Kings River Experimental Watershed:
Monitoring and Restoration of Forest Ecosystems
State Water Resources Control Board Grant Agreement 04-186-555-0

Final Report

for the

Kings River Experimental Watershed

(2005 – 2010)

Prepared by:

USDA Forest Service

Pacific Southwest Research Station, Fresno, CA 93710

Dr. Carolyn Hunsaker, ecologist

MAY 2010

Funding provided by

CALFED BAY-DELTA PROGRAM

Table of Contents Page

List of Figures

List of Tables

Introduction

This final report for the *Kings River Experimental Watershed: Monitoring and Restoration of Forest Ecosystems* was prepared in compliance with State Water Resources Control Board Grant Agreement 04-186-555-0. In addition to highlighting the work completed, this report documents the project's success at meeting the goals and providing the desired outcomes. This report does not attempt to repeat all of the information contained in the 21 quarterly progress reports that were submitted to the Regional Water Quality Control Board over the duration of the project (2005-2010). The quarterly reports should be consulted for details about work completed and copies of work products. Some work products also are available on the Kings River Experimental Watershed (KREW) web site: www.fs.fed.us/psw/programs/snrc/water/kingsriver.

Project Goals and Desired Outcomes

This research project provides the first replicated design of an integrated (physical, chemical, and biological measurement) watershed experiment in the Sierra Nevada. It provides data on both the characteristics and processes of headwater streams and their watersheds under current conditions and after management treatments to reduce fuel loads and improve forest sustainability. These results will be useful to all land management agencies with forested lands on granitic soils where precipitation occurs as both rain and snow. Forest management activities being evaluated are mechanical thinning, prescribed fire (underburning), and road maintenance. KREW data are very useful for calibrating different models (e.g., soil erosion, fire behavior, climate change effects, air pollution critical loads) and using modeling to predict effects. The KREW research provides data that are useful for evaluating many issues including the following.

- climate change effects
- air pollution effects
- multiple stressors (erosion, fire, air pollution, and vegetation removal)
- cumulative effects in headwater ecosystems
- erosion and sedimentation and the need for total maximum daily loads for forest management practices
- effects from fuels reduction and forest restoration treatments

In 2005 when this project started, the CALFED Watershed Program identified important areas of investigation: ecological, physical, social (management methods), and emergent (effects on watershed processes from wildfire and land use). The ecological and physical aspects were addressed by KREW with the collection of pre-treatment data; however, since the forest management treatments have not been implemented this project was not able to address the social and emergent aspects as completely as planned. The monitoring done by KREW addressed non-point source water quality from forested lands. Good agreement existed between the CALFED Watershed Program's suggested monitoring parameters and attributes measured by KREW (e.g., stream invertebrates, nitrogen, turbidity, sediment loads, etc.).

CALFED's primary objectives of **ecosystem quality** and **water quality** were shared by the Forest Service's research objectives for KREW. These were met by gathering and analyzing data for stream (water chemistry, turbidity and sediment, invertebrates, and algae) and watershed attributes (soils, vegetation, fuel loads, atmospheric deposition), as well as processes critical for stream ecosystem condition (movement of nitrogen deposited from air pollution through soils and into streams). The KREW provided much needed information on headwater ecosystems in the southern Sierra Nevada to assist with CALFED's actions "to reduce or eliminate parameters that degrade water quality at its source" and to understand "watershed processes and their relationships with one another."

The KREW assisted CALFED with its objective of facilitating and improving coordination, collaboration, and assistance among government agencies, stakeholders, and local watershed groups in several ways. This project had a goal of making high-quality research and monitoring data available to the public in a reasonable amount of time. One method of doing this was to develop several short handouts written for non-scientists that can be updated annually or as new results are available. These handouts can be used for field trips, lectures, and workshops; and can be available at State of California and Forest Service offices. The handouts are available to the public at the KREW web site. Another method is to make the stream flow and precipitation data measured at KREW available to the public at a Forest Service web site. In 2009 the Sierra Nevada Alliance profiled KREW for the southern Sierra Nevada region and recommended it as deserving of future funding in its publication, "Investing in California's Headwaters: The Sierra Nevada."

The CALFED Watershed program goals are to "provide assistance – both financial and technical – for watershed activities that help achieve the mission and objectives of CALFED, and to promote collaboration and integration among existing and future local watershed programs." KREW has become a long-term, collaborative research watershed that involves a diverse set of research organizations and management partners. At the time this project started, KREW already involved several entities, including industry, other government agencies, universities, and the Museum of the Central Sierra. Involvement has grown through the education and outreach activities and now includes participation in the development of the Southern Sierra Integrated Regional Water Management Plan and assistance to the Upper San Joaquin Watershed Plan. The Providence Site of KREW is hosting one of the first Critical Zone Observatories of the National Science Foundation. This 5-year research effort started in 2007 and brings new instrumentation to the study area and collaboration with the University of California at Merced, Berkeley, Davis, Santa Barbara and Irvine. The National Science Foundation's new National Ecological Observatory Network has selected the KREW research area to be part of its California observatory that is made up of an area starting in the foothills and goes through the mid-elevation forests up to the crest of the Sierra Nevada.

Project Description and Activities/Tasks

This project is in Region 5, Tulare Lake Basin, Kings River (552.0) of the Central Valley Regional Water Quality Control Board. The project is located northeast of Fresno (Figure 1). Specifically the Providence Site is in the Pine Flat Reservoir (52.32) and the Bull and Teakettle Site is in the North Fork of the Kings (52.30).

This project is primarily in the category of "Planning, Research, Monitoring and Assessment"; the primary tasks are research and monitoring with some assessment. One task is in the "Education, Outreach, and Capacity-building" category.

There are seven project activities for the Kings River Experimental Watershed grant; each of these will be discussed with regard to the proposed and accomplished work. Table 1 provides the completion dates for tasks as described in the grant agreement. Tables 2 and 3 are from the Project Assessment and Evaluation Plan and provide the performance indicators for the project's goals/activities listed below.

- Data accessibility
- Cumulative effects analysis and modeling of sediment and water quality
- Education and community outreach
- Integrating stations
- Water chemistry analyses
- Field sampling—vegetation, invertebrates, and algae
- Required reports

Project Funding

The State grant total was $661,000 and provided support from 2005 to 2010. Funding for the project was provided by the State Water Resources Control Board and came from Proposition 50, the Water Security, Clean Drinking Water, Coastal and Beach Protection Act of 2002. During that time, the annual Forest Service investment in KREW ranged from a low of $ 449,000 in 2007 to a high of $494,000 in 2006.

Summary of Work Completed

1 Plans. A Quality Assurance Plan and a Monitoring Plan were completed. The Quality Assurance Plan is posted on the KREW web site.

2.1 Project Assessment and Evaluation Plan. This plan was completed.

2.2 Data accessibility. A KREW website was established in 2005 and is periodically updated (http://www.fs.fed.us/psw/programs/snrc/water/kingsriver). The Quality Assurance Plan for the State and the Forest Service Research Study Plan are both available at this site. Briefing papers for non-scientists and scientists, maps of the research sites, data collection design, and published papers and reports are also provided at this web site.

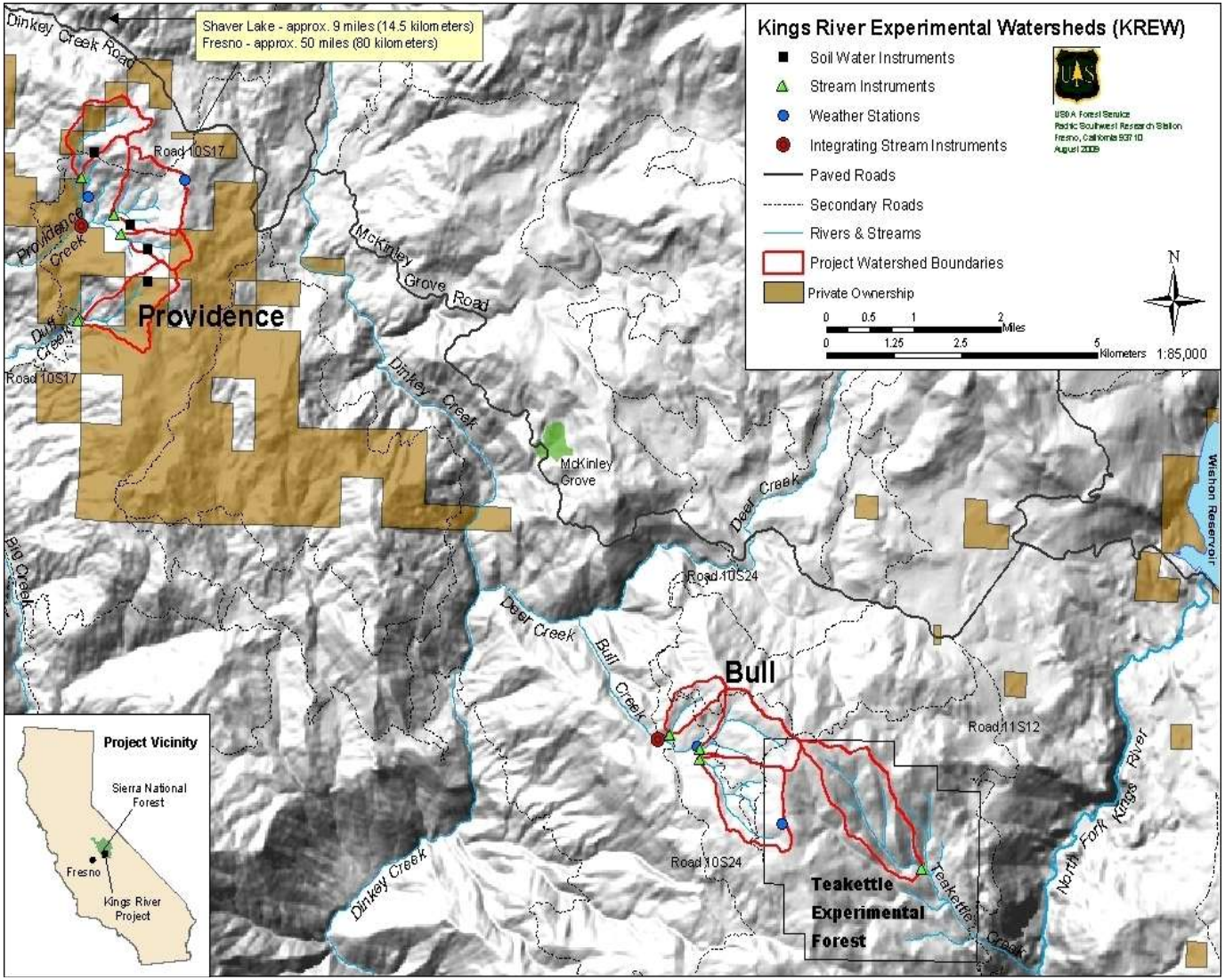

Figure 1. Locations of the Providence and Bull research sites of the Kings River Experimental Watershed on the Sierra National Forest northeast of Fresno, California.

The daily stream discharge and precipitation data for KREW are available to anyone at the Forest Service's Climate and Hydrology Database Projects web site (http://www.fsl.orst.edu/climhy). KEW is the code for KREW. Precipitation data are available through water year (WY) 2009 and stream discharge data are available through WY 2008. While data summaries were not able to be provided every six months because of the time it took to perform data entry and quality assurance and quality control (QA/QC) for all measurements, several data summaries and reports were provided.

The output indicators for this goal were accomplished (Table 2). The target of having 10 to 20 organizations with knowledge of KREW data and results was accomplished through the workshop with nine organizations in 2007 and the 20 outreach activities documented in the quarterly progress reports.

2.3 Cumulative effects analysis and modeling of sediment and water quality. Three models have been applied to the KREW data.

1. Linking vegetation change to stream flow change using the Forest Vegetation Simulator (FVS) and RHESSys (Regional Hydro-Ecologic Simulation System)
2. Geochemical mixing models for water chemistry data
3. Water Erosion Prediction Project (WEPP)

The Forest Vegetation Simulator has been run using the KREW field vegetation data collected for three years. This model has been run for several mechanical thinning prescriptions at 10-year time steps and will be used in the new Environmental Impact Statement for this research. These model results will be linked to a hydrologic model (RHESSys) to predict changes in stream flow from the different treatments. This work was reported in progress reports 16 and 17. The work linking the two models is still in progress, and results will eventually be written up for a journal publication.

The geochemical mixing model work has been completed, a draft manuscript is prepared, and will be submitted soon for a journal publication in *Hydrological Processes* ("Spatial variation of stream flow pathways and topographic and climate controls in small catchments across snow/rain transition in the Southern Sierra Nevada, California"). This work was reported in progress reports 16, 18 and 21.

The Water Erosion Prediction Project modeling has been completed to evaluate changes in erosion once the mechanical thinning is done. This work was reported in progress report 10. The WEPP results will be written up for a journal publication along with annual stream sediment loadings.

The output indicators for this goal were accomplished (Table 2), and the target was met of two or three models being used or parameterized for the KREW project. We were not able to evaluate cumulative effects from forest management treatments because those treatments have been delayed (more information is provided in the conclusions section of this report).

2.4 Education and community outreach. This activity was not funded; however, the tasks were expected to be completed because the grant was given to a Federal agency that has education and outreach as part of its mission.

Meetings with local organizations were ongoing throughout the project period; 20 formal activities were documented in quarterly reports. These activities included field trips for non-governmental organizations, teachers and students, State and Federal agency staff, and interested members of the public; regional and local watershed meetings; and presentations at scientific meetings.

A workshop was held on 31 May 2007 with nine local organizations to get feedback on format and content of briefing papers for nonscientists or the general public. Based on input from this workshop it was decided to develop two sets of handouts—one for nonscientists and one for scientists. The photos and figures are similar, but the structure and writing style are different. The science piece has metric units, and the one for nonscientists has English units. Five briefing papers were completed, published, and put on the KREW web site in December 2009. A project overview, a science and non-science paper on stream discharge, and a science and non-science paper on sediment and soil erosion are available. Future briefing papers will address stream algae, stream invertebrates, and Yosemite toad research at KREW.

The output indicators were accomplished except that a presentation to the Bay-Delta Science Program was never scheduled (Table 3). The targets for this goal were met.

2.5 Integrating stations. Two new stream monitoring stations were established with these grant funds to enable assessment of cumulative effects from the planned forest management. The challenge with addressing cumulative effects is knowing if one should expect the cumulative effect to be the same, less than, or greater than the sum of the parts. State funding paid for installation of instruments and measurements devices. Each station is referred to as an "integrating" station and is downstream of the original experimental watersheds. The Providence station was completed in 2005, and the Bull station was completed in 2006.

At the Providence site the integrating station is P300, and it receives drainage from P301 which will be mechanically thinned and burned, P303 which will be underburned only, and P304 which is a control or no treatment. At this station a permanent weir was constructed for continuous stream discharge measurements and the following instruments were installed: ISCO sampler for water samples, pressure transducer for backup stream discharge, and a turbidity probe for suspended sediment. At the Bull site the integrating station is B200, and it receives drainage from B201, B203, and B204. At this station a permanent stream cross-section was established and a flow-rating curve was developed to provide stream discharge measurements. This station has an ISCO sampler for water samples, an aquarod for backup stream discharge, and a turbidity probe for suspended sediment.

The output indicators for this goal were accomplished (Table 2). The target of two successfully operating integrating stations was accomplished; however, since forest management treatments did not occur, cumulative effects analyses have not been accomplished.

2.6 Water chemistry analyses. The State of California funding provided partial support for the chemical analyses of water at KREW. During the project period these analyses occurred on precipitation (snowmelt samplers), stream water, shallow soil water (Prenarts), and resin lysimeters placed above ground and below ground in shallow mineral soil. The design and sampling protocols can be found in the project's QAPP and monitoring plan. A brief description of the number and type of samples is provided here.

Nutrient fluxes in forest throughfall and shallow mineral soil are measured annually using resin lysimeters placed at 477 evenly spaced points across the eight watersheds.

Number of water samples collected per field visit

- Stream grab or ISCO automatic sampler
  10 locations in water year 2006 = 10 samples
- Prenart vacuum lysimeters at Providence Site
  4 locations each with 12 sampling tips = 48 samples
- Snowmelts
  --at Providence Site
  4 locations at Prenarts each with 7 collectors = 28 samples
  2 meteorology stations each with 2 collectors = 4 samples
  --at Bull Site
  1 meteorology station at lower Bull with 2 collectors = 2 samples

Total samples during wet season per visit = 92
Total samples during dry season per visit = 10 (stream only)

Sample visit frequency
Stream dry season--once a month
wet season--every 2 weeks
spring runoff--2 samples per stream every week (for 1-2 months)
storms—4 samples per stream per rain event (~ 4 storms/year)
Snowmelts every 2 weeks in wet season
Prenarts every 2 weeks in wet season

Wet season varies
long season: October through June = 9 months
short season: December through May = 6 months
Samples per visit during wet season = 92
9 months at 2 visits/month = 1,656 samples
6 months at 2 visits/month = 1,104 samples
spring runoff = 120 samples
storms = 160 samples
Samples per visit during dry season = 10
3 months = 30 samples
6 months = 60 samples

The output indicators for this goal were accomplished (Table 2). The target of providing summary reports was accomplished.

2.7 Field sampling—vegetation, invertebrates, and algae. Biological organisms are good indicators of environmental change. Two years of sampling and data quality control were completed for terrestrial vegetation, stream invertebrates and algae. The sampling designs for these indicators can be found in the Quality Assurance Program Plan (QAPP) and Forest Service Research Study Plan on the KREW web site. The output indicators for these measurements were accomplished (Table 2). The target of having a published journal paper was accomplished for algae; efforts will continue to publish results for the vegetation and invertebrate data.

An agreement was established with the University of California, Santa Barbara, to accomplish the field sampling and taxonomic identification of stream invertebrates (2.7.2). An interagency agreement was established with the United States Geological Survey to accomplish the field sampling and taxonomic identification of stream algae (2.7.3).

2.8 Required reports. Twenty-one quarterly progress reports have been completed from 2005 through April of 2010. A draft project report was submitted in March of 2010; that report was revised to produce this final project report.

Summary of Tasks not Completed

2. Cumulative effects analysis and modeling of sediment and water quality. Three different models were run with KREW data for existing conditions (2.3.3 and 2.3.4). The original reason for parameterizing these models and running them to predict future effects from land management was to be able to compare field data after forest treatments to model predictions. Since the forest treatments have been delayed by the National Environmental Policy Act process and not implemented as of this date, the Forest Service was unable to fully accomplish this task of doing cumulative effects analysis.

Now the Forest Service is preparing an Environmental Impact Statement just for the KREW research areas. The earliest date that mechanical treatments could start at KREW is summer of 2011. In addition to providing much needed data on watershed cumulative effects, KREW should provide direction about best management practices for forested watershed ecosystems on private, state, and federal lands in the Sierra Nevada and perhaps other semi-arid, montane forests. Once the treatments are done, the KREW data can help with the development of Total Maximum Daily Loads (TMDLs) for forest land.

At the end of this project a talk was to be given to the California Bay-Delta Science Program (2.4.3). I am willing to give a presentation, but I was unable to contact an appropriate person to schedule such a talk, and the nature and interests of that Program have changed since this project started.

Table 1. Date project items were completed or delivered by grant agreement item.

Work Item	Items for Review #	Due Date	% Of Work Complete	Date Submitted
EXHIBIT A	1.1 Quality Assurance Plan	4/30/2005	100	Final 7/18/2006
	1.2 Monitoring Plan	4/30/2005	100	9/2006
	2.1 Project Assessment & Evaluation Plan	4/30/2005	100	2/5/2008
	2.2 Data Accessibility			
	2.2.1 Provide quality-assured data	10/2006	100	3/31/2010
	2.2.2 User friendly web site	10/2005	100	12/1/2005
	2.2.3 regular analysis and data summaries	10/2005 & every 6 mo	100	1. 8/23/2007 for 2002-2005 2. 3/31/2010 for 2002-2007
	2.3 Cumulative effects analysis and modeling of sediment and water quality			
	2.3.1 & 2.3.2 Report and review selection of models	10/2005	100	7/29/2009
	2.3.3 Parameterize models	10/2006	100	3/31/2010
	2.4 Education and Community Outreach	4th quarter 2005	100	3/31/2010
	2.4.1 Meet with local organizations	2nd quarter 2005	100	3/31/2010
	2.4.2 Workshop to improve usefulness of information from KREW	1st quarter 2006	100	held on 5/31/2007
	2.4.3 Presentation to CA Bay-Delta Science Program/Panel	4th quarter 2006	Pending	Date never set
	2.5 Integrating Station			
	2.5.1 Buy instruments and supplies	4/2005	100	12/2009
	2.5.2 Two operating stations	10/2006	100	#1 completed 10/2005 #2 completed 11/2006
	2.6 Water chemistry analyses			
	2.6.1. Annual report on water chemistry	10/2006	100	1. 8/23/2007 for 2002-2005 2. 3/31/2010 For 2002-2007
	2.6.2 Water quality probes installed and operating	4/2006	100	10/31/2005
	2.7 Field sampling			
	2.7.1 Annual report on vegetation sampling	10/2005 & annually	100	9/24/2006
	2.7.2 Annual report on invertebrate sampling	10/2005 & annually	100	1. 4/22/2008 2. 3/31/2010
	2.7.3 Annual report on algae sampling	10/2005 & annually	100	Final 4/20/2007
	2.8 Draft and Final Project Report			
	2.8.2 Draft Project Report	11/2007 extended to 5/31/2010	100	3/31/2010
	2.8.3 Final Project Report	2/2008 extended		
EXHIBIT B	6.1 Quarterly Progress Reports			
	#1	4/20/2005	100	12/1/2005

Work Item	Items for Review #	Due Date	% Of Work Complete	Date Submitted
	#2	7/20/2005	100	12/1/2005
	#3	10/20/2005	100	12/1/2005
	#4	1/20/2006	100	10/20/2006
	#5	4/20//2006	100	10/20/2006
	#6	7/20/2006	100	12/20/2006
	#7	10/20/2006	100	4/10/2007
	#8	1/20/2007	100	4/20/2007
	#9	4/20/2007	100	5/15/2007
	#10	7/20/2007	100	8/23/2007
	#11	10/20/2007	100	1/7/2008
	#12	1/20/2008	100	1/16/2008
	#13	4/20/2008	100	4/22/2008
	#14	7/20/2008	100	7/30/2008
	#15	10/20/2008	100	11/12/2008
	#16	1/20/2009	100	2/25/2009
	#17	4/20/2009	100	7/29/2009
	#18	7/20/2009	100	7/29/2009
	#19	10/20/2009	100	12/23/2009
	#20	1/20/2010	100	3/31/2010
	#21	3/31/2010	100	4/31/2010
	6.2 Quarterly Expenditure/Invoice Projections			
	#1 no costs incurred	4/20/2005	100	12/1/2005
	#2 no costs incurred	7/20/2005	100	12/1/2005
	#3	10/20/2005	100	12/1/2005
	#4	1/20/2006	100	11/16/2006
	#5	4/20/2006	100	11/16/2006
	#6	7/20/2006	100	12/20/2006
	#7	10/20/2006	100	4/10/2007
	#8	1/20/2007	100	4/20/2007
	#9	4/20/2007	100	5/15/2007
	#10	7/20/2007	100	8/23/2007
	#11	10/20/2007	100	1/7/2008
	#12	1/20/2007	100	1/16/2008
	#13	4/20/2008	100	4/22/2008
	#14	7/20/2008	100	7/30/2008
	#15	10/20/2008	100	11/12/2008
	#16	1/20/2009	100	2/25/2009
	#17	4/20/2009	100	7/29/2009
	#18	7/20/2009	100	7/29/2009
	#19	10/20/2009	100	12/23/2009
	#20	3/31/2010	100	4/31/2010
	6.3 Grant Summary Form	5/2005	100	3/31/2010
	6.4 Natural Resource Projects Inventory project survey form	Before final invoice	100	5/31/2010
EXHIBIT C	6. CEQA/NEPA Documents	4/30/2005	100	12/1/2005
	22. Signed cover sheets for all permits	4/30/2005	NA	NA

Conclusions

KREW addresses all the areas of investigation that the CALFED Watershed Program had documented in 2005 when this project started: ecological, physical, social (management methods and effects), and emergent (effects on watershed processes from wildfire and land use). Good agreement exists between CALFED's suggested monitoring parameters under the Watershed Program and KREW. The Forest Service's Research Study Plan describes conceptual models, hypotheses to be tested, questions to be answered, and the research statistical design for each study module. The research addresses scientific uncertainties; its ability to address these is dependent on the rigor of the overall statistical design. PSW statistical support staff is involved in KREW design and analyses.

This project addresses the **ecosystem quality** and **water quality** primary objectives of CALFED by gathering and analyzing data for stream and watershed attributes, as well as processes critical for stream ecosystem condition. CALFED wants to "undertake actions to reduce or eliminate parameters that degrade water quality at its source," and KREW can provide much needed information to do this for forested watersheds in the Sierra Nevada. The KREW is unique, as there are no other comprehensive studies of headwater ecosystems in the Sierra Nevada. The research should enable more efficient and cost-effective monitoring protocols for small mountain streams and facilitate future assessments of such ecosystems. The KREW data can assist with the "development of a list of watershed processes and their relationships with one another," as well as providing quantitative data for analysis of cumulative watershed effects.

The project provides much needed data for California's State Water Ambient Monitoring Program (SWAMP). Very little monitoring information is available for Sierra headwater streams. The KREW data fills a gap in surface water monitoring of the upper watersheds of the Tulare Lake Basin, and assists the timber harvest program of the Regional Board. Currently, a permit waiver exists for timber harvest operations, but data are lacking for the effects of timber harvest operations and fuel reduction projects on streams. The proposed research uses many of the SWAMP indicators listed under the question, "Is aquatic life protected?"

The CALFED Watershed program goals are to "provide assistance – both financial and technical – for watershed activities that help achieve the mission and objectives of CALFED, and to promote collaboration and integration among existing and future local watershed programs." KREW has become a long-term, collaborative watershed that involves a diverse set of research organizations and management partners. At the time this project started, KREW already involved several entities, including industry, other government agencies, universities, and the Museum of the Central Sierra. Involvement has grown through the education and outreach activities and now includes participation in the development of the Southern Sierra Integrated Regional Water Management Plan and assistance to the Upper San Joaquin Watershed Plan. The Providence Site of KREW is hosting one of the first Critical Zone Observatories of the National Science Foundation. This 5-year research effort started in 2007 and brings new instrumentation to the study area and collaboration with the University of California at Merced, Berkeley, Davis, and Irvine. The National Science Foundation's new National Ecological Observatory Network has selected the KREW research area to be part of its California observatory.

This project has been unable to evaluate cumulative effects of forest management treatments because the treatments have not been implemented. Originally the treatments (mechanical thinning and underburning) that KREW is designed to evaluate were scheduled to start in 2007. An Environmental Impact Statement (EIS) for the larger Kings River Project (KREW was part of this larger landscape study) was issued in October 2006. Environmental groups opposed the implementation of this larger study primarily because they felt the risk to a terrestrial mammal, the fisher, was too large. The Forest Service prepared a supplemental EIS in August of 2008. In January of 2009, the Pacific Southwest Region of the Forest Service decided to not move forward with the larger Kings River Project. Currently an EIS just for the KREW research areas is being prepared. The earliest date that mechanical treatments could start at KREW is summer of 2011. In addition to providing much needed data on watershed cumulative effects, KREW should provide direction about best management practices for forested watershed ecosystems on private, state, and federal lands in the Sierra Nevada and perhaps other semi-arid, montane forests. Once the treatments are done, the KREW data can help with the development of Total Maximum Daily Loads (TMDLs) for forest land.

In 2009, the Sierra Nevada Alliance profiled KREW for the southern Sierra Nevada region and recommended it as deserving of future funding in its publication, "Investing in California's Headwaters: The Sierra Nevada."

Peer Reviewed Articles

Brown, L.R., J.T. May, and C.T. Hunsaker. 2008. Species composition and habitat associations of benthic algal assemblages in headwater streams of the Sierra Nevada, California. *Western North American Naturalist 68(2):194-209.*

Hunsaker, C., A. Bytnerowicz, J. Auman, and R. Cisneros. 2007. Air pollution and watershed research in the central Sierra Nevada of California: nitrogen and ozone. *TheScientificWorld* 7(S1):206-221.

Eagan, S. M.; Hunsaker, C. T.; Dolanc, C. R.; Lynch, M. E.; Johnson, C. R. 2007. Discharge and sediment loads at the Kings River Experimental Forest in the Southern Sierra Nevada of California. pp. 217-224 IN Furniss, M.; Clifton, C.; Ronnenberg, K. (eds). *Advancing the Fundamental Sciences: Proceedings of the Forest Service National Earth Sciences Conference*, San Diego, CA, 18-22 October 2004, PNW-GTR-689, Portland, OR, Pacific Northwest Research Station, Forest Service, U.S. Department of Agriculture.

Forest Service briefing papers (2-4 pages each) authored by C. Hunsaker
September 2009 publications

Kings River Experimental Watersheds, Project Overview
Sediment and Soil Erosion, Kings River Experimental Watersheds, non-technical
Sediment and Soil Erosion, Kings River Experimental Watersheds, technical
Stream Discharge, Kings River Experimental Watersheds, technical
The Importance of Streamflow in California's Southern Sierra Nevada Mountains, non-technical

Two manuscripts are in progress for submission to *Hydrologic Processes*, and more are being planned.

C. Hunsaker, T. Whitaker, and R. Bales. Water yield and runoff timing across the rain-snow transition in California's southern Sierra Nevada mountains.

F. Liu, C. Hunsaker, and R. Bales. Controls of stream flow pathways in small catchments across the snow/rain transition in the southern Sierra Nevada, California.

Project Performance Measures Tables

The tables in this section provide details on project goals, outcome indicators, and target results. Table 2 provides the project performance measures for the research, monitoring and assessment activities. Table 3 provides the project performance measures for the education and outreach activities.

Table 2. Performance Indicators for Research, Monitoring, and Assessment Activities, Kings River Experimental Watershed

Project Goals	Baseline Measurements and Information	Output Indicators (track outputs)	Outcome Indicators (evaluate change)	Measurement Tools and Methods	Targets
1. Data accessibility Item 2.2	Number of data types and amount of data quality assured	Public accessibility 1. a. KREW web site 1. b. data on HydroDB	Increased information on variability of forest headwater systems	Data to answer basic science questions and improve best management practices	10-20 organizations with knowledge of KREW data and results
2. Modeling sediment and water quality for cumulative effects Item 2.3	Number of models being evaluated for use by KREW	Successful use of various models at KREW	Increased ability to predict environmental effects from land management actions	2.a. adequate KREW data for models—spatially and temporally 2.b. ability to parameterize models	Two or three models that can be used for forest lands in the southern Sierra Nevada
3. Integrating stations for cumulative effects Item 2.5	Select locations and design stations	Install two integrating stations	Ability to evaluate cumulative effects at two 3rd-order streams	Successful collection of stream discharge, chemistry, and turbidity at integrating stations	Two successfully operating integrating stations and report on cumulative effects analyses
4. Water chemistry analyses Item 2.6	4.a. Field measurement of pH, temperature and conductivity 4.b. Turbidity measurement by probes and their calibration by grab samples 4.c. Laboratory analyses of other parameters	Regular chemical analyses of stream water, shallow soil water, and precipitation for 10 streams and 8 watersheds	Ability to evaluate baseline (pre-treatment) variability in various chemistry parameters	KREW QAPP and Monitoring Plan	Annual summary reports
5. Field sampling Item 2.7	5.a. Vegetation sample design 5.b. Invertebrate sample design 5.c. Algae sample design	5.a. Completion of 2 years sampling and data QA/QC for vegetation 5.b. Completion of 2 years sampling and data QA/QC for invertebrates 5.c. Completion of 2 years of sampling and data QA/QC for algae	Ability to evaluate baseline (pre-treatment) variability in vegetation (8 watersheds) and invertebrates and algae (10 streams)	KREW QAPP and Monitoring Plan	One submitted or published journal paper each for vegetation, invertebrate, and algae baseline KREW data

Table 3. Performance Indicators for Education and Outreach Activities, Kings River Experimental Watershed

Project Goals	Desired Outcomes	Output Indicators	Outcome Indicators	Measurement Tools and Methods	Targets
1. Education and Community Outreach Item 2.4	Improve use and usefulness of KREW watershed information	1.a. Meet with local organizations 1.b. Conduct workshop 1.c. Give presentation to Bay-Delta Science Program 1.d. Publications	Use input from meetings and workshop to develop materials for non-science audience	Verify completion of output indicators and seek additional comments on usefulness of materials	10-20 organizations with knowledge of KREW data and results At least 4 short handouts (1-4 pages) on results and written for non-scientists