State of California
The Resources Agency
Department of Water Resources

FUEL LOAD MANAGEMENT EVALUATION

FINAL REPORT

L–5

Oroville Facilities Relicensing
FERC Project No. 2100

MAY 2004

ARNOLD SCHWARZENEGGER Governor State of California	**MIKE CHRISMAN** Secretary for Resources The Resources Agency	**LESTER SNOW** Director Department of Water Resources

State of California
The Resources Agency
Department of Water Resources

FUEL LOAD MANAGEMENT EVALUATION

FINAL REPORT

L–5

Oroville Facilities Relicensing
FERC Project No. 2100

This report was prepared under the direction of

Jim Martin.............................. Resource Area Manager, Department of Water Resources
Jim Upholt .... Senior Engineer, Department of Water Resources

by

Mark Greenig .... Senior Planner, EDAW, Inc.
Linda Leeman .... Biologist, EDAW, Inc.

Assisted by

Connie Gallippi... Planner, EDAW, Inc.
Lisa Clement .... GIS Specialist, EDAW, Inc.

This page intentionally left blank.

REPORT SUMMARY

Relicensing stakeholders have expressed concern that historic land management and fire prevention activities within the study area have resulted in increased fuel load, which has led to an increased risk of wildfires. An understanding of current and potential fuel load management issues and conditions within the study area could assist various agencies and entities in efforts to address fuel load concerns.

Relicensing Study L-5 – *Fuel Load Management Evaluation* summarizes existing data on the current fuel load conditions in the study area, presents information on relevant fuel load reduction and management techniques, and summarizes the programs and policies of several land management reports and other local agencies. Based on this information, fuel load reduction measures are discussed that could be appropriate for consideration for areas within the study area. The information presented in this report will not result in a fire management plan for the study area. However, the report may provide a framework or background information that would be useful in developing such a plan.

This page intentionally left blank.

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

ACRONYMS

ACEC	areas of critical environmental concern
af	acre-feet
BLM	Bureau of Land Management
CARB	California Air Resources Board
CDF	California Department of Forestry and Fire Protection
CDZ	Community Defense Zone
cfs	cubic feet per second
dbh	diameter at breast height
DEM	Digital Elevation Model
DFG	California Department of Fish and Game
DFPZ	Defensible Fuel Profile Zone
DPR	California Department of Parks and Recreation
DWR	California Department of Water Resources
EBMUD	East Bay Municipal Utilities District
FERC	Federal Energy Regulatory Commission
FRAP	California Fire Resource Assessment Program
FRZ	Fuel Reduction Zone
GIS	geographic information system
ICS	Incident Command System
LULMAWG	Land Use, Land Management, and Aesthetics Work Group
maf	million-acre-feet
msl	mean sea level
MW	megawatts
NMED	New Mexico Environment Department
OWA	Oroville Wildlife Area
PM&E	protection, mitigation, and enhancement
QLG	Quincy Library Group
RAM	Resource Area Manager
SBF	State Board of Forestry
SNEP	Sierra Nevada Ecosystem Program
SNFPA	Sierra Nevada Forest Plan Amendment
SPLAT	Strategically Placed Area Treatment
SWP	State Water Project
UBC	Uniform Building Code
UCFPL	University of California, Forest Products Laboratory
UFL	University of Florida
UFLCES	University of Florida Cooperative Extension Service
USACE	U.S. Army Corps of Engineers
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
VMP	Vegetation Management Program

1.0 INTRODUCTION

1.1 PURPOSE

The purpose of the Fuel Load Management Evaluation Final Report is to present the results of the L-5 (Fuel Load Management Evaluation). This report is intended to summarize fuel load conditions, review relevant fuel load reduction and management techniques, summarize the programs and policies of relevant land management and other local agencies, and identify potential fuel load treatments to be considered for areas within the study area. The Final Report provides information that would be useful for natural resource and land management entities in and near the Project to consider, but it is not a fire management plan.

The study area extends a quarter mile beyond the Federal Energy Regulatory Commission (FERC) Project No. 2100 boundary. The Project is managed by the California Department of Water Resources (DWR) for the purposes of water supply, flood management, and hydropower generation. The FERC license for the Project expires in February of 2007. The relicensing process was initiated in June of 2000, and the first public meeting for this Project was held in Oroville in the same month. This report has been developed in support of the Oroville Facilities relicensing process.

An interim report was prepared in June of 2003 and was circulated among the Land Use, Land Management, Aesthetics Work Group (LULMAWG), other work groups, and other interested parties in order to solicit comments on the report. Comments and suggestions made by the LULMAWG and others are addressed in the Final Report to the extent possible.

This report was also reviewed by interested parties (agencies, DWR Resource Area Managers [RAMs], the LULMAWG, and other Oroville Project study authors), and comments or suggestions received were incorporated.

This Final Report is organized in the following manner:

- Section 1 provides the purpose and background information for the study;
- Section 2 describes study objectives;
- Section 3 describes study methods;
- Section 4 describes the fire history and fuel load conditions in the study area;
- Section 5 describes fuel load reduction techniques and management strategies, discusses their advantages and disadvantages, and evaluates their effectiveness;
- Section 6 describes fuel load management policies and plans being used by natural resource and land management entities in the Project region;
- Section 7 discusses fuel load reduction measures to consider within the study area. Additional relevant data are discussed in Section 7, including past fire ignitions and preliminary vegetation mapping. Some treatment methods are described that could be appropriate in the study area given its vegetation, topography, and other constraints; and

- Section 8 lists the references cited throughout this document.

1.2 BACKGROUND FOR L-5 (FUEL LOAD MANAGEMENT EVALUATION)

FERC does not require fuel load studies as part of the relicensing process. However, potentially destructive wildfire is an issue that land managers in the California foothills frequently address. Relicensing stakeholders have expressed concern that historic land management and fire prevention activities within the study area have resulted in increased fuel load, which has led to an increased risk of wildfires. An understanding of current and potential fuel load management issues and conditions within the study area could assist various agencies and entities in addressing the fuel load concerns. As mentioned in the preceding section, this Final Report will not result in a fire management plan for the study area.

1.3 DESCRIPTION OF FACILITIES

The Oroville Facilities were developed as part of the State Water Project (SWP), a water storage and delivery system of reservoirs, aqueducts, power plants, and pumping plants. The main purpose of the SWP is to store and distribute water to supplement the needs of urban and agricultural water users in Northern California, the San Francisco Bay area, the San Joaquin Valley, and Southern California. The Oroville Facilities are also operated for flood control and power generation, to improve water quality in the Delta, enhance fish and wildlife, and provide recreation.

FERC Project No. 2100 encompasses 41,100 acres and includes Oroville Dam and Reservoir, three power plants (Hyatt Pumping-Generating Plant, Thermalito Diversion Dam Power Plant, and Thermalito Pumping-Generating Plant), Thermalito Diversion Dam, the Feather River Fish Hatchery and Fish Barrier Dam, Thermalito Power Canal, Oroville Wildlife Area (OWA), Thermalito Forebay and Forebay Dam, Thermalito Afterbay and Afterbay Dam, transmission lines, and a relatively large number of recreational facilities. An overview of these facilities is provided in Figure 1.3-1. Oroville Dam, along with two small saddle dams, impounds Lake Oroville, a 3.5-million-acre-foot (maf) capacity storage reservoir with a surface area of 15,810 acres at its maximum normal operating level of 900 feet above mean sea level (msl).

The hydroelectric facilities have a combined licensed generating capacity of approximately 762 megawatts (MW). The Hyatt Pumping-Generating Plant is the largest of the three power plants with a capacity of 645 MW. Water from the six-unit underground power plant (three conventional generating and three pumping-generating units) is discharged through two tunnels into the Feather River just downstream of Oroville Dam. The plant has a generating and pumping flow capacity of 16,950 cubic feet per second (cfs) and 5,610 cfs, respectively. Other generation facilities include the 3-MW Thermalito Diversion Dam Power Plant and the 114-MW Thermalito Pumping-Generating Plant.

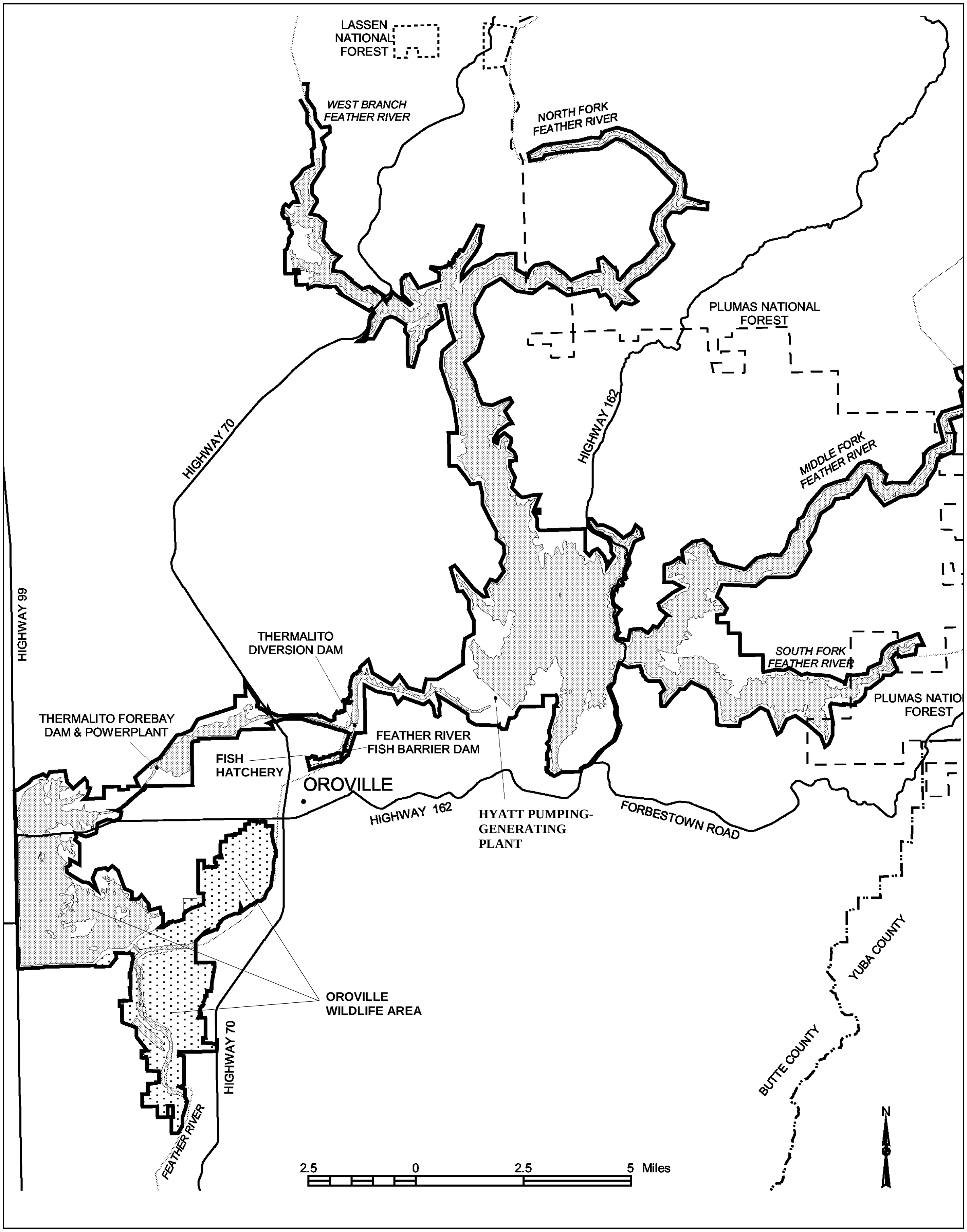


Figure 1.3-1. Oroville Facilities FERC Project 2100 boundary.

Thermalito Diversion Dam, four miles downstream of the Oroville Dam, creates a tail water pool for the Hyatt Pumping-Generating Plant and is used to divert water into the Thermalito Power Canal. Thermalito Diversion Dam Powerplant is a 3-MW power plant located on the left abutment of the diversion dam. The power plant releases a maximum of 615 cfs of water into the river.

The Thermalito Power Canal is a 10,000-foot-long channel designed to convey generating flows of 16,900 cfs to the Thermalito Forebay and pump-back flows to the Hyatt Pumping-Generating Plant. Thermalito Forebay is an off-stream regulating reservoir for the Thermalito Pumping-Generating Plant. The Thermalito Pumping-Generating Plant is designed to operate in tandem with the Hyatt Pumping-Generating Plant and has generating and pump-back flow capacities of 17,400 cfs and 9,120 cfs, respectively. When in generating mode, the Thermalito Pumping-Generating Plant discharges into Thermalito Afterbay, which is contained by a 42,000-foot-long earthfill dam. The Afterbay is used to release water into the Feather River downstream of the Oroville Facilities, and helps regulate the power system, provides storage for pump-back operations, provides recreational opportunities, and provides local irrigation water. Several local irrigation districts receive Lake Oroville water via the Afterbay.

The Fish Barrier Dam is downstream of the Thermalito Diversion Dam and immediately upstream of the Feather River Fish Hatchery. The flow over the dam maintains fish habitat in the low flow channel (LFC) of the Feather River between the dam and the Thermalito Afterbay outlet, and provides attraction flow for the hatchery. The hatchery is an anadromous fish hatchery intended to compensate for salmon and steelhead spawning grounds made unreachable by construction of Oroville Dam. Hatchery facilities have a production capacity of 10 million fall-run salmon, 5 million spring-run salmon, and 450,000 steelhead annually (pers. comm., Kastner 2003). However, diseases have occasionally reduced hatchery production in recent years.

The Oroville Facilities support a wide variety of recreational opportunities. These opportunities include boating (several types), fishing (several types), fully developed and primitive camping (including boat-in and floating sites), picnicking, swimming, horseback riding, hiking, off-road bicycle riding, wildlife watching, and hunting. There are also visitor information sites with cultural and informational displays about the developed facilities and the natural environment. There are major recreation facilities at Loafer Creek, Bidwell Canyon, Spillway, Lime Saddle, and Thermalito Forebay. Lake Oroville has two full-service marinas, five car-top boat launch ramps, 10 floating campsites, and seven two-stall floating toilets. There are also recreation facilities at the Lake Oroville Visitors Center, Thermalito Afterbay, and OWA.

The OWA comprises approximately 11,000 acres west of Oroville that is managed for wildlife habitat and recreational activities. It includes Thermalito Afterbay and surrounding lands (approximately 6,000 acres) along with 5,000 acres adjoining the Feather River. The 5,000-acre area is adjacent to or straddles 12 miles of the Feather River, and includes willow- and cottonwood-lined ponds, islands, and channels. Recreation areas include dispersed recreation (hunting, fishing, and bird watching), plus recreation at developed sites, including Monument Hill DUA, model airplane grounds, and three boat launches on the afterbay and two on the river, and two primitive camping areas. The California Department of Fish and Game's (DFG) habitat enhancement program includes a wood duck nest-box program and dry-land farming for nesting cover and improved wildlife forage. Limited gravel extraction also occurs in a few locations.

1.4 CURRENT OPERATIONAL CONSTRAINTS

Operation of the Oroville Facilities varies seasonally, weekly, and hourly, depending on hydrology and the objectives that DWR is trying to meet. Typically, releases to the Feather River are managed to conserve water while meeting a variety of water delivery requirements, including flow, temperature, fisheries, diversion, and water quality. Lake Oroville stores winter and spring runoff for release to the Feather River as necessary for project purposes. Meeting the water supply objectives of the SWP has always been the primary consideration for determining Oroville Facilities operation (within the regulatory constraints specified for flood control, instream fisheries, and downstream uses). Power production is scheduled within the boundaries specified by the water operations criteria noted above. Annual operations planning is conducted for multiyear carryover storage. The current methodology is to retain half of the Lake Oroville storage above a specific level for subsequent years. Currently, that level has been established at 1.0 maf; however, this does not limit drawdown of the reservoir below that level. If hydrology is drier or requirements greater than expected, additional water could be released from Lake Oroville. The operations plan is updated regularly to reflect forecast changes in hydrology and downstream operations. Typically, Lake Oroville is filled to its maximum operating level of 900 feet above msl in June and then lowered as necessary to meet downstream requirements, to a minimum level in December or January (approximately 700 msl). During drier years, the reservoir may be drawn down more and may not fill to desired levels the following spring. Project operations are directly constrained by downstream operational demands and flood management criteria as described below.

1.4.1 Downstream Operation

An August 1983 agreement between DWR and DFG entitled *Agreement Concerning the Operation of the Oroville Division of the State Water Project for Management of Fish & Wildlife* (DWR and DFG 1983) sets criteria and objectives for flow and temperatures in the low-flow channel and the reach of the Feather River between Thermalito Afterbay and Verona. This agreement: (1) establishes minimum flows between the Thermalito Afterbay outlet and Verona that vary by water year type; (2) requires flow changes under 2,500 cfs to be reduced by no more than 200 cfs during any 24-hour period (except for flood management, failures, etc.); (3) requires flow stability during the peak of the fall-run Chinook salmon spawning season; and (4) sets an objective of suitable temperature conditions during the fall months for salmon and during the spring/summer for shad and striped bass.

1.4.1.1 Instream Flow Requirements

The Oroville Facilities are operated to meet minimum flows in the lower Feather River as established by the 1983 agreement (see above). The agreement specifies that

Oroville Facilities release a minimum of 600 cfs into the Feather River from the Thermalito Diversion Dam for fisheries purposes. This is the total volume of flows from the diversion dam outlet, the diversion dam power plant, and the Feather River Fish Hatchery pipeline.

Generally, the instream flow requirements below Thermalito Afterbay are 1,700 cfs from October through March, and 1,000 cfs from April through September. However, if runoff for the previous April–July period is less than 1,942,000 acre-feet (af) (i.e., the 1911–1960 mean unimpaired runoff near Oroville), the minimum flow can be reduced to 1,200 cfs from October to February, and 1,000 cfs for March. A maximum flow of 2,500 cfs is not exceeded from October 15 through November 30 to prevent spawning in overbank areas that might become de-watered.

1.4.1.2 Temperature Requirements

The Diversion Pool provides the water supply for the Feather River Fish Hatchery. The hatchery temperature objectives are 52°F for September, 51°F for October and November, 55°F for December through March, 51°F for April through May 15, 55°F for last half of May, 56°F for June 1–15, 60°F for June 16–August 15, and 58°F for August 16–31. In April through November, a temperature range of plus or minus 4°F is allowed for objectives.

There are several temperature objectives for the Feather River downstream of the Thermalito Afterbay outlet. During the fall months, after September 15, the temperatures must be suitable for fall-run Chinook salmon. From May through August, the temperatures must be suitable for shad, striped bass, and other fish.

National Oceanic and Atmospheric Administration–Fisheries (NOAA Fisheries) has also established an explicit criterion for steelhead trout and spring-run Chinook salmon, memorialized in a biological opinion on the effects of the Central Valley Project and SWP on Central Valley spring-run Chinook and steelhead. As a reasonable and prudent measure, DWR attempts to control water temperature at Feather River mile 61.6 (Robinson’s Riffle in the low-flow channel) from June 1 through September 30. This measure attempts to maintain water temperatures less than or equal to 65°F on a daily average. The requirement is not intended to preclude pump-back operations at the Oroville Facilities needed to assist the State of California with supplying energy during periods when the California Independent System Operator (ISO) anticipates a Stage 2 or higher alert.

The hatchery and river water temperature objectives sometimes conflict with temperatures desired by agricultural diverters. Under existing agreements, DWR provides water for the Feather River Service Area contractors. The contractors claim a need for warmer water during spring and summer for rice germination and growth (i.e., minimum 65°F from approximately April through mid-May, and minimum 59°F during the remainder of the growing season), though there is no explicit obligation for DWR to meet the rice water temperature goals. However, to the extent practical, DWR does use its operational flexibility to accommodate the Feather River Service Area contractors' temperature goals.

1.4.1.3 Water Diversions

Monthly irrigation diversions of up to 190,000 af (July 2002) are made from the Thermalito Complex during the May–August irrigation season. The total annual entitlement of the Butte and Sutter County agricultural users is approximately 1.0 maf. After these local demands are met, flows into the lower Feather River (and outside of the Project 2100 boundary) continue into the Sacramento River and into the Sacramento-San Joaquin Delta. In the northwestern portion of the Delta, water is pumped into the North Bay Aqueduct. In the south Delta, water is diverted into Clifton Court Forebay where the water is stored until it is pumped into the California Aqueduct.

1.4.1.4 Water Quality

Flows through the Delta are maintained to meet Bay-Delta water quality standards arising from DWR's water rights permits. These standards are designed to meet several water quality objectives such as salinity, Delta outflow, river flows, and export limits. The purpose of these objectives is to attain the highest reasonable water quality, considering all demands being made on the Bay-Delta waters. In particular, they protect a wide range of fish and wildlife including Chinook salmon, Delta smelt, striped bass, and the habitat of estuarine-dependent species.

1.4.2 Flood Management

The Oroville Facilities are an integral component of the flood management system for the Sacramento Valley. During the wintertime, the Oroville Facilities are operated under flood control requirements specified by the U.S. Army Corps of Engineers (USACE). Under these requirements, Lake Oroville is operated to maintain up to 750,000 af of storage space to allow for the capture of significant inflows. Flood control releases are based on the release schedule in the flood control diagram or the emergency spillway release diagram prepared by the USACE, whichever requires the greater release. Decisions regarding such releases are made in consultation with the USACE.

The flood control requirements are an example of multiple use of reservoir space. When flood management space is not required to accomplish flood management objectives, the reservoir space can be used for storing water. From October through March, the maximum allowable storage limit (point at which specific flood release would have to be made) varies from about 2.8 maf to 3.2 maf to ensure adequate space in Lake Oroville to handle flood flows. The actual encroachment demarcation is based on a wetness index, computed from accumulated basin precipitation. This allows higher levels in the reservoir when the prevailing hydrology is dry. When the wetness index is high in the basin (i.e., high potential runoff from the watershed above Lake Oroville), required flood management space is at its greatest to provide the necessary flood protection. From April through June, the maximum allowable storage limit is increased as the flooding potential decreases, which allows capture of the higher spring flows for use later in the year. During September, the maximum allowable storage decreases again to prepare for the next flood season. During flood events, actual storage may encroach into the flood reservation zone to prevent or minimize downstream flooding along the Feather River.

2.0 STUDY OBJECTIVES

The objectives of this study are to:

- Provide the reader with background information regarding fuel loading and fuel load management issues;
- Characterize the general fuel load conditions in the study area;
- Discuss and evaluate the efficiency level and/or drawbacks of various fuel load management and reduction methods;
- Communicate relevant information to other work groups for their use and evaluation;
- Summarize the analyses of other work groups with regard to the effects that various fuel load management strategies and techniques might have on other resources; and
- Examine fuel load management and reduction techniques to consider for use in the study area.

This page intentionally left blank.

3.0 STUDY METHODS

3.1 ASSESSMENT OF CURRENT FUEL LOADS WITHIN THE STUDY AREA

A literature and data review of appropriate study area-related land management and fire control data was conducted. California Department of Forestry and Fire Protection (CDF) personnel, websites, geographic information system (GIS) databases, and published documents were the primary sources of data. The California Fire Plan (CDF 1996) and the CDF Butte Unit's Fire Management Plan (CDF 2002a) were reviewed. The Fuel Hazard Ranking model that CDF developed for the Butte Unit was also reviewed to evaluate the fire hazard for the study area. The information gathered in this task is included in Section 4.

3.2 IDENTIFY FUEL LOAD REDUCTION TECHNIQUES, STRATEGIES, MANAGEMENT POLICIES, AND PROGRAMS

This task involved conducting literature reviews and interviews. CDF staff were consulted regarding fuel treatment and management techniques. The California Fire Plan and other CDF information regarding various fuel management and treatment techniques were consulted. In addition, land management and fire control officials from the U.S. Forest Service (USFS) and California Department of Parks and Recreation (DPR) were interviewed regarding ongoing fuel reduction programs. The DPR Wildfire Management Planning Guidelines and Policy (DPR 2002) and the Butte County General Plan (1996) were reviewed. Personnel at other entities such as the Bureau of Land Management (BLM), DFG, and the City of Oroville were contacted. Section 5 identifies fuel load reduction techniques and management strategies, their advantages and disadvantages, and summarizes what is known about the overall effectiveness of the methods. Section 6 describes the fuel load management policies and plans currently used by agencies in the study area.

3.3 FUEL LOAD REDUCTION MEASURES TO CONSIDER

This task used the information gathered in the previous tasks to discuss some general fuel load reduction measures to consider for the study area. Fuel reduction measures that are discussed for consideration are based on the review of various techniques, programs, and policies currently being used by local agencies, as well as general vegetation types within the study area. This task was not intended to be a part of a fire reduction or management plan, but does contain data that could be expanded to develop such a plan. The measures discussed in this task could be used to develop protection, mitigation, and enhancement (PM&E) measures.

This page intentionally left blank.

4.0 FUEL LOAD ISSUES AND FUEL LOAD CONDITIONS IN THE STUDY AREA

This section is composed of two subsections. The first provides general background information on the ecological role of fire and the effects of the last century's management of forests and wildlands as they relate to fuel load conditions. The second describes the fire history in the study area and characterizes the general fuel load conditions there.

4.1 THE ROLE OF FIRE AND HISTORY OF FIRE MANAGEMENT IN THE SIERRA NEVADA

4.1.1 The Ecological Role of Fire and Presettlement Conditions

Fire is a natural evolutionary force that has influenced Sierra Nevada ecosystems for millennia, influencing biodiversity, plant reproduction, vegetation development, insect outbreak and disease cycles, wildlife habitat relationships, soil functions and nutrient cycling, gene flow, selection, and, ultimately, sustainability (Sierra Nevada Ecosystem Program [SNEP] 1996).

The various forest habitats and communities in the Sierra Nevada today were created by the influence of fire over thousands of years (Barbour et al. 1987). California has a Mediterranean climate with cool, wet winters and warm, dry summers, which provides suitable weather and dry fuels for burning. Lightning during thunderstorms provides a natural ignition source (SNEP 1996). Native Americans who inhabited the region were also known to frequently ignite low-burning forest fires for numerous cultural purposes, such as controlling understory growth from competing with desirable species such as oaks (which provided acorns, a main staple of their diet), plants favorable for basket weaving, clearing brush around their homes, and enhancing habitat for game species (McKelvey et al. 1996; Skinner and Chang 1996). In the absence of suppression efforts, fires would spread until weather conditions or fuels were no longer suitable (SNEP 1996).

Much of the vegetation in the Sierra Nevada exhibit traits that allow survival and reproduction in this environment of regular fire. Prior to the mid-1800s, many plant communities experienced fire at least once, and often a number of times, during the life span of the dominant species (McKelvey et al. 1996). Chaparral and mixed conifer communities adapt to frequent fires; in fact they depend on fire for their reproduction and as a means of competing with other biota. Fire-scar records in tree rings have shown variable fire-return intervals in presettlement (i.e., prior to 1900) times, with median values consistently less than 20 years for the foothill, ponderosa pine, and mixed conifer zones of the Sierra Nevada (SNEP 1996) (Table 4.1-1). Intervals between fires vary depending on climate, elevation, topography, vegetation, soil chemistry, and human cultural practices (Skinner and Chang 1996).

The variable nature of presettlement fire helped create diverse landscapes and variable forest conditions. In many areas, frequent surface fires are thought to have minimized fuel accumulation, keeping understories relatively free of small trees and other vegetation that could form fuel ladders, which allow fire to move into the main canopy. The effects of frequent surface fires would explain reports and photographs of early Euro-American settlers who describe Sierran forests as typically "open and park-like." However, there are also many reports from the same period that describe the forests as dark, dense, and impenetrable. From the differing reports, it is likely that Sierran forests were a mix of open forests and impenetrable stands of brush and young trees (SNEP 1996).

Table 4.1-1. Historical and contemporary fire-return intervals.

Forest Type	Fire-Return Interval (Years)	
	20th Century	Pre-1900 (presettlement)
Red fir	1,644	26
Mixed conifer-fir	644	12
Mixed conifer-pine	185	15
Ponderosa pine	192	11
Blue oak	78	8

Source: SNEP 1996

The way that fire affects the landscape is a largely a result of its frequency (return-interval), spatial extent (size), and its magnitude. The magnitude of a fire refers to both its “intensity” and “severity”. Intensity is a technical term used to describe the amount of energy released from a fire and may or may not be directly related to fire effects. Severity is related to the change in the ecosystem caused by the fire. Fires that burn only surface fuels (i.e., surface fires), and in which most of the woody vegetation survives, are usually considered “low-severity” fires. Fires that kill most small trees, with only some of the subcanopy trees killed or damaged and occasionally overstory trees killed, are considered “moderate-severity” fires. Fires that kill large trees over more than a few acres by burning their crowns (i.e., crown fires) are usually considered “high-severity” fires (Skinner and Chang 1996).

Most presettlement fires were low- to moderate-severity, with only a few patches of high-severity. High-severity fires likely occurred occasionally but were probably much less common than today. These conclusions are based on research of fuel dynamics, forest age structure analysis, written accounts of early fires, and observations of modern fires (SNEP 1996). More frequent fire-return intervals reduced the horizontal and vertical biomass in the forest, which regulated the severity of the fire at a low or moderate level and helped prevent crown fires (McKelvey et al. 1996; Skinner and Chang 1996). As a result, the landscape consisted of a mosaic of forest patches in a variety of stand ages, which is more likely to function as a diverse ecosystem than an even-aged stand generated by a severe and widespread fire (Skinner and Chang 1996).

Another difference between presettlement and current fire patterns is the location of the fires. The presettlement return interval for fires in the foothills (i.e., blue oak forest) through the upper mixed conifer zone did not differ much (Table 4.1-1). However, recent fire patterns show a decrease in fire frequency with an increase in elevation. The distribution of fires in the 20th century is closely associated with drought conditions and probably due to effective suppression of low- to moderate-intensity fires. Prior to 1900, 10 times as much area in the foothills burned when compared with the 20th century, and 60 times as much burned in the red fir zone (McKelvey et al. 1996).

Periodic fires performed a number of ecological functions. Fire damaged or killed some plants, creating conditions for regenerative or vegetative succession. Fire influenced many processes in the soil and forest floor by consuming organic matter and inducing thermal and chemical changes; nutrient cycling is also affected by fire. Periodic fires removed biomass from small shrubs and trees, which contribute to surface and ladder fuels and promoted large tree growth. Periodic fires also generate mosaics of vegetation in different successional stages across the landscape (SNEP 1996).

4.1.2 Euro-American Settlement: Logging and Fire Suppression

Euro-American settlement following the discovery of gold in California in the mid-1800s initiated profound changes in the role of fire in Sierra Nevada ecosystems (SNEP 1996). Many factors have influenced changes in fire patterns in the Sierras over the last century (e.g., population decline among native peoples, grazing, mining, logging, recreation, settlement, fire management) (McKelvey et al. 1996; Skinner and Chang 1996). However, logging and fire suppression are probably the two most influential activities affecting forest fuels due to the intensity and widespread distribution of these activities.

Logging was initially undertaken to supply mines and later to support the growing population of the new State. Timber volumes harvested in the Sierras continued to increase well into the 20th century, reaching a peak in the 1970s and 1980s. Typically, loggers harvested the large trees and fire-resistant species, which were replaced by more fire-susceptible smaller trees. This pattern of biomass removal contrasted markedly with that of presettlement surface fires, which tended to kill small trees, leaving most large trees to survive (SNEP 1996). Logging also tends to result in large quantities of debris left on the ground, which contributes to fuel loading and to severe fires. The forest management practices used in the 20th century have significantly contributed to younger, denser, more homogenous forest structures (McKelvey et al. 1996).

The settlement of the Sierras also resulted in an emphasis on extinguishing any and all fires in order to protect property and homes. After a series of disastrous fires in 1910 and a period of trial and debate about the merits of "light burning" as a management tool in forests and rangelands, intentional broadcast burning was repudiated, and aggressive fire control became firmly established as State and Federal policy. Combined with the loss of ignitions by Native Americans, fire suppression activities significantly reduced the areas burned by wildfires during the last century (SNEP 1996). Although fire suppression efforts have varied throughout the landscape, depending on location, severity, accessibility, cost, and vegetation type, the policy emphasized keeping wildland fires as small and inexpensive as possible (Husari and McKelvey 1996).

The virtual exclusion of widespread low- to moderate-severity fires has affected the structure and composition of most Sierra Nevada vegetation, especially in low- to middle-elevation forests. Conifer stands generally have become denser and consist of mainly small and medium size classes of shade-tolerate and fire-sensitive tree species. Vertical fuels have become more continuous, contributing to higher risk of canopy fires (Figure 4.1-1). In combination with the removal of large trees for timber, conditions have promoted the establishment of dense, young forests. As a result, stands in many areas have experienced increased mortality recently from the cumulative effects of competition (primarily for water and light), drought, insects, disease, and in some cases, air pollution (SNEP 1996).

Today's forest conditions more readily support severe fires due to the structure of the forest vegetation and the accumulation of fuel (McKelvey et al. 1996). The increased

Source: Quincy Library Group, Hungry Creek Fuel Project

Figure 4.1-1. Example of vertical (or ladder) fuels, which may allow fires to spread from ground to canopy.

density of young trees together with increased fuels from fire suppression and tree mortality have created conditions favorable to more intense and severe fires. The understory vegetation is left to flourish, providing a connection between ground fuels and the canopy trees, in addition to adding fuel to the forest floor. The denser forests have intertwined canopies, allowing fire to spread easily from one tree to the next. Moreover, severe fires are more likely to be large in size because they are more difficult to suppress (SNEP 1996). After a widespread and severe fire, large areas of even-aged stands regenerate, decreasing the variability of the landscape (McKelvey et al. 1996).

Human settlement in the Sierra Nevada is continuing, and the populations of many communities have been rapidly increasing in the last few decades (SNEP 1996). The propensity of people to build homes in forested areas without mitigating fire hazards and risks has increasingly placed homes and other valuable property at risk to loss to severe wildfires (SNEP 1996). Although fire fighting technologies have improved and many resources are dedicated to protecting people, structures, and other resources, many hundreds of homes have been destroyed by wildfires in the Sierra over the past few decades (SNEP 1996).

In summary, three major fire-related "problems" have been identified in the Sierra Nevada:

- Too many high-severity fires and high probability for future high-severity fires if fuel load condition trends continue;
- Too few low- to moderate-severity fires, with a variety of ecological changes attributed at least in part to this deficiency; and
- A large number of homes and other structures at risk due to both existing and continued rural development in areas with extreme fire hazards that are not reduced to acceptable levels (SNEP 1996).

These problems can be translated into three closely related and complementary broad goals for fire management in the Sierra Nevada:

- Substantially reduce the area and average size of acres burned by large, high-severity wildfires;
- Restore more of the ecosystem functions of frequent low- to moderate-severity fire; and
- Encourage a more rational approach for the expansion of homes among wildland vegetation with high fire-risk hazard (SNEP 1996).

Understanding the ecology and history of fire in the region will assist in management decisions and developing successful fuel load management strategies. The following management practices have been recommended by fire scientists to assist in restoring and/or maintaining forest ecosystem functions (McKelvey et al. 1996):

- Restore ecosystem functions that are characteristic of frequent and less severe fires;

- Cooperate with landowners for fire prevention where development has encroached upon fire hazard areas;
- Thin smaller diameter trees or conduct biomass removals to shape a more open-structured forest;
- Dispose of slash from tree removal to control the severity of the fire;
- Apply fuel treatments periodically to maintain the low fuel load;
- Carefully consider locations for fuel load management effectiveness and economic viability;
- Use a landscape-level strategy;
- Use treatments that are successful in reducing the hazard but are also compatible with ecosystem sustainability;
- Remove biomass at a rate that exceeds production;
- Choose treatment strategies based on historic patterns of fire risk;
- Use prescribed burning at a landscape level for fuel reduction and restoration of ecosystem processes, but not as a sole treatment method; and
- Modify the current fire suppression strategy; use less than full control strategies that remain economical but do not completely suppress the fire and allow it to burn under control.

4.2 EXISTING FUEL LOAD CONDITIONS WITHIN THE STUDY AREA

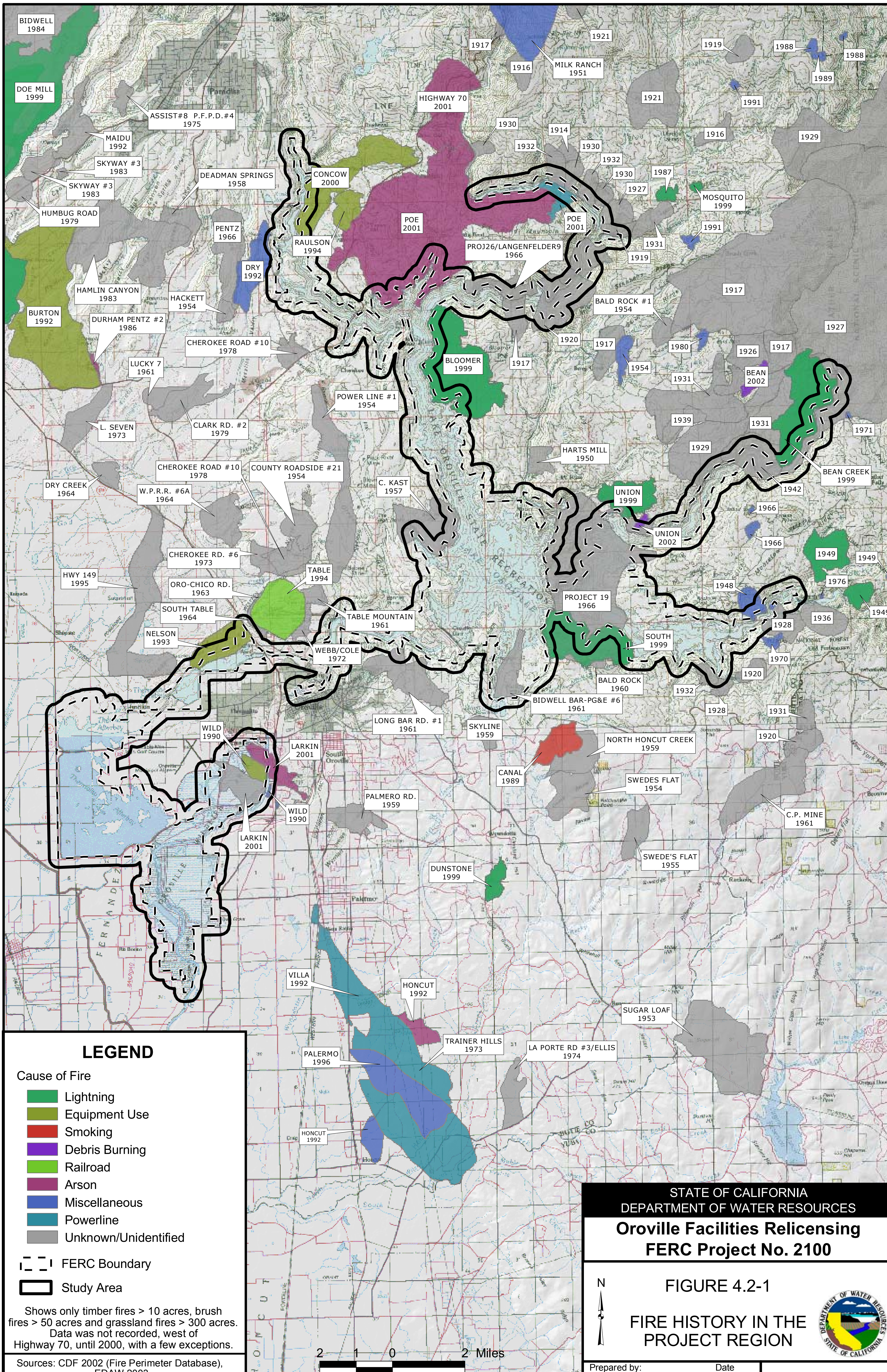
The descriptions of the fire history and existing fuel load conditions within the study area are based on data provided by CDF. To develop fire management plans, CDF maintains detailed and up-to-date GIS databases for fire history, ignition locations, fuel type, and other information to allow for comprehensive analysis of fire hazards, assets at risk, and level of service. Section 4.2.1 summarizes the fire history in the study area. Using this information and other data, CDF has developed a fuel hazard model, described in Section 4.2.2. Model results specific to the study area are presented in Section 4.2.3.

4.2.1 Fire History in the Project Region

CDF maintains a database of where fires have occurred in the past; the database includes records of fires from the early 1900s to present. In 2003, CDF began mapping timber fires 10 acres or greater, brush fires 50 acres or greater, and grassland fires 300 acres or greater; prior to 2003, only fires over 300 acres were mapped. Figure 4.2-1 shows the extent of significant-sized fires within the study area region. Before 2000, CDF generally only recorded fires within the State Responsibility Area (east of Highway 70 in the study area). Since 2000, CDF has included fires in the Local Responsibility Area (generally west of Highway 70 in the study area). Therefore, the fire perimeter data for the OWA and other areas west of Highway 70 are incomplete prior to 2000. However, a couple of fires in 1990 are shown.

In recent years (since 1990), there have been large fires in the northern portion of Lake Oroville (e.g., "Bloomer" in 1999, "Concow" in 2000, "Poe" in 2001), a few fires in the

PLACE HOLDER FOR FIGURE 4.2-1



STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

Oroville Facilities Relicensing
FERC Project No. 2100

FIGURE 4.2-1

FIRE HISTORY IN THE PROJECT REGION

Prepared by:	Date	
EDAW (LC)	6-30-03	X 4.2-1.mxd

BACK OF FIGURE 4.2-1

Middle Fork ("Bean Creek" in 1999 and "Union" in 1999 and 2002), and a fire in the Loafer Creek Area ("South" in 1999). Other recent fires have occurred in the OWA ("Wild" in 1990 and "Larkin" in 2001) and near the Thermalito Afterbay ("Nelson" in 1993 and "Table" in 1994). Table 4.2-1 lists the recent fires that have at least partially occurred within the study area, the total acreage burned, and the cause of the fire.

4.2.2 California Department of Forestry and Fire Protection (CDF), Fuel Hazard Model

CDF has developed a fuel assessment methodology to describe current fuel load conditions and rank fuel hazard situations to assist prefire planners and Fire Safe councils target critical areas for fuel treatment. The fuel ranking methodology assigns ranks based on current flammability of a particular fuel model and includes variables such as slope, ladder fuels, and crown density. The model uses GIS technology to build and analyze the data.

In the study area, as in the surrounding Sierra Nevada ecosystem, grass, brush, and timber are the most common fuel types. Each has its own burning characteristics based on several factors, including moisture content, volume, live to dead vegetation ratio, size, structure, and inherent species characteristics such as volatility. Fuel load is measured in tons per acre. For example, grass is considered a light fuel with a volume of approximately 3/4 tons per acre; thick brush is considered a heavy fuel, with a volume of over 21 tons per acre.

The first step in developing the fuel hazard model is to determine fuel types. The fuel types are initially determined from aerial photograph interpretation and validated, where necessary with on-the-ground assessments. The mapping unit is 450-acre blocks, based on dividing a 7.5-minute topographic quadrangle into 81 sections (a 9-by 9-grid), called Quad 81st. Each Quad 81st is then categorized into one of 13 fuel models based

Table 4.2-1. Size and cause of recent fires in the study area.

Fire Name	Year	Acres Burned	Cause
Wild	1990	30	Miscellaneous
Wild	1990	257	Equipment Use
Dry	1992	820	Miscellaneous
Nelson	1993	743	Equipment Use
Union	1999	736	Lightening
Bloomer	1999	2,610	Lightening
South	1999	1,572	Lightening
Bean Creek	1999	1,785	Lightening
Concow	2000	1,835	Equipment Use
Larkin	2001	487	Arson
Poe	2001	8,333	Powerline
Larkin	2001	627	Unknown/Undetermined
Poe	2001	8,055	Arson
Union	2002	58	Debris Burning

Source: CDF, 2002b

on their burn characteristics. These 13 fuel models are based on the Fire Behavior Prediction System developed by USFS. The models take into account vegetation type and other fuel characteristics.

Fire history is added to the model to create a more accurate and current representation of fuel hazard. The fire history layer shows where vegetation has burned over a fire area, and computer modeling is used to predict the regrowth of native vegetation over the area based on principles of ecological succession. For example, after a fire occurs in an area of brush, in the following year, grass will generally dominate the area. After 5 years, shrubs are predicted to resprout, and the predominant vegetation will shift from grass to shrubs.

Once the fuel model is determined, one of the six slope classes is integrated to a particular Quad 81st using Digital Elevation Model (DEM) data to arrive at a surface fuel hazard rank. Indices for crown and ladder fuels are also added to the model to derive an overall hazard score of “Moderate”, “High”, or “Very High.” Figure 4.2-2 shows the CDF Fuel Hazard Ranking for Butte County.

4.2.3 CDF Fuel Hazard Ranking in the Study Area

The model described above was used to determine the fuel hazard rank for land only within the study area (Figure 4.2-3). Most of the study area (53 percent) is classified as having Moderate fuel hazard, 32 percent of the area is classified as High hazard, and 15 percent is classified as Very High hazard. Table 4.2-2 shows the fuel hazard ranking classification for the study area by acres and percent of area.

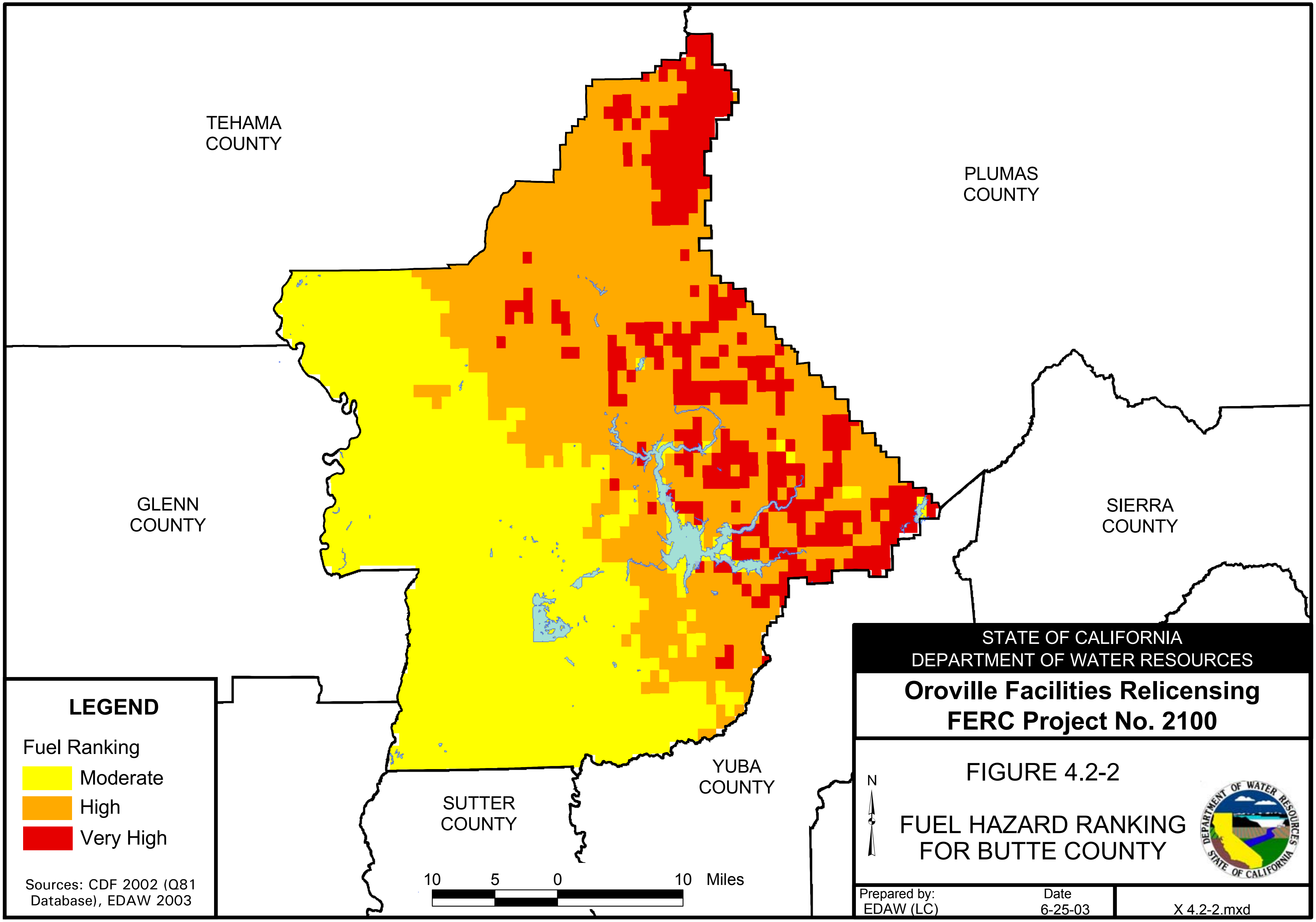
The study area is divided into three general areas: Lake Oroville and Thermalito Diversion Pool, Thermalito Forebay and Afterbay, and OWA (Figure 4.2-3). The fuel hazard ranking of the general Lake Oroville and Diversion Pool area is classified as mostly High, with some areas classified as Very High or Moderate. Thermalito Forebay, Thermalito Afterbay, and OWA are classified as Moderate. Figure 4.2-4a through Figure 4.2-4c show some general fuel conditions within the study area.

Table 4.2-2. Fuel hazard ranking classification within the study area.

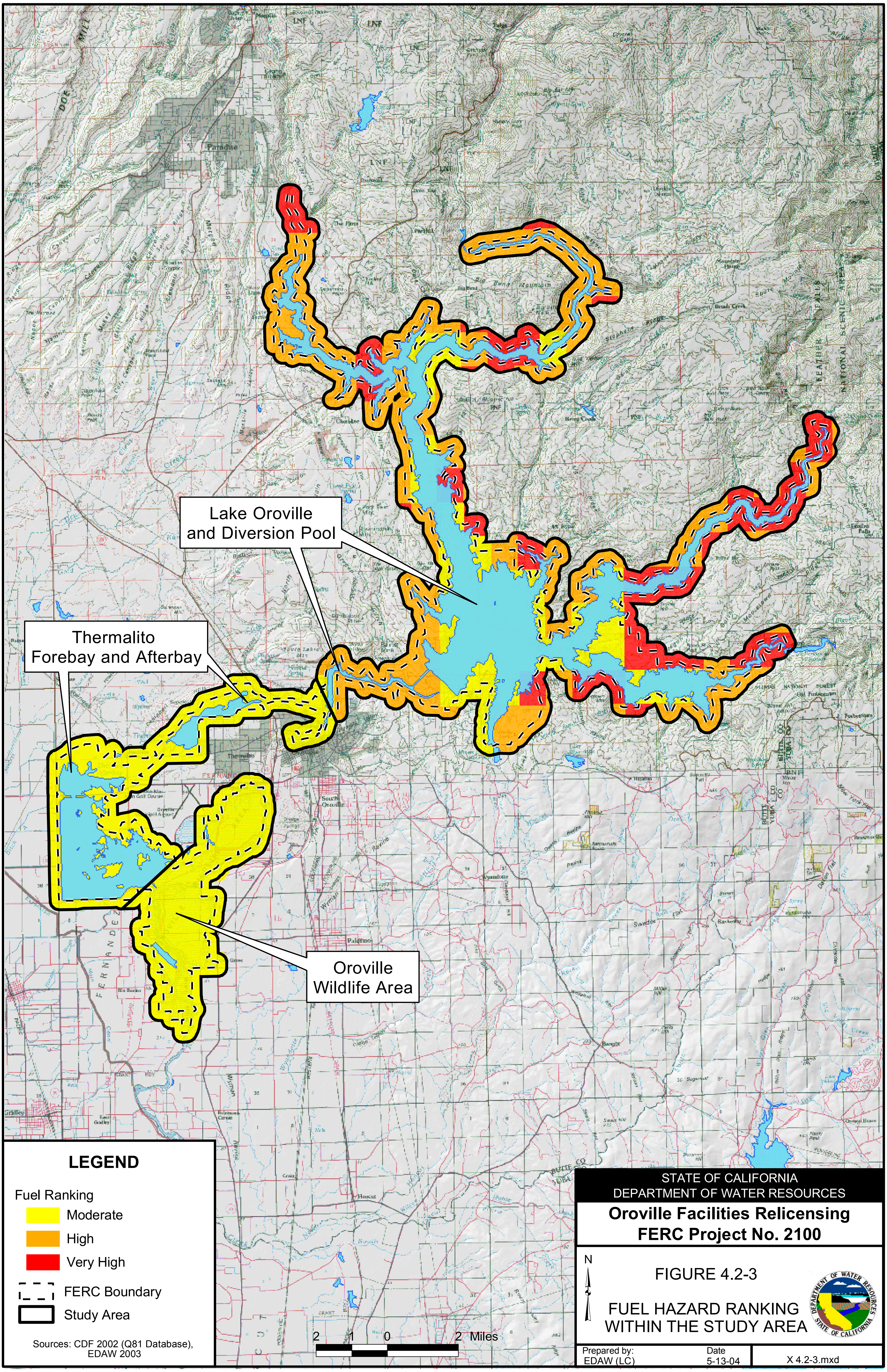
Area	**Fuel Hazard Classification Approximate percent of area (acres)**		
	Very High	**High**	**Moderate**
Lake Oroville and Thermalito Diversion Pool	15% (10,765)	32% (22,493)	22% (15,549)
Thermalito Forebay and Afterbay	-	0% (4)	18% (12,744)
OWA	-	-	13% (8,977)
Total	**15% (10,765)**	**32% (22,497)**	**53% (37,270)**

Source: CDF 2002c

PLACE HOLDER FOR FIGURE 4.2-2


TEHAMA COUNTY
PLUMAS COUNTY
GLENN COUNTY
SIERRA COUNTY
YUBA COUNTY
SUTTER COUNTY
LEGEND
Fuel Ranking
Moderate
High
Very High
Sources: CDF 2002 (Q81 Database), EDAW 2003
10 5 0 10 Miles
N
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
Oroville Facilities Relicensing
FERC Project No. 2100
FIGURE 4.2-2
FUEL HAZARD RANKING FOR BUTTE COUNTY
Prepared by: EDAW (LC)
Date 6-25-03
X 4.2-2.mxd

This page intentionally left blank.


Lake Oroville and Diversion Pool
Thermalito Forebay and Afterbay
Oroville Wildlife Area
LEGEND
Fuel Ranking
Moderate
High
Very High
FERC Boundary
Study Area
Sources: CDF 2002 (Q81 Database), EDAW 2003
2 1 0 2 Miles
N
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
Oroville Facilities Relicensing
FERC Project No. 2100
FIGURE 4.2-3
FUEL HAZARD RANKING WITHIN THE STUDY AREA
Prepared by: EDAW (LC)
Date 5-13-04
X 4.2-3.mxd

BACK OF FIGURE 4.2-3