The preferred spelling is gauge, but if you have used gage throughout the document, let this spelling stay.

(3) Wherever possible, reroute or eliminate trail segments currently located within riparian reserve boundaries. If this is not possible, minimize the length of trail within the boundary, construct a stable grade, aggregate base stream crossing (or bridge), and manage the road drainage system to minimize sediment delivery. A comprehensive transportation plan would assist in making road decommissioning and realignment decisions.

(4) Continue studies to assess potential acid mind drainage from abandoned mines. Willow and Crystal creeks should be evaluated first, given that comparison data is available from the 1984 RWQCB study. If metals are seeping from the mines, implement remediation and restoration, as is being done at Greenhorn Mine. Construct diversions to minimize impacts before and during remediation.

(5) Use gravel transported down to the reservoir for restoring fish spawning grounds below the Whiskeytown Dam.

(6) Work with Caltrans to reduce transportation hazards along Highway 299.

6.2 FUELS AND FIRE

FINDINGS:

- In many areas, timber stands are at an increased hazard of stand-replacing fire due to high fuel loading. Of special concern is fuel loading in LSRs, riparian reserves, and timber plantations.

- Effective fire prevention and suppression programs have altered the character of the forests, resulting in extremely high fuel loads and combustibility, the introduction of exotic plant species, and the removal of indigenous species. High fuel loads could produce catastrophic wildfires with the potential to destroy wildlife habitat and private property, including houses and timber stocks, and to increase soil loss and sedimentation. Of special concern are fuel loading in developed areas.

- A limitation of the analysis is the lack of historical habitat, vegetation, and wildlife population data for the watershed.

GOALS:

- Reduce fire risk and hazard.

- Maintain a cost-effective detection, prevention, suppression, and fuels management program mix in support of other resources and programs.

- Decrease fuel loading of dead trees resulting from insects or disease damage, especially in the three-inch diameter tree size class.

- Given the lack of time series data, monitor the watershed for fire hazards, such as fuel loading, and for fire risk, such as ignition sources.

RECOMMENDATIONS:

(1) Implement a coordinated effort to model fire hazard potential in the watershed to determine areas of high, moderate, and low risk. Data sets collected by the CDF FFRAP can be used along with climate data to determine the likelihood and geographic extent of high-risk areas. This will require cooperation between the FS Weaverville District, which evaluated fire hazard potential in the CCLSR, and the CDF, which developed fuel maps within the rest of the watershed. Data layers have been done for the lower watershed.

(2) Develop a coordinated fire management plan among federal and state agencies and private landowners. Use fire incidence and fire start data and maps to determine areas of high ignition and compare against areas determined to incur the greatest impact from fire and the greatest loss.

Opportunities exist among federal agencies, private companies, and residents to develop vegetation management plans. These plans can be coordinated throughout the watershed to reduce the levels of dead and living fuel buildups and thereby reduce the hazard of catastrophic high intensity wildfires. As part of this effort, fire history should be researched to determine how changes in fire regimes have modified plant community structure and how prescribed burns should be used to mitigate these impacts.

A joint task force or team can be developed from CDF, BLM, NPS, and FS staff and charged with fire protection and fire management. This task force would coordinate the watershed-based fire management plan program among the agencies, private companies, and residents to educate them about the importance of reducing fire hazard and risk potential.

The coordinated fire management plan should stratify the watershed based on vegetation, fire hazard modeling, and terrain. The end product would provide geographically defined management prescriptions. Prescribed burns, salvage sales, thinning, biomass harvesting, and construction and maintenance of fuel breaks are examples of common fire management tools that should be evaluated in the plan. The end objective would be a return to managing natural fire regimes in the watershed.

(3) Develop and implement a watershed-based integrated pest management program to reduce the probability of epidemic insect and disease outbreaks.

(4) Digitize fire-related data for the watershed into a GIS to create a fire atlas. Maps in this analysis provide a baseline for future data collection.

6.3 VEGETATION AND WILDLIFE

FINDINGS:

- Fire exclusion has allowed conifers to invade other types of vegetation, such as grass, brush, and hardwoods. This process gradually is depriving the watershed of important vegetation species, which provide wildlife habitat diversity.

- Fire suppression has degraded the diversity of the chaparral assemblage, resulting in a dominance of species in the late-seral stage. This has reduced the number and quality of ceanothus in the watershed for the Whiskeytown deer herd and has decreased the amount of available forage.

- Habitat for late successional wildlife species is at high risk from a stand-replacing catastrophic fire. Such a fire may leave little of the LSR habitat in functioning condition. It is particularly important that this habitat be maintained or improved and that fire hazards be reduced adjacent to the LSR and riparian reserves. An increase in a mosaic of different vegetation types would benefit these species.

- The presence of fish up to Slate Creek implies that a functional level of aquatic habitat exists in the watershed.

- The checkerboard ownership pattern (Figure 1-2) makes coordinated wildlife management difficult. Different uses and management objectives between federal and private lands have had different effects on wildlife habitat.

GOALS:

- Maintain and restore structural diversity of plant communities and animal diversity.

- Maintain or improve the diversity of habitat to support viable populations of native and nonnative but desirable and appropriate flora and fauna (e.g., wild turkey and kokanee).

- Protect and enhance conditions of late successional and old growth forest ecosystems within LSRs to provide for the viability of late successional and old growth-related species.

RECOMMENDATIONS:

(1) Conduct vegetation and wildlife surveys to field check Landsat vegetation mapping of the Klamath Bioregional Mapping program and to inventory and establish baseline information on population distributions in the watershed. NPS, BLM, FS and others should combine data sets and mapping information on known species distributions to determine consistency or nonconsistency of methodology and geographic extents of the data. The watersheds then can be systematically surveyed by such agencies within their administrative boundaries, and the data can be combined among agencies. Vegetative surveys should note assemblages and seral stages; the wildlife survey should focus on vertebrates and significant invertebrates.

(2) Determine the compliance status of "survey and managed" species, as compiled for the FS and BLM records. Determine the status and location of each category I-IV species and the management requirements that still need to be implemented for future management plans that involve ground-disturbing activities on federally administered lands.

(3) Develop a wildlife and vegetation management plan that outlines management prescriptions and identifies tools for implementation. The plan also should provide procedures for monitoring trends in native vegetation and T&E plant and wildlife species and for monitoring backcountry use levels and associated impacts on flora and fauna. A component of the plan should be an integrated pest management program to prevent an epidemic insect or disease outbreak.

(4) Create an institutional mechanism to use future timber sales to support ecosystem management objectives. For example, timber volume could be exchanged for private land interests or used as barter in a competitive stewardship contract for restoration services within the watershed.

(5) Reintroduce a regime of frequent, low intensity fires to rehabilitate early successional habitat types within the watershed. Delineate areas of the watershed that would benefit from fire treatments in the vegetation and wildlife management plan based on wildlife location (by species) and the historic distribution of early

successional vegetation. For example, lands within the Whiskeytown deer herd range that are known to have supported ceanothus would be a priority fire regime management area. Regarding fire regime management, the vegetation and wildlife management plan should address such issues as quality, soil stability, regime rotation periods, and timing in relation to seasons and vegetative reproduction and growth.

(6) Thin and conduct understory burning or other fuel treatment in older stands in the LSR and riparian reserves to reduce the risk of stand-replacing wildfires and to accelerate creation of late successional forest conditions.

(7) Many opportunities for deer and riparian habitat improvement projects exist in the watershed. The WSRCD and FS should seek cooperation and support from the CDFG and the NRCS to implement these projects. Likewise, there are opportunities to involve colleges and universities in research and survey projects.

(8) Monitor vegetation management in LSR and riparian areas to assess changes in late successional species.

(9) Evaluate and survey the watershed for neo-tropical bird habitat.

6.4 Soils and Erosion

Findings:

- Different erosion problems exist throughout the watershed due to different lithologies and ground-disturbing land use activities.
- Funding for road maintenance on public land has decreased and will result in an increase in erosion and sedimentation.
- A data gap in the erosion, hydrology, and water quality analysis is the lack of a reasonable sediment budget for the watershed.
- Conflicting data make it uncertain if abandoned mines pose an erosion hazard. Most data suggest that mine sites continue to experience some level of erosion, although control measures have reduced erosion rates compared to those between 1850 and the mid-1900s.

Goals:

- Maintain and restore the sediment regime by decreasing erosion in the watershed.

Recommendations:

(1) Conduct a sediment source inventory and develop a sediment budget for the watershed, including detailed data on the largest slides and earth flows. This data should be used in developing slide stabilization strategies and in determining when and how best to phase controlled burns and other sediment-generating projects.

(2) Implement a coordinated effort to monitor erosion areas and to reduce erosion and sedimentation in and around Clear Creek tributaries and in the Shasta Bally area. The monitoring program should assess and delineate between sediment generated from human causes and from natural forces. Rank erosion areas by priority for allocating staff.

(3) Develop feasibility of various erosion control measures that could be applied to solve different erosion problems in the watershed where erosion of decomposed granite can affect aquatic habitats. Erosion control measures may include revegetating hillslopes, grading or shaping the landscape and hillslope gradients, and establishing vegetative buffer zones to trap sediments and other pollutants from entering the stream system.

(4) Erosion hazards should be mapped and evaluated to determine what measures can be taken to reduce the potential for negative impacts due to unstable lands and sediment erosion and transport problems associated with roads and trails.

(5) Develop and implement a comprehensive transportation plan to reduce erosion and sedimentation problems associated with existing roads and trails. Elements of this plan should include a road and trail needs assessment, decommissioning and realignment recommendations, and maintenance procedures. Expand erosion rehabilitation efforts, such as are being done on Big Gulch Road, to other roads with erosion problems. While funding for road maintenance on public lands has decreased, most rehabilitation and management costs would be recovered through reduced net maintenance costs resulting from decommissioning roads.

(6) Encourage agreements between nontimber-producing landowners and NRCS to repair and maintain private roads. Timber-producing landowners should be encouraged to work with CDF to reduce erosion.

(7) Downgrade selected roads to narrow the width of two-track or single-track routes to provide access and to reduce volume and velocity of water runoff, thereby reducing erosion.

(8) Begin monitoring sediment flow at head of Whiskeytown Reservoir.

6.5 HUMAN USES

FINDINGS:

- Human activity during the last 150 years, including logging, mining, suppressing fires, and developing land and roadways, has altered the historical equilibrium of the upper watershed ecosystem.

- Trends in the watershed suggest that recreation, housing and land development, and ecosystem preservation will increase, while extractive uses will decrease. Although considered nonconsumptive uses, recreation and land development can result in moderate to high impacts to the ecosystem if not properly managed (see Table 5-1). Also, no action can result in high impacts.

- Human use of the watershed is expected to increase in correlation with increases in population in and around Shasta County. This will increase demand for recreational services and opportunities, roadways, and development permits.

- Abandoned mines should be considered dangerous and a hazard to the public.

- Through human occupation and use of the watershed, black bears have become habituated to human activity.

GOALS:

- Manage lands for multiple use using ecosystem principles.

- Ensure that all recreational programs and existing facilities are in attainment with ACS objectives.

- Ensure that the public is not exposed to unreasonable hazards.

- Educate watershed users on wildlife to minimize human-wildlife conflicts.

RECOMMENDATIONS:

(1) Restrict off-highway vehicle use to designated roads and trails. Evaluate off-highway vehicle trails for usage (demand) and impacts from usage. Decommission trails with low usage or high impacts and modify other trails to form loops within off-highway vehicle management areas. Future off-highway vehicle trail development should be conducted in accordance with the Soil Conservation Guidelines/Standards for Off-Highway Vehicle Recreation Management (California State Parks–Off-Highway Recreational Vehicle Management Division, Bureau of Land Management, Forest Service) and the Guide to Off-Road Motorcycle Trail Design and Construction (American Motorcycle Association, prepared with assistance from the Wenatchee National Forest, Angeles National Forest, Deschutes National Forest, Talladega National Forest, and BLM).

(2) Conduct a recreation survey and develop a recreation management plan. The plan should account for current demands, trends, and impacts from different types of

uses and should stratify recreational opportunities by ecosystem constraints. For example, dispersed recreational activities, such as hunting and fishing, generally are consistent with the objectives of the LSR, while off-road vehicle use generally conflicts with LSR objectives.

(3) Implement abatement measures to reduce safety and erosion hazards from abandoned mine sites. Signing, fencing, and grated gates could be used to limit public access, while backfilling and constructing concrete bulkheads are examples of means to seal off mine sites. Prior to sealing, survey the site for the presence of bats.

(4) Develop educational programs and coordinated resource management program plan for the upper Clear Creek watershed. Coordination with or expansion of the lower Clear Creek CRMP should be used as a stepping stone to understanding and organizing the similarities and differences between the upper and lower watersheds. Community support and interest can greatly aid in the success of different resource management activities and also may provide volunteers to participate in surveys and monitoring and project construction activities.

(5) Develop strategies to eliminate sources of human food for black bears. This may be a component of the education program (see previous recommendation). Informational fliers posted along recreational areas and distributed to residents would provide a quick and inexpensive means of outreach. Campfire programs by rangers are also effective in influencing human behavior.

6.6 ECOSYSTEM / WATERSHED MANAGEMENT FRAMEWORK

FINDINGS:

♦ Effective management of the upper Clear Creek watershed will require a coordinated effort among federal, state, and local agencies and with landowners within the watershed, especially SPI.

♦ The Shasta-Tehama Bioregional Council (STBC) and Northwest Sacramento PAC is a public/private partnership organization formed in 1992 that includes a broad range of stakeholders with interests in the upper Clear Creek watershed. The focus of the STBC is to develop and implement a collaborative ecosystem management plan for the upper Clear Creek watershed. The STBC has a well-defined mission statement and rules of operation that are consistent with CRMP principles. The STBC is capable of serving as the foundation for developing and implementing an ecosystem management framework for the upper Clear Creek watershed.

♦ The STBC requires some additional capacity building to more effectively coordinate the activities of participating stakeholders. The STBC recently submitted a grant in response to the CALFED Ecosystem Restoration Proposal Solicitation with the objectives of funding several ecosystem management pilot projects and to establish a framework for long-term collaborative planning among watershed stakeholders. The grant was not funded because the amount requested exceeded the available funds. However, the STBC remains committed to obtaining the resources necessary to develop the capacity to provide long-term coordination and community involvement in the Clear Creek watershed. The STBC should continue to be the focus of resource management activities in the watershed.

GOALS:

♦ Develop an ecosystem/watershed management framework for an integrated watershed-level ecosystem management strategy/plan covering the six federal management areas (Figure 1-4) and private lands within the upper watershed. The purpose of the plan is to ensure that the watershed is managed with ecosystem principles and in accordance with the ACS (USDA, USDI 1994). The plan can address issues of the upper watershed alone or of management programs integrated within the lower watershed.

RECOMMENDATIONS:

1. The first step of this process should be to develop a list of ecosystem management indicators. These are select parameters and indices that can be used to characterize overall conditions in the watershed and provide benchmarks for assessing success of ecosystem management efforts. A list of ecosystem management indicators can serve several important functions including the following:

   ✔ Defining assessment objectives to guide the adaptive management process;

   ✔ Identifying information needs for a strategic monitoring plan for upper Clear Creek;

   ✔ Establishing criteria for selecting project priorities; and

   ✔ Developing educational tools regarding the STBC's activities and progress.

   Indicators should be developed for all aspects of the ecosystem management plan. The STBC can use this watershed analysis to begin defining a suite of indicators, which can be based on the STBC's management objectives for each core topic of the watershed analysis process. The vegetation core topic could address indicators for management indicators that include the frequency and severity of wildfires, fuel buildup, and the acreage that has been treated under fire management guidelines. Other indicators could be developed for water quality to help determine the extent that water quality beneficial uses have been impaired. Biological indices that measure taxa richness of fisheries or benthic macroinvertebrates is a useful indicator of the status of beneficial uses. These indicators also can be used to help interpret the ecological significance of an occasional violation of Basin Water Quality Objectives (i.e., standards). Each core topic should have more than a single indicator. The discussion necessary to develop indicators for the core topics will promote consensus among the STBC on management objectives for the watershed.

2. Additional primary and secondary data collection is needed, including an inventory of many of the watershed's resources. With this data in hand, a long-term monitoring strategy needs to be developed to track the health of ecosystems over time.

3. Coordinated efforts among land administrators will be required to minimize duplication, to share costs, and to ensure consistency in training staff and implementing survey and monitoring efforts.

4. To manage data temporally and spatially, a GIS should be developed. The GIS figures developed for this analysis may be used as the template and modified accordingly. To ensure effective communication among all the management entities, a centralized bibliography and library of watershed research should be developed. A potential model is computerized bibliographic information system developed by the NPS in 1997 for the WSTNRA.

5. Continue to pursue grant opportunities to fund a watershed coordinator position to facilitate the STBC stakeholder group.

7. REFERENCES

SECTION 7
REFERENCES

Agee, J. K. 1993. Fire ecology of Pacific Northwest forests. Washington, DC: Island Press.

Albers, J. P. 1964. Geology of the French Gulch Quadrangle, Shasta and Trinity Counties, California. US Geological Survey Bulletin 1141-J. US Geological Survey Contributions to General Geology; 70pp.

Albers, J. P. 1965. Economic Geology of the French Gulch Quadrangle, Shasta and Trinity Counties, California. California Division of Mines and Geology, Special Report 85; 43pp.

Albers, J. P. 1966. Economic Deposits of the Klamath Mountains. California Division of Mines and Geology, Bulletin 190; pp51-62.

Albini, F. A. 1976. Estimating wildfire behavior and effects. USDA Forest Service General Technical Report INT-30. Intermountain Forest and Range Experiment Station Ogden, Utah; 92pp.

Anderson, H. E. 1982. Aids to determining fuel models for estimating fire behavior. USDA Forest Service General Technical Report INT-122. Intermountain Forest and Range Experiment Station Ogden, Utah; 22pp.

Babcock, Curt. 1998. California Department of Water Resources. Personal Communication with Tetra Tech, Inc.

BLM (Bureau of Land Management). 1993. Redding Resource Management Plan and Record of Decision. Bureau of Land Management, Redding Resource Area; Redding, California. June 1993; 55pp.

BLM. 1996. Interlakes Special Recreation Management Area Final Plan and Environmental Impact Statement with Preliminary Watershed Analysis. Bureau of Land Management. December 1996.

BLM. 1997. Interlakes Special Recreation Management Area Final Plan and Environmental Impact Statement with Preliminary Watershed Analysis. Bureau of Land Management. October 1997.

BOR. 1998. US Department of Interior, Bureau of Reclamation [http:/www.usbr.gov/main/abuutus/mission-vision.html].

California Forest Products Commission. 1998. Measuring the wild – New study on owls one of the most extensive in the State. In: Words of the Woods Newsletter produced by the California Forest Products Commission. Summer, 1998.

CDFG. (California Department of Fish and Game). 1998a. California Natural Diversity Data Base. Natural Heritage Division. July 1998.

CDFG. 1998b. Endangered and Threatened Animals of California. Natural Heritage Division. April 1998.

CDFG. 1998c. Endangered, Threatened, and Rare Plants of California. Natural Heritage Division, Endangered Plant Program. April 1998.

CDFG. 1998d. Special Plants List. April 1998.

Chang, C. 1996. Ecosystem Responses to Fire and Variations in Fire Regimes. IN: Sierra Nevada Ecosystem Project: Final report to Congress, vol II, Assessments and scientific basis for management options. Davis: University of California, Centers for Water and Wildland Resources, 1996; Chapter 39, p1071-1099.

Clark, W. B. 1970. Gold Districts of California. Bulletin 193. California Division of Mines and Geology, Sacramento, California.

Davis, G. A. 1966. Metamorphic and granitic history of the Klamath Mountains. IN: Geology of Northern California; California Division of Mines and Geology, Bulletin 190; pp39-50.

Dubois. 1935. (Cultural).

Dunne, T. and L. B. Leopold. 1978. Water in Environmental Planning. W.H. Freeman and Company, New York, New York.

DWR. 1998. California Department of Water Resources California-programs-for-biodiversity-conservation [http://ice.ucdavis.edu/guide-to-/dwr/dwr.html].

Ferguson, H. G. 1914. Gold Lodes of the Weaverville Quadrangle, California. US Geological Survey Bulletin 540-A, p. 11-21.

Foster-Wheeler. 1995. Northwest Forest Plan Record of Decision Species: Implications to Forest Management by Private Timber Companies in California. 10pp.

FS (Forest Service). 1982. Soil Resource Inventory Report – Soils of the Shasta-Trinity National Forest. Prepared by Ken Lanspa, Shasta-Trinity National Forest. November 1982.

FS. 1982. Soil Resource Inventory Report, Shasta-Trinity National Forests.

FS. 1994. Final Environmental Impact Statement, Shasta-Trinity National Forests Land and Resource Management Plan. Forest Service, Shasta-Trinity National Forest.

FS. 1997. Clear Creek Late-successional Reserve (RC-334) Management Assessment. Report and Map Package. USDA Forest Service, Shasta-Trinity National Forests; 41pp, with additional maps and addendum.

Fujitani, Paul. 1998. Personal Communication with Tetra Tech, Inc.

FWS (Fish and Wildlife Service). 1995a. Endangered and Threatened Wildlife and Plants. 50 CFR 17.11 & 17.12.

FWS. 1995b. Federally Listed Plants in California. September 1, 1995.

FWS. 1996. Endangered and Threatened Wildlife and Plants; Review of Plant and Animal Taxa that are Candidates for Listing as Endangered or Threatened Species; 50 CFR Part 17. February 28, 1996.

Harvey, C., and G. Ring. 1993. General notes on biological resources that may be affected by mine hazard abatement at selected mines in Whiskeytown National Recreation Area. National Park Service, Whiskeytown Unit of Whiskeytown-Shasta-Trinity National Recreation Area.

Healey, Terri. 1998. California Department of Fish and Game. Personal Communication with Tetra Tech, Inc.

HSU. 1997. (Klamath Bioregional Assessment Project).

Irwin, W. P. 1966. Geology of the Klamath Mountain Province. IN: Geology of Northern California. Bulletin 190. California Division of Mines and Geology, San Francisco, pp 19-38.

Ivey, Bud. 1998. National Park Service. Personal Communication with Tetra Tech, Inc.

LaPena, Frank. 1978. Winter. IN: Handbook of North America Indians, Smithsonian Institution, Washington DC. Pp. 324-346.

Mallory, J. L., W. L. Colwell, Jr., and W R Powell. 1973. Soils and Vegetation of the French Gulch Quadrangle (24D-1,2,3,4) – Trinity and Shasta Counties, California. USDA Forest Service Resource Bulletin PSW-12; Pacific Southwest Forest and Range Experiment Station, 41pp.

Mayer and Landenslayer. 1988. (CA WHR Classification System).

Murphy, Ed. 1998. Sierra Pacific Industries. Personal Communication with Tetra Tech, Inc. California.

National Park Service (NPS). 1997. Whiskeytown National Recreation Area Resource Management Plan. National Park Service: Whiskeytown Unit of Whiskeytown-Shasta-Trinity National Recreation Area. August 1997.

Rechtenweld, Harry. 1998. California Department of Fish and Game. Personal Communication with Tetra Tech, Inc.

Regional Interagency Executive Committee. 1995. Ecosystem Analysis at the Watershed Scale: Federal Guide for Watershed Analysis. Revised August 1995. Version 2.2. Portland, Oregon.

Regional Interagency Executive Committee. 1995. Ecosystem Analysis at the Watershed Scale – Federal Guide for Watershed Analysis. Regional Interagency Executive Committee and Intergovernmental Advisory Committee. Version 2.2. Revised August 1995.

Riggs, H. C. 1972. Low-Flow Investigations. Book 4, Chapter B1 of Techniques of Water Resources Investigations of the USGS.

Rothermel, R. C. 1972. A mathematical model for fire spread predictions in wildland fuels. USDA Forest Service Research Paper INT-115. Ogden, Utah: USDA, Forest Service, Intermountain Forest and Range Experiment Station. 40pp.

Sapsis, D., B. Bahro, J. Spero, J. Gabriel, R. Jones, and G. Greenwood. 1996. An assessment of current risks, fuels, and potential fire behavior in the sierra nevada IN: Sierra Nevada Ecosystem Project: Final report to Congress, vol III, Assessments, Commissioned Reports, and Background Information. Davis: University of California, Centers for Water and Wildland Resources, 1996; Chapter 19, p759-786.

Skinner, C. N. 1997a. Fire history records in Northwest Sacramento Province. USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Redding, California.

Skinner, C. N. 1997b. Toward an understanding of fire history information. Proceeding of the 6th Biennial Watershed Management Conference. S. Sommarstrom, ed. Water Resources Center Report No. 92. University of California, Davis; pp 15-22.

Skinner, C. N. 1998. US Forest Service. Personal Communication with Tetra Tech, Inc.

Soho, David. 1998. California Department of Forestry and Fire Protection. Personal Communication with Tetra Tech, Inc.

Strahler, A. N. 1964. Quantitative geomorphology of drainage basins and channel networks; Section 4-2 in Handbook of Applied Hydrology (ed. Ven te Chow), McGraw-Hill, New York, New York.

Thomas, W. O., A.M. Lumb, K. M. Flynn, and W. H. Kirby. 1998. Users Manual for Program PEAKFQ, Annual Flood Frequency Analysis Using Bulleting 17B Guidelines. (Draft). US Geological Survey, Reston, Virginia.

USDA, Soil Conservation Service. 1974. Shasta Country Soil Survey.

USDA, USDI (US Department of Agriculture, US Department of Interior). 1994. Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents within the Range of the Northern Spotted Owl – Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth forest Related Species within the Range of the Northern Spotted Owl. April, 1994.

USDI. 1997. Central Valley Improvement Act Administrative Proposal on Management of Section 3406(b)(2) Water. US Department of the Interior. November, 1997.

USGS (US Geological Survey). 1982. Guidelines for Determining Flood Flow Frequency. Water Resources Council Bulletin 17B, Reston, Virginia.

Water Resources Council. 1967. A Uniform Technique for Determining Flood Flow Frequencies. Water Resources Council Bulletin 15. Washington, DC.

Water Resources Council. 1977. Guidelines for Determining Flood Flow Frequency. Water Resources Council Bulletin 17A. Washington, DC.

Weatherspoon, C. P. 1996. Fire-silviculture relationships in Sierra forests. IN: Sierra Nevada Ecosystem Project: Final report to Congress, vol II, Assessments and scientific basis for management options. Davis: University of California, Centers for Water and Wildland Resources, 1996; Chapter 44, p1167-1176.

Weatherspoon, C.P. and C. N. Skinner. 1996. Landscape-Level Strategies for Forest Fuel Management. In: Sierra Nevada Ecosystem Project: Final Report to Congress, Vol. II, Assessments and Scientific Basis for Management Options. Davis University of California, Centers for Water and Wildland Resources, 1996; Chapter 4, pp. 1471-1491.

Western Shasta Resource Conservation District. 1996. Lower Clear Creek Watershed Analysis. January 1996.

Appendix A. Watershed Analysis Preparers and Upper Clear Creek Technical Advisory Committee

Appendix A. Watershed Analysis Preparers and Upper Clear Creek Technical Advisory Committee

Name	Agency	Address
Project Team		
Clayton Creager	Tetra Tech Project Manager Watershed Resources Specialist	Tetra Tech, Inc. 2436 Foothill Blvd., Suite J Calistoga, CA 94515
David Batts	Tetra Tech Natural Resource Planner	Tetra Tech 180 Howard St., Suite 250 San Francisco, CA 94105
Kelly Cuffe	Tetra Tech Geologist/Hydrologist	Tetra Tech, Inc. 180 Howard St., Suite 250 San Francisco, CA 94105
Megan Goddard	Tetra Tech GIS Specialist	Tetra Tech, Inc. 180 Howard St., Suite 250 San Francisco, CA 94105
Jeff Souza	WSRCD	Western Shasta RCD 3179 Bechelli Lane, Suite 110 Redding, CA 96002
Technical Advisory Committee		
Tom Engstrom	WSRCD c/o SPI	C/o Sierra Pacific Industries P.O. Box 496014 Redding, CA 96049-6014
Ed Murphy	SPI	Sierra Pacific Industries P.O. Box 496014 Redding, CA 96049-6014

Name	Agency	Address
Darrel Ranken	FS	FS - Shasta-Trinity National Forest 2400 Washington Ave Redding, CA 96001
Carl Skinner (FS-PSW)	FS	FS - Pacific Southwest Research Station 2400 Washington Ave Redding, CA 96001
David Soho	CDF	CDF- Shasta Trinity Ranger Unit 1000 W. Cypress Ave Redding, CA 96001
Bud Ivey (NPS- Whiskeytown)	NPS	National Park Service – Whiskeytown Unit P.O. Box 188 Whiskeytown, CA 96095
Dennis Heiman	RWQCB	Regional Water Quality Control Board 415 Knollcrest Drive Redding, CA 96002
Curt Babcock	DWR	Department of Water Resources – Northern District 2440 Main Street Red Bluff, CA 96080-2398
Buford Holt	BOR	Bureau of Reclamation 16349 Shasta Dam Blvd. Shasta Lake, CA
Bob Bailey	NRCS	Natural Resources Conservation Service 3179 Bechelli Lane, Suite 107 Redding, CA 96002
Francis Berg	BLM	Bureau of Land Management 355 Hemsted Drive Redding, CA 96002
Kelly Wolcott	FWS	Fish and Wildlife Service 10950 Tyler Road Red Bluff, CA 96080

Name	Agency	Address
Terri Healey	CDFG	Department of Fish and Game – Region 1 601 Locust Street Redding, CA 96001
Carl Weidert	PAC	Sacramento Provincial Advisory Committee 30646 Loop Road Shingletown, CA 96088

Additional Assistance Provided by:

Dave Irion	Data Gathering Alpine Land Systems	McCloud
Todd Cottengim	GIS Assistance Alpine Land Systems	Redding

Appendix B. Partial List of Laws Pertaining to Federal Land Management

Appendix B
Partial List of Laws Pertaining to Federal Land Management

LAW OR REGULATION	INFLUENCE	
	HIGH	MEDIUM
Abandoned Shipwreck Act of 1987 [43 USC 2101]		X
American Indian Religious Freedom Act of 1978, as amended [42USC1996] [PL95-341]		X
Anadromous Fish Conservation Act (1965) [16 USC 757]		X
Antiquities Act of 1906 [16 USC 431] [PL 59-209]		X
Archaeological and Historic Resources Management [DoDD 4710-1]	X	
Archaeological and Historic Data Preservation Act of 1974 [16 USC 469]		X
Archaeological Resources Protection Act of 1979 [16 USC 470] [PL 96-095]	X	
Bald Eagle Protection Act of 1940 [16 USC 668]		X
Clean Air Act (CAA) (1955) [42 USC 7401]		X
Clean Water Act (CWA) (1972) [33 USC 1251] [PL 92-500]	X	
Coastal Zone Management Act of 1972 [16 USC 1451] [PL 92-583]		X
Conservation and Rehabilitation Program on Military and Public Lands (PL 93-452)		X
Conservation Programs on Military Reservations (Sikes Act) [16 USC 670] [PL 86-797]	X	
Curation of Federally Owned and Administered Archaeological Collections [36CFR79]	X	
Determination of Eligibility for Inclusion in the National Register of Historic Places [36 CFR § 63]	X	
Emergency Wetlands Resources Act of 1986 [16 USC 3901]		X
Endangered Species Act (ESA) [PL 93-205]	X	
Environmental Protection and Enhancement: Subpart H Historic Preservation [32 CFR § 650]		X
Erosion Protection Act [33 USC 426]		X
Estuary Protection Act of 1968 [16 USC 1221]		X
Farmland Protection Policy Act of 1981 [7 USC 4201] [PL 97-098]		X
Federal Cave Resources Protection Act of 1988		X
Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), as amended [7USC 136]	X	
Federal Land Policy and Management Act of 1976 [43 USC 1701]		X
Federal Noxious Weed Act of 1974, as amended [7 USC 2801]	X	
Fish and Wildlife Conservation Act of 1980 [16 USC 2901] [PL 96-366]		X
Fish and Wildlife Coordination Act of 1934 [16 USC 661]		X
Food, Agricultural, Conservation and Trade Act of 1990 (Pesticide Reporting) [7 USC 136I]		X
Forest Rangeland Renewable Resource Planning Act of 1974 [16USC1600] [PL 93-378]	X	
Historic Preservation Certificates [36 CFR § 67]		X
Historic Sites Act of 1935 [16 USC 461] [PL 74-292]		X
Historic Preservation [AR 420-40]	X	
Hunting, Fishing and Trapping on Military Lands		X
Indian Sacred Sites [EO 13007]	X	
Lacey Act of 1900		X
Marine Mammal Protection Act of 1972 [16 USC 1361] [PL 92-522]		X

NATURAL RESOURCE LAWS AND REGULATIONS, CON'T.	**INFLUENCE**	
LAW OR REGULATION	**HIGH**	**MEDIUM**
Migratory Bird Treaty Act (1918) [16 USC 703] [PL 65-186]	X	
Multiple-Use Sustained Yield Act of 1960 [16 USC 528]		X
National Environmental Policy Act of 1969 (NEPA) [42 USC 4321] [PL 91-190]	X	
National Historic Landmarks Program [36 CFR § 65]		X
National Historic Preservation Act of 1966, as amended [16 USC 470] [PL 89-665]	X	
National Register of Historic Places [36 CFR § 60]	X	
Native American Graves Protection and Repatriation Act of 1990 [25 USC 3001] [PL 101-601]	X	
Native American Graves Protection and Repatriation Act Regulations	X	
North American Wetlands Conservation Act [16 USC 4401]	X	
Outdoor Recreation on Federal Lands		X
Outleasing for Grazing and Agriculture on Military Lands [10 USC 2667]	X	
Preservation of American Antiquities [43 CFR § 3]		X
Protection and Enhancement of the Cultural Environment [EO 11593]	X	
Protection and Enhancement of Environmental Quality [EO 11514]		X
Protection of Archaeological Resources: Uniform Regulations [32 CFR § 229]	X	
Protection of Historic and Cultural Properties [36 CFR § 800]	X	
Protection of Wetlands [EO 11990]	X	
Recreational Fisheries [EO 12962]	X	
Religious Freedom Restoration Act		X
Rivers and Harbors Act of 1899 [33 USC 401]		X
Safe Drinking Water Act of 1974, as amended [42 USC 300] [PL 93-523]		X
Salmon and Steelhead Conservation and Enhancement Act of 1980		X
The Secretary of Interior's Standards for Historic Preservation Projects[36 CFR § 68]	X	
Soil and Water Resources Conservation Act of 1977 [16 USC 2001]		X
Taylor Grazing Act (1934) [43 USC 315] [PL 73-482]		X
Timber Sales on Military Lands [10 USC 2665]	X	
Waiver of Federal Agency Responsibility under Section 110 of the National Historic Preservation Act [36 CFR § 78]		X
Water Resources Planning Act [42 USC 1962]		X
Watershed Protection and Flood Prevention Act [16 USC 1001] [33 USC 701]		X
Wild and Scenic Rivers Act of 1968 [16 USC 1271] [PL 90-542]		X
Environmental Effects Abroad of Major Federal Actions		X
Exotic Organisms [EO 11987]	X	
Floodplain Management [EO 11988]		X
Intergovernmental Coordination Act (1968) [42 USC 4231] [PL 90-577]		X
Protection of Wetlands [EO 11990]	X	
Use of Off-Road Vehicles on Public Lands		X

Sources: Guidelines to Prepare Integrated Natural Resource Management Plans for Army Installations and Activities, US Army Environmental Center, April 1997. The Principle Laws Relating to Forest Service Activities, US Department of Agriculture, Forest Service, 1993.

Appendix C. Determination of Extreme Flows from Streamflow Data

Appendix C. Determination of Extreme Flows from Streamflow Data

Predicting Extreme Flow Events

The daily mean discharge values, the exceedance probability for mean daily flows, the maximum annual peak discharge values, and the average annual 7-day low flow minima are shown in figures C-1, C-2, C-3, and C-4.

To predict infrequent events with long recurrence intervals, a parametric fit to the data is often used. The Water Resources Council (1967, 1977) has established parametric analysis with the log Pearson Type III extreme value distribution as the official method for estimating flood frequencies and return periods.

The log Pearson Type III distribution works with the base 10 logarithms of the annual maxima. The distribution has three parameters or sufficient statistics, determination of which allows the prediction of the base 10 logarithm of the flow for any recurrence interval T, X_T, via

$$X_T = m_x + K_T s_x$$

Where

m_x is the mean of the base 10 logarithms,
s_x is the standard deviation of the base 10 logarithms, and
K_T is a frequency factor derived for recurrence interval T, which depends on the skew coefficient of the natural logarithms.

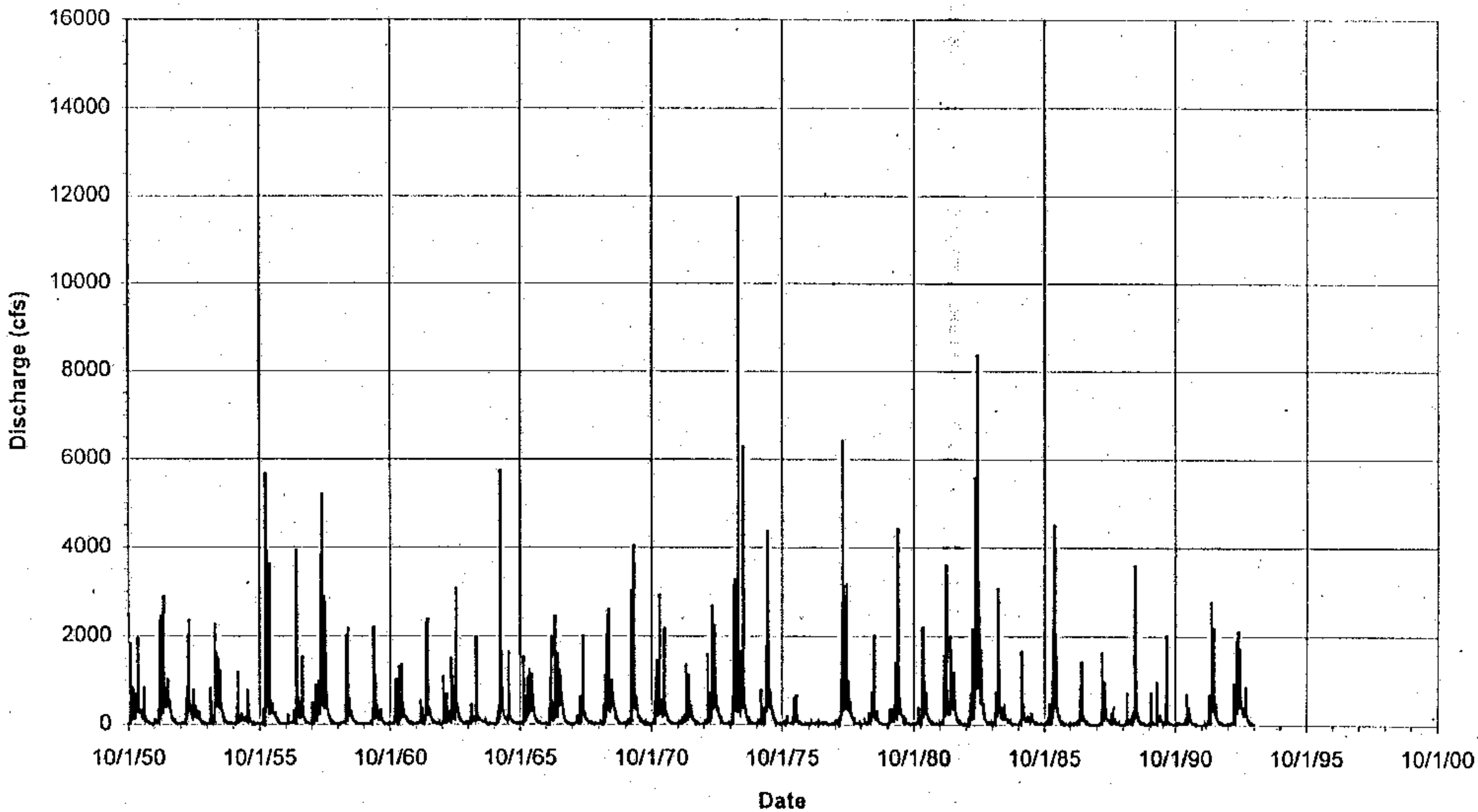
The frequency factor for the log Pearson Type III distribution is not given by an exact closed-form formula but has been tabulated conditional on the skew coefficient and recurrence interval (e.g., USGS 1982). A program for fitting the log Pearson Type III distribution to annual maxima, PEAKFRQ, is also available from USGS (Thomas et al. 1998).

Use of the log Pearson Type III distribution requires an estimate of the skew (or third moment) of the data. The formula for estimating the skew from a set of *n* samples is:

$$C = \frac{n\sum_{i=1}^{n}(x_i - m_x)^3}{(n-1)(n-2)s_x^3}$$

Unfortunately, estimation of the skew from sample data can be rather unreliable for sample sizes less than 100, which in turn effects the log Pearson estimates. For this reason, the Water Resources Council recommended a stabilized estimate in which the skew estimated on the sample is weighted with a generalized regional estimate of the skew:

$$Cs = \alpha C + (1-\alpha)\overline{C}$$



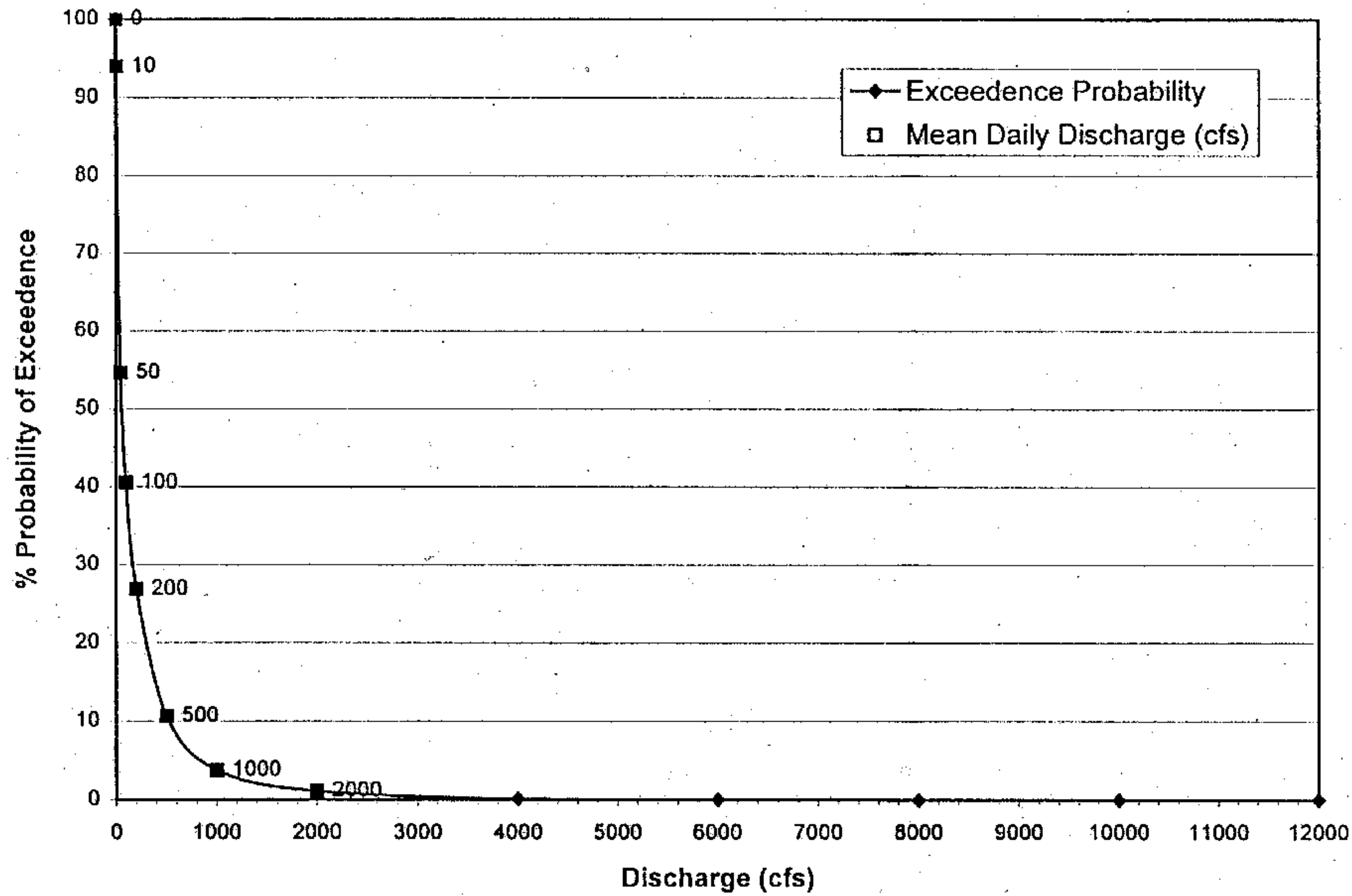
Source: Tetra Tech 1998

Daily Mean Discharge Values

Clear Creek at French Gulch

Tetra Tech, Inc.

Figure C-1



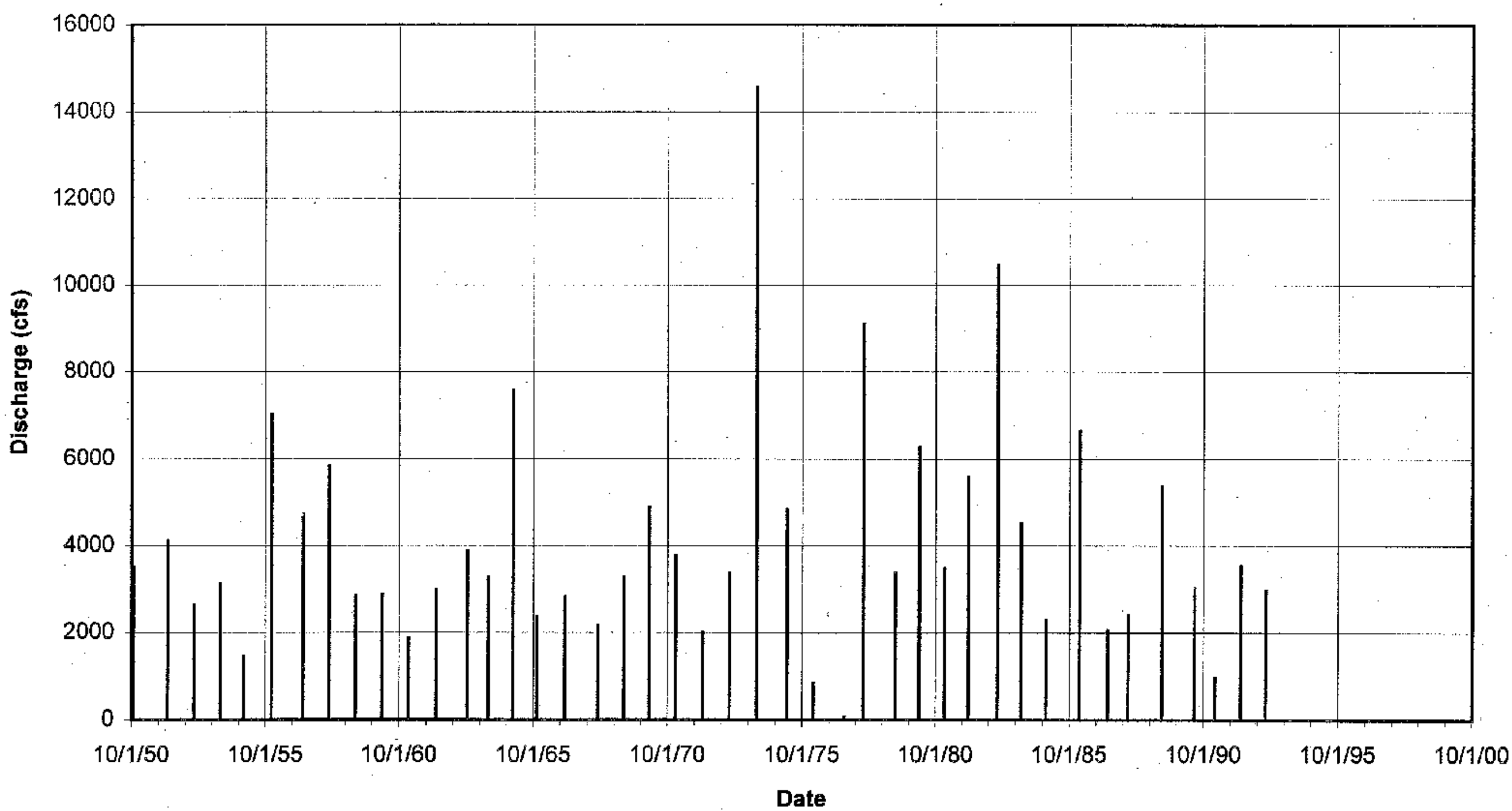
Source: Tetra Tech 1998

Exceedence Probability for Mean Daily Flows

Clear Creek at French Gulch

Tetra Tech, Inc.

Figure C-2



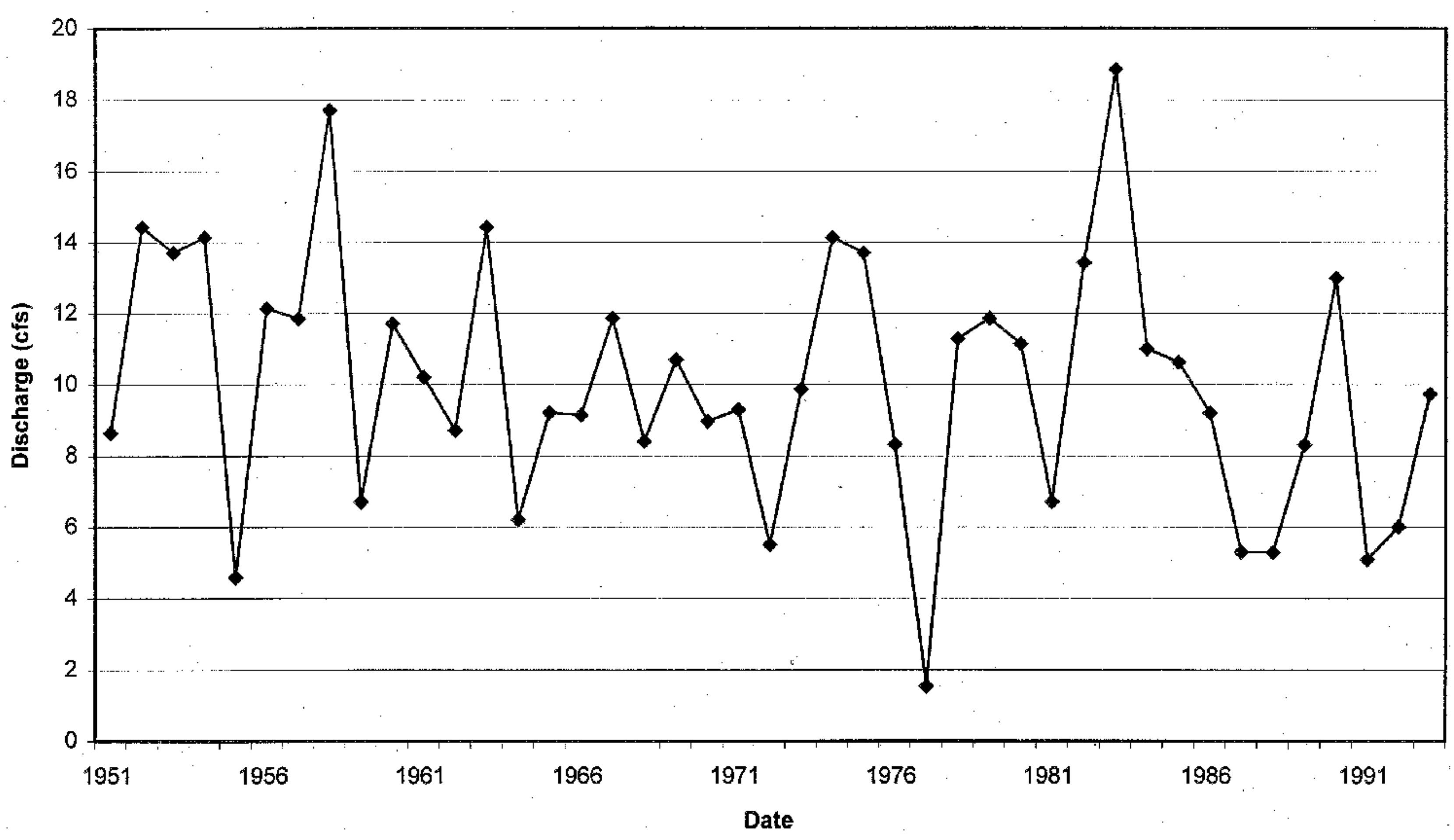
Source: Tetra Tech 1998

Maximum Annual Peak Discharge Values

Clear Creek at French Gulch

Tetra Tech, Inc.

Figure C-3



Average Annual 7-Day Low Flow Minima

Clear Creek at French Gulch

Tetra Tech, Inc.

Figure C-4

where $\overline{C}$ is the generalized regional value of skew, and α is a weighting factor based on the relative variances of the site and regionalized skew estimates:

$$\alpha = \frac{V(\overline{C})}{V(C) + V(\overline{C})}$$

The observed logarithms of annual maxima at French Gulch have a mean of 3.5171, standard deviation of 0.3394, and skew of -2.043. The generalized regional skew for the area is -0.057.

The program PEAKFRQ was used to fit the log Pearson Type III distribution to the French Gulch annual maxima, and is shown in the Figure C-5 as the "Bull. 17-B frequency." Observed data, with empirical estimates of exceedance probability, are shown as diamonds on this plot.

For parametric analysis of low flows where the stream never goes completely dry, USGS (Riggs 1972) also recommends use of the log Pearson Type III extreme value distribution. Low flows are not, however, addressed in the PEAKFRQ program, and frequency factor tables express the frequency factor in terms of the recurrence frequency of events greater than the one indicated, as is required for analysis of floods. For low flows, we want the recurrence interval of events less than the one indicated. The "greater than" tables may still be used by substituting an equivalent "greater than" recurrence interval value ($RI_{X>}$) for the desired "less than" recurrence interval ($RI_{X<}$):

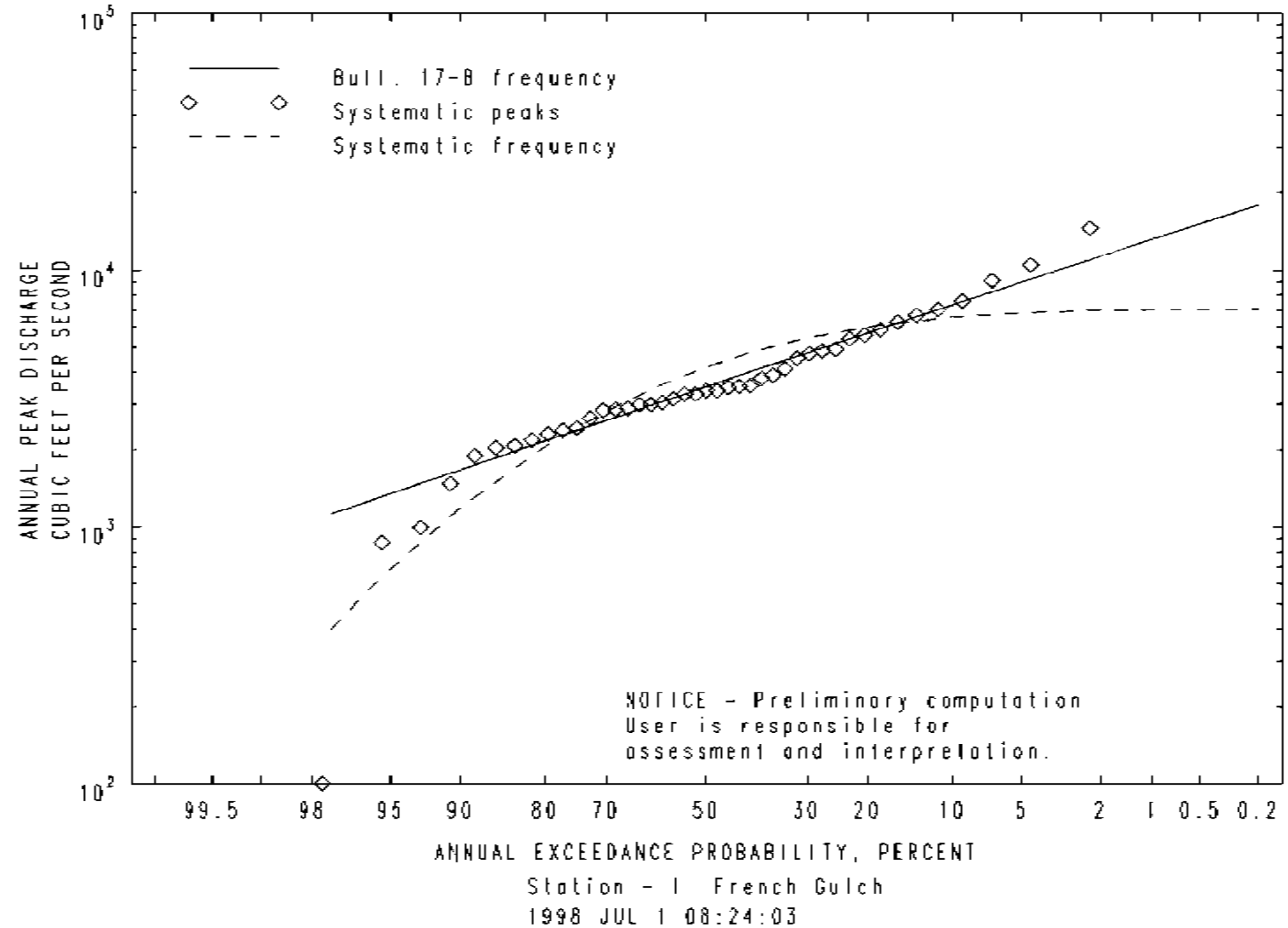
$$RI_{x>} = \frac{1}{1 - 1/RI_{x<}}$$

For instance, the appropriate frequency factor for a low-flow analysis at a recurrence interval of 20 years can be obtained by entering a table of high-flow frequency factors at an $RI_{X>}$ recurrence interval of 1.053 years.

A numerical approximation to the frequency factor can be obtained by using the following formula:

$$KT = \frac{2}{C_s}\left(\left[\left(U_T - \frac{C_s}{6}\right)\frac{C_s}{6} + 1\right]^3 - 1\right)$$

where C_s is the skew and U_T is a standard normal deviate corresponding to the desired recurrence interval. For instance, for the 20-year event, the *p* value is 1/20 = 0.05. The corresponding standard normal deviate is one which leaves five percent of the total area under the standard normal curve on the "less than" side,



Source: Tetra Tech 1998

Log Pearson Type III Distribution of Peak Flows

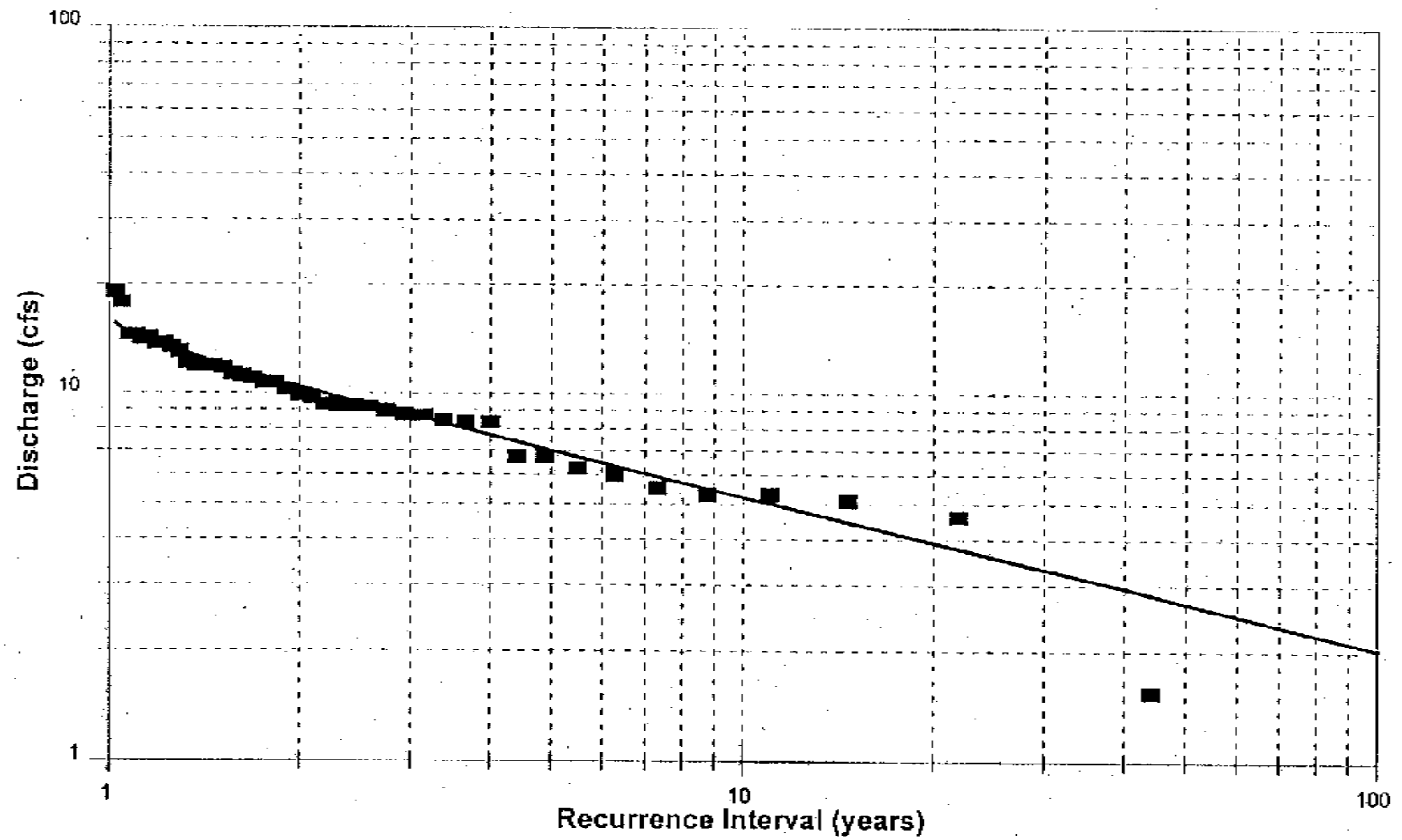
Clear Creek at French Gulch

Tetra Tech, Inc.

Figure C-5

or approximately -1.64 from a standard normal table (available in any standard statistics reference). This approximation is most accurate for skew values between -1.0 and +1.0. Observed skews for low flows are around -1.5, so the analysis presented below using this approximation is subject to some error.

The log Pearson Type III fit for 7-day low flows is shown in Figure C-6.



Source: Tetra Tech 1998

Log Pearson Type III Distribution of Average Annual 7-Day Low Flows

Clear Creek at French Gulch

Tetra Tech, Inc.

Figure C-6

Appendix D. Soil Mapping Units found in the Upper Clear Creek Watershed

Appendix D

Table D-1
Soil Mapping Units Found in the Upper Clear Creek Watershed

Soil Series	Map Units	Parent Materials	Soil Group	Soil Survey Reference
Chaix (and Chawanakee)	CaE3, CaF3, CbE, CbF	Granitic rock	Mountains	Shasta County
Corbett	CxE, CxF3, CxG, CyG	Granitic rock	Mountains	Shasta County
Holland	HcE, HcF	Granitic rock	Mountains	Shasta County
Josephine	JbD, JbE, JbF, JdD, JdE	Sandstone and shale	Mountains	Shasta County
Kanaka	KcE, KcF2	Granitic rock	Mountains	Shasta County
Marpa	MaE, MaG	Shale and sandstone	Mountains	Shasta County
Maymen	MbG2	Sandstone and shale	Mountains	Shasta County
Stonyford	SsE, SsG	Metamorphic basic igneous or sedimentary	Mountains	Shasta County
Sheetiron	SgE, SgF	Meta-sedimentary	Mountains	Shasta County
Sites	SnF, SoD, SpE	Meta-sedimentary	Mountains	Shasta County
Boomer-Skalan	4Jc	Metamorphic	Mountains	FS
Marpa-Skalan	14Mc	Meta-sedimentary	Mountains	FS
Neuns-Hugo	1Gc, 1Gd	Metamorphic basic igneous or sedimentary	Mountains	FS
Deadwood	5c, 5d	Meta-sedimentary	Mountains	FS
Deadwood-Neuns	5Ab, 5Ac, 5Ad	Metamorphic	Mountains	FS
Etsel	19d, 19Fd	Shale	Mountains	FS
Skymor	134d	Metamorphic basic igneous	Mountains	FS
Auburn	AnD, ArD, AtE2, AuF	Schistose metamorphic igneous or sedimentary	Foothills	Shasta County
Behomotosh	BeE2, BhF2	Rhyolitic	Foothills	Shasta County
Boomer	BkD, Bke, BlF, BoE2	Metavolcanic rock	Foothills	Shasta County

Table D-1
Soil Mapping Units Found in the Upper Clear Creek Watershed *(continued)*

Soil Series	Map Units	Parent Materials	Soil Group	Soil Survey Reference
Goulding	GdD, GeE2, GeF2	Metamorphic basic igneous or sedimentary	Foothills	Shasta County
Kidd	KgF2	Rhyolitic rock	Foothills	Shasta County
Millsholm	MeG	Sandstone, conglomerate	Foothills	Shasta County
Neuns	NdE, NdG	Metamorphic basic igneous or sedimentary	Foothills	Shasta County
Anderson	Ad	Mixed alluvium	Low Terraces	Shasta County
Churn	CeA, CeB, CfB	Mixed alluvium	Low Terraces	Shasta County
Newton	NeE2, NfE2	Mixed alluvium	High Terraces	Shasta County
Red Bluff	RcB	Mixed alluvium	High Terraces	Shasta County
Redding	RdB	Mixed alluvium	High Terraces	Shasta County

Miscellaneous Land Types	
Cobbly Alluvial Land	Ch
Colluvial land	CsF
Landslides	LaE
River wash	Rw
Rock land	Rxf
Tailings and Placer Dredgings	TaD