Upper Feather River Watershed (UFRW) Irrigation Discharged Management Program

State Water Resources Control Board
Proposition 50 Agricultural Water Quality Grant
Agreement Number 04-317-555-2

Awarded to:

The Regents of University of California

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A. Summary of Project

Introduction

This report on the irrigated agriculture of the Upper Feather River Watershed (UFRW) was prepared in compliance with the State Water Resource Control Board Grant Agreement Number 04-317-555-2. This report describes project scope, monitoring activities, approach, and partners involved. This report does not reproduce all information presented in quarterly reports previously submitted to the State Water Resource Control Board over the course of this project. The overall objective of this project was to interact with local agricultural landowners and support work activities within the UFRW which would be responsive to the requirements of the Irrigated Lands Regulatory Program (ILRP) and to proactively address water quality issues associated with discharge from irrigated lands in this area.

Background & Purpose

The Upper Feather River Watershed (UFRW) is 3,222 square miles in area and is drained by the Middle and North Forks of the Feather River westward from the northern Sierra Nevada into the Sacramento River. There are approximately 45,000 irrigated agricultural acres in the watershed, comprised primarily of grazed pasture and hay land. For the purposes of this project, the UFRW is defined as the portion of the North Fork Feather River Watershed upstream of the confluence of Indian Creek and the North Fork Feather River (including the Indian Creek sub-basin), and the Middle Fork Feather River Watershed above Portola, CA. The waters of the UFRW (Middle and North Forks Feather River, Indian Creek, Spanish Creek, Greenhorn Creek, Goodrich Creek, and their tributaries) are important for recreational, fishery, and aquatic habitat benefits, in addition to contributing to local and state supplies for agricultural, industrial, and municipal uses. Irrigated agriculture on private lands takes place principally within three large valley areas: 1) Sierra Valley which drains to the upper reaches of the Middle Fork Feather River above Portola; 2) Indian Valley which drains to Indian Creek between Crescent Mills and Taylorsville; and 3) American Valley which drains to Greenhorn and Spanish Creeks near Quincy. Other irrigated lands are located on Goodrich Creek which is a tributary to the East Branch of the North Fork Feather River which was monitored as a part of this project. Please see pages 31-32 for maps of the 4 major valleys that were the focus of this program.

The purpose of this project was the establishment of a locally led, proactive program to identify and address water quality impacts from irrigated agricultural operations in the UFRW. This program involved a cooperative, non-threatening partnership effort by UC personnel, local, state and federal resource agencies, and private landowners engaged in irrigated agriculture. The desired results of this project were: (1) Compilation of comprehensive and accurate information on existing irrigated agricultural operations, and known or potential water quality impacts from those operations, (2) Implementation of an ambient water quality monitoring program to compare water quality of streams immediately above and below irrigated agricultural operations, and to compare pollutant levels below irrigated agricultural operations to Central Valley Regional Water Quality

Control Board (CVRWQCB) Irrigated Lands Regulatory Program water quality objectives, (3) Transfer of information from the above item to the agricultural community, the CVRWQCB - ILRP, and other watershed stakeholders in order to facilitate informed decision making, and (4) Establishment of a process by which individual farm owners/managers could evaluate their current operations, identify problems or concerns, and plan for any needed management improvements. The expected benefit was improved water quality in the rivers and streams of the UFRW and the continuation of a viable agricultural economy, working towards the mutual benefit of industry and environmental interests.

Scope & Objectives

At the beginning of this project, there was limited information describing management practices of irrigated agriculture in the UFRW. There was virtually no information specific to water quality impacts from irrigated agriculture (primarily pastures and hayland) in the upper watersheds. Agricultural chemicals related toxicity in the UFRW was not believed to be an important water quality issue due to nominal use. For example, in 2002 only 433 pounds of active pesticide ingredients were reportedly applied to irrigated agricultural lands in Plumas-Sierra Counties. The overall objective of this project was to interact with local agricultural landowners and support work activities within the UFRW which would be responsive to the requirements of the ILRP and to proactively address water quality issues associated with discharge from irrigated lands in this area. Specific objectives are listed below:

Objective 1: Establish a baseline Water Quality Monitoring Plan consistent with Phase I requirements of the RWQCB Ag Waiver Program bracketing irrigated agriculture in the main valleys of the UFRW with sites in Sierra Valley, Indian Valley, American Valley and Goodrich Creek area above Lake Almanor.

Objective 2: Compile information about local irrigated agricultural operations and identify other activities in the major irrigated valleys that may be contributing to water quality impacts.

Objective 3: Compile information about technical and financial resources to assist landowners and resource professional in assessing problems and implementing management measures.

Objective 4: Establish on-ranch demonstration sites across the UFRW to evaluate effectiveness of Management Measures on specific water quality constituents.

Objective 5: Facilitate Completion of Conservation or Farm/Ranch Plans with willing cooperators via small group training events.

Objective 6: Conduct stakeholder training, educational outreach and extension of project activities.

Activities Completed

The capacity building activities associated with this project has led to the development of a cooperative partnership and increased communication with UC personnel, local, state, & federal agencies and landowners. The local irrigated agriculture watershed group has expanded their understanding of their potential role in influencing water quality and a number of them have stepped up and implemented management practices to mitigate impacts from agriculture. They increased their capacity to participate in oral and written communication with each other as well as variety of regulatory agencies and organizations on the topics of irrigated agriculture water quality, management practices, collaborative funding opportunities and ongoing education and outreach. Through participation in this project, they've gained the experience to collect their own field samples, saving the local watershed group thousands of dollars

Surveys were conducted to gather information on the variety of irrigated agricultural management practices existing within UFRW. Results were compiled along with resources and shared with all existing irrigated ag operators in the watershed and posted on our website: http://ucanr.org/waterquality.

Working with the local watershed group we identified 19 sampling sites across the UFRW in the four main valleys (Sierra, Indian, America, and Goodrich Creek) to collect ambient water quality data in streams. Phase I of this project compared water quality of streams immediately above and below irrigated agricultural operations in the four main valleys plus compared pollutant levels below irrigated agricultural operations in the main valleys to CVRWQCB Irrigated Lands Regulatory Program water quality objectives.

Based on the findings of the first year, it appeared that *E. coli* was the only real constituent of concern related to and responsive to management so we worked with a number of willing cooperators to conduct on-ranch monitoring to support decision making by landowners related to grazing and/or irrigation management changes to potentially reduce *E. coli* contributions to streams and drainage canals, Phase II.

On a number of locations across the watershed, we monitored water table depth, soil moisture, and forage production/quality at wet (high risk of pollutant transport/moderate forage quality), moist (low risk of pollutant transport/high forage quality), and dry (no risk of pollutant transport/low forage quality) irrigation scenarios across sites in UFRW. The purpose was to provide incentive for appropriate irrigation water application management, which would result in reduced pollutant transport risk, and enhance agricultural productivity.

Techniques

This project involved water quality monitoring, on-ranch demonstration sites, field discussions of beneficial management practices, community education, and farm/ranch planning. Activities conducted and information collected during this project lead to implementation of practices to mitigate water quality concerns and build relationships among local landowners and organizations (capacity building). Relative to established Irrigated Land Regulatory Program (ILRP) water quality objectives, we observed occasionally high indicator *E. coli* concentrations, seasonally low dissolved oxygen, and seasonally high pH at select monitoring locations during this project. Outreach, site specific monitoring, and irrigation management case studies were conducted to facilitate implementation of management to reduce *E. coli* contributions to streams from grazed, irrigated pastures. A special monitoring study was conducted in an attempt to determine factors driving seasonally high pH and low dissolved oxygen levels.

Table 1. Constituents monitored

Constituent	Purpose	Collection and Determination
Water Temperature	Constituent of concern for aquatic habitat degradation.	Measured each 0.5 hour via automatic recording temperature data loggers installed at each sample site (May through September).
Dissolved Oxygen	Constituent of concern for aquatic habitat degradation.	Measured with calibrated dissolved oxygen meter on each sample collection event.
Instantaneous Streamflow*	Constituent of concern for aquatic habitat degradation. Required in conjunction with constituent concentrations to determine instantaneous constituent load.	Calculated via area-velocity method from in field measurements of stream water width, average depth, and average velocity along a cross-section at each sample site on each sample collection event.
Dissolved Organic Carbon	Constituent of concern for drinking water quality.	Grab sample; laboratory analysis
Total Organic Carbon	Constituent of concern for drinking water quality.	Grab sample; laboratory analysis
E. coli	Constituent of concern for drinking water quality.	Grab sample; laboratory analysis
Total Nitrogen	Constituent of concern for aquatic habitat degradation.	Grab sample; laboratory analysis
Nitrate	Constituent of concern for aquatic habitat degradation; drinking water quality.	Grab sample; laboratory analysis
Ammonium	Constituent of concern for aquatic habitat degradation.	Grab sample; laboratory analysis
Total Phosphorus	Constituent of concern for aquatic habitat degradation.	Grab sample; laboratory analysis
Phosphate	Constituent of concern for aquatic habitat degradation.	Grab sample; laboratory analysis
Total Suspended Solids	Constituent of concern for aquatic habitat degradation	Grab sample; laboratory analysis
Turbidity	Constituent of concern for aquatic habitat degradation.	Grab sample; laboratory analysis
pH	General water quality constituent.	Grab sample; laboratory analysis
Electrical Conductivity	General water quality constituent.	Grab sample; laboratory analysis
Color	General water quality constituent.	Grab sample; laboratory analysis
Total Dissolved Solids	General water quality constituent.	Grab sample; laboratory analysis
Ultraviolet Absorbance at 254 nm	General water quality constituent.	Grab sample; laboratory analysis
Macroinvertebrate Community Composition	Constituent of concern for aquatic habitat degradation.	Collected in the field at each sample site using standard CA DF&G California Stream Bioassessment Protocol; laboratory analysis
Ceriodaphnia dubia (water flea) and larval *Pimephales*	Requirement for Coalition Monitoring and Reporting	Laboratory analysis

promelas (fathead minnow)	Program; acute water toxicity**	
Selenastrum capricornutum (green algae)	Requirement for Coalition Monitoring and Reporting Program; herbicide water toxicity**	Laboratory analysis
Hyalella azteca or *Chironomus tentans*	Requirement for Coalition Monitoring and Reporting Program; sediment toxicity**	Laboratory analysis

* Instantaneous streamflow and water quality not sampled at Site #14 during stagnant flow conditions.
** Monitoring and Reporting Program No. R5-2005-0833 for Conditional Waiver of Discharge Requirements for Discharges from Irrigated Lands within the Central Valley Region. CVRWQCB August 15, 2005.

Table 2. Sampling locations monitored

Sample Site Designation	Sample Site Location	Purpose and other comments
1 – Greenhorn Creek Above American Valley	039° 55’ 50.30” N 120° 50’ 38.65” W	Measure water quality and streamflow above irrigated agriculture; American Valley.
2 – Spanish Creek Below Greenhorn Creek Confluence	039° 58’ 23.85” N 120° 54’ 35.96” W	Measure water quality and streamflow below irrigated agriculture; American Valley.
3 –Greenhorn Creek: Chandler Road (Pocket) Bridge	039° 58’ 4.24” N 120° 54 51.79” W	Measure water quality and streamflow below irrigated agriculture; American Valley.
4 – Spanish Creek: Chandler Road (Pocket) Bridge	039° 58’ 4.55” N 120° 54’ 53.79” W	Measure water quality and streamflow below irrigated agriculture; American Valley.
5 – Spanish Creek: Hwy 70/89 Bridge	039° 56’ 42.14” N 120° 57’ 18.37” W	Measure water quality and streamflow above irrigated agriculture; American Valley.
6 – Arlington Bridge: Indian Creek	040° 05’ 3.69” N 120° 54’ 56.77” W	Measure water quality and streamflow below irrigated agriculture; Indian Valley.
7 – Lights Creek	040° 09’ 1.01” N 120° 47’ 38.29” W	Measure water quality and streamflow above irrigated agriculture; Indian Valley.
7 – (Revised 2007) Lights Creek	040° 10’ 24.85” N 120° 47’ 24.01” W	Measure water quality and streamflow above irrigated agriculture; Indian Valley
8 – Indian Creek: Taylorville Rodeo Bridge	040° 04’ 29.23” N 120° 49’ 49.03” W	Measure water quality and streamflow above irrigated agriculture; Indian Valley.
8 – (Revised 2007) Indian Creek: Taylorsville Bridge (Nelson St.)	040° 05’ 14.71” N 120° 50’ 3.68” W	Measure water quality and streamflow above irrigated agriculture; Indian Valley
9 – Wolf Creek: Above Park	040° 08’ 21.20” N 120° 55’ 59.42” W	Measure water quality and streamflow above irrigated agriculture, below town of Greenville; Indian Valley.
10 – Little Last Chance Creek: Below USFS Campground	039° 51’ 9.79” N 120° 09’ 9.31” W	Measure water quality and streamflow above irrigated agriculture; Sierra Valley.
11 – Middle Fork Feather River: County Road A23 Bridge	039° 49’ 8.85” N 120° 23’ 25.97” W	Measure water quality and streamflow below irrigated agriculture; Sierra Valley.
11.5 – (Revised 2007) Middle Fork Feather River: Above Grizzly Creek Confluence	039° 48’58.69” N 120° 25’32.59” W	Measure water quality and streamflow below irrigated agriculture; Sierra Valley.
12 – Perry Creek: Hwy 89 Bridge	039° 35’ 26.18” N 120° 22’ 12.98” W	Measure water quality and streamflow above irrigated agriculture, below town of Sierraville; Sierra Valley.
13 – Smithneck Creek: Sierra Brooks Bridge	039° 38’ 57.42” N 120° 13’ 23.61” W	Measure water quality and streamflow above irrigated agriculture, above town of Loyalton; Sierra Valley.
14 – Middle Fork Feather River: Dyson Lane (Steel) Bridge	039° 45’ 46.34” N 120° 20’ 7.31” W	Measure water quality and streamflow below irrigated agriculture; Sierra Valley.
15 – Cold Creek: Upper	039° 37’ 10.08” N 120° 26’ 04.97” W	Measure water quality and streamflow above irrigated agriculture; Sierra Valley.

Sample Site Designation	Sample Site Location	Purpose and other comments
16 – Turner Creek	039° 33' 48.95" N 120° 21' 36.03" W	Measure water quality and streamflow above irrigated agriculture; Sierra Valley.
17 – Goodrich Creek: Upper	040° 21' 0.00" N 120° 57' 3.87" W	Measure water quality and streamflow above irrigated agriculture; Goodrich Creek.
18 – Goodrich Creek: Hwy 36 Bridge	040° 19' 45.38" N 120° 55' 48.70" W	Measure water quality and streamflow below irrigated agriculture; Goodrich Creek.
19 – Goodrich Creek: Lower	040° 18' 15.88" N 120° 56' 38.81" W	Measure water quality and streamflow below irrigated agriculture; Goodrich Creek.

Partners

The Upper Feather River Watershed Group (UFRWG), local coalition of over 100 local agricultural irrigators was the primary partner and helped facilitate on-ranch access. The Natural Resources Conservation Service (NRCS) along with Sierra Valley and Feather River Resource Conservation Districts, Plumas-Sierra Cattlemen's Association, Plumas-Sierra Farm Bureau, and Sierra Valley Ground Water Management District were partners, providing actually dollars and/or in-kind contributions to assist with this project. The Plumas County Watershed Forum and the Feather River Regional Water Management Group and the Coordinated Resource Management Group also assisted with outreach efforts.

B. Management Practices & Management Measures Implemented

During Phase II of this project, demonstration sites were identified and a variety of management measures (MM) were implemented across the UFRW. Project team members worked closely with landowners to assess different aspects of ranches and develop a summary of: operations, production practices, irrigation and tail water, creek information, and goals/concerns. Based on Phase I monitoring, E. coli was identified as a constituent of concern which resulted in the implementation of Best Management Practices (BMP) to reduce E. coli concentrations. The following are a summary of management practices that were implemented across the UFRW to reduce livestock direct access to stream channels and irrigation ditches:

- Stream bank fencing
- Irrigation control measures
- Offsite water - Solar, rubber tanks
- Grazing management
- Stream bank stabilization
- Ponds & wetlands to reduce tailwater return
- On-farm assessment monitoring – photo and water quality monitoring

In some instances a general assessment was done by project team members or local agencies which motivated landowners to implement future BMPs. There is several at landowner that have continued on-ranch water quality monitoring for E. coli while working with the UFRW Group and NRCS as a follow-up to the monitoring program that had been established via this project. In fact, there are landowners in the 3 major valleys that are following up with projects in regards to stream temperature, soil moisture, and irrigation efficiency. Several landowners across the UFRW have stepped up and taken a proactive role in addressing water quality concerns by implementing best management practices (BMPs) and monitoring soils to determine when irrigation is needed.

C. Project Performance

As outlined in the PAEP, the project had 3 project performance goals for planning, research, monitoring, and assessment. In addition, there were 4 project performance goals for education, outreach, and capacity building activities.

The following tables summarize the results of the PAEP:

- Table 3 – Project Performance Measures for Planning, Research, Monitoring or Assessment Activities
- Table 4 – Project Performance Measures for Education, Outreach, and Capacity Building Activities

Table 3. Project Performance Measures for Planning, Research, Monitoring, or Assessment Activities in U*pper Feather River Watershed Irrigation Discharge Management Program*

<table>
<tr><th>Project Goals</th><th>Results</th></tr>
<tr><td>1. Project Administration</td><td>• Quarterly progress reports & invoices were submitted regularly. To date all quarterly reports were accepted & invoices were processed & paid.

• Ongoing communication via phone, email, and meetings with University & SWRCB staff to learn and understand invoice procedures & quarterly document procedures. Also to ensure documents/invoices were processed in a timely manner.</td></tr>
<tr><td>2. Establish a baseline Water Quality Monitoring Plan consistent with Phase I requirements of the RWQCB Ag Waiver Program bracketing irrigated agriculture in the main valleys of the UFRW</td><td>• QAPP & MP were submitted and approved (See “Table of Items for Review” on page 17 for dates submitted)

• Two years of Phase I data was collected from 19 sites, across the UFRW (See attachments for maps)
o http://groups.ucanr.org/Ag_Water_Quality/Water_Quality_Monitoring/Water_Monitoring_Results.htm
o Data was collected monthly during the irrigation season & 2x during storm events
o Data collected entered into Surface Water Ambient Water Monitoring Program (SWAMP)
▪ SWAMP compliant database will be submitted to Grant Manager with last quarterly report

• Special projects – project team worked with the UFRW Group to develop “Special Projects” to evaluate elevated dissolved oxygen (DO) fluctuations at the bottom of major valleys.</td></tr>
<tr><td>3. Establish on-ranch demonstration sites across the UFRW to evaluate effectiveness of Management Measures on specific water quality constituents</td><td>• Team members worked closely with landowners to establish demonstration sites and to implement on-the-ground Management Measures (MM)
o Ongoing/regular meetings regarding on-the-ground practices & progress of demo sites
o Communication via numerous meetings, property visits, creek walks, phone calls, email, etc.

• Factsheets & Producer Stories were developed related to management practices
o Factsheets: pH, DO, E. coli, Carrying Capacity, Grazing Systems, Livestock Distribution
(To be included with final quarterly report & available online: http://groups.ucanr.org/Ag_Water_Quality/)</td></tr>
</table>

	o Producer Stories: http://ucanr.org/producerstories o Passion of the Land Stories: http://artofregionalchange.ucdavis.edu & http://www.youtube.com/PassionForTheLand • In 2009 UC Davis Masters Thesis "Surface Water Quality & Irrigated Pasture: Field Studies in Sierra Valley, California" by was submitted by Laura Anne Murphy who participated in this project • **<u>DRAFTS</u>** of technical reports in progress (Please see attachments) o Depth to Water Table, Soil Moisture, and Plant Community Effects on Forage Quality of Irrigated Pastures and Mountain Meadows in the Upper Feather River Watershed (DRAFT June 2010) o Water Quality Above & Below Irrigated Agriculture: Limited Concerns in the Upper Feather River Watershed (DRAFT June 2010) o A Study of Dissolved Oxygen Drivers within Streams of the Upper Feather River Watershed (DRAFT June 2010)

Table 4. Project Performance Measures for Education, Outreach, and Capacity-building Activities for U*pper Feather River Watershed Irrigation Discharge Management Program*

Project Goals	*Results*
1. Establish Project Steering Committee	• See public outreach table – summary of meetings, activities, communications involving members of the Project Steering committee (Please see attachments) • Communication & interaction of landowners with water resource protections agencies, watershed conservation agencies, local RCDs, NRCS, RWQCB, and Sacramento Valley Water Coalition expanded and improved • Members of project team regularly communicated with members of the UFRW Group & the executive director via email, phone, and meetings to discuss project issues and plans o Team members were in attendance at regular UFRW Group meetings ▪ Project updates and information was regularly shared • Team members have collaborated with the UFRW Group on several activities/meetings: o Printing of Ag. Booklet, review of ILRP documents, field days, development of monitoring program after this project, grant writing meetings, funding opportunities, members participated in meetings regarding alternative programs & future plans for group • Regular correspondence via phone & email with Sacramento Valley Coalition & Larry Walker Associates staff regarding monitoring data & project plans
2. Augment existing information about irrigated agricultural operations in UFRW	• Landowner survey developed – 145 surveys mailed, 35% return / response rate o Producers responded to a variety of questions regarding water use and irrigation practices, production figures, and pasture or crop management practices • Irrigated Agricultural Practices in UFRW Report submitted o Final report available: http://groups.ucanr.org/Ag_Water_Quality/files/46576.pdf o Includes survey summary
3. Compile a listing of technical resources and potential funding opportunities to assist landowners in	• At all meetings & activities the project team provided factsheets, handouts, book, etc to assist landowners with ranch planning and implementation of management practices o Cows & Fish Factsheets were compiled: http://www.cowsandfish.org/publications/fact_sheets.html o Project website "Resources": http://groups.ucanr.org/Ag_Water_Quality/Useful_Information/

writing ranch plans and implementing management practices.	o UFRW Agricultural Water Quality Booklet – distributed to all UFRW irrigated ag. landowners and interested members of the public o Farmland Self Assessment Workbook o Irrigated Ag. Practices Report provided list of resources o Filming of DVD – "Management Options to Reduce Pollutants in Runoff from Irrigated Pastures" • http://stream.ucanr.org/irrigated_pastures/index.html o Map development o Collaboration with local NRCS, RCD, Plumas County Watershed Forum, IRWMP & other agencies regarding funding opportunities
4. Facilitate Completion of Ranch Plans with willing cooperators via small group training events.	• Project team worked closely with various landowners to develop individual management plans o Aerial photographs maps, property inventory, calendar of operations o Current farming, irrigation & grazing practices o Identification of water quality concerns o Sources of technical assistance o Funds to implement proposed practices along with a way to monitor water quality results following changes in practices • Ranch planning activities & trainings (See attached public outreach table) o Development of UFRW Agricultural Water Quality Booklet o NRCS Workshop w/Alan Bower – conservation/ farm ranch planning & projects. o Filming of DVD – water quality management on irrigated pasture o Ranch Planning Study Halls – development of individual ranch plans • Regular communication with landowners on the implementation of on the ground MM at demonstration sites o Ongoing meetings regarding on-the-ground practices & progress of demo sites o Meetings, property visit, creek walks, phone calls, emails

D. Lessons Learned

What worked: Having the University of California Cooperative Extension, as a non-regulatory entity, as the lead allowed Project Team members (including regulatory staff) to engage in conversations about management as well as access to private property across the Upper Feather River Watershed, particularly, in Sierra Valley, to help all of us better understand irrigation and livestock grazing practices relative to water quality. Many landowners are interested in learning about management practices they can implement on their properties and are willing to spend a reasonable amount of money to achieve results. This project raised the awareness of several local organizations including the Feather River Regional Water Management Group to include irrigated lands as part of their work plan and Plumas County Watershed Forum who allocated funding to Upper Feather River Watershed Group members (via NRCS) for on-the-ground improvements to mitigate water quality issues.

What did not work? It was very difficult to schedule on-campus laboratory analysis of water samples collected from on-ranch field sampling for Phase II from sites across a large geographic area like the UFRW especially when it had to coincide with the a variety of management practices (timing of irrigation, livestock grazing, etc.). We ended up sampling around dates to accommodate the laboratory and field crews and documented the associated field activities at the time water samples were collected.

How similar efforts could be utilized in the future: This type of project was VERY HELPFUL in building capacity of local residents to participate in the process, provided funds and technical expertise to collect and analyze water quality samples to better understand the water quality impacts from irrigated agriculture, which in the case of the UFRW are really limited.

E. Outreach

Throughout this project, team members participated in a variety of outreach opportunities by participating or hosting a variety of meetings, workshops, field days, and activities. Meetings consisted of formal public meetings organized to provide the landowners, public, agencies, and other interested parties with monitoring data and project details. In addition, there were formal one-on-one consultations held with landowners and agency personnel. Throughout the project a variety of educational outreach materials were developed that were shared at meetings, workshops, field days, conferences, and conventions in the local area and abroad. The educational materials include, but are not limited to the development of factsheets, booklets, posters, PowerPoint, newsletters, website, and digital stories. Please see the attached public outreach table for more details.

Year 1: Outreach focused on familiarizing landowners and local agencies with projects goals and scope of work via community meetings, newsletters, and surveys. It was important to let the landowners know who we were and what we wanted to do within the UFRW. More importantly, outreach involved capacity building activities to establish a cooperative, non-threatening partnership among UC personnel, local, state, and federal resource agencies, and private landowners. In addition, there was a large amount of communication with landowners and local agencies and organizations (NRCS, FRCRM, etc.) regarding the establishment of Phase I monitoring sites. Several landowners stepped up to allow us access to monitoring sites via their private properties.

***Year 2*:** Outreach focused on sharing the data that the project team collected related to the survey of management practices and field water quality sampling, including interpretation of monitoring results. Project members participated in a variety of activities (meetings, conferences, workshops, etc.) in order to share information about the project via presentations or posters. There was also the development of a website that specifically focused on project activities and included a variety of resources and materials for clientele. In addition, team members worked closely with landowners in order to identify demonstration sites and management measures to be implemented. Several landowners agreed to participate in on-ranch monitoring for Phase II of this project. There continued to be the increase in communication and interaction of local landowners and local agencies. A number of ranch planning workshops were held in cooperation with NRCS. There was regular communication with project team members and landowners about demonstration sites. In addition, outreach involved providing information to landowners via factsheets, booklets, newsletters, agency consultations, team consultations, and meetings with project team members about management measures and funding opportunities.

Year 3: Outreach focused on providing an understanding of what was learned during the course of the project. Team members worked closely with the UFRW Group to develop monitoring plans post Prop. 50 Project. The UFRW Group has developed a monitoring plan that was implemented during the 2009 irrigation season. In addition, we have landowners that have continued the on-ranch monitoring program that had been established via this project. The project team collaborated with the UC Davis Art of Regional Change and local landowners to create Passion for the Land collection digital stories by local landowners about agriculture viability, resource stewardship and preserving rural communities. The products (DVD and online stories) were completed in 2009 and have been distributed widely.

F. Project Funding

Funding for this project in the amount of $512,512 was provided by the State Water Resources Control Board and cam from Prop. 50, the Agricultural Water Quality Grant. Match funds exceeded $219,953.

Project Costs: *(budget figures are based upon Amendment 2)*

- **Personnel Services ($170,033)** – Salary & benefits for staff hired for field data collection, lab analysis, preparation of grant deliverables, and organization of project and stakeholder meetings & activities.

- **Operating Expenses ($52,000)** – Purchase of supplies for monitoring & shipping water and macro invertebrate samples. Field sampling equipments & supplies for water monitoring crews. Digital cameras and computer equipment, software, and hardware for data management. Office supplies. Educational materials & supplies for meetings, workshops, and other outreach activities.

- **Travel ($22,976)** – Mileage and gas for regular field sampling & water sample transport. Travel to work with landowners, field visits, workshops, conferences, field days, project team meetings and training, educational outreach activities and interaction with resource agencies and organizations.

- **Professional/Consultant Services ($267,503)** – University of California, Davis (Plant Sciences) for data analysis, field work, lab work, reports, participation in meetings & activities; Pacific EcoRisk for water column and sediment toxicity analysis. (Note, the money originally budgeted for California Department of Fish and Game for macro-invertebrate analysis was reallocated as another cooperator (CVRWCB) covered this cost).

- **TOTAL from SWRCB = $512,512**

- **Match Figures:** The Natural Resource Conservation Service (NRCS) contributed $5,000 by providing assistance with maps, coordination & collaboration with landowners, printing area watershed maps, office/computer space, & printing/copying access. The Plumas-Sierra University of California Cooperative Extension (UCCE) contributed $2,379 for support and collaboration on several activities such as soil analysis, field days, stewardship outreach workshops, and project team trainings. In addition there was $212,953 for UC salary/benefits (in-kind).

G. Next Steps

During the 2009 irrigation season, the UFRW Group collected water quality monitoring throughout the UFRW vs. paying an outside consultant and will continue to do so in the 2010 season. As a result of the data collected on this project, the UFRW Group was able to have the number of ILRP monitoring sites reduced for the 2010 season.

The CVRWQCB is in the process of updating requirements for the ILRP and needs to incorporate findings from field research like this and allow a more flexible system that will meet the needs of the watershed of interest. It is important for the program to focus on local watershed improvements and partnerships, while also coordinating with other ongoing programs and efforts. In fact, the UFRW Group and the Plumas County Board of Supervisors have developed a partnership in both the Feather River Regional Water Management Group and in the implementation of best management practices on irrigated land with financial support through the Plumas Watershed Forum. The Plumas Watershed Forum has allocated funding that will assist with a number of on the ground management measures to mitigate water quality concern.

H. Photos or Graphics

Please see previously submitted progress reports and visit project website: http://ucanr.org/waterquality.

I. Table of Items for Review

Work Items for Review	% Of Work Complete	Date Submitted
	(__%)	(mm/dd/yy)
1.1 Project Assessment & Evaluation Plan	100%	4/10/06
1.2 Monitoring Plan (MP)		
1.2.1 Baseline Water Quality MP	100%	4/8/06 Modified 5/2/06
1.2.1.f Water quality monitoring program implementation at baseline sites		
1.2.1.g Annual progress reports of baseline sites	100%	Ongoing
1.2.2 Demonstration Site MP to Evaluation Management Measures (MM)	100%	4/3/07
1.2.2.a Identify and develop demonstration sites	100%	
1.2.2.e List of proposed demonstration sites with brief rationale for selection	100%	3/29/07
1.2.2.g Annual progress reports of demonstration sites	100%	
1.3 Quality Assurance Project Plan (QAPP)		
1.3.1 Baseline quality assurance project plan	100%	5/2/06
1.3.2 Demonstration site QAPP reference & amendments	Do not anticipate new QAPP	
2.1 Project Team		
2.1.1 List of Project Team Members	100%	
2.2 Project Steering Committee (PSC)	100%	
2.2.1 List of PSC members	100%	
2.2.2 Agendas, attendees, and meeting materials		
2.3 Augment Existing Information on Irrigated Agriculture Operations in Upper Feather River Watershed (UFRW)	100%	
2.3.1 Compilation and Augment of Existing Information about Land Management Practices on Irrigated Agricultural Lands within the UFRW	100%	
2.3.2 Survey Forms	100%	4/11/06 Draft to Grant Manager 6/1/06 Mailed landowner
2.3.4 Draft report of irrigated agricultural practices in UFRW	100%	9/12/06
2.3.5 Final report of irrigated agricultural practices in UFRW	100%	4/5/07
2.4 Program Coordination and Participation		
2.4.1.1 Survey forms		
2.4.2 GIS Locations	100%	
2.4.4 List of Resources		
2.4.5 List of Attendees for the meetings, newsletters, and agendas	100%	Ongoing
2.4.6 Copies of newsletters, website, posting, field trip announcements, agendas, and list attendees	100%	Ongoing

Work Items for Review	% Of Work Complete	Date Submitted
2.4.7 Submit website address	100%	Ongoing
2.5 Facilitation of Completion of Conservation or Farm/Ranch Plans		
2.5.1 Submit farm planning workgroup promotional materials	100%	Ongoing
2.5.4 List of participants for Workshops and Training Events		
2.5.5 Submit announcements of trainings & workgroup meetings		
2.6 Draft and Final Projects		
2.6.1 Draft Project Report	100%	5/10/10
2.6.2 Final Project Report	100%	6/10/10
1.0 Invoices		#1-9/28/06 Revised #1 & #2 - 11/30/06 #3 – 4/10/07 #4 – 4/30/07 #5 – 8/3/07 #6 – 11/13/07 #7 – 2/27/08 #8 – 5/28/08 #9 – 8/19/08 #10 -11/24/08 #11 – 4/21/09 #12-#16 – 3/12/10 #17 – 5/10/10
3.0 STANDARD REQUIREMENTS CERTIFICATION FORM		
4.0 REPORTS		
4.1 Progress Reports		#1 - 7/19/06 #2 – 10/30/06 #3 – 1/30/07 #4 – 4/19/07 #5 – 7/19/07 #6 –11/2/07 #7 – 1/18/08 #8 – 4/23/08 #9 – 7/30/08 #10 – 10/21/08 #11 – 1/8/09 #12, #14, #15 – 3/12/10 #13 -4/6/10 #16 – 4/30/10
4.2 Expenditure/Invoice Projections		
4.3 Grant Summary Form	100%	7/19/06
6 Copy of final CEQA/NEPA documentation	100%	4/28/06
20 Signed cover sheets for all permits		

J. Other Information - Data Descriptions

The quantity of water in creeks and streams influences water quality tremendously. Over the course of this project, Feather River Basin precipitation and subsequent runoff levels varied considerably (http://cdec.water.ca.gov/snow/bulletin120/) (Figure 1). The 2006 water year was the wettest with runoff at a level of 180% of average. In 2007, runoff levels fell to 38% of average, and in 2008 66% of average. Subsequently, in 2007 and 2008 Sierra Valley irrigators had to reduce water usage for surface irrigated lands in order to meet the needs of stock downstream. In other valleys irrigators were unable to irrigate as long as they desired given the low flows.

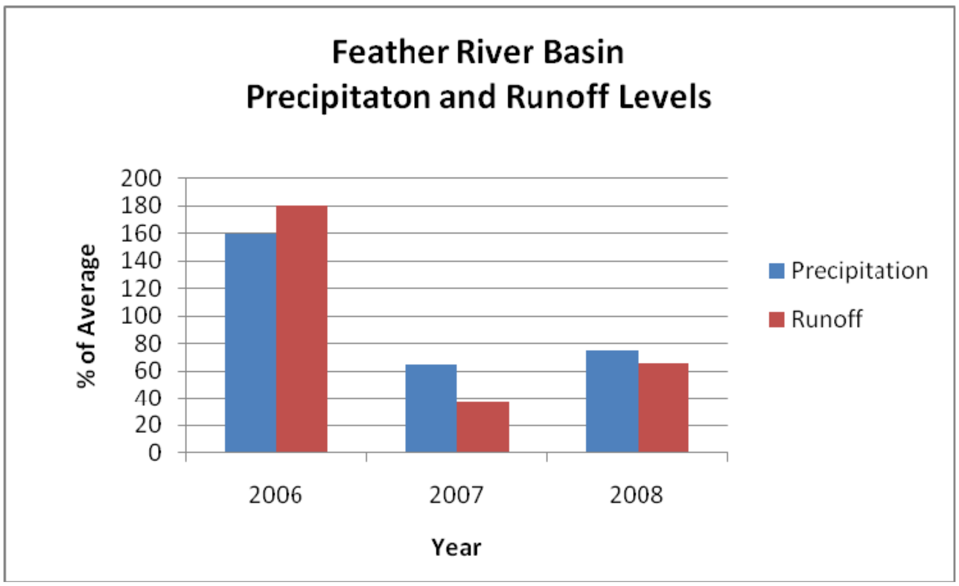


Figure 1 - 2006-2008 precipitation and runoff levels for the Feather River Basin.

The completed Master's of Science thesis for the UC Davis graduate student, L.A. Murphy, who participated in this project, along with the project Monitoring Plan and Quality Assurance Protection Plan, on file with SWRCB, provide an in depth reporting of monitoring objectives, field and laboratory methods, sample locations, sample timing, statistical and graphical analysis of data, summary of results, and conclusions for all aspects of the data collected during this project. In addition, the Surface Water Ambient Monitoring Program (SWAMP) compliant database will be submitted with the final quarterly report. The SWAMP database contains all sample analysis results, QAQC analysis results, sample location, sample collection and analysis times, and analysis methods for every sample processed during this project.

Below we provide a summary of findings:

- **Finding #1:** Reports from the California Department of Pesticide Regulation reveal chemical applications in Plumas and Sierra counties are limited with the greatest amount of chemical pesticide use associated with forest/timberland management and rights of way (http://www.cdpr.ca.gov/docs/pur/purmain.htm), Figure 2. Agricultural valley elevations ranging from 3,400-5,000 feet, a narrow summer growing season (June-September) governs the suitability for intensive agricultural production. Low-density livestock operations and low-intensity irrigated crop operations require little chemical input.

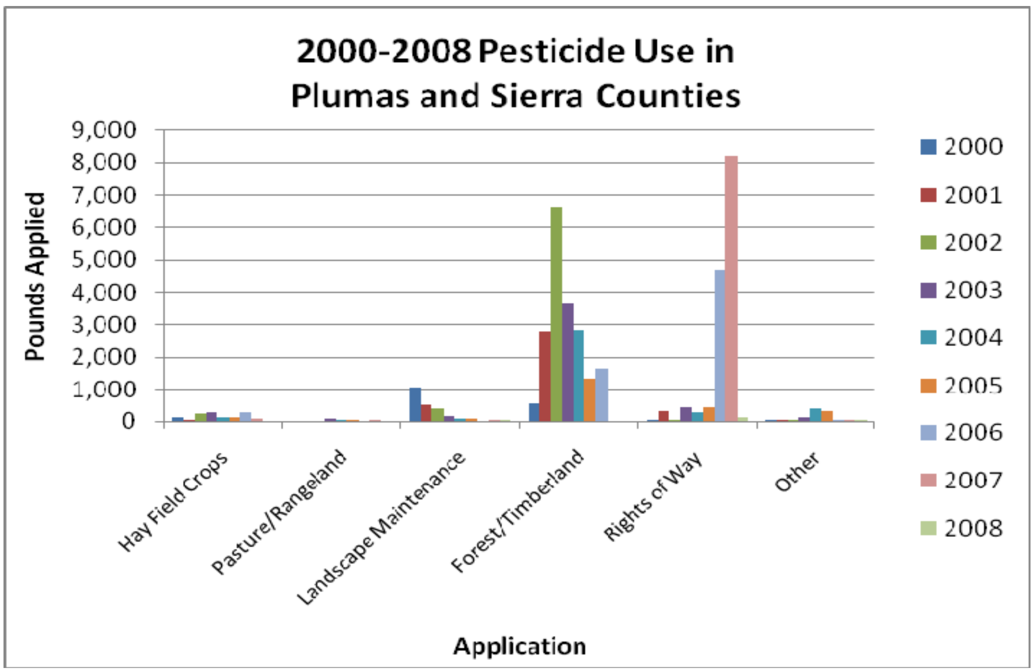


Figure 2 - Pounds of pesticide use in Plumas and Sierra Counties from 2000-2008. http://www.cdpr.ca.gov/
***Other includes: ditch bank, greenhouse plants, regulatory/structural pest control, vertebrate control, etc.**

We are aware of no application of metals associated with any of the agricultural practices conducted within UFRW. Water samples collected during the 2006 irrigation season were analyzed for metals (B, Al, Fe, Ni, Cu, Zn, As, Se, Cd, Pb) at the UC Davis Soil Science Laboratory with all values extremely low, below levels of concern.

Water column and sediment/substrate toxicity assessments were conducted during the irrigation and wet season of 2006 and 2007 with laboratory analysis being done by Pacific Eco Risk and there was no evidence of toxicity below any of the four agricultural valleys (American, Indian, Sierra, or Goodrich) (Table 5).

Table 5. Summary of water column (W) and substrate (S) toxicity results from UFRW assessment monitoring locations for 2006 and 2007.

Sample Location		Date	***S. capricornutum*** cells/mL (control)	***C. dubia*** % survival (control)	***P. promelas*** % survival (control)	***H. azteca*** % survival (control)
UFRW-2	W	6/20/2006	1.56 (0.53)	100 (90)	100 (100)	--
	W	7/24/2006	1.52 (0.32)	100 (100)	100 (100)	--
	W	8/22/2006	2.34 (0.21)	50 (100)*	100 (100)	--
	W	9/26/2006	2.55 (0.52)	100 (95)	100 (100)	--
	S	10/9/2006	--	--	--	98.9 (97.5)
	W	2/09/2007	2.06 (0.88)	100 (100)	97.5 (100)	--
	S	4/17/2007	--	--	--	96.2 (96.2)
	W	5/08/2007	2.63 (1.42)	100 (100)	100 (100)	
UFRW-6	W	6/20/2006	1.83 (0.53)	100 (90)	100 (100)	--
	W	7/24/2006	2.01 (0.32)	100 (100)	100 (100)	--
	W	8/22/2006	2.24 (0.21)	85 (100)	100 (100)	--
	W	9/26/2006	2.43 (0.52)	100 (95)	97.5 (100)	--
	S	10/10/2006	--	--	--	91.2 (97.5)**
	W	2/09/2007	2.09 (0.88)	95 (100)	100 (100)	--
	S	4/17/2007	--	--	--	96.2 (96.2)
	W	5/08/2007	2.59 (1.42)	100 (100)	100 (100)	
UFRW-11	W	6/20/2006	2.00 (0.53)	100 (90)	97.5 (100)	--
	W	7/24/2006	1.27 (0.32)	100 (95)	100 (100)	--
	W	8/22/2006	1.41 (0.21)	95 (100)	100 (100)	--
	W	9/26/2006	1.99 (0.52)	100 (95)	100 (100)	--
	S	10/9/2006	--	--	--	92.5 (97.5)
	W	2/09/2007	2.44 (0.88)	100 (100)	97.5 (100)	--
	S	4/17/2007	--	--	--	91.2 (96.2)
	W	5/08/2007	2.24 (1.42)	100 (100)	100 (100)	--
UFRW-19	W	6/20/2006	2.07 (0.53)	90 (90)	100 (100)	--
	W	7/24/2006	1.88 (0.32)	95 (100)	100 (100)	--
	W	8/22/2006	2.13 (0.21)	5 (100) *	100 (100)	--
	W	9/26/2006	2.31 (0.52)	95 (95)	100 (100)	--
	S	10/10/2006	--	--	--	93.8 (97.5)
	W	2/09/2007	1.84 (0.88)	100 (100)	100 (100)	--
	S	4/17/2007	--	--	--	87.5 (96.2)***
	W	5/08/2007	2.49 (1.42)	100 (100)	97.5 (100)	--

* Targeted Phase 1 TIE follow-up indicated no toxicity.
** The reduction in survival from control was statistically significant, but not toxicologically significant; the response was >80% of the control.
*** The reduction in survival from control was statistically significant, but not toxicologically significant; the response was >90% of the control.

Following protocols recommended by CDF&G/USEPA aquatic macro-invertebrate sampling was conducted at the 18 sites above and below irrigated agriculture during the summers of 2006 and 2007. The Department of Fish and Game Lab in Chico reported on 142 different metrics. We used five for a summary analysis, (Table 6).

During the summer of 2008, only the outlet sites in the three larger valleys (American, Indian and Sierra) were sampled. There was a lot of variability, but with enough averaging there was surprising consistency between the four valley results. While there is no quantitative standard for aquatic macroinvertebrate metrics; the relatively high values for these pollution sensitive metrics do not indicate toxicity issues in UFRW.

TWO YEAR SUMMARY (2006-2007) Macro-Invertebrate Sampling in the UFRW

	TAXA RICHNESS	DIVERSITY	% EPT	% TOLERANT	% INTOLERANT
SITES					
SIERRA VALLEY					
Above	22	1.97	52	8	33
Below	19	2.01	39	24	3
INDIAN VALLEY					
Above	25	2.34	57	8	27
Below	17	2.09	32	25	9
AMERICAN VALLEY					
Above	34	2.52	54	9	35
Below	27	2.38	37	12	20
GOODRICH CREEK					
Above	34	2.74	51	13	39
Below	26	2.42	56	9	25

Table 6. Two year summary (2006-07) of macro-invertebrate sampling at 18 sites above and below irrigated agriculture in the UFRW.

GENERAL CONCLUSIONS

- For taxa richness and diversity, modest decline in metric quality when comparing above and below valley sites
- % EPT, % Tolerant, and % Intolerant showed a stronger and more consistent signal of decline in quality when comparing above and below valley sites
- With some exceptions, little difference between pre and post irrigation season results (pre and post results are combined in the table above)
- % Intolerant Taxa the most consistent metric in showing decline in quality from above valley to below valley sites

● **Finding #2**: Nutrient contributions from low-density livestock operations and low-intensity irrigated crop operations were found to be negligible with nutrient concentrations consistently measuring very near laboratory detection limits and never approaching exceedance of water quality standards. Agricultural use of fertilizers is very limited within the UFRW. Fertilizer application is limited to alfalfa crops located primarily in the arid, north eastern side of Sierra Valley. These systems are irrigated primarily with low-pressure wheel-line and center pivots, generating no irrigation runoff. Nutrient analysis for the 2006 and 2007 water samples collected at the bottom of the three main irrigated valleys is summarized in Table 7.

Table 7. Summary of nutrient results from UFRW core/assessment monitoring locations for 2006 and 2007.

Constituent (mg/L)	Statistic	American Valley	Indian Valley	Sierra Valley
2006				
Total N	Mean	0.209	0.144	0.851
	Median	0.168	0.142	0.866
	Maximum	0.347	0.180	1.191
Nitrate (NO3-N)	Mean	0.095	0.006	0.004
	Median	0.105	0.006	0.002
	Maximum	0.157	0.010	0.014
Ammonium (NH4-N)	Mean	0.013	0.015	0.013
	Median	0.013	0.004	0.011
	Maximum	0.040	0.084	0.031
Total P	Mean	0.049	0.057	0.080
	Median	0.021	0.055	0.077
	Maximum	0.230	0.064	0.143
Ortho-phosphate (PO4-P)	Mean	0.005	0.016	0.010
	Median	0.004	0.016	0.006
	Maximum	0.012	0.029	0.041
2007				
Total N	Mean	0.184	0.141	0.667
	Median	0.192	0.133	0.717
	Maximum	0.277	0.219	0.939
Nitrate (NO3-N)	Mean	0.036	0.007	0.004
	Median	0.041	0.007	0.006
	Maximum	0.068	0.017	0.008
Ammonium (NH4-N)	Mean	0.023	0.012	0.019
	Median	0.014	0.009	0.017
	Maximum	0.065	0.024	0.033
Total P	Mean	0.017	0.053	0.055
	Median	0.015	0.049	0.059
	Maximum	0.038	0.099	0.112
Ortho-phosphate (PO4-P)	Mean	0.006	0.016	0.012
	Median	0.004	0.017	0.009
	Maximum	0.017	0.025	0.023

Extremely low levels of nitrogen and phosphorus were observed at these sites, well below any water quality standards for human health. Levels are also low enough to be unlikely to stimulate excessive aquatic vegetation growth. During this time period we simultaneously sampled all surface water entering these valleys, allowing calculation of the mass balance of nutrient load entering and exiting these agricultural areas. For all sample events over 2 years, we found a net reduction of in-stream nutrient loads in each valley. This is due to diversion of stream water entering the valleys and sequestration of nutrients in pasture/meadow vegetation and soil. The low nutrient values observed below agricultural areas, the net loss of in-stream nutrients through agricultural areas, and the limited agricultural use of fertilizers within the UFRW do not suggest nutrients as a water quality concern.

● **Finding #3**: Commensal *E. coli* water quality standards (235 cfu/100mL) were exceeded at some sample location sites above and below major irrigated agriculture. In Sierra Valley, the largest agriculture area in the watershed with the most cattle, we did not see an E. coli exceedence at the sampling site below irrigated agriculture (at the bottom of the valley) during 2006, 2007 or 2008. During these three irrigation seasons the standard was exceeded 5-7 times from May-September each year at sites above irrigated agriculture as well as 4-5 times at the wetland area in the middle of the Sierra Valley; but never in the waters that left the valley. Figure 3 shows the 2006 results from Sierra Valley…the trend was similar for 2007 and 2008.

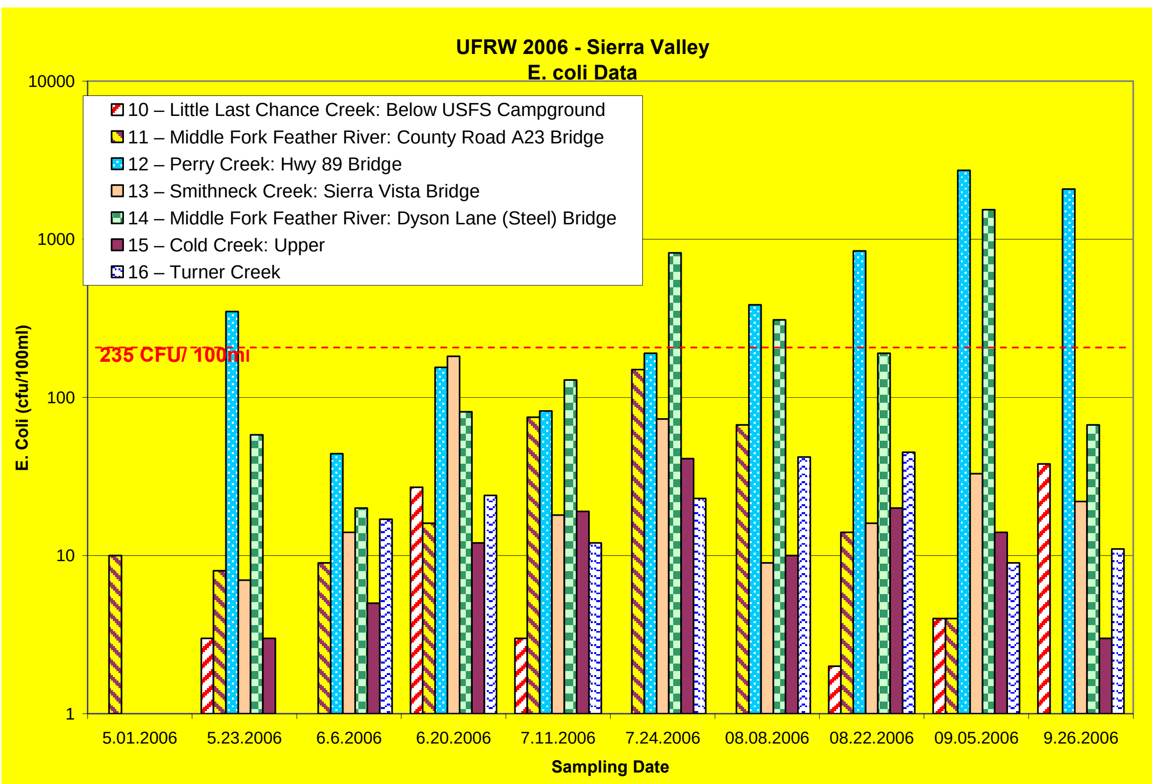


Figure 3. 2006 E. coli Data in Sierra Valley

In American Valley the standard was exceeded in July 2007 and 2008 at sites above irrigated agriculture. In 2006 there was one and 2007 there were 6 exceedences at sites towards the middle bottom of the valley; but only one exceedence in the three year period at the bottom of this valley, that being October 2007.

In Indian Valley there were no exceedences in 2006 and in 2007 one in June at the bottom of the valley and one in July above the bulk of the irrigated agriculture. In 2008, *E. coli* was only sampled at the bottom of this valley and the standard was exceeded one time (October).

In Goodrich Creek, the standard was exceeded once in 2006 (June), twice in 2007 (June and August) and not at all in 2008…always at the bottom of the valley.

The project team, UFRWG sub-watershed Board of Directors and membership think that several contributing sources are leading to repeated *E. coli* exceedences observed over the study. These sources include cattle grazing on irrigated pastures, rural residential septic systems, township septic systems, municipal dischargers, and wildlife species common throughout the sub-watershed. Results of on-ranch monitoring conducted under Phase II described above) during the irrigation season of 2007 documented that *E. coli* concentrations increase significantly in stream water passing through the town of Sierraville, in Sierra Valley.

To reduce commensal *E. coli* contributions from cattle we developed and implemented an outreach program specifically tailored for livestock producers in the sub-watershed, as well as conducted Phase II on-ranch monitoring to assists with site specific problem and solution identification. The goal of this outreach was to stimulate implementation of effective management practices to lower *E. coli* levels transported from pastures and meadows. There is good reason to expect that implementation of a combination of irrigation, grazing management, and vegetative filter management practices can reduce *E. coli* contributions from grazed, irrigated pastures. As described below, this outreach included town hall meetings, newsletters, field days, demonstration projects, and one-on-one education. We provided ranchers with information about: 1) grazing and irrigation practices that increase the risk of *E. coli* transport from pastures and meadows; 2) grazing and irrigation practices that decrease the risk of *E. coli* transport from pastures and meadows; and 3) the effectiveness of filter strips and wetlands to filter *E. coli* in pasture and meadow runoff; and 4) technical and financial support available to evaluate possible problems, as well as identify, fund, and implement solutions.

● **Finding #4**: For the period 2006 through 2008, the dissolved oxygen (DO) water quality standard for cold water designation (<7.0 mg/L) was exceeded at monitoring locations below: 1) Indian Valley 2 times in 2006 and 2 times in 2007; and 2) Sierra Valley 8 times in 2006 (Table 4). Note that in 2006, the Sierra Valley monitoring location was located at the County Road A23 Bridge crossing the Middle Fork Feather River (UFRW Site 11.0). In 2007, the Sierra Valley monitoring location was moved approximately 0.5 mile downstream of the original site, immediately upstream of the confluence of Grizzly Creek with the Middle Fork Feather River (UFRW Site 11.5). The original site was considered to be unrepresentative of the influence of agriculture on streamflow exiting Sierra Valley because: 1) it is located in a completely stagnant, pooled reach of the stream; 2) there is heavy recreational use (swimming, etc.) at this site due to access along County Road A23; and 3) discharge from grazed, irrigated pasture enters the Middle Fork Feather River below this original site.

There were no DO exceedences at American Valley during any years. For the period 2006 through 2008, there were exceedences of the pH water quality standard (>8.5) at monitoring locations below Sierra Valley 1 time in 2005, 2 times in 2006, and 4 times in 2007 (Table 8). There were no pH exceedences at Indian or American Valleys.

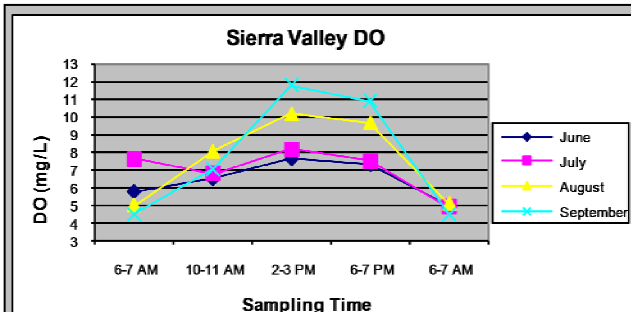
The single point in time, monthly data collected at Sierra Valley and Indian Valley does not provide sufficient information to determine the biological significance of the DO and pH exceedences, or to determine which factor(s) are driving DO and pH dynamics at each site (Table 8).

Table 8. Dissolved oxygen, pH, total nitrogen, total phosphorus, dissolved organic carbon, total suspended solids, and water temperature at Sierra Valley and Indian Valley monitoring locations during 2006 and 2007 irrigation season.

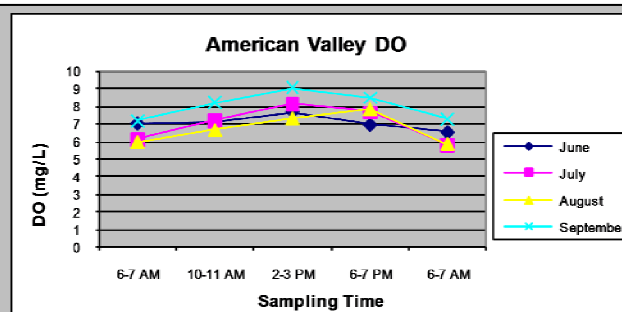
Location	Sample Date	Sample Time	DO (mg/L)	pH	TN mg/L	TP mg/L	DOC mg/L	TSS mg/L	Water Temperature (F)
Sierra Valley*	5/23/2006	14:36	**5.8**	7.4	0.64	0.03	9.6	5.9	59.5
	6/6/2006	16:39	**6.4**	7.2	0.70	0.04	9.7	7.1	72.9
	7/11/2006	15:20	**5.0**	7.6	0.87	0.05	11.4	21.8	71.6
	8/8/2006	15:35	**5.4**	7.9	0.97	0.10	10.6	31.8	68.5
	9/5/2006	16:35	**6.5**	8.3	0.88	0.12	10.9	50.8	66.7
	9/26/2006	13:45	7.7	**8.7**	0.99	0.14	11.2	51.7	61.3
Indian Valley	5/23/2006	9:05	8.6	7.1	0.16	0.06	2.7	18.8	50.0
	6/6/2006	8:30	7.9	7.1	0.13	0.07	2.4	12.4	57.7
	7/11/2006	8:45	6.5	7.1	0.16	0.04	2.1	11.2	64.6
	8/8/2006	8:00	6.6	7.4	0.15	0.06	1.8	14.1	64.6
	9/5/2006	9:05	8.2	7.5	0.16	0.06	2.0	12.9	62.4
	9/26/2006	11:20	9.7	7.6	0.11	0.05	1.7	5.9	54.3
Sierra Valley*	5/8/2007	13:40	-	8.1	0.79	0.07	11.2	20.6	-
	6/5/2007	16:15	8.7	8.5	0.78	0.05	10.6	12.4	72.7
	7/10/2007	14:20	12.3	**9.2**	0.94	0.07	11.2	6.5	80.8
	8/7/2007	15:00	15.8	**9.8**	0.43	0.11	10.2	8.8	79.9
	9/4/2007	13:55	8.3	**8.9**	0.66	0.02	6.8	4.1	69.8
	10/2/2007	14:25	11.5	**9.0**	0.42	0.01	7.6	5.9	59.9
Indian Valley	5/8/2007	11:20	-	7.4	0.16	0.03	2.4	8.8	57.9
	6/5/2007	11:15	7.3	6.9	0.22	0.05	2.2	15.3	63.0
	7/10/2007	10:45	**6.6**	7.4	0.13	0.06	1.6	12.4	68.9
	8/7/2007	10:15	**5.7**	-	0.08	0.10	1.8	7.1	63.7
	9/4/2007	14:45	7.1	7.6	0.12	0.05	1.5	8.2	66.7
	10/2/2007	13:40	7.4	7.7	0.13	0.03	2.3	12.4	56.3

* Sierra Valley monitoring location during 2006 was at the County Road A23 bridge crossing the Middle Fork Feather River. This monitoring location was moved downstream ~0.5 mile in 2007, immediately above the confluence of Grizzly Creek with the Middle Fork Feather River.

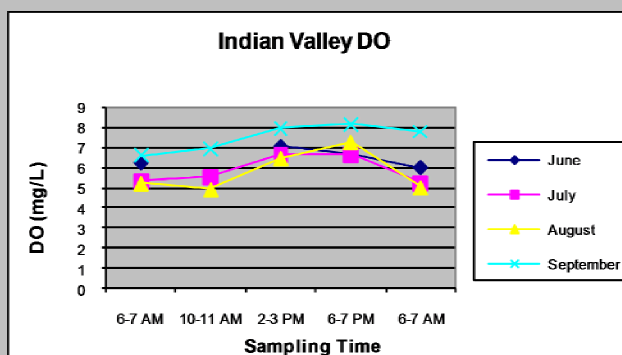
During the 2008 irrigation season we conducted a special monitoring project to identify the factors determining DO and pH levels, and thus exceedences, at the Sierra Valley (Site 11.5, above Grizzly Creek) and Indian Valley monitoring locations. In short, monitoring revealed substantial diurnal fluctuations in DO levels at all sites (Figure 4). Lab analyses revealed most constituents to either be below detection levels or within the standard limits. TSS levels, however were somewhat high.



Month	Turbidity (ntu)	pH	EC (uS/cm)	TSS (mg/L)	NH4 (ppm)	NO3 (ppm)	Total N (ppm)	PO4 (ppm)	Total P (ppm)	DOC (ppm)
June	8.46	7.67	161.00	13.53	0.04	0.00	1.09	0.03	0.07	16.71
July	6.39	7.54	190.00	11.18	0.02	0.01	0.68	0.03	0.05	9.66
August	8.52	7.77	193.00	17.00	0.04	0.01	0.65	0.00	0.04	9.29
September	8.36	7.93	195.00	12.35	0.02	0.01	0.54	0.00	0.02	8.86



Month	Turbidity (ntu)	pH	EC (uS/cm)	TSS (mg/L)	NH4 (ppm)	NO3 (ppm)	Total N (ppm)	PO4 (ppm)	Total P (ppm)	DOC (ppm)
June	5.13	7.50	119.00	12.35	0.01	0.01	0.24	0.02	0.05	2.18
July	8.86	7.26	169.00	21.76	0.01	0.01	0.54	0.02	0.05	1.73
August	12.60	7.27	167.00	35.80	0.03	0.01	0.16	0.01	0.06	2.23
September	13.70	7.46	202.00	22.60	0.02	0.01	0.16	0.01	0.05	2.77



Month	Turbidity (ntu)	pH	EC (uS/cm)	TSS (mg/L)	NH4 (ppm)	NO3 (ppm)	Total N (ppm)	PO4 (ppm)	Total P (ppm)	DOC (ppm)
June	2.24	7.70	101.00	2.35	0.01	0.04	0.19	0.00	0.02	1.52
July	5.15	7.48	139.00	6.47	0.01	0.07	0.06	0.01	0.00	0.96
August	3.77	7.28	137.00	10.00	0.02	0.04	0.07	0.00	0.00	1.31
September	7.70	7.77	149.00	10.00	0.01	0.02	0.01	0.00	0.01	1.06

Figure 4. Graphs displaying diurnal swings in DO at three valley outlets. Red numbers indicate measurements below detection levels - standardized to 0.005 (N) or 0.0025 (P) for graphical purpose.

The relationship between water temperature, DO (mg/L) and elevation for UFRW sites revealed, once temperatures exceed 74°F, it is impossible for DO levels to rise above 7mg/L unless there is oxygen generation occurring. Nutrient analyses of N and P in three irrigated agricultural valleys were found to be insignificant and therefore not contributing to excessive aquatic vegetation growth. Lab results revealed TSS at levels that could potentially be driving biological oxygen demand and therefore contributing to diurnal DO swings. TSS components (mineral and organic) will be further explored.

● **Finding #5:** We found that when irrigation management creates prolonged saturated soil conditions, pasture plant communities become composed of species such as sedges and rushes. Compared to grasses and clovers, sedges and rushes have low forage quality for livestock. These saturated soil conditions are associated with irrigation practices such as continuous irrigation, or frequent application of excessive volumes. These irrigation practices also can have negative water quality impacts by increasing runoff rates. We found that the type of plants associated with a consistently high water table level tend to be low palatability species. High palatable species such as timothy, bluegrass, and clovers tend to be associated with moist soil conditions, but with water table deeper than 2 ft most of the growing season. While wet sites produce somewhat greater amounts of forage, moist sites maintain higher forage quality (Figure 5). Irrigation in response to plant and soil water demand will make more efficient use of water, produce a higher quality forage crop, and reduce runoff and pollutant transport. Monitoring of soil moisture status would provide the manager real-time feedback on moisture status and the need for irrigation.

Figure 5. Relationship between forage quality & quantity at pasture sites irrigated to maintain dry, moist, or wet soil moisture conditions (2007).

Soil Moisture	Description
wet	High water table (<24 in) with adequate soil moisture all season.
moist	Moderate water table (>24 in) with adequate soil moisture all season.
dry	Low water table (>36 in) and inadequate soil moisture season.

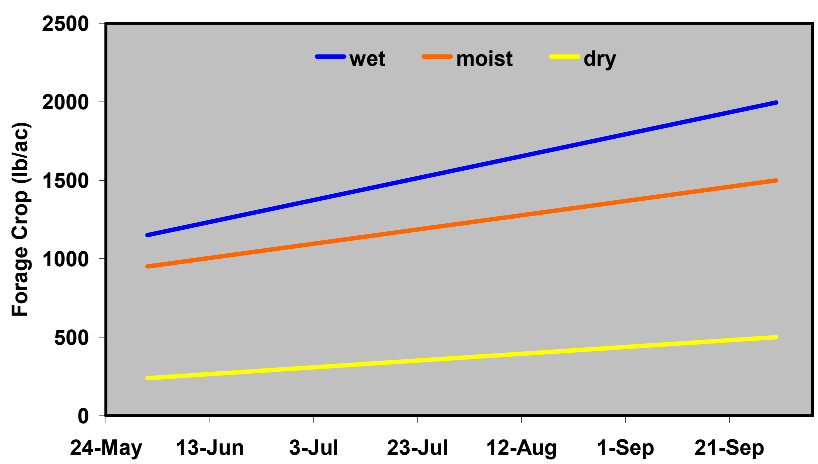


Figure 5a. ***Forage quantity*** **at pasture sites irrigated to maintain soil moisture (dry, moist, wet) conditions**

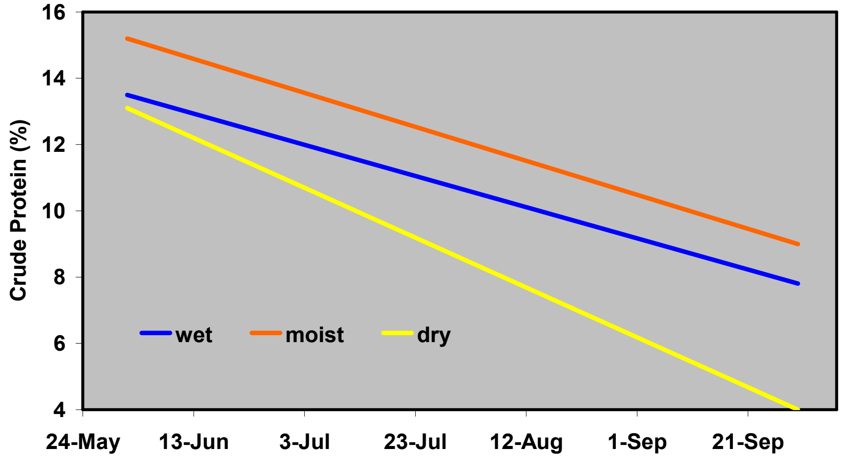


Figure 5b. *Forage quality* at pasture sites irrigated to maintain soil moisture (dry, moist, wet) conditions

Attachments

A. UFRW Maps (Sierra Valley, Indian Valley , American Valley, Goodrich Creek)

B. Public Outreach Table

C. Drafts of Technical Reports

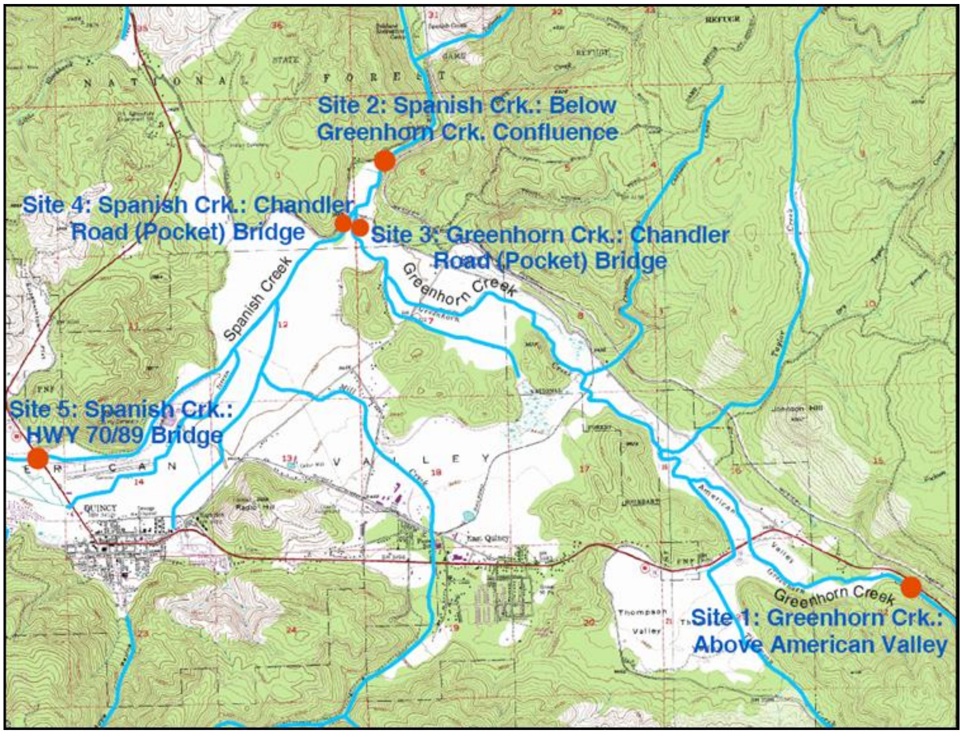
   1. Depth to Water Table, Soil Moisture, and Plant Community Effects on Forage Quality of Irrigated Pastures and Mountain Meadows in the Upper Feather River Watershed (DRAFT June 2010)

   2. Water Quality Above & Below Irrigated Agriculture: Limited Concerns in the Upper Feather River Watershed (DRAFT June 2010)

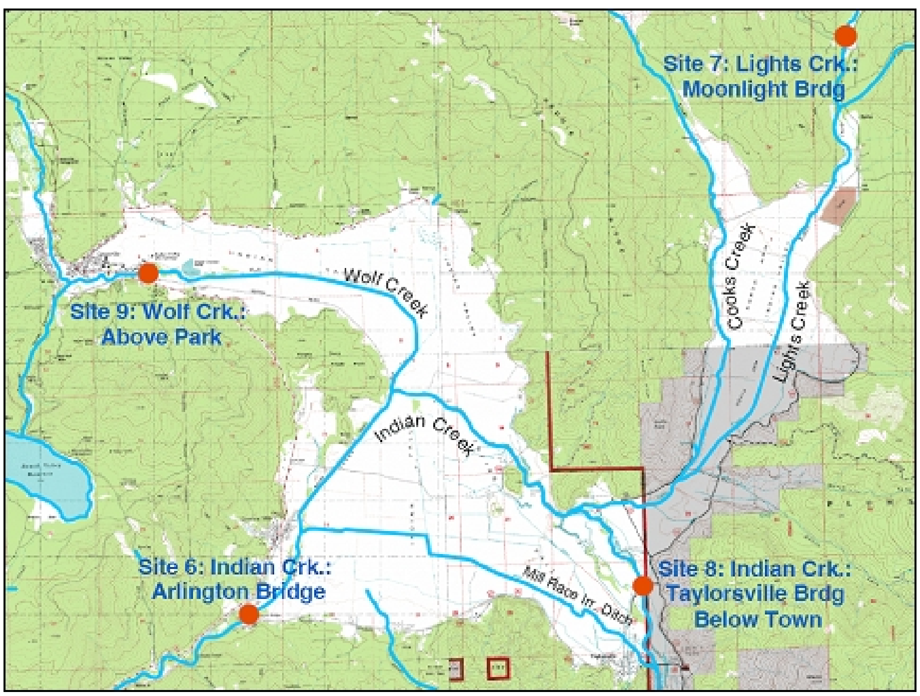
   3. A Study of Dissolved Oxygen Drivers within Streams of the Upper Feather River Watershed (DRAFT June 2010)

Attachment A - Upper Feather River Watershed (UFRW) Maps

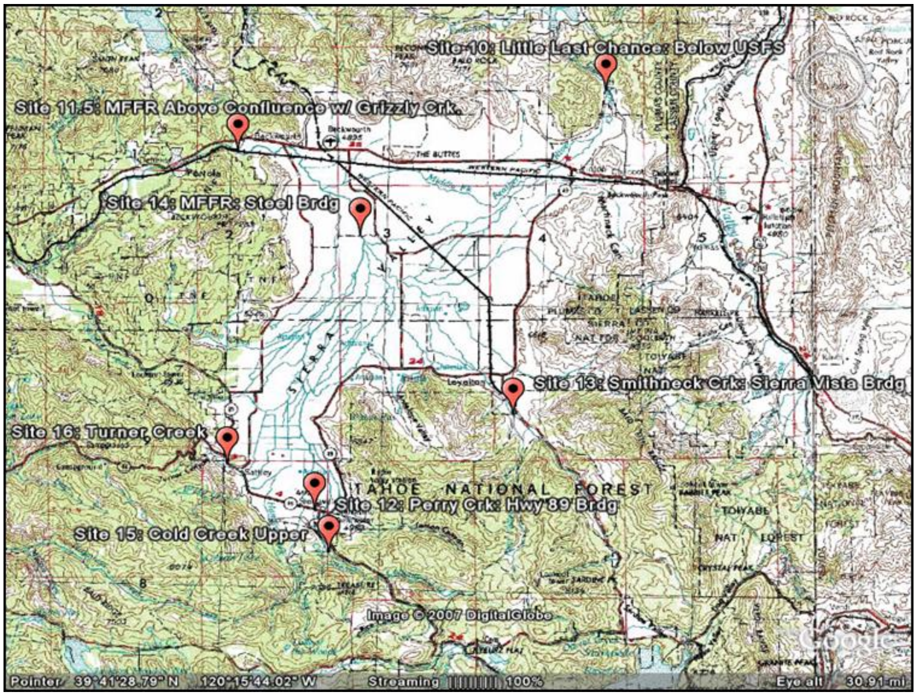
AMERICAN VALLEY – PHASE I MONITORING SITES



INDIAN VALLEY – PHASE I MONITORING SITES

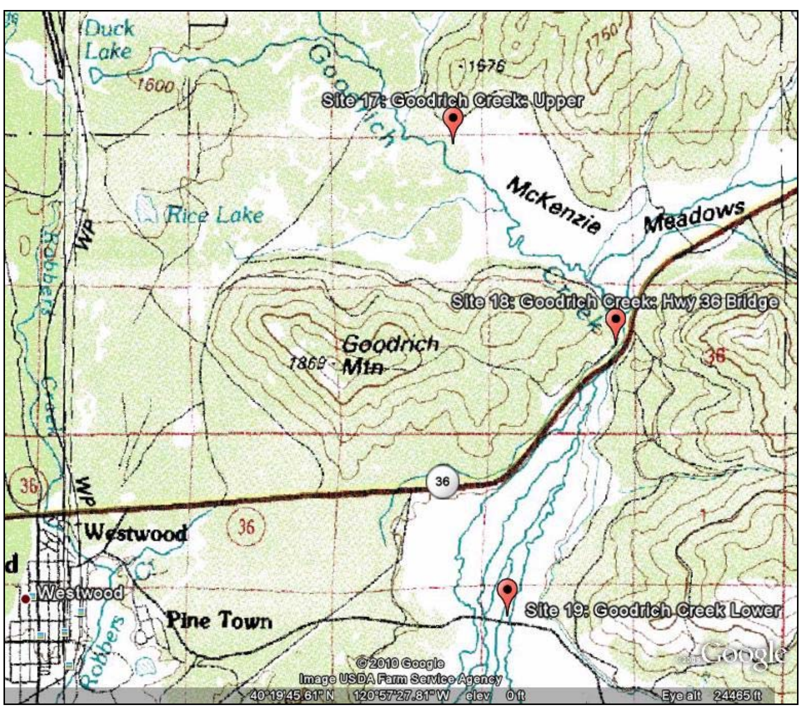


SIERRA VALLEY – PHASE I MONITORING SITES



In 2007, the Sierra Valley monitoring location was moved approximately 0.5 mile downstream of the original site, immediately upstream of the confluence of Grizzly Creek with the Middle Fork Feather River (UFRW Site 11.5).

GOODRICH CREEK – PHASE I MONITORING SITES



SUMMARY OF PUBLIC OUTREACH

Throughout the project team members participated in a variety of outreach opportunities by participating or hosting a variety of meetings/workshops/ field days/activities.

ATTACHMENT B
6/10/10

	DESCRIPTION	DATE	ATTACHMENTS / NOTES
Report Period #1 (June 15, 2005 - March 31, 2005)			
	General public, County BOS, BOD of UFRW Group		
	Feather River Current Newsletter - 1st Issue	January	http://groups.ucanr.org/Ag_Water_Quality/documents/Feather_River_Currents12983.pdf
Reporting Period #2 (July 1, 2006 - September 30, 2006)			
➔ ***Outreach Activities***			
	Landowner Survey - created to help augment existing info. on irrigated ag. operations in the UFRW. Mailed to 145 landowners & 32% response rate.	6/1/2006	http://groups.ucanr.org/Ag_Water_Quality/files/46576.pdf
➔ ***Outreach Documents***			
	Irrigated Ag. Practices in UFRW (DRAFT)	9/29/2006	
➔ ***Meetings/Workshops Attended***			
	UFRW Group Meeting	9/27/2006	
	Farm Bureau Meeting	7/26/2006	
	Plumas-Sierra Cattlemen's Meeting	8/2/2006	
	SVRCD Sustainable & Organic Ag. Workshop	9/29/2006	
	Public Lands Council Tour - Sierra Valley	9/8/2006	
	RCD Meetings, Trout Unlimited		
Reporting Period #3 (October 1, 2006 - December 31, 2006)			
➔ ***Outreach Activities***			
	Stakeholder Meeting (40 attendees, Quincy Library) - Shared results of the 2006 water quality monitoring & plans for the 2007 season.	11/28/2006	http://ucanr.org/2006stakeholdermtg
➔ ***Outreach Documents***			
	Feather River Currents Newsletter - 2nd Issue	Nov. 2006	http://groups.ucanr.org/Ag_Water_Quality/documents/Feather_River_Currents12982.pdf
➔ ***Meetings/Workshops Attended***			
	Poster presented by Laura Murphy - American Society of Agronomy,	11/13/2006	
	Crop Science Society of America, Soil Science Society		
	of American		
	Rangeland Watershed Workgroup - project presentation	12/13/2006	http://groups.ucanr.org/Ag_Water_Quality/files/73388.pdf
Reporting Period #4 (January 1, 2007 - March 31, 2007)			
➔ ***Outreach Documents***			
	Irrigated Ag. Practices in UFRW (FINAL DRAFT)	4/5/2007	http://groups.ucanr.org/Ag_Water_Quality/files/46576.pdf

➔ ***Meetings/Workshops Attended***			
	UFRW Group Meeting - project status report	3/1/2007	
	Plumas-Sierra Cattlemen's Meeting	3/29/2007	
	Natural Resource Coordinating Conference - project poster presented	3/14-3/15	http://groups.ucanr.org/Ag_Water_Quality/files/73388.pdf
➔ ***Other***			
	Updated project website - 2006 season info		http://groups.ucanr.org/Ag_Water_Quality/Water_Quality_Monitoring/Field_Work_during_2006_Irrigation_Season.htm
Reporting Period #5 (April 1, 2007 - June 30, 2007)			
➔ ***Outreach Activities***			
	NRCS Workshop w/ Alan Bower - Workshop with local team members on conservation planning. Focused on NRCS goals/objectives and conservation planning. Included field tours of current NRCS projects	4/9-4/10	
➔ ***Outreach Documents***			
	Feather River Currents Newsletter - 3rd Issue	May	http://groups.ucanr.org/Ag_Water_Quality/documents/Feather_River_Currents12981.pdf
➔ ***Meetings/Workshops Attended***			
	UFRW Group Meeting - project status report	4/12/2007	
	FR CRM Meeting	6/15/2007	
	Cattlemen's Meeting	6/13/2007	
Report Period #6 (July 1, 2007 - September 30, 2007)			
➔ ***Meetings/Workshops Attended***			
	PS Cattlemen's Association Meeting	July / Sept	
	SV RCD Meeting	July	
	SV RCD Sustainable & Organic Agriculture Workshop	9/28/2007	
	SV Groundwater Management District	10/1/2007	
	SV RCD Meeting	October	
	SV Water Company Meeting	10/8/2007	
	FR RCD Meeting	10/11/2007	
	Farm Bureau Meeting - project poster presented		http://groups.ucanr.org/Ag_Water_Quality/files/73388.pdf
	BMP Field Day	7/26/2007	
	SV Field Day - Laura Murphy	9/6/2007	
➔ ***Outreach Documents***			
	Feather River Currents Newsletter - 4th Issue	October	http://groups.ucanr.org/Ag_Water_Quality/documents/Feather_River_Currents12980.pdf
➔ ***Other***			
	Updated the website		
	Compiled publications & resources from Alberta "Cows and Fish"		http://groups.ucanr.org/Ag_Water_Quality/Useful_Information/
			http://www.cowsandfish.org/publications/fact_sheets.html
Report Period #7 (October 1, 2007 - September 30, 2007)			
➔ ***Outreach Activities***			

Stakeholder Meeting (60+ attendees, Quincy Mineral Building) - Project team shared 2007 E. coli & water monitoring plans and discussed plans for the 2008 season.)	11/15/2007	http://groups.ucanr.org/Ag_Water_Quality/Water_Quality_Monitoring/Nov_15,_2007_-_Annual_Stakeholder_Meeting.htm
➔ Meetings/Workshops Attended		
SV Ground Management District	10/8/2007	
SV Water Company	10/11/2007	
Farm Bureau	10/23/2007	
Watershed Forum & Flood Control Water Conservation District Mtg.	10/23/2007	
Plumas Sierra Cattlemen's Association	10/25/2007	
Team members were present at the SV RCD, FR RCD, FR CRM mtgs		
➔ Other		
2007 National Convention on Ag & the Environment - presented poster	11/7 - 11/9	http://groups.ucanr.org/Ag_Water_Quality/files/73388.pdf
NEW website created specific to the project		http://groups.ucanr.org/Ag_Water_Quality/index.cfm
Report Period #8 (January 1, 2008 - March 31, 2008)		
➔ Outreach Activities		
Ranch Management Meeting (25 attendees, Quincy) - Covered a wide array of management topics. UC Davis veterinarians attended. Discussed 2007 Soil Moisture/Forage Quality study, 2007 Pathogen Study, & pros/cons of E.coli testing	2/26/2008	http://groups.ucanr.org/Ag_Water_Quality/Water_Quality_Monitoring/Feb_26,_2008_-_Ranch_Management_Meeting.htm
➔ Outreach Documents		
Feather River Currents Newsletter - 5th Issue	Feb. 2008	http://groups.ucanr.org/Ag_Water_Quality/documents/Feather_River_Currents13359.pdf
➔ Meetings/Workshops Attended		
Society for Range Management (SRM) Kentucky	1/28-1/31	PPT presentation - submitted via Progress Report
National Water Conference - Sparks, NV	2/4-2/6	PPT presentation - submitted via Progress Report
SV RCD Meeting	3/6/2008	
Plumas County Watershed Form	3/12/2008	
Plumas County BOS	3/12/2008	
Plumas Sierra Cattlemen's Meeting	3/20/2008	
➔ Other		
Research regarding digital storytelling - interactive, educational outreach		
Continued development & additions to website		
Report Period #9 (April 1, 2008 - June 31, 2008)		
➔ Outreach Activities		
Ranch Planning Study Halls (Portola & Quincy) - collaborated with NRCS. NRCS & UC employee worked with landowners. Maps & questionare was provided to assist in ranch planning efforts. Resources were compiled & made available on website. Worked on the development of individual ranch plans	4/9-4/10	http://groups.ucanr.org/Ag_Water_Quality/Useful_Information/Ranch_Planning.htm
➔ Outreach Documents		
Feather River Currents Newsletter - 6th Issue	July	http://groups.ucanr.org/Ag_Water_Quality/documents/Feather_River_Currents14607.pdf
➔ Meetings/Workshops Attended		

ATTACHMENT B
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	Plumas County BOS - presentation on project	April	PPT presentation - submitted via Progress Report
	Four County (Modoc, Lassen, Plumas, Sierra) BOS Quad Mtg	4/29/2008	PPT presentation - submitted via Progress Report
	Indian Valley Forest Tour	6/21/2008	
	Plumas Sierra Cattlemen's Meeting	6/11/2008	
➔ ***Other***			
	Ranch Planning/Mgt resources were compiled for website		
	Research regarding digitial storytelling - interactive, educational outreach		
Report Period #10 (July 1, 2008 - September 30, 2008)			
➔ ***Outreach Activities***			
	Sierra Valley Water Quality Field Day & BBQ (36 attendees, SV) - Coordinated event sponsored by UFRW Group, Farm Bureau, Cattlemen's, UCCE. Opportunity for ranchers to "share experiences about imporving livestock/forage mgt. and mitigating water quality concerns, undertstand special studies, discuss how to document positive efforts, explore optionsfor funds to implement a variety of on-the-ground practices and assist with compliance monitoring for the ILRP in the UFRW.	8/8/2008	http://groups.ucanr.org/Ag_Water_Quality/Water_Quality_Monitoring/UFRW_Water_Quality_Field_Day_-_August_8th,_2008.htm
	Digital Storytelling Workshop - Workshop to introduce UFRW landowners and other parties to digital story telling project as a form of educational outreach	9/4/2008	
➔ ***Outreach Documents***			
	Completed & distributed "Agricultural Water Quality" booklets		
➔ ***Meetings/Workshops Attended***			
	Statewide California Cattlemen's Association Meeting		
	Rangeland Management Workshop - Planning Meeting	8/27/2008	
	Sierra Valley Resource Conservation District (RCD) Meeting		
	Plumas Sierrra Cattlemen's BBQ	July	
	Sierra-Nevada Conservancy (SNC) Meeting	July	
	PS Farm Bureau meeting	July	
	SV Sustainable Ag. Workshop		
	2009 Society for Range Management - poster & paper presented	Poster	http://groups.ucanr.org/Ag_Water_Quality/files/73389.pdf
		PPT	http://groups.ucanr.org/Ag_Water_Quality/files/73386.pdf
Report Period # 11 (October 1, 2008 - December 31, 2008)			
➔ ***Outreach Activities***			
	Last Annual Stakeholder Meeting (30 attendees, Quincy) - Team members provided a summary of 3 years of monitoring data collected and discussed plans after the project ends.	12/4/2008	http://groups.ucanr.org/Ag_Water_Quality/Water_Quality_Monitoring/December_4,_2008_-_LAST_Annual_Stakeholder_Meeting.htm
➔ ***Outreach Documents***			
	Feather River Currents Newsletter - 7th issue	Nov. 2008	http://groups.ucanr.org/Ag_Water_Quality/documents/Feather_River_Currents15563.pdf
➔ ***Meetings/Workshops Attended***			
	UFRW Group Membership Meeting	10/30/2008	
	FR CRM Meeting - presentation on status of project	11/8/2008	
	Resource Stewardship Outreach training	12/8/2008	

Report Period #12 (January 1, 2009 - March 31, 2009)			
	No project outreach - freeze project funds		6/10/10
Report Period #13 (April 1, 2009 - June 30, 2009)			
	No project outreach - freezon project funds		
Report Period #14 (July 1, 2009 - September, 30, 2009)			
	Project team meetings with the UFRW Group and attendance at		
	activities		
	Passion for the Land: Personal Stories from SV (DVD completed): Interactive, educational outreach		http://www.youtube.com/PassionForTheLand#p/u
			http://www.artofregionalchange.ucdavis.edu
Report Period #15 (October 1, 2009 - December 31, 2009)			
➔ ***Outreach Activities***			
	Passion for the Land Videos shown at various locations throughout the area		
	Plumas - Sierra County Fair, Farm Bureau, California Rangeland		
	Coalition, Defenders of Wildlife, Pacific Forest Trust, Cattlemen's Association,		
	NCWA		
➔ ***Outreach Documents***			
	Producer Stories were developed		http://groups.ucanr.org/Ag_Water_Quality/Producer_Stories_-_Upper_Feather_River_Watershed_Farmers_%26_Ranchers/
➔ ***Meetings/Workshops Attended***			
	CA/NV Cattlemen's Association meeting	November	
	California Resource Conservation & Development Conference	November	
	Meeting with Bay Area Farm Advisors	December	
Report Period #16 (January 1, 2010 - March 31, 2010)			
➔ ***Outreach Activities***			
	Planning of several outreach activties for the month of May		
➔ ***Meetings/Workshops Attended***			
	Rangeland Coalition Summit	January	Presentation
	Society for Range Management (SRM) Conference	February	Presentation
	Oakdale Livestock Forum	March	
	Planning Commission	March	
	Sierra Business Council (SBC) & Sierra Nevada Conservancy (SNC)	March	
Report Period #17 (April 1, 2010 - June 30, 2010)			
➔ ***Outreach Activities***			
	Community meetings & discussions, video screening, fields visits on	May	
	manangement measures, small group meetings		
	Local DVD screening	5/18/2010	
➔ ***Outreach Documents***			

	Additional producer stories were developed and added to the website		http://groups.ucanr.org/Ag_Water_Quality/Producer_Stories_-_Upper_Feather_River_Watershed_Farmers_%26_Ranchers/
➔ ***Meetings/Workshops Attended***			
	UC Davis Site Builder 3 - Website Training	May 18-19	

ATTACHMENT C.1.

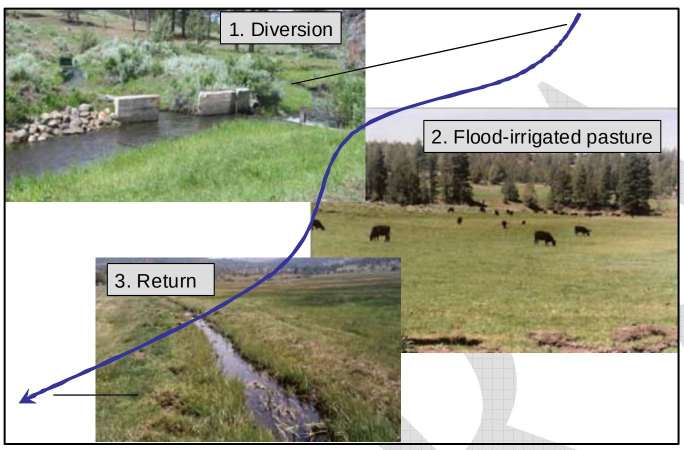
Depth to Water Table, Soil Moisture, and Plant Community Effects on Forage Quality of Irrigated Pastures and Mountain Meadows in the Upper Feather River Watershed

(6/10/10)

DRAFT - Report for UFRW Prop 50 Grant Project

Introduction

Irrigated pastures and mountain meadows are a widely used summer forage base for beef cattle producers in the Upper Feather River Watershed (UFRW) and throughout northeastern California. As such, meadow and irrigated pasture production systems play an important role in the economic sustainability of cattle ranches in the region. While touring and discussing best management practices with cooperating ranches for the UFRW project, it became clear to the University of California Cooperative Extension (UCCE) team that management of available irrigation water, livestock grazing, and the potential for downstream water quality are intertwined into larger ranch production systems.



Stream flow is diverted into a ditch and distributed across a pasture. Pasture tailwater is then returned to the stream, or used to irrigate other pastures.

Irrigated pastures in northern and central California provide critical summer forage for livestock. In many cases, water is diverted from small streams and transported to pastures for flood irrigation. These stream diversion irrigation systems have the potential to impact downstream water quality by:

1) Reduction of in-stream flow volumes

2) Return of pasture tailwater to the stream, carrying pollutants to the stream.

As in all agriculture enterprises, it important to maximize production over base costs to ensure economic sustainability. A fundamental question is whether there could be a production based or economic opportunity for improved water management on mountain meadows that could go hand in hand with water quality and conservation goals. There has been little research emphasis on the overall production potential of high elevation irrigated pasture and mountain meadows. Our objective in this study was to examine how interactions between soil moisture and plant community affect meadow productivity, forage quality and the overall potential for beef production.

Observations of irrigated meadows show that they are typically comprised of variable plant communities and soil moisture regimes. Both spatially and temporally, we commonly see considerable differences in soil wetness. For example, in the early spring summer some areas appear excessively wet, while by mid-summer forage growth on many sites is limited by lack of adequate soil moisture.

ATTACHMENT C.1.

How do these wide swings in available soil moisture affect the forage species that occur on these sites, as well as their nutritive quality and production potential for livestock?

The first step in this endeavor would be to sample representative pastures and meadow forage types, and to quantify and compare these different sites in terms of forage value and production potential. If some sites produced better quality forage than others, and such differences were based on soil moisture factors that could be affected by management, such information would help demonstrate to what extent management practices might provide an economic as well as conservation benefit.

Meadows from four different ranches were enrolled in this study – one meadow per ranch. Three sites were selected within each meadow pasture that appeared to represent plant community and soil moisture that occurred within the pasture. At each site, three cages were set up to exclude cattle such that we could record total herbaceous production as well as soil moisture and depth to free water (see photos and Figure 1). Monthly forage samples were collected at each site and sent to the lab for forage quality analysis which included crude protein and digestibility which is reported as Total Digestible Nutrients (%TDN) a common method of quantifying energy value of livestock feeds and forages. Plant species composition was recorded within each cage. Three sites (sets of cages) within pastures on four different ranches provided us with 12 total monitoring locations.

Grazing exclosure cage

Cage close-up showing above-ground portion of site well (black pipe), soil moisture meters (white pipe), and data logger

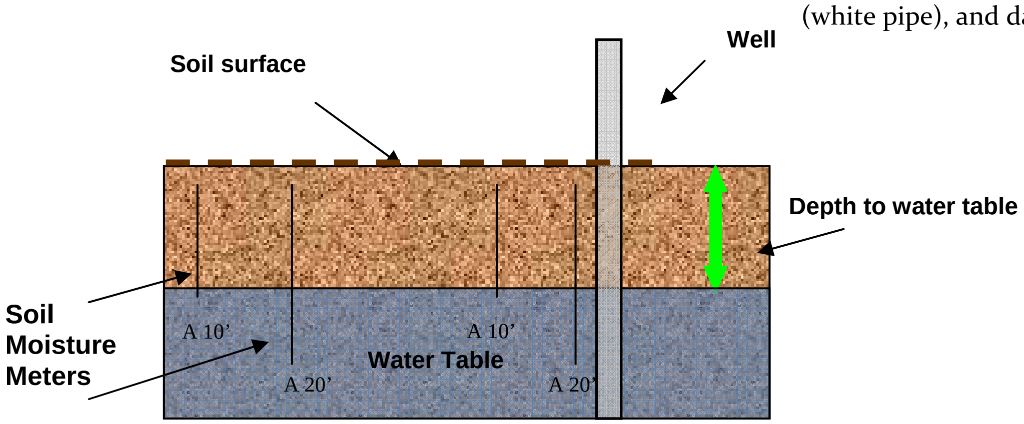


Figure 1. Schematic of soil moisture and water table monitoring lay out that was installed at each of 12 monitoring locations

ATTACHMENT C.1.

Forage Groups

To more easily explain and display the data, we grouped the 12 study sites into definable forage types that were similar in terms of vegetative community and soil moisture regime. These types are described in such a way that they can be recognized by ranchers and farm managers. Using depth to water table, soil moisture and plant species composition as critical variables, the 12 sites were grouped into four distinct types. Three of the four ranches had meadow sites in two different groups.

The four groups are described below in terms of their soil moisture and vegetative complex. The sites are generally listed from driest to wettest, although there can be considerable year to year variation in water availability and irrigation management.

Forage Group Descriptions

Forage Group 1 - These sites are not affected by the presence of a high water-table within the root zone. Depending on annual conditions, they may lack adequate irrigation water mid to late season in dry years. The plant community is dominated by grasses w/ some narrow-leafed sedge. There are no clovers. 25% or three of the 12 sites were in this group.

Forage Group 2 - Sites may be modestly affected by a high water table during spring early summer. May or may not have adequate irrigation for the entire season depending on year. When irrigation water is short, mid-season productivity and quality declines. Plant community is comprised of a mix of species including rushes, grasses, narrow-leaf sedge and clover. Clovers are a distinguishing characteristic from other types and may comprise 5 to 20% of the species mix. Note the clover flowers present in photo. 33% or four of the 12 sites were in this group.

Forage Group 3 - These sites may experience moderate impact from high water table early in the season and usually have adequate soil moisture through the summer. The plant community is similar to that of Group 1, which is a blend of sedges and perennial grasses. There is a somewhat higher percentage of water loving species. No clover is present. 17% or two of the 12 sites were placed in this group

Forage Group – 4 This group is characterized by wet saturated conditions at least in the early part of the growing season. Free water may be at the soil surface during this time. Some of these sites do eventually dry down and may be lacking water by late summer. Sedges, either wide or narrow leafed species (or both) are the dominant vegetation. Sometimes a considerable number of rushes are present as well. There are no clovers, few broadleaf forbs and few true grasses present. Note wide coarse leaves of sedges in the photo. 25% or four of the 12 sites were in this group.

ATTACHMENT C.1.

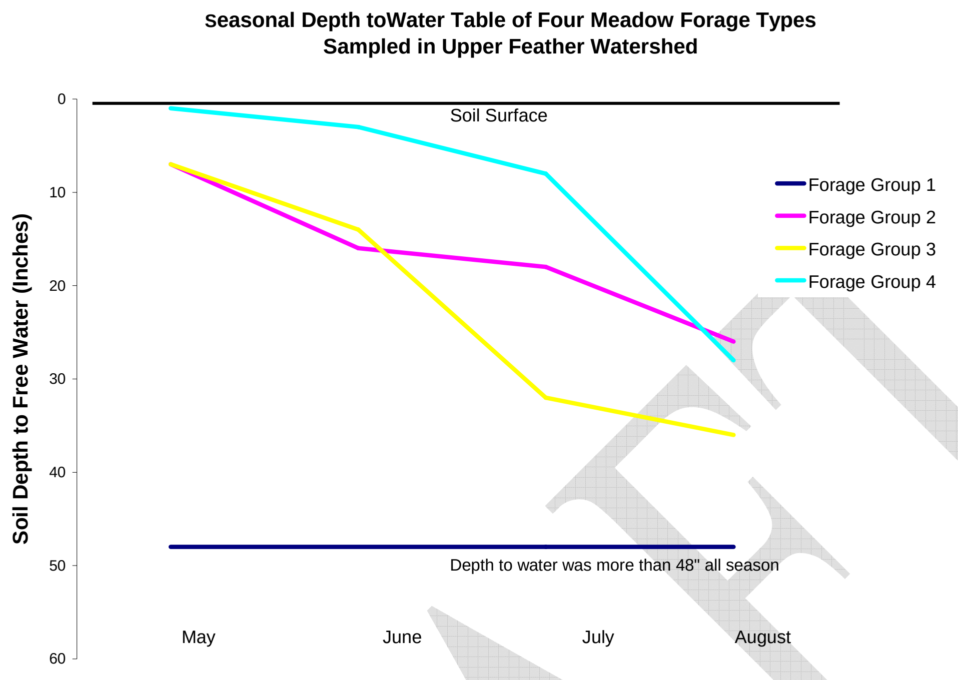


Figure 2. Seasonal depth to water table.

Soil Moisture and Depth to Water Table

Differences in seasonal depth to water table are shown in Figure 2. Three of the four sites begin the growing season with a water table well within the root zone. Only sites in Group 1 were not affected. A high water table persists through much of the season on Group 4 sites and explains the dominance of water loving sedges and rushes. By mid-summer Groups 2 and 3 have about two feet of root zone above free water which apparently allows a broader spectrum of forbs and grasses to persist.

Soil moisture fluctuated more dramatically by site and would increase and decrease with specific irrigation events. In spring soils were very wet trending toward much drier conditions in mid to late summer. At drier sites, plant growth and forage quality became severely limited by lack of moisture. Our experience indicates that soil moisture meters which are commonly used in intensively managed field crops, could also be used in irrigated meadows to time irrigation sets as long as adequate irrigation water is available.

Forage Quality Results and Discussion

Seasonal forage quality for the four forage groups is shown in Figures 3 and 4. In all cases there is a seasonal decline in forage quality as plant species mature and soils begin to dry. For all groups the overall nutritive quality is significantly lower in mid to late summer. There are also clear differences in forage quality between forage groups, with Group 2 having the highest overall forage quality while Groups 1 and 4 have the poorest. The differences in Crude Protein and TDN between the four groups are meaningful in terms of expected gain by cattle. Table 1 indicates the total expected gain that can be calculated given the known quality of forage present through the summer gazing season.

ATTACHMENT C.1.

While it is well known that different plants and forage species thrive under varying soil moisture regimes (i.e. some do well under saturated soil conditions, while others do not) this study demonstrates the corresponding effects that varying plant communities have on forage quality and nutritive value for cattle that graze on mountain meadows and irrigated pastures.

Based on calculations of overall cattle gains, those sites (represented in Group 1) that lack adequate water and experience severe mid-season drying and those areas that had water tables near the soil surface well into the growing season (Group 4) are most negatively affected compared to optimal conditions. These sites could be expected to produce 29% and 36% less beef per head than Group 2 sites respectively. Given the drought cycle that corresponded with our study, the dry soil conditions we observed may have been more prevalent than normal.

The presence of clover, the defining characteristic of Group 2, was a good indicator of high quality forage in these meadow pastures. This is probably due both to the direct contribution of the clovers themselves and that the presence of clovers also indicates a site that has a desirable blend of forage species more optimal soil moisture regime.

It is important to remember that most mountain meadow pastures are quite heterogeneous and a single pasture often contains sites that fall into two or more of these forage groups. So in reality a cow will usually consume a diet comprised of forages from more than one of the groups described above. However, grazing cattle do selectively forage and will spend more time feeding in locations that contain the best available forage. For example at one ranch, by seasons end the cattle had consumed 72% of the available forage within the Forage Group 2 site, but less than 40% of available forage in Forage Group 4 areas. Thus, overall pasture productivity and cattle gains might be increased if plant community could be optimized through management, ie: XXX.

Based on our findings, at least the *potential* to improve overall forage value by management is demonstrated by this study. The follow-up that is needed is a more detailed and clearer understanding of how to influence existing plant communities and expand the most desirable types through management of irrigation and other factors. It is likely that some improvement in production can be achieved on many meadows, while reducing downstream impacts, ie: XXX.

Table 1. Expected Average Daily Gain (ADG lbs /day) of 600 lb moderate framed steers, based on monthly protein and energy values of forage types found on Upper Feather River pastures/meadows.

Forage group	May	June	July	August	September	Total pounds gained over summer grazing season	Percent reduction in seasonal gain compared to Group 2
1	2.5	2.0	0.8	0.0	0.0	157	29%
2	2.0	2.1	1.5	1.0	0.8	220	--
3	2.4	1.8	1.4	0.8	0.3	195	13%
4	1.8	1.7	1.0	0.4	0.0	140	36%

ATTACHMENT C.1.

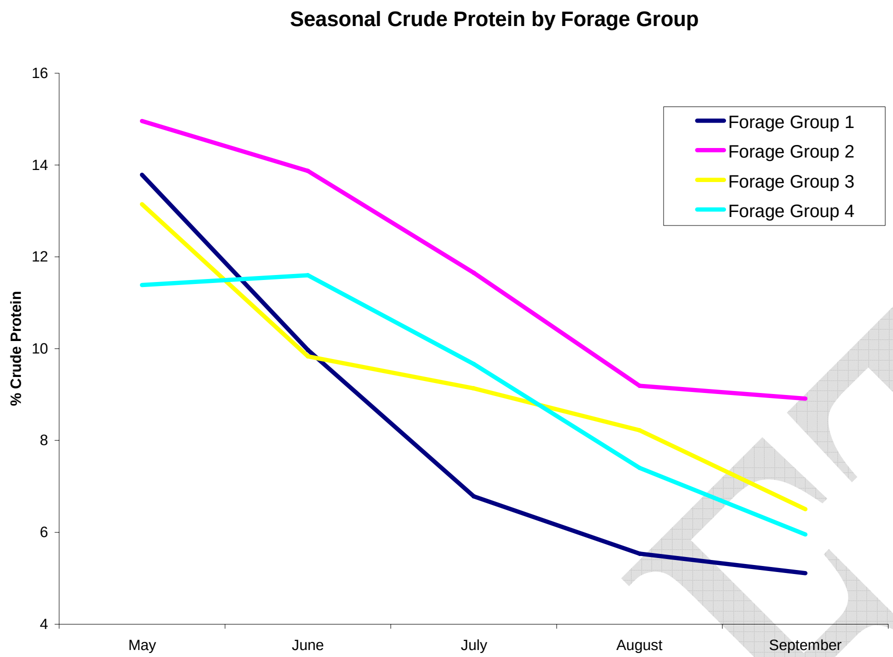


Figure 3. Seasonal Crude Protein by Forage Group

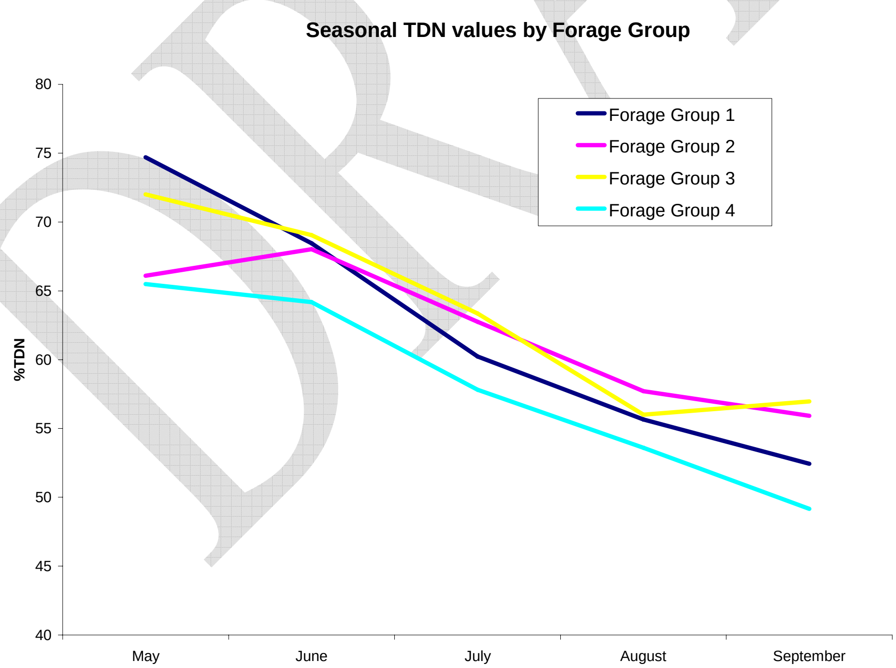


Figure 4. Seasonal Total Digestible Nutrients (%TDN) by Forage Group

Water Quality Above & Below Irrigated Agriculture: Limited Concerns in the Upper Feather River Watershed

(Working DRAFT for Cal Ag June 2010)

Water is the life blood of California, our *Blue Gold*. There are significant concerns of negative water quality impacts from the different 'allowable beneficial users', environmental, municipal, agricultural and recreational interests, vying for this limited resource as demonstrated by the array of programs implemented over the last few years to 'protect the waters of the state'.

Scrutiny of agriculture, the largest user of this precious resource has resulted in the Irrigated Lands Regulatory Program (ILRP) administered by the State's Regional Water Quality Control Boards, http://www.swrcb.ca.gov/centralvalley/water_issues/irrigated_lands/index.shtml .

The Central Valley Regional Water Quality Control Board (CVRB) which covers a geographic area from Modoc County to Kern County has identified broad categories of concern related to irrigated agriculture across this diverse area including potentially toxic chemicals from herbicides and pesticides, nutrients from fertilizers and microbial constituents from livestock. Because there was not any good data available about the relative risk of different types of irrigated agriculture in the region, the CVRB more or less implemented an across the board monitoring and reporting program that is very expensive and questionably does little to change on the ground management practices. Research by Allan Fulton and Mark Lubell from University of California found that many orchard producers needed an average of nine contacts with a 'diffusion network'before they adopted a new management practice to protect water quality http://californiaagriculture.ucanr.org/pressroom.cfm?news=8 .

With cooperation from irrigated agricultural operators in the UFRW, University of California Cooperative Extension secured funding from the State Water Resources Control Board via Proposition 50 and developed a watershed monitoring program to identify the quality of receiving, using and releasing (discharge) water in the four main agricultural valleys of the UFRW. By evaluating the change in concentrations of constituents of concern above and below irrigated agriculture we hoped to pinpoint specific constituents where management may have an impact on water quality and then work with landowners to find economically viable ways to modify management for the long term sustainability of our natural resources as well as rural ranching communities.

Most of the land in this watershed (70-80%) is publically owned and managed primarily by the US Forest Service. Like most of northeastern California and Central Sierra Nevada mountain valleys and meadows, irrigated agriculture in the UFRW commonly takes the form of irrigated pasture for seasonal livestock grazing and/or hay production. While technically part of California, the growing conditions are more limited like that of the Great Basin. For these agricultural valleys, precipitation comes mainly in the form of winter snow.

Upper Feather River Watershed, portions of Lassen, Plumas and Sierra Counties

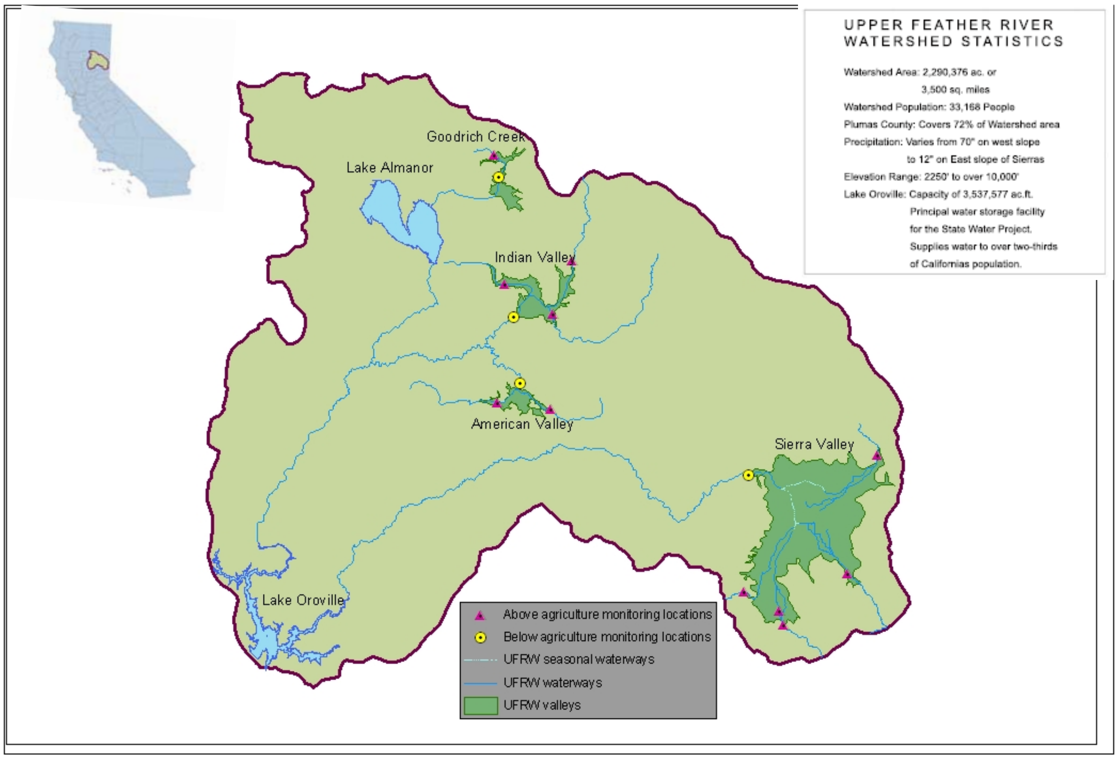


Figure 1 - The four primary agricultural valleys and key streams, rivers, and lakes of the UFRW delivering water to Oroville Reservoir, a major source of freshwater for the California State Water Project.

The UFRW straddles the northern extent of California's Sierra Nevada range with four main drainages flowing southwest to Lake Oroville, the California State Water Project’s principle water storage facility. The network of UFRW streams and rivers deliver water to over two-thirds of the state’s population (UFRW IRWMP, 2005). Stream flows are highest in the spring in response to snowmelt and diminish significantly by early July.

Four main agricultural valleys: Goodrich, American, Indian and Sierra contain almost 50,000 irrigated agricultural acres (http://www.countyofplumas.com/agcomm/). Valley bottoms are primarily privately owned with surrounding uplands of public forest managed by the U.S. Forest Service. The irrigation season generally begins in May with flood and sprinkler irrigation providing water for the agricultural commodities of alfalfa, meadow and grain hay crops, and pasture for cow-calf and yearling stocker production. Most agricultural operations are flood-irrigated by stream diversion ditches that flow into mid-summer depending upon elevation, annual snowpack, and site-specific water rights. With agricultural valley elevations ranging from

3,400-5,000 feet, a narrow summer growing season (June-September) governs the suitability for intensive agricultural production.

Valley Name	Estimated # Acres	Estimated # Irrigated Acres	Estimated # Livestock	Comments
Goodrich	2,500	1,100	1,100	One main tributary feeds this system
American	6,720	1,850	500-1,000	Two main tributaries enter the valley
Indian	14,000	4,800-5,000	5,600	Three main tributaries enter the valley. Adjudicated Water Master Area
Sierra	300,000	40,000	15,000	Multiple tributaries enter this large valley including up to 60,000 cfs diverted from the Little Truckee River via Sierra Valley Water Company to augment 'natural flows' for irrigated agriculture. This is the largest alpine valley in lower 48 states.

Table 1. Description of four main irrigated agricultural valleys in the UFRW.

Low-density livestock operations and irrigated crop operations require little chemical input. Reports from the California Department of Pesticide Regulation reveal chemical applications in this watershed are limited with the greatest amount of chemical pesticide use associated with forest/timberland management and rights of way (http://www.cdpr.ca.gov/docs/pur/purmain.htm)

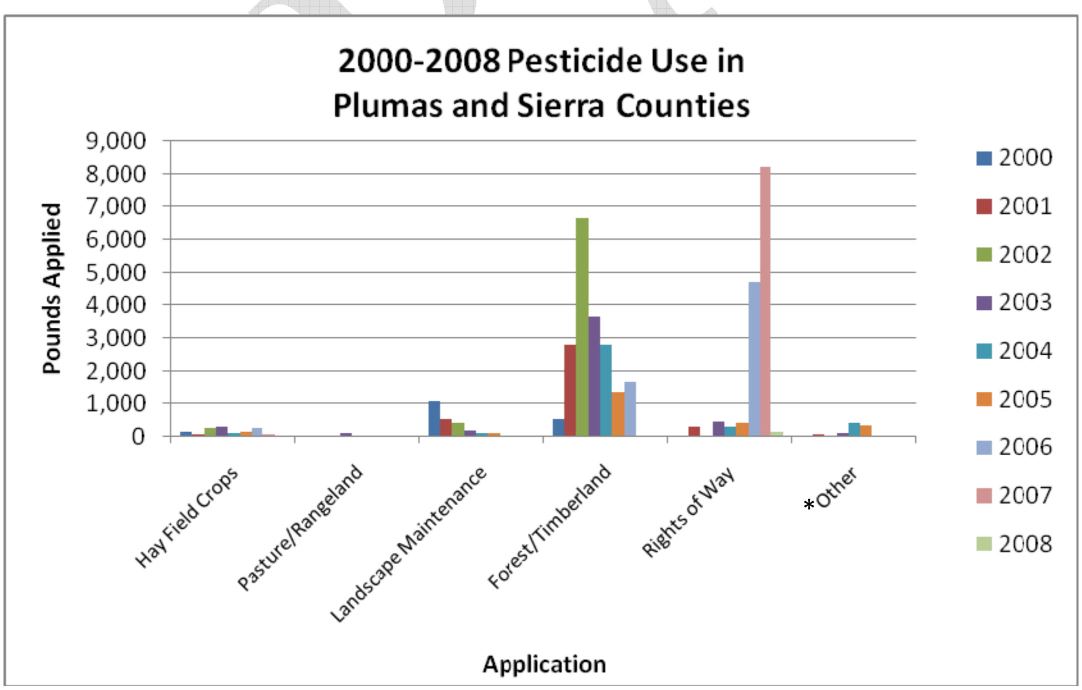


Figure 2 - Pounds of pesticide use in Plumas and Sierra Counties from 2000-2008. *Other

includes: ditch bank, greenhouse plants, regulatory/structural pest control, vertebrate control, etc.

Over the course of the monitoring period, Feather River Basin precipitation and subsequent runoff levels varied considerably (http://cdec.water.ca.gov/snow/bulletin120/) (Figure 3). The 2006 water year was the wettest with runoff at a level of 180% of average. In 2007, runoff levels fell to 38% of average, and in 2008 66% of average. Subsequently, in 2007 and 2008 Sierra Valley irrigators had to reduce water usage for surface irrigated lands in order to meet the needs of stock downstream. In other valleys irrigators were unable to irrigate as long as they desired given the low flows of 2007 and 2008.

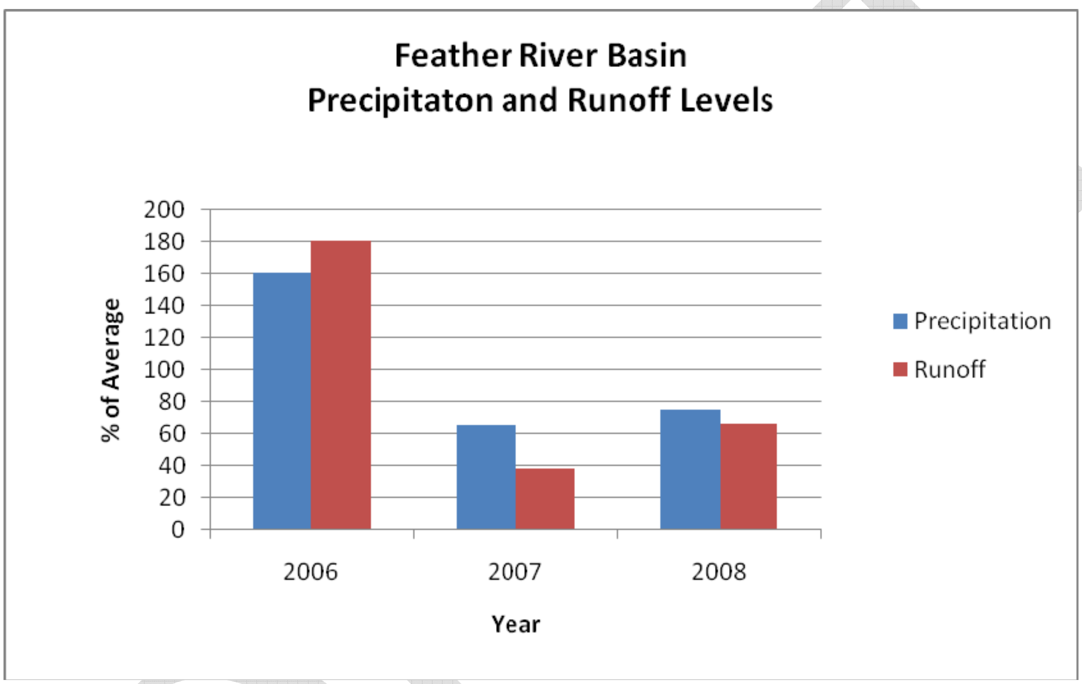


Figure 3 - 2006-2008 precipitation and runoff levels for the Feather River Basin.

In-stream Flows

Measurements of stream flow rates provided an opportunity to examine seasonal and annual flow variation and the effects of that variation on constituent concentrations for sites above and below irrigated agriculture across four morphologically different valley systems. Because of the correlation between flows and constituent concentrations, it will be important to keep the factors of annual and seasonal flow variation and specific valley characteristics in mind as we discuss monitoring results.

When compared to 2007 and 2008, the above average 2006 precipitation and runoff levels confirmed expectations producing the highest and longest duration of flows for all four valleys. Annually, valleys experienced peak flows from April to May with summer flows gradually decreasing until the return of September/October precipitation. American and Indian Valleys and Goodrich creek maintained similar flow patterns for the three irrigation seasons, with flows entering the valleys at higher levels above irrigated agriculture than exit flows below irrigated agriculture. The loss of flow rates may be attributed to use of allocated agricultural water; however residential use, loss to groundwater, and evapotranspiration are a few additional influential factors that were not taken into account in this monitoring program. Flow rate patterns in American and Indian Valleys were most similar given their similar elevation, slope, and size while Goodrich Creek is situated at a higher elevation with the watershed and is the valley least impacted by rural residential development.

Sierra Valley also experienced higher entrance flow rates above irrigated agriculture than exit flows below irrigated agriculture. By early August each season, 100% of inflowing water remained in the valley with no measurable outflow. While similar influential flow factors are likely at hand in addition to agricultural use, the valley morphology is very unique, more characteristic of a wetland system. High gradient tributaries deliver cool water at a fast rate to a large low gradient valley (the largest alpine valley in the U.S.) containing various natural channels and agricultural conveyance ditches and canals interspersed among irrigated agriculture and rural residential. Water levels at the valley bottom fluctuate considerably throughout the season.

As this study did not include an inventory of agricultural use and related flow budget, it is difficult to decipher the effects of irrigated agriculture among other influential factors. Furthermore, there is little record of historic flow information prior to agriculture. We do know a reduction of outflowing water relative to inflowing water, as seen in all valleys during mid-irrigation season, can be beneficial given fewer pollutants are transported downstream and potentially stored and cycled within the valleys. Simultaneously, the effect may be undesirable given the potential for increased temperatures and buildup of constituent concentrations that can impact aquatic health and function. Prior to this monitoring program, however, constituent levels and potential effects of irrigated agriculture among other land uses within the UFRW were unknown.

Water Quality Monitoring Protocols

The ambient water quality monitoring program was designed to isolate and quantify change in in-stream constituents of concern (Table 1.) thereby ‘bracketing’ irrigated agriculture. Monitoring was conducted from May-October at 20 sites located above and below irrigated agriculture in four sub-watersheds (agricultural valleys) of the UFRW. The first year of water quality sampling in 2005 secured preliminary data and a full-scale watershed monitoring plan was implemented in the summers of 2006, 2007, and 2008.

At each of the 20 sites, a one liter water grab sample was collected twice per month in 2006 and monthly in 2007. In 2008 monitoring was conducted monthly at three major valley outlet sites in American, Indian, and Sierra Valleys only. Samples were transferred within 24 hours to UC Davis labs for nutrient and E. coli analyses. In 2006 additional samples were collected each month at valley bottoms for toxicity and metals analyses. Field measurements of flow, DO, EC, and pH were also taken along with digital photographs at the time of each sampling. Stream temperature was recorded automatically each 0.5-hr using automatic temperature loggers.

ATTACHMENT C.2.

Table 2. Comparison of constituent values below compared to above irrigated UFRW valleys.

		2005		2006		2007	
Constituent	**Valley**	**Outlet Mean**	**% Change**	**Outlet Mean**	**% Change**	**Outlet Mean**	**% Change**
Instantaneous Stream Flow (cfs)	Goodrich	unavailable	unavailable	43.56	-56.97	8.19	-65.10
	American	unavailable	unavailable	105.50	176.93	52.87	184.80
	Indian	unavailable	unavailable	251.58	1060.33	37.40	137.36
	Sierra	unavailable	unavailable	426.04	2390.94	16.59	56.15
Electrical Conductivity (µS/cm)	Goodrich	unavailable	unavailable	94.72	2.52	119.73	5.60
	American	129.00	8.12	97.49	10.36	136.12	13.79
	Indian	152.33	29.37	102.34	18.11	154.17	22.62
	Sierra	161.67	40.59	134.22	62.26	184.50	60.86
Turbidity (NTU)	Goodrich	unavailable	unavailable	4.03	147.30	3.19	419.84
	American	0.27	-17.83	2.74	-9.04	1.54	246.82
	Indian	2.18	624.10	6.16	132.47	5.02	381.60
	Sierra	7.33	415.69	10.52	160.69	4.01	63.25
Total Suspended Solids (mg/L)	Goodrich	unavailable	unavailable	12.27	141.80	7.16	121.21
	American	4.41	141.07	8.24	-1.95	4.61	42.42
	Indian	8.77	195.38	15.17	95.65	10.69	179.49
	Sierra	26.18	282.11	23.09	73.38	9.71	37.12
Ammonium - NH4 (ppm)	Goodrich	unavailable	unavailable	0.01	6.10	0.01	-0.64
	American	0.01	-25.22	0.01	11.69	0.02	62.48
	Indian	0.02	37.05	0.01	-12.72	0.01	40.25
	Sierra	0.03	162.03	0.01	36.50	0.02	29.41
Total Nitrogen (ppm)	Goodrich	unavailable	unavailable	0.14	34.95	0.12	97.71
	American	0.15	63.86	0.21	59.31	0.16	71.00
	Indian	0.11	144.02	0.15	6.81	0.13	77.45
	Sierra	0.97	616.27	0.78	327.27	0.51	310.09
Nitrate - NO_3 (ppm)	Goodrich	unavailable	unavailable	<0.01	-72.28	0.03	471.43
	American	0.16	72.94	0.08	76.94	0.06	46.69
	Indian	0.03	43.09	0.01	-53.85	0.04	-0.64
	Sierra	0.11	39.21	<0.01	-77.96	0.18	304.00
Total Phosphorus (ppm)	Goodrich	unavailable	unavailable	0.02	45.38	0.02	48.11
	American	<0.01	-23.30	0.05	116.65	0.02	-21.28
	Indian	0.04	283.06	0.06	97.27	0.03	158.04
	Sierra	0.05	201.26	0.08	85.50	0.04	53.06
Ortho-phosphate - PO_4 (ppm)	Goodrich	unavailable	unavailable	0.00	15.02	0.01	119.91
	American	<0.01	27.98	<0.01	-59.58	0.01	42.82
	Indian	0.02	199.53	0.02	63.08	0.01	62.28
	Sierra	0.01	-49.46	0.01	-22.51	0.01	19.03
Dissolved Organic Carbon (ppm)	Goodrich	unavailable	unavailable	1.45	81.37	1.71	94.92
	American	0.70	-9.39	1.27	6.32	1.18	34.96
	Indian	1.76	41.70	2.20	-0.68	1.97	44.94
	Sierra	10.73	464.65	9.58	326.50	9.58	422.10
E.coli (cfu/100ml)	Goodrich	unavailable	unavailable	121.50	941.43	213.00	602.20
	American	60.00	0.56	61.00	106.43	174.33	258.22
	Indian	227.00	458.20	112.80	235.05	242.00	260.00
	Sierra	16.33	-83.30	35.30	-76.86	28.00	-89.61

Table 2. Valley discharge (below agriculture) mean and the percent change in constituent values from receiving location (above agriculture) to discharge location for the four major irrigated UFRW agriculture valleys. Data represent average constituent values for the 2005 - 2007 irrigation seasons (approximately May-October).

Macroinvertebrates were collected twice per sampling season from 2006-2008 following the California Department of Fish and Game Stream Bioassessment Protocol. Storm event sampling was conducted once in the spring and fall each year. All methods and quality assurance protection protocols were designed to comply with CVRB's requirements.

This sampling strategy provide an opportunity to: 1) examine above and below in-stream water quality changes attributed to agriculture, but also other influential factors of residential development, recreation, and environmental variables of valley morphology, weather, and geology; 2) assess differences in flow volumes and constituent loads both above and below agriculture; and 3) account for changes in water quality and flow over three irrigation seasons.

Dissolved Nutrients

Nutrient contributions from low-density livestock operations and low-intensity irrigated crop operations were found to be negligible with nutrient concentrations consistently measuring very near laboratory detection limits and never approaching exceedance of water quality standards. Valley load balances for sites above and below agriculture, revealed the greatest amount of nutrients present in streams during high spring flows. As the irrigation season progressed and summer flows decreased, the nutrient levels either equilibrated or the valleys began acting as nutrient sinks until the return of fall precipitation.

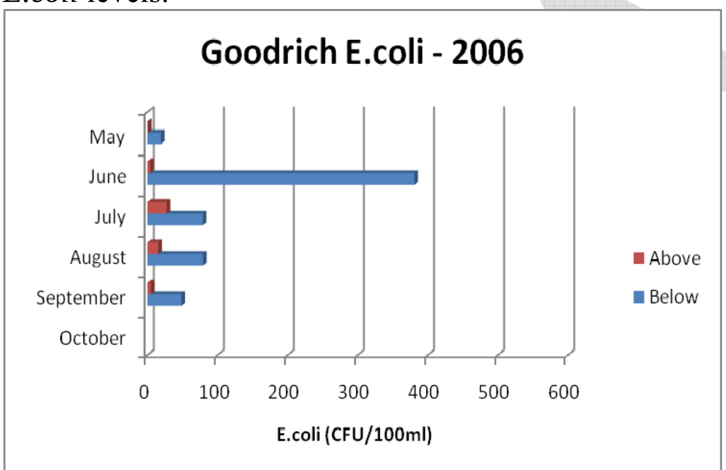
DOC shared similar seasonal patterns yet DOC loads, particularly in Sierra Valley, were the highest of all nutrients. It is difficult to determine the specific effect of irrigated agriculture or the context of DOC levels in Sierra Valley given there is currently no State standard. However, the function of Sierra Valley as a large wetland with carbon deposition likely explains the high DOC levels observed when compared to the other three. Similarly TSS (measure of suspended undissolved inorganic and organic material >0.45µm in diameter) load levels were relatively high. The organic components of DOC and TSS if present in excess may be providing a medium for bacterial growth and consumption of DO. Further investigation is underway.

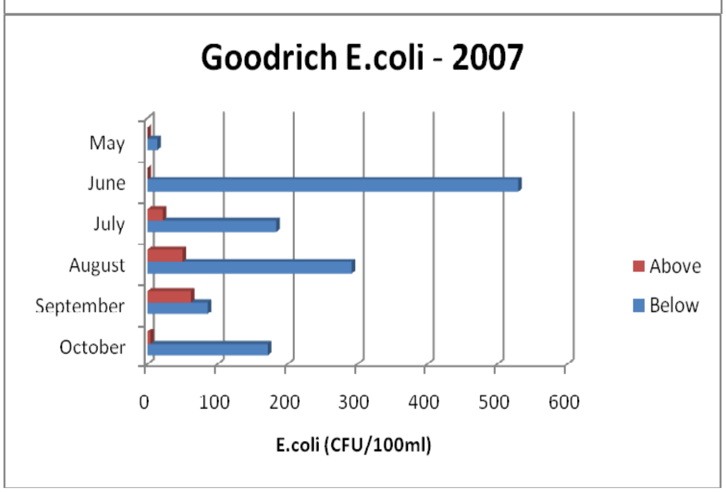
Turbidity and TSS

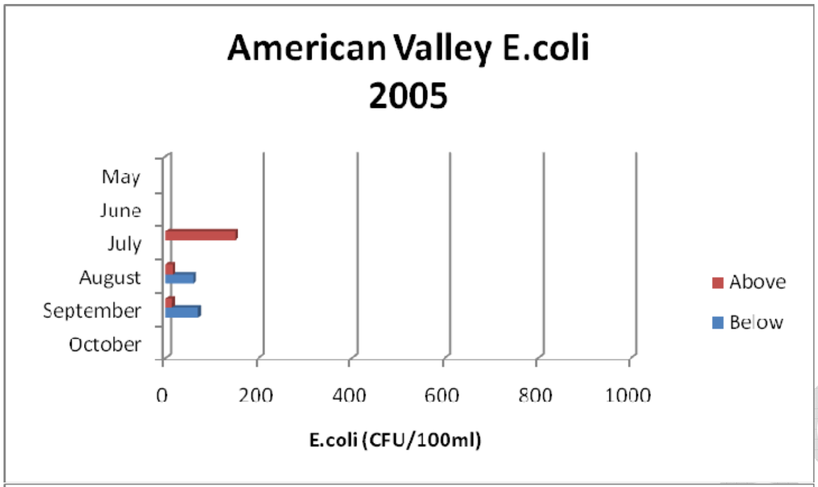
While turbidity (measure of water clarity) and TSS are not direct measures of sediment, in this study they served as proxies for sediment transport in the UFRW given their sediment components. Turbidity and TSS levels followed similar patterns with high spring flows delivering valley sediments to streams. American and Indian Valley 2006 and 2007 loads revealed the valleys did not act as a sink for sediments as in Sierra Valley and Goodrich Creek, but rather served as sediment sources. Sediment levels leaving the two valleys were greater than those entering. Sediment levels likely reflect the variance in valley morphology and function as discussed earlier. It is possible irrigated agriculture is a contributing component to the relative increased sediment loads observed. Additional monitoring targeted at identifying the effects of management practices, may provide further insight into the specific effects of irrigated agriculture on sediment loads at a valley scale.

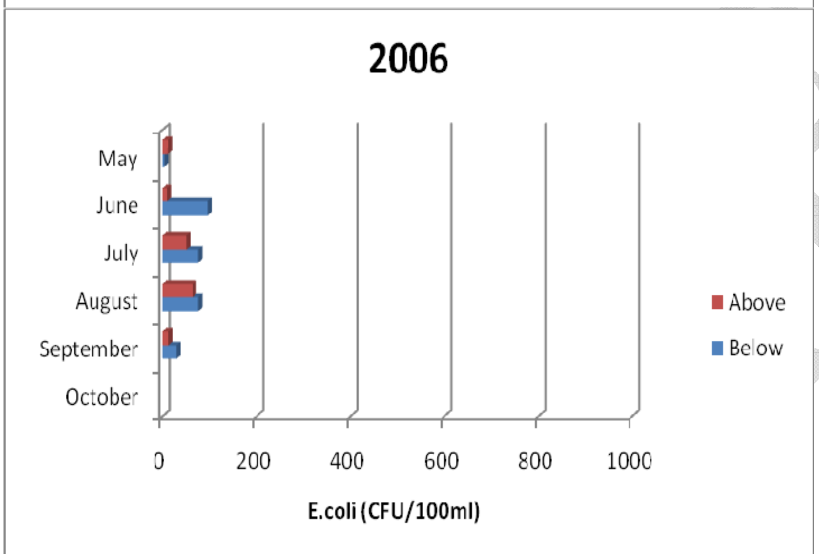
pH
pH is a measure of the acidity or alkalinity and EC is correlated with solute concentrations in the water. To meet the state standard, pH must range between 6.5 and 8.5 and EC must be ≤150 uS/m. The Sierra Valley outlet site experienced a first pH exceedance in late September of 2006. In 2007 and 2008, the valley outlet exceeded the pH standard continuously from the beginning of July through October. The lower precipitation, runoff, and flows of 2007 and 2008 were likely a major factor. In American and Indian Valleys exceedances were rare and along Goodrich Creek, nonexistent.

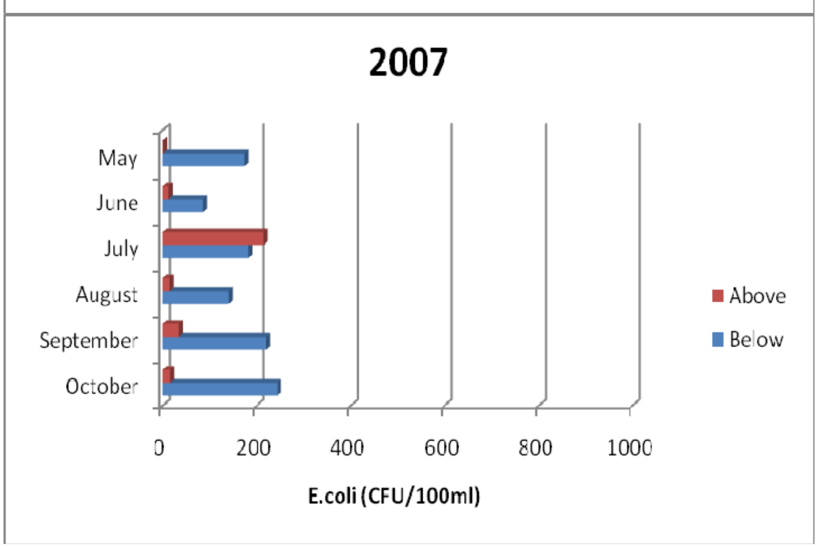
E. coli (graphs below)
While commensurate *E.coli* concentrations are not necessarily an appropriate indicator of the pathogenic *E.coli* harmful to humans, waters of the UFRW are required to meet the state and federal standard for contact recreation (≤ 235 cfu/100ml) nonetheless. Sites above and below major irrigated agriculture exceeded the *E.coli* standard throughout the monitoring season in Sierra and American Valleys in 2006 and 2007. Indian Valley and Goodrich creek experienced limited exceedances only in 2007 and 2008. A special study was conducted in 2007 and 2008 in Sierra, American, and Indian Valleys to gain insight into the effects of livestock management on *E.coli* levels. Monitoring revealed management practices targeted at reducing manure input (fencing, irrigation timing, management of tailwater, etc.) successfully reduced downstream *E.coli* levels.

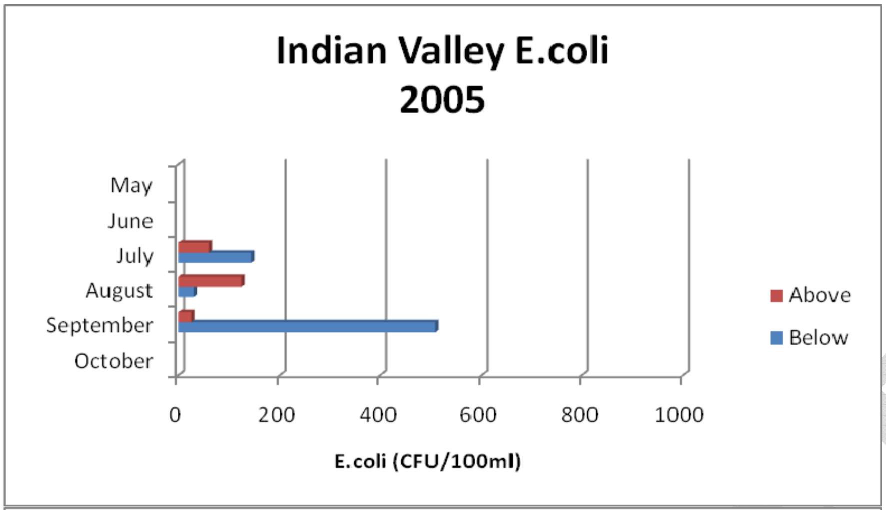


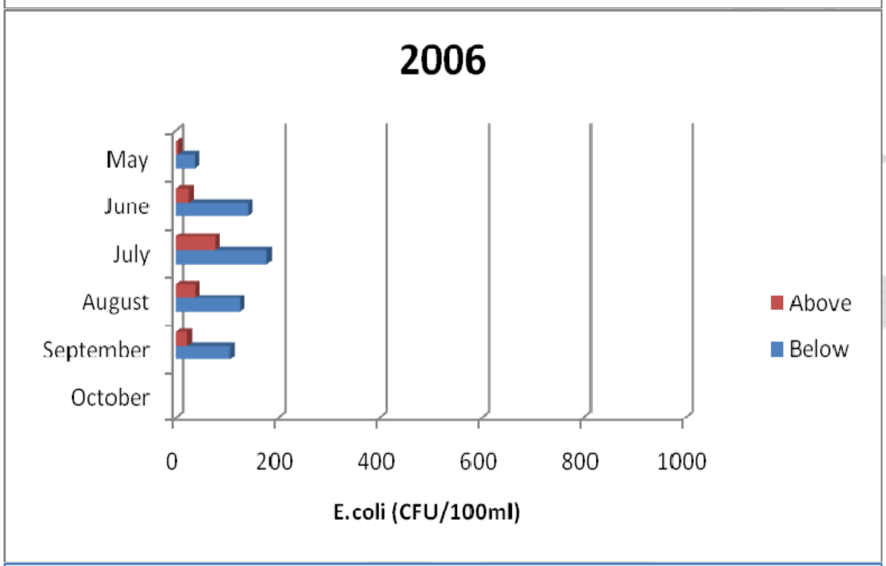


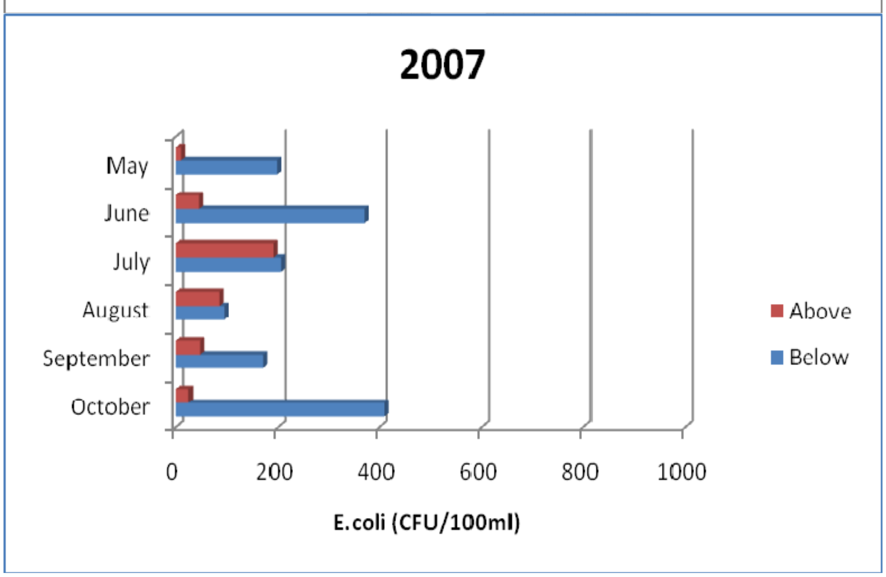

American Valley E.coli
2005
May
June
July
August
September
October
0
200
400
600
800
1000
E.coli (CFU/100ml)
Above
Below

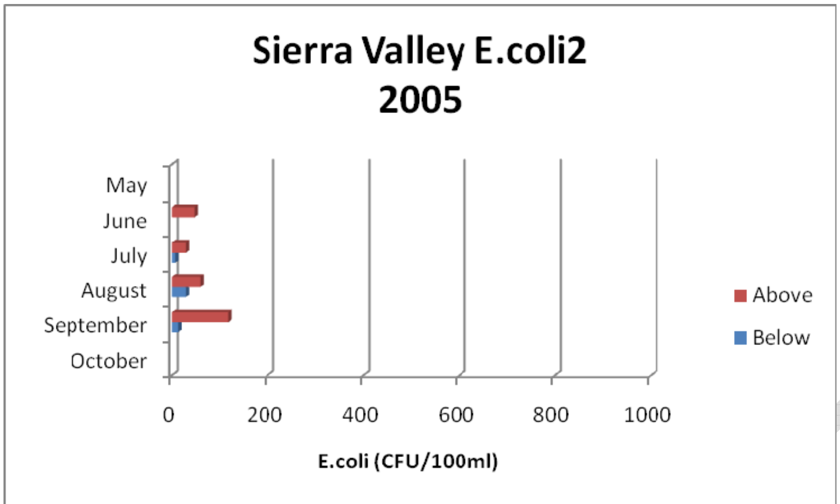

2006
May
June
July
August
September
October
0
200
400
600
800
1000
E.coli (CFU/100ml)
Above
Below

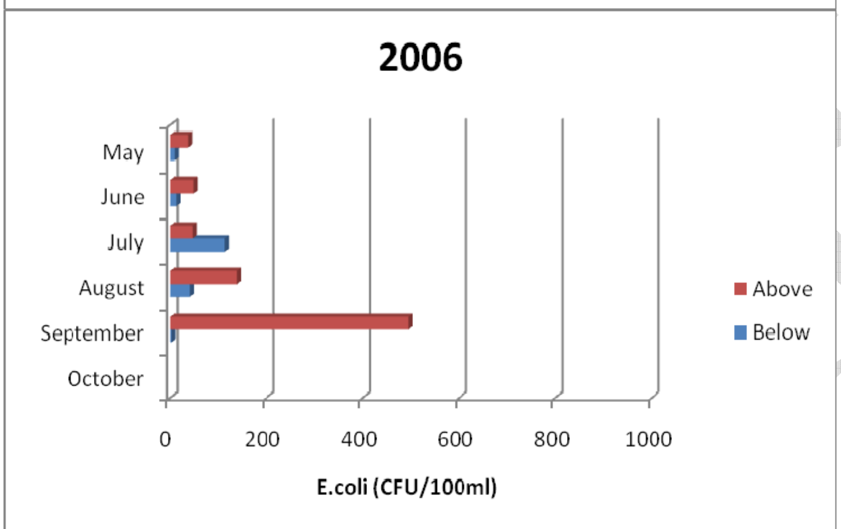

2007
May
June
July
August
September
October
0
200
400
600
800
1000
E.coli (CFU/100ml)
Above
Below


Indian Valley E.coli
2005
May
June
July
August
September
October
0
200
400
600
800
1000
E.coli (CFU/100ml)
Above
Below


2006
May
June
July
August
September
October
0
200
400
600
800
1000
E.coli (CFU/100ml)
Above
Below


2007
May
June
July
August
September
October
0
200
400
600
800
1000
E.coli (CFU/100ml)
Above
Below


Sierra Valley E.coli2
2005
May
June
July
August
September
October
0
200
400
600
800
1000
E.coli (CFU/100ml)
Above
Below


2006
May
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October
0
200
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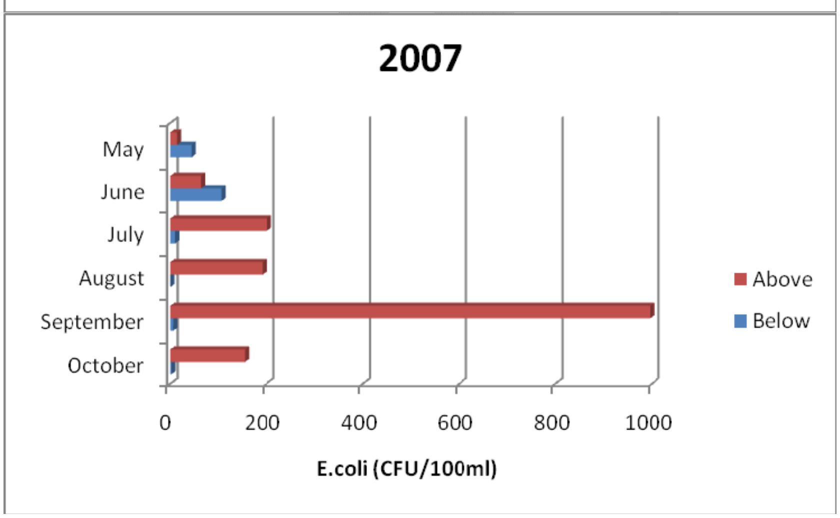
E.coli (CFU/100ml)
Above
Below


2007
May
June
July
August
September
October
0
200
400
600
800
1000
E.coli (CFU/100ml)
Above
Below

Metals and Toxicity

Although the issue of toxicity from various agricultural chemicals has been documented as a serious problem in California waterways, we did not expect to find toxicity due to agricultural chemicals because so few are applied in the UFRW. Toxicity results supported this notion.

Major industrial activity with potential to contribute high loads of trace metals to waters of the UFRW are limited, yet historic mining activities have left a legacy of mercury in parts of the watershed. Additionally, bedrock and soils can be responsible for high levels of trace metals. Metals analyses revealed concentrations well below recommended maximum values.

Macro-Invertebrate Monitoring

Table 3. Two year summary (2006-07) of macro-invertebrate sampling at 18 sites above and below irrigated agriculture in the UFRW.

	TAXA RICHNESS	DIVERSITY	% EPT	% TOLERANT	% INTOLERANT
SITES					
SIERRA VALLEY					
Above	22	1.97	52	8	33
Below	19	2.01	39	24	3
INDIAN VALLEY					
Above	25	2.34	57	8	27
Below	17	2.09	32	25	9
AMERICAN VALLEY					
Above	34	2.52	54	9	35
Below	27	2.38	37	12	20
GOODRICH CREEK					
Above	34	2.74	51	13	39
Below	26	2.42	56	9	25

Conclusions

Irrigated agricultural operators in the UFRW are interested and concerned about the impacts of their management on water quality. Based on the monitoring done in the Upper Feather River Watershed, there appears to be limited water quality concerns related to management of irrigated agriculture. *E. coli* is the main constituent in this watershed that management can impact. Limited resources from federal, state and private entities need to be focused on implementation of on-the-ground management measures to mitigate direct direct livestock access to waterways and where possible, minimize tailwater return from pastures where livestock are actively grazing.

A STUDY OF DISSOLVED OXYGEN DRIVERS WITHIN STREAMS OF THE UPPER FEATHER RIVER WATERSHED
(*Draft 6/10/2010*)

➢ DISSOLVED OXYGEN (DO):
Dissolved oxygen refers to the amount of gaseous oxygen (O2) dissolved in aqueous solution. For the Upper Feather River Watershed (UFRW), a California State designated coldwater fishery, DO must fall within the standard of 7mg/L or greater.

➢ SOURCES:
Diffusion from Air
Aeration
Product of Photosynthesis
Microbial Activity

➢ POTENTIAL DRIVERS:
Biological
- Aquatic Vegetation
- Microbial Activity

Physical
- Water Temperature
- Elevation (Atmospheric Pressure)
- Nutrient Levels (N, P, C)
- Groundwater Loss/Influx
- Water Flow, Turbulence

➢ DISSOLVED OXYGEN IN THE UPPER FEATHER RIVER WATERSHED:
Repeated exceedences in DO levels identified during ambient water quality monitoring in 2006 and 2007 at three valley outlets in the UFRW triggered a special study to examine sources and potential drivers of DO.

Study Methods
In 2008, from June-September, the three valley outlets and other additional sites of interest were monitored monthly over one 24-hour period. Measurements of air and water temperature, DO (mg/L & % Sat), pH, EC, and flow were collected *in situ* along with the collection of a one liter grab sample. Samples were delivered to the Tate lab at UC Davis and analyses were conducted for turbidity, TSS, pH, EC, DOC, N, and P. Aquatic vegetation species presence and coverage data were also collected in the field.

Field Measurements: 24-hour period (7AM, 10AM, 1PM, 4PM, 7AM)
- Sierra Valley Outlet – Middle Fork Feather River
- American Valley Outlet – Spanish Creek
- Indian Valley Outlet – Indian Creek + 2 sites downstream (turbulence effects)

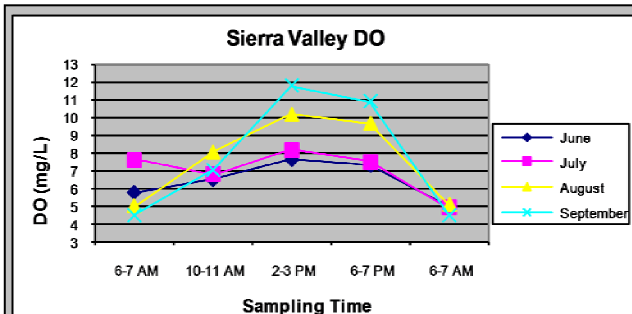
Field Measurements: 3 valley outlets + additional sites
- Air and Water Temp, DO (mg/L & % Sat), pH, EC, Flow, Aquatic Vegetation

Water Sample Lab Analyses: - 3 valley outlets
- Turbidity, TSS, pH, EC, DOC, Nutrients (N, P, C)

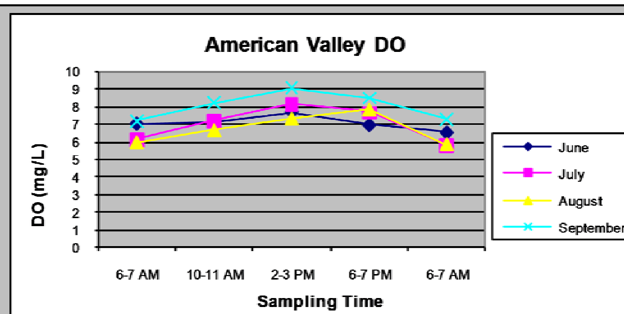
-

Field and Lab Results

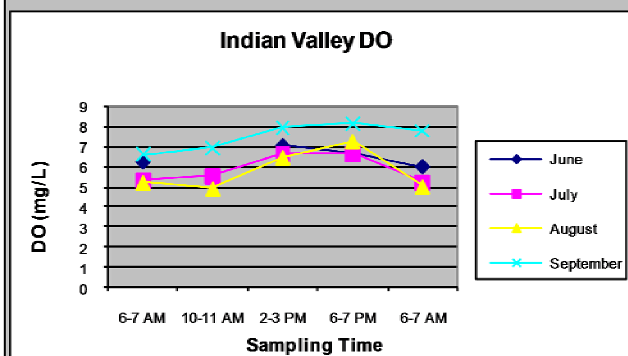
Monitoring revealed substantial diurnal fluctuations in DO levels at all sites (Figure 1). Lab analyses revealed most constituents to either be below detection levels or within the standard limits. TSS levels, however were somewhat high.



Month	Turbidity (ntu)	pH	EC (uS/cm)	TSS (mg/L)	NH4 (ppm)	NO3 (ppm)	Total N (ppm)	PO4 (ppm)	Total P (ppm)	DOC (ppm)
June	6.46	7.67	161.00	13.53	0.04	0.00	1.09	0.03	0.07	16.71
July	6.39	7.54	190.00	11.18	0.02	0.01	0.68	0.03	0.05	9.66
August	8.52	7.77	193.00	17.00	0.04	0.01	0.65	0.00	0.04	9.29
September	8.36	7.93	195.00	12.35	0.02	0.01	0.54	0.00	0.02	8.86



Month	Turbidity (ntu)	pH	EC (uS/cm)	TSS (mg/L)	NH4 (ppm)	NO3 (ppm)	Total N (ppm)	PO4 (ppm)	Total P (ppm)	DOC (ppm)
June	5.13	7.50	119.00	12.35	0.01	0.01	0.24	0.02	0.05	2.16
July	8.86	7.26	169.00	21.76	0.01	0.01	0.54	0.02	0.05	1.73
August	12.60	7.27	167.00	35.80	0.03	0.01	0.16	0.01	0.06	2.23
September	13.70	7.46	202.00	22.50	0.02	0.01	0.16	0.01	0.05	2.77



Month	Turbidity (ntu)	pH	EC (uS/cm)	TSS (mg/L)	NH4 (ppm)	NO3 (ppm)	Total N (ppm)	PO4 (ppm)	Total P (ppm)	DOC (ppm)
June	2.24	7.70	101.00	2.35	0.01	0.04	0.19	0.00	0.02	1.52
July	5.15	7.48	139.00	6.47	0.01	0.07	0.06	0.01	0.00	0.96
August	3.77	7.28	137.00	10.00	0.02	0.04	0.07	0.00	0.00	1.31
September	7.70	7.77	149.00	10.00	0.01	0.02	0.01	0.00	0.01	1.06

Figure 1. Graphs displaying diurnal swings in DO at three valley outlets. Photos of study sites, and tables listing lab analysis results. Red numbers indicate measurements below detection levels - standardized to 0.005 (N) or 0.0025 (P) for graphical purpose.

Discussion

The relationship between water temperature, DO (mg/L) and elevation for UFRW sites revealed, once temperatures exceed 74°F, it is impossible for DO levels to rise above 7mg/L unless there is oxygen generation occurring (Figure 2).

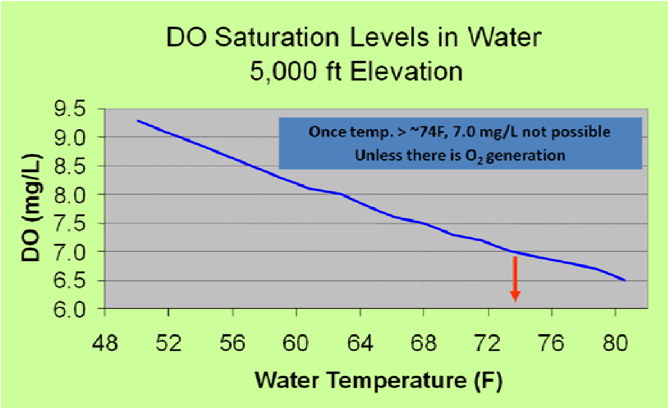


Figure 2. Relationship between water temperature, DO (mg/L), and elevation for UFRW sites.

DO was measured at levels beyond 100% saturation suggesting aquatic vegetation was providing additional oxygen input (Figure 3). Aquatic vegetation coverage assessments, however, did not appear to correlate with DO levels throughout the season. Therefore, it is possible there were other less visible drivers at hand.

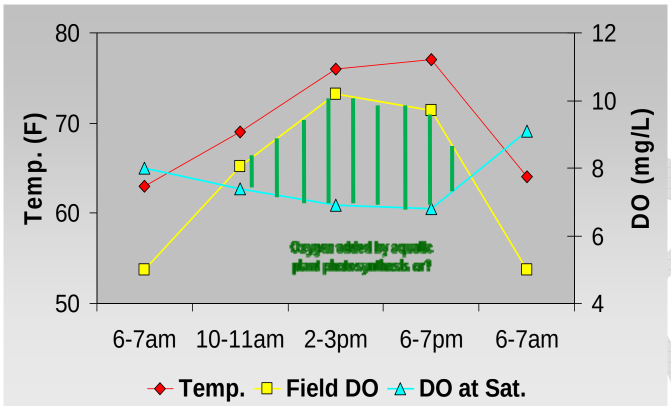
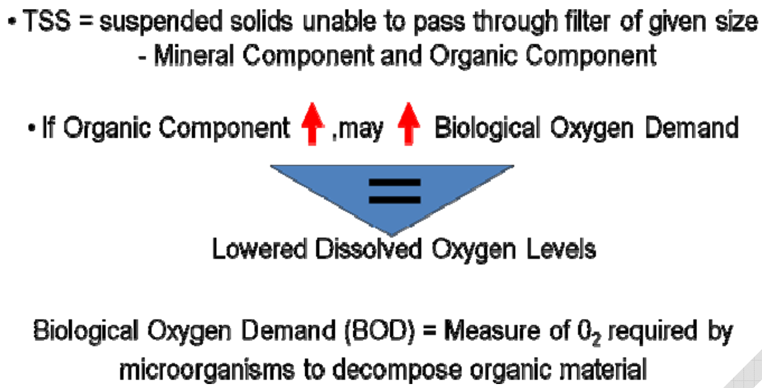


Figure 3. In situ DO (mg/L) measurements for Sierra Valley in August, 2008 in relation to water temperature and known DO saturation relationships.

Conclusions

- Nutrient analyses of N and P in three irrigated agricultural valleys were found to be insignificant and therefore not contributing to excessive aquatic vegetation growth.
- Lab results revealed TSS at levels that could potentially be driving biological oxygen demand and therefore contributing to diurnal DO swings. TSS components (mineral and organic) will be further explored.

ATTACHMENT C.3.



- Known relationships between elevation, water temperature, and oxygen saturation levels applied to the UFRW parameters suggested water temperature must drop considerably during summer months for DO levels to meet the CA State standard of 7mg/L for cold water fisheries. Such a measureable drop in temperature may not be attainable in the near future given present watershed condition and appropriated land uses.
- Aquatic vegetation likely influenced DO levels, however correlation was limited suggesting the presence of other influential drivers.
- Sites monitored below the Indian Valley outlet provided an opportunity to examine the effect of turbulence on DO levels. Turbulence did not always increase DO levels.

For additional project information please visit:
http://groups.ucanr.org/Ag_Water_Quality/

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