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FINAL DRAFT

THE POTENTIAL FOR UPPER WATERSHED REHABILITATION TO AMELIORATE OR MITIGATE IMPAIRMENTS TO COLD WATER STREAM TEMPERATURES AND COLD WATER FISHERIES IN THE MAINSTEM OF THE NORTH FORK OF THE FEATHER RIVER.

Leah Wills
With additions by Bob Orange, May 25 2005

EXECUTIVE SUMMARY

Cooling of summer water temperatures is a reasonably achievable outcome from successful stream rehabilitation in the East Branch of the North Fork of the Feather River (EBNFFR). As much as 8-10° F cooling of stream waters near or at the bottoms of 3 or more foot deep pools, that are overhung at least 25%, by riparian vegetation in low width stream segments is possible. Using current technology and knowledge, this outcome is achievable within 10 years,.

Reconnecting restored stream channels to re-watered floodplains would increase groundwater inputs to summer baseflows, Increased groundwater could cool summer stream temperatures more than 8-10°F.

Coldwater fisheries and warm water fisheries have always co-existed in the Feather River watershed. The EBNFFR can be restored to support extensive rather than exclusive coldwater fish habitat. It is possible, we believe, to bring alluvial valley and canyon streams in Plumas County much closer to their historic trout habitat potential. Every foot of the EBNFFR may not always meet 20°C at the water surface during peak summer heating periods. But a coldwater fishery may thrive with the development of connective system of coldwater refugia areas, where the temperature standard is met at the bottom end and edges of the water column, even if it is being exceeded at the stream surface during peak heating periods.

It becomes apparent from the sheer magnitude of past work, that restoring the EBNFFR watershed is more of a déjà vu, a "back to the future" concept, than something brand new. Plumas County, PG&E, DWR, California Department of Fish and Game, the Plumas National Forest, and the State Water Resources Control Board, have all been engaged in watershed improvements in the Feather River watershed for decades now. We have the necessary foundation in terms of working relationships and internal capacity, to move forward.

The Plumas County Flood Control and Water Conservation District (PCFC&WCD) in cooperation with districts and other groups already active in the watershed, has the capacity to implement cold water fishery and water quality studies and improvement projects throughout the EBNFFR. Moving forward with refining this alternative further could include the following actions:

- <u>Develop a central data archive.</u> $10 k
- <u>Design and conduct ~~restudies~~ evaluations of selected stream restoration projects.</u>
- <u>Develop a better understanding of temperature dynamics in the Moccasin reef area.</u>
- <u>Seed and support pilot projects</u>.
- Bob Orange recommendation

The authors would like to thank the 2105SG, the ERC and the 2105LG for the opportunity to take a closer look at this alternative from a local perspective. Our short investigation has confirmed that many, many Plumas County residents see water as one of the area's most important and valuable natural assets. Decades of watershed improvements in Plumas County-by the both the public and the private sectors- on both public and private lands- indicates a strong local commitment to the long-term stewardship of the forests and waters of the Feather River watershed.

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Completing the last 9 miles of the Last Chance Creek project (to the Doyle Crossing gage) would provide the opportunity to document temperature and fishery benefits from the 20 miles of upstream riverine and floodplain restoration above the Doyle Crossing gage. The Doyle Crossing gage regularly records surface stream temperatures in excess of 70˚F. and even 80˚F during June, July and August. (SWRCB/FR CRM, 2004:13) Monitoring/modeling needs for all 19 miles of Last Chance Creek above Doyle Crossing for 5 years would be $500,000. (Mink)

(4) Provide current fishery and water temperature monitoring data.

Water quality and fishery monitoring data has been collected by the FRCRM at 21 sites for the years 2001, 2002, and 2003 and is available on the web @ www.Feather-River-CRM.org and in a document named "Final Report for the Feather River Coordinated Resource Management Watershed Monitoring Program" (SWRCB Agreement #00-115-150-0).

Twelve (12) monitoring sites, (approximately 1000 ft. long stream segments) are located in the EBNFFR. Of these 12 sites, 10 have continuous temperature recorders installed during the summer months. The ENNFFR sites include, the confluence of the EBNFFR with the NFFR (#6), the confluence of Spanish and Indian Creeks (#13&#17), the confluence of Spanish and Greenhorn Creeks (#15&#16), the confluence of Rock and Spanish Creeks (#14), Wolf Creek near the confluence of Wolf and Indian Creeks (#7), the confluence of Lights and Indian Creeks (#8), Indian Creek @ Taylorsville (#12), Indian Creek @ the confluence of Red Clover Creek (#11), the confluence of Red Clover and Last Chance Creeks (#9&#10).

Annual stream flow and temperature measurements were taken at the following locations: Doyle crossing, Notson bridge, Indian and Red Clover confluence, Flournoy bridge, Taylorsville bridge, Deadfall bridge, Greenville Main Street bridge, Crescent Mills, Spanish Creek @ Keddie, and Spanish Creek @ Gasner bridge.

Continuous recording stations (CRS) are located at Gansner Bridge (Spanish Creek), Greenville Main Street Bridge (Wolf Creek), Lights Creek @ Deadfall Bridge, Taylorsville and Flournoy Bridges (Indian Creek), Indian Creek @ the DWR weir above Red Clover, Red Clover Creek @ Notson Bridge, and at Doyle Crossing (Last Chance Creek).

The 3-year (2001, 2002, and 2003) ambient water quality monitoring program used the SCI (Stream Classification Inventory) protocol. The SCI protocol is important for comparisons with USFS data, and for correlation of water temperatures with other parameters such as stream width and substrates, etc. The SCI analytic approach relies on congruence between a number of parameters to indicate stream condition trends. This approach also helps verify the accuracy of temperature measurements. Where temperature data seem incongruous with other measures, temperature recording equipment can be rechecked. Confounding factors or other reasons for the anomaly can be identified.

Because the area around the Arlington Bridge is bedrock, the SCI protocol precluded a continuous recording station from being established there. Difficulties affecting gages at the Flournoy and Taylorsville Bridges makes temperature comparisons in Indian Creek and its tributaries problematic without more years of data. (FR CRM/SWRCB, 2004:P17)

What do three years of data tell us?

Flows declined from 1999 to 2001. Precipitation increased from 2001 to 2003 as did fish biomass. A prolonged spring runoff and a rapid drop characterized 2003 in stage in mid summer. Precipitation was about 99% of normal in 1999, 101% of normal in 2000, 56% of normal in 2001, 77% of normal precipitation for 2002 and about 111% of normal precipitation for water year 2003. (FR CRM/SWRCB, 2004:10)

Stream temperatures cook in the summer.

The FR CRM stream temperature monitoring data from June through September of 2001 and 2003, reports surface stream temperatures well above 20˚C during June, July and August. For example, an 83.7˚F reading was recorded in the EBNFFR above the NFFR in 2003. A maximum temperature of 80˚F was recorded in Indian Creek at the Dawn Institute in 2003. A 78˚F peak surface water temperature was recorded in Spanish Creek above Indian in 2003, and in Wolf Creek in Greenville in 2001. 87.3˚F was the maximum temperature in Lights Creek in 2001.

Temperatures fluctuated by around 20˚ F from day to night. Water temperatures were, on the average, 3 to 10 degrees cooler than air temperatures during hot spells. Hot spells lasted for over a week with water temperatures rising throughout hot periods. Lights Creek, the hottest part of the EBNFFR in 2001, reported reaching average daily surface stream temperatures of 75˚F+ 4 times, 74˚F+ 3 times, 73˚F+ 8 times, 72˚F+ 10 times, 71˚F+ 17 times, 69˚F+ 8 times and 68˚F+ 13 times.

From the data presented so far, the Spanish Creek branch of the EBNFFR appears to consistently be between 5˚ to 10˚ cooler during peak heating periods than the Indian Creek branch of the EBNFFR

More years of data are needed to draw conclusions from stream temperature data, especially where the other parameters provide data that is "ambiguous" for interpreting water quality and aquatic habitat trends. (Mink,)

Ambient monitoring is not correlated with project monitoring because correlating project stream temperatures with ambient water temperatures was not the purpose of the ambient water quality monitoring program.

Project-level temperature and fishery data, is usually limited (by funding constraints) to a single year or two of pre- and post- project monitoring. This data is usually found in reports or archives for individual projects. Much of the watershed project monitoring information is not currently compiled in one easily accessible place such as a central archive or website-again due to funding limitations. The FRCRM has done as much as has been possible to post FR CRM project monitoring data on their website. (www.Feather-River-CRM.org). Some watershed project monitoring information is available on the Plumas National Forest (PNF) website under the Herger -Feinstein Quincy Library Group Forest Recovery Act Pilot Project Status Report to Congress Fiscal Year 2003. The PNF website is (www.fs.fed.us/r5/snfpa).

For some projects it may be worthwhile to locate and examine archived data (e.g. data that is neither published, nor on a website). In other cases, it might be worthwhile to recollect fishery and water quality data in order to take a better and longer look at post-project trends. Water temperature information is limited to surface water temperatures. Heating accumulation by stream reach is difficult to determine. The report concludes that *"the ambiguous results in many parameters made it difficult to rank the sites by temperature impairment...If one were to set objectives of a 7 day average of no greater than 66˚F, and an absolute max no greater than 75˚F, (both of which are conducive to trout production), then most monitoring sites do not meet these objectives. The six sites that do or nearly meet these objectives are: NFFR above Lake Almanor, NFFR above the EBNFFR, Butt Creek, Red Clover at Drum, Indian above Red Clover, and Jamison Creek.... All but six monitoring sites had temperature regimes that were not conducive to cold water fisheries...No salmonids were detected in Wolf, Lights and Last Chance Creeks* [at sampling locations, though trout are present in these systems. Sampling sites at Bridges are affected by bridge maintenance requirements. (Wilcox)] *...Spanish Creek was generally in better temperature condition than Indian Creek in 2001 and 2003."* (FR CRM/SWRCB, 2004:11-16).

In the "Next Steps" section of this report we suggest further refinements to the temperature and fishery data collection and evaluation process. As an example of how existing data might be presented more clearly to answer Question #4, please see Appendix A-2.

(5) Provide information on stream miles rehabilitated in the FR watershed.

Approximately 16 miles (Wilcox).

(6) Provide information on stream miles degraded in the FR watershed.

Approximately 100 degraded stream miles (Benoit) and 200,000 degraded acres of meadows (Wilcox).

(7) Propose a methodology for extrapolation to the whole watershed of current information.

Information now considered important is unavailable from project level monitoring and for watershed ambient monitoring, as it is currently designed and implemented. For example, pool temperature profiles and water temperatures at tributary confluences are not available. Surface water temperature readings are not always correlated with air temperature readings. Surface water temperatures are not often correlated with solar aspect (solar radiation) and stream cover (solar interception). Temperature readings are correlated with flow at permanent stations, and intermittently elsewhere.

More research is needed to correlate surface stream temperatures with stream bottom temperatures. More research is needed to correlate surface stream temperatures and stream bottom temperatures with groundwater and tributary contributions to summer stream flows and stream temperatures.

FR CRM research is currently focused in the Last Chance Creek subwatershed of the EBNFFR, where a nine-mile, 4000 acre watershed restoration project was installed in 2002, and where the next ten miles will be treated in 2007 if funding becomes available. (Mink).

The UC Davis WHEY linked surface and groundwater watershed model is being applied to and calibrated in the Last Chance Creek watershed. Preliminary results should be available by summer of 2005. *"The WHEY model has the capability of detailing the makeup of the outflow hydrograph into its different components (i.e. groundwater direct channel precipitation, subsurface streamflow, surface runoff, etc."* (Mink).

A companion pilot study by Stanford University, (Loheide) in the Last Chance Creek watershed, which will be completed in 2006, will test the application of infrared photo technology to documenting relationships between groundwater levels and groundwater temperatures to stream water temperatures. Groundwater levels, overlying vegetative composition and vegetative evapotranspiration rates will also be correlated to stream flows and stream temperatures. Both modeling studies rely on intensive field monitoring and calibration of field data with modeling results for modeling validation over the next two years.

A key component of field monitoring will be identifying the sources for baseflows in streams especially at peak heating periods. For example, in the Charles Creek reach of last Chance Creek, preliminary results from analyzing stream chemistry indicate that the groundwater contribution into Last Chance Creek from one streambank is from a different groundwater source than the water flowing into Jordan Creek from the opposite streambank. (Bohm)

This stream chemistry data offers the most preliminary glimpse at the potential groundwater contribution that the 94% of the upland forest landscape could be making to the 6% of the watershed's area that is covered by rivers, lakes, and meadows. (Wilcox-Bohm)

Over 20 years, the FR CRM has evolved towards a riparian and aquatic restoration strategy that seeks to improve groundwater retention in the floodplains adjoining streams in order to enhance groundwater recharge into stream waters during peak heating periods.

Stream channel narrowing associated with increased pool and riffle development and denser and taller riparian cover along and over streams, retains the cooling effects of groundwater infiltration in pools and riffle gravels, even during peak heating periods. The FR CRM has developed a conceptual model of groundwater and surface water interactions and has initiated the three-part research program, summarized above, in the LCCDP to test hypotheses relating to the attached conceptual model. See Appendix A-4 and the conceptual model (Appendix A-2)

There is extensive literature on groundwater effects on baseflows and fishery habitat. (Ponce, 1989 and SCS, 1993. (See Appendix A-3)

After pilot testing and calibration, the WHEY model combined with water chemistry analysis, infrared photographic trend monitoring, and focused field monitoring; should become a scientifically rigorous set of tools for extrapolating from project level treatments and monitoring to larger sub-watershed and watershed scales.

(8) Provide information on repair and maintenance costs.

About 5% of construction costs (in unconfined systems) up to 15% of construction costs in confined system should be retained for repair and maintenance, especially for the first 10 years of the projects' life. (Wilcox)

(9) Document the July and August benefits of projects for cold water fisheries and 20° C water

After the winter precipitation and runoff season ends, surface water flow derives almost entirely (80%or more) from groundwater and tributary flows (Benoit). In healthy systems, fully recharged groundwater aquifers feed surface flows throughout the summer. Some models estimate that shallow meadows completely drain groundwater into streams each year or each 2 or three years, depending on the previous year's precipitation (Loheide). Mature riparian and aquatic vegetation, and defined and self maintaining pools and riffles (ideally at a 1:1 ratio), maintain cooler stream temperatures and provide cold water refugia for fish, even during prolonged peak heating spells during the four to five month summer droughts that are common to this watershed. For example, the "Indian Creek Watershed Study" (SCS1993: 37-38) predicts a 2.3°F reduction in summer stream temperatures from a 25% increase in riparian shading and a 3.9°F decrease in summer stream temperatures from a combination of 25% increase in riparian cover and a 50% decrease in stream width in Indian and Genesee valleys. Other studies have documented 4 or more degrees F cooler water in stream pool bottoms (Kavvas). A possible outcome from successful stream rehabilitation could be as much as 8-10° F cooling of stream waters at the bottoms of 3 or more foot deep pools overhung by at least 25% riparian vegetation. This outcome would be achievable within 10 years, depending on vegetation recovery and vegetative management practices.

Reconnecting restored stream channels to re-watered floodplains would add longer influxes of 50°+F groundwater to summer baseflows, with an unknown but potentially significant additional stream cooling.

(10) Develop information on the incremental benefits over time from rehabilitation treatments such as livestock exclusion, streamside re-vegetation, meadow re-watering, etc. (Also, see the discussion of the Genesee Valley pilot project, Appendix A-4)

FR-CRM's project costs per mile range from around $3000/mile for seasonal stream corridor fencing, to over $500,000/mile for pond and plug treatments that rewater and reconnect floodplains to reconstructed and revegetated, narrow, deep, stream channels. (Wilcox).

(11) When can the expected benefits be fully realized under the best and worst of circumstances?

In the best of circumstances, benefits can be fully realized in three (3) to five (5) years in meadow re-watering projects -e.g. "unconfined" systems. In the best of circumstances, benefits can be fully realized in up to eight (8) to ten (10) years in "confined" –e.g. incised channel systems (Wilcox, Benoit)

The duration of benefits is probably up to a 45 year magnitude flood event for mature projects in confined systems and may be up to a 75 year or greater magnitude flood event for mature projects in unconfined systems. The timing of benefits and costs is most dependent on the time interval between project implementation and the next peak flood event and whether the treated stream is entrenched or unconfined. A 100 year flood occurring in the first runoff season after the installation of a project in a confined system creates an almost 100% risk of significant damage because vegetation has not had enough time to become established. Unconfined systems, due to the energy dispersal of the floodplain, have a much lower (10%-20%) risk of substantial damage from a 100-year flood in the first year after construction. Whether a peak flood event is the last high flow event of a runoff season or the first event in a series of high water events in a season also affects the risks for damages in any year. If a project has the next growing season to recover from the last flood event's damage, there will be less risk of damage from future flood events.

Rehabilitation work in stream systems that are unconnected to their historic floodplains is inherently more risky than work in unconfined stream systems. Entrenched or incised streams, as they are called, carry larger volumes of flood waters within their stream channels rather than spreading higher flood flows across wide floodplains. Concentrating flood flows within a narrower cross-sectional area exponentially increases the erosive force of flood waters. In addition, streambank vegetation in entrenched or incised channels tends to be less vigorous, because incised channels are more isolated from groundwater inflows during the summer growing season, More stream power combined with weaker vegetative protection creates the potential for higher failure risks and longer recovery times for incised streams. The Wolf Creek project in Greenville has demonstrated that vanes are a streambank treatment in confined systems that can withstand flood velocities. (See Appendix A-4 for "before and after" pictures of FR CRM project on Wolf Creek).

Estimated times for achieving project benefits also assumes a rest period from livestock grazing in the project (stream and riparian corridor) area for one to two years pre- and one to two years post- project installation. Thereafter, it is assumed that including controlled periodic grazing where grazing is used as a vegetation management tool can minimize future costs and protect project benefits. (Benoit-Wilcox). The attached Genesee Valley pilot project could provide more definitive answers.

(12) Provide information on groundwater and surface water interactions during peak heating periods.

Only recently has the FR CRM obtained the scientific expertise and technology needed to begin to quantify the effects of increasing surface and groundwater interactions during peak heating periods. Previously, all information on groundwater and surface water interactions has been derived from work with ephemeral streams. Prolonged surface stream flow in an ephemeral stream is an easily observed and measured surrogate indicator for more direct measurements of increased surface and groundwater interactions. Re-watering adjoining meadows has prolonged surface stream flows in ephemeral streams. In some cases, during especially wet years, ephemeral streams have returned to perennial stream flow conditions all summer, after being reconnected with their floodplains. Longer duration base flows in ephemeral streams has allowed more riparian and instream vegetation to develop. FR CRM projects are beginning to generate data that documents that baseflows are prolonged and that mesic vegetation in ephemeral streams is expanding and becoming more vigorous. Unfortunately, ephemeral streams rarely produce stream flows (or fisheries) during peak summer heating periods. Therefore these projects can only indirectly answer questions about groundwater and surface interactions during peak heating periods.

The FR CRM's monitoring of the recently completed Last Chance Creek meadow rewatering and stream rehabilitation project has documented a 10°F reduction in stream temperatures from the top of the project area to the downstream end of the project (4 miles) in June. 2004, the first year after reconstruction in Last Chance Creek (Wilcox). Leslie Mink points out that the temperature increase in monitoring site #3 (in the middle of the project) is probably due to the heating of exposed bedrock in that location. (See Appendix A-4).

The 1994 Big Flat project demonstrated a 30-day extension of perennial flow in ephemeral Cottonwood Creek from groundwater accretion after completion of the project. Groundwater temperatures in the gravels in the rewatered reach were 50°F to a high of 58°F. (Wilcox, Seagraves) The Big Flat Project on one mile of Cottonwood Creek produced a trout increase of 1000 rainbow trout per mile, post-project, from 0 trout per mile, pre-project condition (Mink). This project achieved such dramatic gains in coldwater fishery populations through a combination of habitat and water quality improvements. A low width (2-4')-depth (4'-6') sinuous channel with undercut banks was constructed and the 47 acre adjoining floodplain was re-watered. Groundwater inflow from uplands and the adjoining meadow was reconnected to the stream channel, so that groundwater accretion to the channel was prolonged. Stream temperatures were maintained by the low width-depth ratio for good coldwater trout habitat during a longer period of the summer (Mink). (See Appendix 4 for more information.)

In the "Red Clover Demonstration Project Research Summary Report (1985-1995)", the following information is presented. *"These results show that substantial heating of the stream occurs upstream of the demonstration area. They also show that the ponds were deep enough to provide pockets of water that were considerably cooler .... 20°C was exceeded 71-98% of the days near the surface of the pond (3-foot depth) compared to 0-55% of the days at the bottom (8-foot depth). Exceedance of 22°C near the surface occurred on 31-74% of the days compared to 0-16% at the bottom of the pond."*

(Surface stream temperatures upstream of the project reached 27.5°C and 29.7°C during the same July-August 1989-1993 period. And it is important to note that the ponds were completely unshaded.)

The author's conclude that, *"Lowering water temperatures throughout Red Clover Creek would require substantial channel narrowing and development of riparian cover, possibly in combination with increased base flows from groundwater."* (Seagraves, 1995:8-10)

In the Red Clover Demonstration Project, as in the NFFR, lack of spawning habitat, intense competition for cold water refugia (with non-game fish species), and selective predation (including poaching) are important causes of decreased rainbow trout abundance and reproductive success, along with water temperatures.

Lack of spawning habitat in the Red Clover Project led directly to the current "pond and plug" meadow rewatering design as an alternative to instream check dams. As the preferred way to re-water meadows and to re-connect streams and floodplains, a "pond and plug" restoration treatment, plugs the old gully with fill collected from off-stream pond development. A small narrow sinuous stream channel is allowed to develop, or is reconstructed, on top of the re-watered and pond filled floodplain. In this way pool riffle stream features are reestablished and spawning habitat is enhanced because ponds do not replace free flowing streams, as they do in instream check dam designs. Instead, ponds replace the old gullies. Re-running the Red Clover Project data could provide more definitive answers to questions 1-12.

(13) Include funding and support for enhanced enforcement of fishing regulations and streamline rules for congruity.

During the public comment period for Project 2105, Game Warden Bob Orange (second generation game warden) presented a comprehensive management strategy to address the health and well being of salmonids along with increased surveillance for the protection of the public and energy infrastructure facilities.

In addition to citing the cleaning of trash racks and installation of improved fish passage areas along the railroads and highways, Mr. Orange addressed the issue of poaching. The proposed management should be through the County Fish & Game Commission.

Mr. Orange proposes that PG&E fund on Game warden position full time in Plumas County for the life of this agreement. The primary focus of this position would be enhanced enforcement of the fishing regulation for the waters of FERC 2105. This Warden would serve as enhanced security and public relation contact for recreational users. This should include boat patrol of both Butt and Almanor.

A yearly overtime budget of $50,000 CPI should be included, and a maintenance routine for the cleaning of migration barriers at loggers Flat, Mill Creek and Rich Bar.

NARRATIVE DISCUSSION AND NEXT STEPS

Refining the questions, refining the goal.

Coldwater fisheries and warm water fisheries have always co-existed in the Feather River watershed. The Soil Conservation Service (now called the Natural Resource Conservation Service, NRCS), at the request of the Indian American Valleys RCD (renamed the Feather River RCD) completed a watershed assessment of the Indian and Genesee valleys portions of the Indian Creek watershed in 1993, *"All 50 miles of Indian Creek are listed as having intermediate impairment in the 1992 Water Quality Assessment published by the State Water Resources Control Board...Indian Creek once flowed freely and supported a large fish population along with spawning ground for salmon and steelhead, but it no longer does... The most dominant species in the Genesee and Indian Valleys are the Sacramento suckers and squawfish. Local residents report catching rainbow trout in Indian and Genesee valleys but now these reaches no longer support any trout.... The primary limiting factors for fish (particularly trout) in Indian and Genesee Valley are high water temperatures, streambank vegetation and a low percentage of pools. The high temperatures limit trout production, increase algal growth, elevate bacterial levels, and reduce dissolved oxygen. The wide, shallow and sometimes braided creek also lacks diversity in instream habitat structures such as logs, limbs, root wads, large boulders and deep pools.... Upstream of the Flournoy Bridge, the riparian corridor is relatively healthy. The high quality habitat continues on upstream of Genesee valley to Antelope Lake. (p. 29)...Red Clover and Ward Creeks provide good spawning and rearing habitat for rainbow trout and are important tributaries for recruitment into Indian Creek. (p. 33)... Indian Valley is not conducive to trout habitat and may never have been, though local citizens report catching rainbow trout in the past... "(p. 34)*
It is important to remember that one Maidu Indian name for Indian Creek translates as "sand creek", indicating that a boulder strewn and gravelly streambed may never have been the dominant geomorphic character of Indian Creek in the Genesee and Indian Valleys.

In late 2004, Dave Vogel, a fisheries consultant for the Lake Almanor 2105 Committee, makes a number of interesting observations in his draft report on fishery benefits in the

NFFR, from the proposed Prattville Intake modifications. He points out *"at the upper limit of salmon eggs thermal tolerance, just a degree or two Celsius increase can cause major mortality (e.g. 100% mortality at 16.7°C). ...Temperatures slightly exceeding 25°C would not cause* {adult} *fish mortality, although the conditions would be suboptimal. In fact rainbow trout can tolerate water temperatures as high as 25.5°C for short periods with no mortality."* He goes on to quote a 1973 study. *"Rainbow trout are most successful in habitats of temperatures of 70°F (21°C) or slightly lower, but so long as there is cooler, well oxygenated water into which they can retreat, they can thrive in lakes which warm to well over 70°F (21°C) for long periods in the summer."* (Vogel, 2004:6).

Also, in 2004, Sharon Storer, in the State Water Resources Control Board's (SWRCB) 10-27-04 comments to the Federal Energy Relicensing Commission (FERC) says the following, *"Data provided in the Poe Project First Stage Consultation Package (Table S-9) records water temperature temperatures monitored in the NFFR just upstream of the Poe powerhouse during July and August (1999 and 2000) that exceed a daily mean of 20°C in 110 of 120 days, and monitoring presented in the Poe Application License (December 2003, Appendix E2-3) reports hourly water temperatures climbing as high as 25.6°C in June, 2000. 26°C in July 2003, 24.7°C in August 2003 and 23.4°C in September, 2003, just upstream of the Poe Powerhouse....Optimal temperatures for growth of rainbow trout are generally recognized to be in the range of 15-18°C"* (Storer, 2004:5).

The Feather River meanders west from east of the Sierra Crest through broad valleys and down steep canyons that drop from ridgetop to valley and valley to valley until the Feather reaches the floor of the Sacramento Valley. This canyon-valley topography alternates between trout-dominated canyon and tributary stream reaches with warm-water fishery dominated alluvial valley reaches. It is unlikely that trout production in the alluvial valleys was ever as good as trout production in the canyon reaches. However, through restoration, coldwater fishery habitat can be enhanced beyond what it is today. Restoration provides the opportunity to expand summer refugia for trout in the alluvial valley segments of the EBNFFR through enhancing overstream and instream cover, deepening and increasing pool topography, and through maximizing groundwater accretion.

During the summer, air temperatures in the EBNFFR will be hot or hotter than they have always been. Stream temperatures at or near the stream bottom and under overhanging, vegetated stream banks, maybe restored to a condition of 10 to 20 degree cooler stream temperatures than air temperatures. Alluvial valleys in the EBNFFR can be restored to support extensive rather than exclusive coldwater fish habitat. It is possible, we believe, to bring alluvial valleys in Plumas County much closer to their historic trout habitat potential. This involves refining the question and refining the goal. Every foot of the EBNFFR may never meet the 20°C at the water surface during peak summer heating periods. But a coldwater fishery may thrive with the development of connective system of coldwater refugia areas, where the temperature standard is met at the bottom end and edges of the water column, even if it is being exceeded at the stream surface during peak heating periods.

<u>**Refining "success".**</u>

<u>The upper watershed management alternative (UWA) is either part of a solution that includes:</u>

- Operating Caribou 1 @ 800 cfs and Seneca/Canyon Dam lower gate @ 400 cfs or
- Operating Seneca/ Canyon Dam lower gate@ 400 cfs up to to 600 cfs, while Caribou 1&2 are shut down.
- Cooling towers, piped tributary water, etc.
- Different combinations of different alternatives to the Prattville Intake modification alternative

<u>Success</u> in this context means that upper watershed management improvements in the ENNFFR contribute directly to lowering impaired water temperatures and cold water fish habitat in the mainstem NFFR, including compensating for the complete loss of the cold water fishery and continued seasonal violation of the basin standard in some NFFR between Belden and Poe. Or to state it differently, that a best (faith and science) effort to lower stream temperatures in Indian Valley and just upstream and downstream of Indian Valley will, in combination with other cooling tower and hydroelectric re-operation actions, lower stream temperatures in the NFFR between Belden and Poe to 20˚C during peak summer heating periods.

<u>**Or, The upper watershed management alternative (UWA) is"offsite mitigation" or a "stand alone" solution.**</u>

<u>Success</u> in this context means that we are seeking to mitigate cold water temperature and coldwater fishery impairments in the NFFR at Belden or Poe, by achieving the highest possible cold water and coldwater fishery benefits, wherever we can in the watershed. This means that Indian Valley and the area from the "T" to the "Y" becomes less important than the "biggest bang for buck" water quality and trout enhancement projects that are likely located elsewhere in the watershed. Success in this case would be achieving the best trout habitat and cold water possible by restoring hydrologic function to degraded streams and floodplains in the upper Feather River watershed. Overall improvement in summer water quality and coldwater fisheries in the upper Feather River watershed would compensate by a factor of "X" times for localized impairments in the NFFR between Belden and Poe, at a comparable cost to the Prattville Intake modification alternative.

<u>**Or the UWA is a combination of both, and we develop multiple measures of success.**</u>

<u>**Getting the answers**</u>

- <u>**Develop a central data archive.**</u>

We need to develop a central data archive for watershed temperature and fishery information and for watershed project costs and benefits, by treatment types. This is a

task that the Plumas County Resource Analyst would like to undertake.
See Appendix A-1.

- **<u>Design and conduct restudies of selected old projects.</u>**

We need to update and link monitoring information for the Red Clover Creek and Last Chance Creek, Big Flat, Clarks Creek, Ward Creek, Greenhorn Creek or other FR CRM or PNF or CDF&G projects which have been in place long enough and will encompass contiguous treated areas in the future that are extensive enough to generate meaningful results. See Appendix A-2.

- **Develop a better understanding of temperature dynamics in the Moccasin reef area.**

There are 5 ambient water temperature monitoring sites on Indian Creek in Indian Valley and a downstream site on Indian Creek at the apple orchard at the Dawn Institute near Indian Falls. The apple orchard site is below Moccasin Creek and Dixie Creek and Soda Rock, so we cannot tell if the thermal springs at Soda Rock are heating stream water in that reach (a PG&E concern). We need to determine from the data that we have, if the approximately nine (9) stream miles from the "T" to the "Y" heat cool or "hold" stream temperatures exiting Indian Valley at the Arlington Bridge. See Appendix A-1.

- **Support integrated assessments**

We lack information on flooding and ground water recharge and on streamflow and groundwater interactions in confined stream systems. We lack specific information on water quality and fishery responses to treatments that: increase stream shading, reduce stream widths, develop stable pool riffle relationships characteristic of the geomorphic attributes of the stream segment, Research now underway being undertaken by the FR CRM which have potential to be able to do the water temperature correlations that we need to develop and to extrapolate such correlations and data sets across the whole watershed. These state- of- the- art assessments may help to assure the SWRCB and others that, over time, we will be able to predict costs and benefits from watershed-wide work both locally and downstream at Poe in August. See Appendix A-4

- **Seed and support pilot projects**.

We have been identified: the Sierra Valley flood study, the Genesee Valley trout and water quality enhancement project. The Last Chance Creek Demonstration project, and the Wolf-Round Valley flow augmentation, water quality project as important ways to advance our watershed knowledge and demonstrate successful approaches. See Appendix A-4

Defining success by looking forward, then looking backward.

The following Appendices propose some future actions and projects. The proposed work outlined in Appendices A-1 through A-4 allows us to develop more information on the Upper Watershed Alternative (UWA). Appendix A-5 suggests economic reasons for supporting a locally based watershed management program for the Feather River watershed. It becomes apparent from the proposed work and the past work that this alternative is more of a déjà vu, a "back to the future" concept, than something brand new to Plumas County, PG&E, DWR, California Department of Fish and Game the Plumas National Forest and the State Water Resources Control Board. We have all been engaged in watershed improvements in the Feather River watershed for some time now, and have the necessary foundation in terms of working relationships and internal capacity, to move forward.

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All studies referenced and quoted in this report are available on the FR CRM website @ www.Feather-River-CRM.org (under "publications").

APPENDICES

A-1. Data presentation examples and central data archive proposal
A-2 Updating data on selected projects
A-3 Selected Bibliography
A-4 Pilot project concepts
A-5 Economic considerations

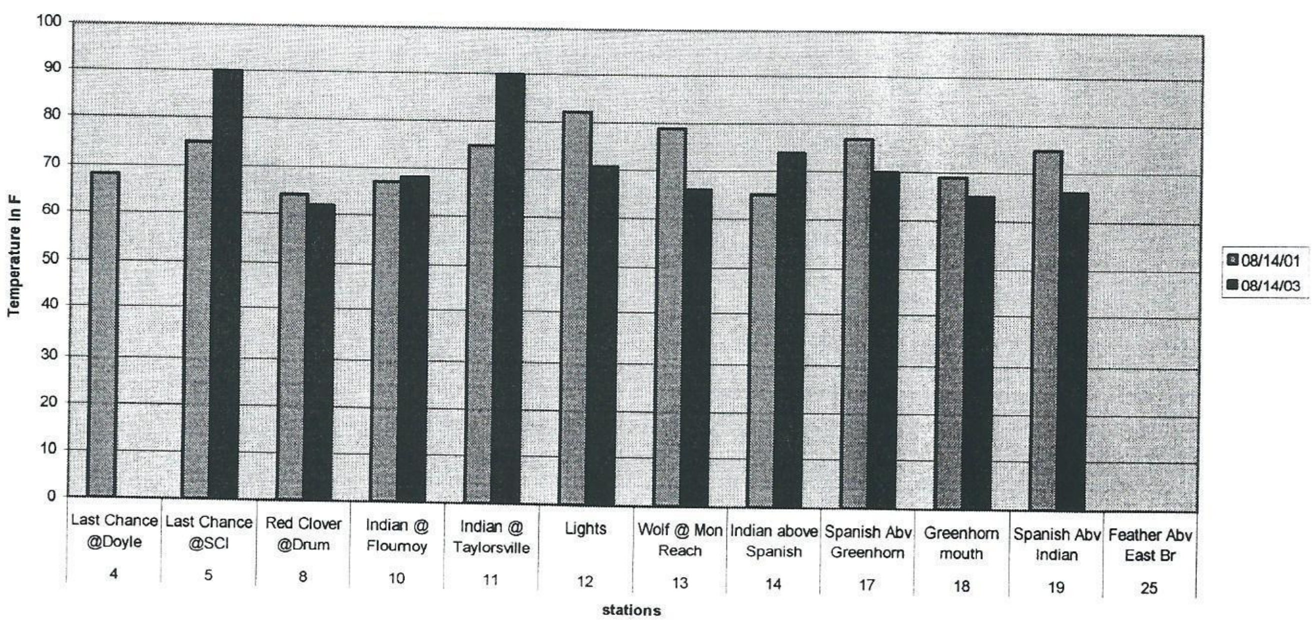
APPENDIX A-1: <u>Data presentation examples and central data archive proposal</u>

It is known that extensive research, analysis and projects have been performed in and around the Feather River Watershed, which is in almost it's entirety located in Plumas County. PG&E, Plumas, Tahoe and Lassen National Forests, California Dept. of Water Resources, Natural Resources Conservation Service, the Feather River Coordinated Resources Management and various volunteer groups have all contributed to a vast array of parameters that could measure, in dollars and productivity, the effects of stream restoration and upper watershed health to downstream waterbodies. However, the disparate and proprietary nature of the data collection and management renders most of the monitoring in the watershed incongruent and useless on a watershed basis.

The following chart represents the type of data available and the applicability of combining reach knowledge into a streamcourse analysis. Addition of other parameters including maximum and minimum air temperatures and stage would provide a meaningful picture to those interested in rating the potential of future watershed projects.

Plumas County proposes to define an end product that would be more useable to researches and project proponents by identifying gaps, retrieving data from various sources and combining resources to identify baseline conditions in the watershed and evaluating watershed management and restoration loosely based on the State CDEC system, applied locally.

Thermal Inputs from Upper Feather River Watershed



Plumas proposes the following scope of work:

• Identify current monitoring plans and applicable Quality assurance project plans	$2,500.00
• Identify watershed management organizations and list of members	500.00
• Establish coordination between various TAC's	500.00
• Identify information to be exchanged and how	750.00
• Continue GIS database coverage Exisiting New information	2,500.00
• Update existing project information and develop rating sheet	2,500.00
• Report to committee, bibliography and next steps	750.00
Estimated budget for preliminary archive	$10,000.00

APPENDIX A-2: Updating data on selected projects

The SWAMP report, the Red Clover Restoration Report and others identify recommendations for future projects within the watershed, including Humbug Creek, a PG&E holding. Assessment by the ERC and others will require easy accessibility to pre and post project data, review of appropriate protocols and discussion of successes and failures.

In an effort to develop a rating system for potential projects within the watershed, identifying what is where, who has it and assigning project costs, it is imperative that Plumas County update all available data on existing projects. Following is a sample report on what is currently available. The most distinguishing feature of this chart is the empty boxes!

[illegible]

Name of Project	Date Completed	Biota	#/mile Trout	Surface H20 temperature	Groundwater temperature
Red Clover Creek Demonstration project	1985-1995[1]	y	y[2]	y	y
Poco Creek	1986/89		Archived info		
Dotta Canyon Project	1988/1990		Archived info		
Noble Red Clover Creek	1990	y		y	
Wolf Creek I,II,III	1989/1993/2002	y	fund	fund	n
Rush Creek & Soda Creek fish ladders	1989/1991	Soda Washed out			
Greenhorn Creek	2002		fund	fund	
Dunn Pasture	1992			fund	
Clarks Creek	2001			N[3]	Y[4]
Bagley Creek Phase II	1996		Archived info		
Black Rock Creek	1996		Archived info		
Hamilton Branch Spill Channel			Archived info		
Benner Creek	1997		Archived info		
Boulder Creek	1997			Hobo temps	
Rowland Creek	1997		Archived info		
The Spanish Creek Vortex	1997		Archived info		

[1] PG&E Red Clover Creek Erosion contol Demonstration Project 1985-1995 Ten Year Research Summary
[2] Longanecker, D.R. and T. H. Sagraves. 1991 Erosion Control Demonstration Project in Red Clover Valley: Fish and Water Quality Study. Report 009.4-9.1
[3] DWR report due out soon
[4] http://www.feather-river-crm.org/projects/clarks/clarks.html

Gravel [illegible] Sampler					
Ward Creek	1999		fund	Kossow	n
Chester Park	2001	no	no	no	no
Haskins Creek	1993	Washed out			
Walker Mine Tailings	1994/1996	Archived info			
Bagley Creek	1993	Archived info			
Red Clover Creek II	1994/1996	y		y	

Project Name	Date Completed	Biota	#/mile Trout	Surface Water Temperature	Groundwater elevations
Big Flat meadow Re-watering	1985[5]		DWR	Flow data	y
Jamison Creek	1995	y	To big	y	n
Poplar Creek	1995		Archived info		
Willow Creek	1996		Archived info		
Little Stony Creek	1996		Archived info		
Stone Dairy	2001				Y: pre & post
Carmen Creek	2001				
Hosselkus Creek	2002		n	n	y
Upper Last Chance Creek	2002	y	Pre-project: fund follow-up	y	Charles Creek wells
North Canyon Creek	2002		Archived info		
Wolf Creek		y		y	
Carmen Creek	2002[6]				
Greenhorn Creek	1996[7]	y		y	fund
Indian Creek	EA 1993	y	y[8]	DWR	

[6] Carmen Creek Watershed Restoration; video
[7] http://www.feather-river-crm.org/publications/studies/spanish/geo8.htm

APPENDIX A-3: Selected Bibliography

(Ponce, SCS IC, RCCDP)

APPENDIX A-4: Pilot project concepts

Pilot Project Summaries:

- ***Last Chance Creek Demonstration Watershed Project*** and short history of the FR CRM . This project answers Question #12 with modeling and monitoring. Complete 9 miles of meadow and stream restoration with integrated modeling and monitoring surface and groundwater interactions component for a total of19 miles of restored channel and floodplain upstream of the Doyle Crossing stream temperature and flow gage. Costs are estimated @ $3.5 million for the rehabilitation work and 1 million for 5 years of monitoring) (See attachment)

- ***Genesee Valley Integrated Resources Management Project (IRMP)*** and short description of the FRLT. This project answers question #10 with monitoring. Project demonstrates riparian and aquatic vegetative response from permanent livestock exclusion from incised floodplain along 2 miles of Indian Creek, downstream of Flournoy Bridge in upper Genesee Valley. Demonstrates the effectiveness of riparian corridor revegetation for accelerating stream shading and reducing stream width, on 2.6 miles of Indian Creek. Investigates the use of rootwads, boulders and vanes for instream pool development and investigates terrace irrigation management options for instream flow augmentation and groundwater recharge on the 290.4 irrigable acres of the Heart "K" Ranch. Estimated initial cost is $150,000 ($50,000 for fencing and $100,000 for steam corridor re-vegetation, water and land management planning, including maybe installing one or more fishery habitat enhancement features as tests and offstream livestock water. (See attachment)

- ***Plumas County- Greenville Community Services District's Wolf Creek -Round Valley IRMP.*** Raising the dam at Round Valley Reservoir was considerd as an alternative method for increasing cold water flows to the NFFR during peak summer heating periods. This alternative proposes similar benefits, for the cost of a new well, for the cost of the water (up to 6000AF of water annually), and for the cost of revegetation for enhanced stream shading. Investigate reservoir re-operation Round Valley (and perhaps in coordination with the re-operation of Antelope Lake and Taylor Lake), for instream flow augmentation along Wolf and Indian Creeks to the mainstem of the NFFR. The project includes a riparian corridor vegetation enhancement and education component in and around the town of Greenville. The project includes drilling a new drinking water well for the town of Greenville. The storage capacity of Round Valley Reservoir, when combined with the water storage capacity of Antelope Lake, and the Heart K water rights (stored and riparian), approximately equals the volume of water presently diverted from the EBNFFR in Indian and Genesee Valleys. The instream flow

[8] Watershed Plan and Environmental Assessement Indian Creek Watershed Project: USDA Soil Conservation Service, 1993 p. 35http://www.feather-river-crm.org/publications/studies/indian/watersh17.htm

augumentation potential from integrated operation of Round Valley, Antelope and Taylor Lakes could be significant. (Seed funds are estimated at $40,000: $10,000 for revegetation along Wolf Creek in and around Greenville, $10,000 for re-running the Wolf Creek Project monitoring data (Phases 1-IV. See Wolf Creek Project Report @ www.Feather-River-CRM.org) and $10,000 for Round Valley water transfer development, and $10,000 for exploring integrated lake and reservoir re-operation scenarios)

Plumas County-Sierra Valley IRMP Answers question #7 with integrated monitoring and modeling in the largest valley in the Sierra Nevada Range.

- ***THE SIERRA VALLEY INTEGRATED RESOURCE MANAGEMENT PROJECT***

  Sierra Valley is 600 square miles of wetlands, rivers, streams, irrigated pasture, with clusters of urban development. This largest valley in the Sierra Nevada range is home to more than 140 bird species (including the bald eagle, golden eagle and Swainson's Hawk) and the migration corridor for the Loyalton-Truckee Deer Herd. Sierra Valley wetlands support more than 100 bird species, including sandhill cranes, bald eagles, white-faced ibis and a variety of waterfowl and raptor species. Agriculture is the main economic activity. Expanding recreational and year round developments are increasing demands on local surface and groundwater water supplies.

  Recognizing the value of water resources in Sierra Valley, the Sierra Valley Groundwater Management District was created in 1980 by an act of the State Legislature and the Boards of Supervisors of Plumas and Sierra Counties. See Uncodified Act 7662 (Deerings, 2001); Stats 1980, ch 449, *as amended.* Since the inception of that legislation, the District has been successful in establishing numerous data collection activities in an effort to gain detailed understanding of the groundwater basin. The District has worked cooperatively with the California Department of Water Resources in carrying out investigations and has participated in an active groundwater level monitoring program for over 20 years. The technical database has afforded the information necessary to evaluate the groundwater condition in Sierra Valley and is integral in the management of the resource. Also, a number of technical reports utilizing the data have been published for public distribution. The latest report was generated by the District through the successful completion of a grant awarded to the District under Local Groundwater Management Assistance Act. of 2002, (AB303). The report document is entitled "Hydrogeology and Groundwater Monitoring in Sierra Valley, May 2003". The District has a well established track record for executing groundwater investigations. (Dillon)

  The Sierra Valley GMD recently submitted a proposal for funding to install more monitoring wells near Chilcoot. The Plumas County Flood Control and Water Conservation District (in June of 2004) requested proposals for the mapping and delineation of the 100 year floodplain in the Plumas County part of Sierra Valley.

Discussions are ongoing between Plumas County and the Department of Water resource and the rest of the State Water Contractors about the future operation and management of Lake Davis and Frenchman Lake. Plumas County's interest in a greater role in determining the future management of the three State Water Project reservoirs located in the County, became part of the Monterey Settlement Agreement between Plumas County and the other State Water Contractors. Instream flows downstream of Sierra Valley into the Middle Fork Feather River Canyon for coldwater fish habitat enhancement are a recent issue that has arisen as part of the hydroelectric relicensing application to the FERC for the Lake Oroville facility in the Sacramento Valley. The Middle Fork of the Feather River, a "Wild and Scenic River", drains to Lake Oroville.

The development of integrated analytic tools is key to integrated resource planning in the Sierra Valley. The County and the SVGWMD seek to increase their capacity to timely evaluate the impacts of both proposed and cumulative land and water use changes in Sierra Valley to sustain groundwater resources. The County is also interested in better flood forecasting and increased flood hazard protection for Valley residents. The County is also interested in investigating connections between Davis and Frenchman reservoir operations upstream of Sierra Valley and downstream temperature and flows in the Middle Fork Feather River Canyon. Seed money ($10,000) is needed to better understand how the integrated modeling and monitoring now being tested in the Last Chance Creek (LCC) watershed can be applied to flood flow, instream flow and groundwater management issues in the Sierra Valley basin.

Current research in the Last Chance Creek watershed should provide information on the following subjects:

- the use of high resolution thermography (aerial and hand-held infrared thermometers) to indicate groundwater inputs to streams and to identify cold water zones and strata in streams,
- the use of high resolution thermography (aerial and hand-held infrared thermometers) to track trends in stream width, riparian vegetative cover and stream water temperature trends,
- the use of vegetation (infrared photo) monitoring to indicate groundwater levels and stream temperatures, and aquatic and riparian habitat quality,
- the use of a coupled surface and groundwater hydrology modeling and monitoring to predict flood flows and base flows in stream systems during normal and extreme climate events,
- the use of a coupled surface and groundwater hydrology modeling and monitoring to identify groundwater recharge areas in floodplains, and streams,
- the use of isotope analysis of well water in piezometers, TDR probes, and tensiometers, to identify sources of groundwater in floodplains and streams

The Sierra Valley IRMP would both pilot the extrapolation of Last Chance Creek research to another part of the watershed, and expand the use and application of the research approaches being piloted in the Last Chance Creek watershed.

Watershed science would be enhanced by the Sierra Valley Project in the following ways:

- by adding an upland watershed source, storage, and runoff component above Lake Davis and Frenchman Lake,
- by coupling surface and groundwater watershed hydrology modeling with HEC-RAS floodplain delineation and mapping analyses of the Sierra Valley,
- by using the Sierra Valley Groundwater Management District's (SVGMD) extensive archive of existing groundwater well data and groundwater analyses to calibrate the UC Davis WHEY hydrology model and thermographic information,
- by adding climate change (CO2) analyses to normal and extreme water balance analyses,
- by using the SVGMD's extensive archive of existing groundwater well data and groundwater analyses and to validate recharge zone identification obtained through modeling and thermographic imagery, and
- by exploring connections between the shallow and deep aquifers in Sierra Valley
- by exploring connections between reservoir re-operations and connections between the shallow and deep aquifers in Sierra Valley

(est. cost $1million to $1.5 million)

Discussion of Last Chance Creek Watershed Restoration to Remedy NF Temperature Issues

15 December 2004

Overview of Watershed Conditions:

The Feather River Coordinated Resource Management (FRCRM) group has been implementing an aggressive program of watershed restoration in the Feather River watershed since 1990. The FRCRM is a 23-entity consortium of federal, state and local, public and private agencies dedicated to collaboratively addressing watershed problems through restoration, management and education. Many of the stakeholders involved in the North Fork Feather River temperature decisions are signatory members of the FRCRM.

The FRCRM was originally conceived around the issue of erosion and sedimentation. The FRCRM through its restoration projects and adaptive management program has recognized that the watershed-wide erosion problem (SCS, 1989) was simply one symptom of an overall loss of watershed function. Other symptoms include increased flood peaks and frequency, water quality impairments (nutrients, temperature, sediment) and, loss of aquatic and terrestrial habitats.

The primary physical process resulting in these symptoms is channel incision in the meadows and valleys of the upper 2/3 of the watershed (Clifton, 1994). Channel incision is due to both the cumulative effects of 150 years of land use and the underlying sensitivity of the fine-grained alluvial soils which comprise the meadows and valleys.

Once initiated, incision continues until a new channel base level is reached. On many of the larger channel systems this process has reached depths of 14'- 16'. Concurrently, the incised channel begins widening by eroding the streambanks below the protective rooting depth of the native meadow sod. As the incising channel capacity increases more streamflow is captured, reducing the effectiveness of the naturally-evolved floodplain. In many areas of the watershed virtually no flood flows access the historic floodplains. The concentration of streamflows and attendant desertification of the original riparian vegetation community leads to an ever-increasing exacerbation of the above mentioned watershed symptoms.

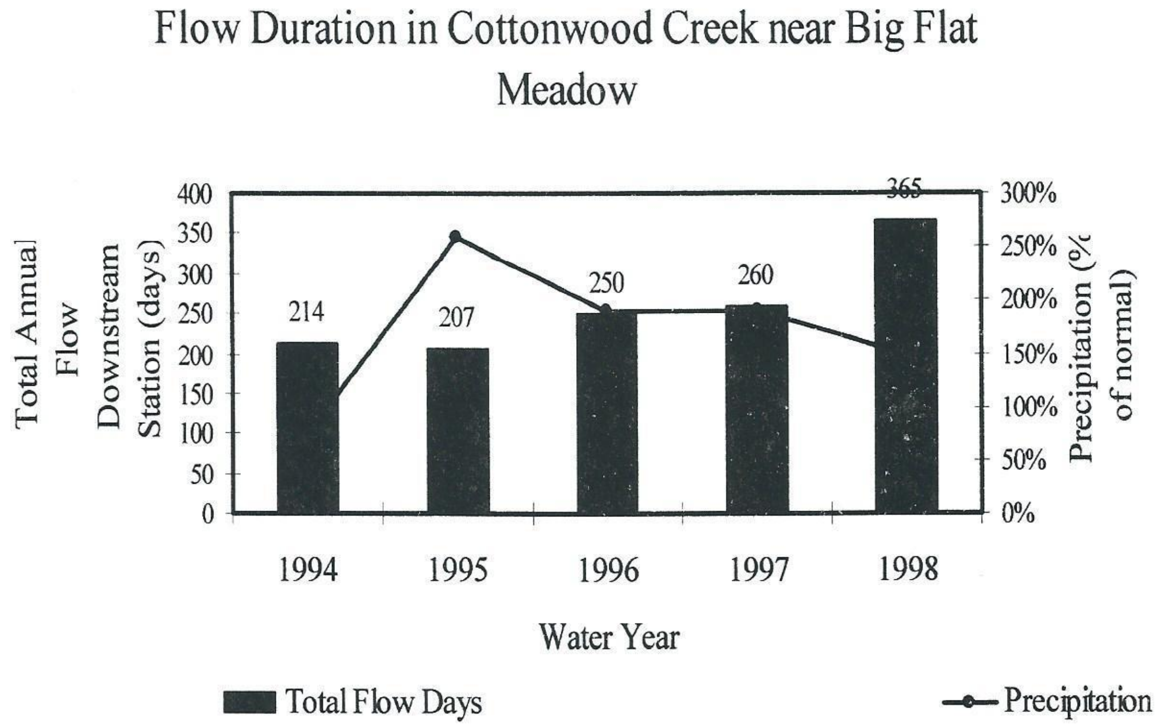
<u>Overview of FRCRM Project History (1985- present):</u>

The first FRCRM project undertaken was a 1 mile long, loose-rock, check dam project in Red Clover Valley. This project was a test of both the premise that erosion control was feasible and that the nascent group could work collaboratively. The success of this project in both respects spurred the initiation of a program of watershed studies and a search for technologies to address stream channel issues. The next major project addressing erosion was undertaken on Wolf Creek in Greenville, Ca. This project involved using the innovative geomorphic approach to channel restoration. It was quickly followed by similar projects on Greenhorn and Jamison Creeks. These projects all involved attempting to restore a stable channel/floodplain relationship within the incised channel boundaries.

Intensive qualitative and quantitative monitoring of these projects over time demonstrated that the inherent concepts were valid. However, the projects also showed that working in the incised, or inset, channel setting subjected all restoration work to higher and more frequent flood stresses than would naturally occur. Concurrent with this evolving understanding was the introduction of a new technology that moved the stream channel completely out of the incised gully and into remnant or constructed channels on the historic floodplains. As a geomorphic approach, this technique demonstrated far less stress on the restoration project, even in major flood events such as 1997, and a wider range of watershed benefits.

The first project of this type was constructed in 1995 at Big Flat on Cottonwood Creek in the Last Chance Creek watershed. Though experimental, and with several design flaws, the 1 mile long, 47 acre project response was immediate and wide ranging. Water table elevations rose, meadow vegetation replaced encroaching sagebrush, summer baseflows were extended and enhanced, a vibrant fishery developed (DWR, 2000), sediment delivery was reduced both from the lack of gully wall erosion and the filtering of upper watershed sediments by the meadow. Other similar projects were implemented in a wide variety of channel and meadow systems continuously using feedback from the monitoring process to refine and enhance the application of the technology.

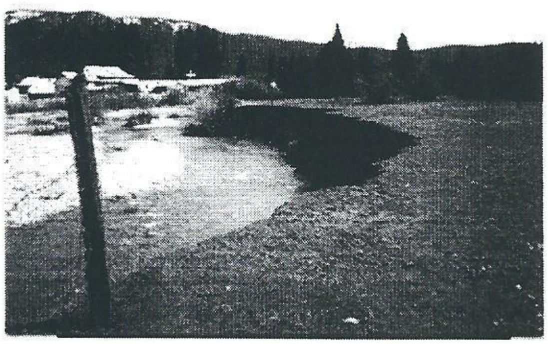
Figure 1: Timing of Flow Changes



The FRCRM, as of the end of 2004, has implemented or assisted in 14 miles of meadow channel restoration projects. Of this total, nearly 8 miles has been implemented in the Last Chance Creek watershed, culminating in the just completed Upper Last Chance Creek Watershed Restoration Project that treated 6 miles of mainstem and tributary channels. The FRCRM currently has an additional +5 miles of meadow restoration funded. There is landowner interest in a further 20 miles of work undergoing the initial outreach and coordination phase.

Concurrently, the FRCRM is still implementing restoration projects in inset channel settings such as Wolf Creek and Spanish Creek. Improved restoration techniques are being used that incorporate the unique sediment/flow interactions of incised low-gradient channel systems to successfully stabilize gully walls. Techniques such as boulder vanes as depicted in Illustration 1, help maintain more optimal width/depth ratios, allow for effective bank revegetation, and improves riparian and aquatic habitats

Above, Wolf Creek, Dunham bank May 2004.
Below, pre-project, 1999. Project was completed in 1999.



Monitoring and Research History:

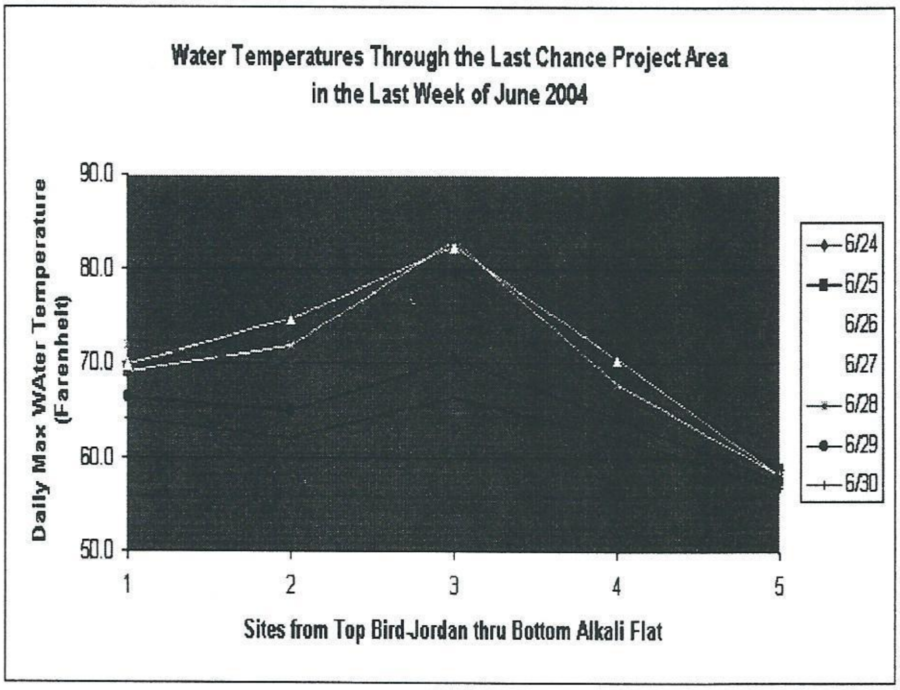
Historically, monitoring of restoration projects at either the project or watershed scale has been poorly funded. As a result, the FRCRM has a minimum project performance monitoring program for every project that consists of photo points, cross-sections and qualitative observation. Depending on expected responses, targeted benefits or regulatory mitigation, additional monitoring components are implemented as resources are available. For example, six (6) meadow restoration projects have ongoing water level monitoring. Figure 3 illustrates the extended elevated groundwater both post-project and compared to the downstream control reach.

Recognizing the need to understand the potential watershed benefits of cumulative restoration, the FRCRM implemented a watershed trend monitoring network in 1999. This network, funded under a 319(h) grant, is intended to track long term changes in watershed condition relative to restoration. This network consists of continuous recording stations at 11 strategic locations in the upper watershed that record streamflow and air/water temperature. The premise behind this long-term monitoring was that the effects of large-scale restoration would be reflected in increased summer baseflow and decreased summer water temperatures. These metrics were chosen as having less multi-year variability (data noise) than more stochastic metrics such as flood peaks and sediment. Figure 2 illustrates a decrease in stream temperature through the 4 mile restored study reach.

One of the key stations in the network, relative to this discussion, is located at Doyle Crossing on Last Chance Creek. Several years of FRCRM restoration work has been concentrated in the 100 mi^2 watershed above this station. At the present, only 9 miles of mainstem channel remains to be restored. When accomplished virtually all channel reaches above this station will have been restored to pre-degradation condition.

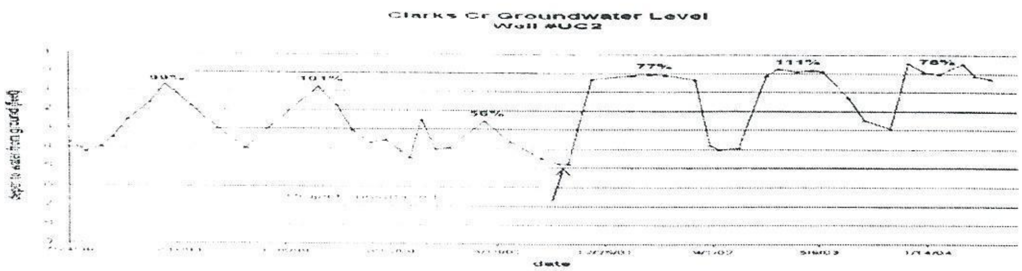
Supplementing the FRCRM efforts are several research projects that are focusing on certain metrics and/or technologies to further understand and quantify the watershed response to meadow restoration. These floodplain meadows and valleys have recently been posited as macro-hyporheic zones for the watershed (Stanford and Ward, 1993) The first is the application of a newly developed, physically-based watershed model developed by the University of California, Davis. This is the largest watershed on which this model, UCDHRL, has been field tested. Funded by CALFED, the model is expected to be able to quantify changes in flood and annual hydrographs from restoration or land management changes. The modeling project is scheduled for completion by the end of 2005. One project product is to install the model locally as an ongoing tool for the watershed.

Figure 2- Example Temperature Data:



Typical Well Monitoring Data

The second research project is an environmental temperature sensing effort using low-level, aerial infrared thermography in conjunction with a ground-based sensor network. Designed by Stanford University, the purpose is to detect and quantify the presence and movement of shallow (meadow) groundwater through water and vegetation temperature signatures. Initial rough data results dramatically display the effects of meadow restoration on subsurface water movement and channel recharge.



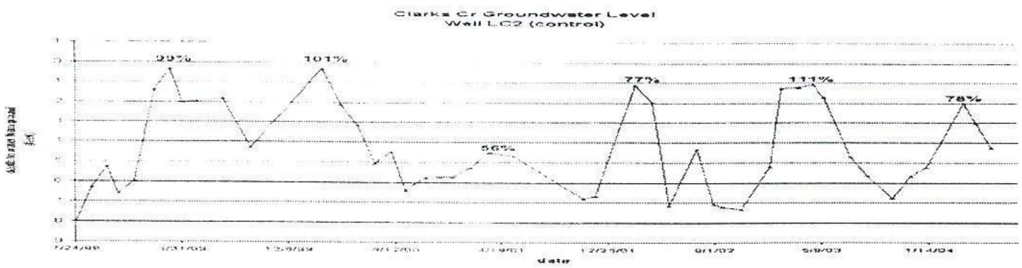
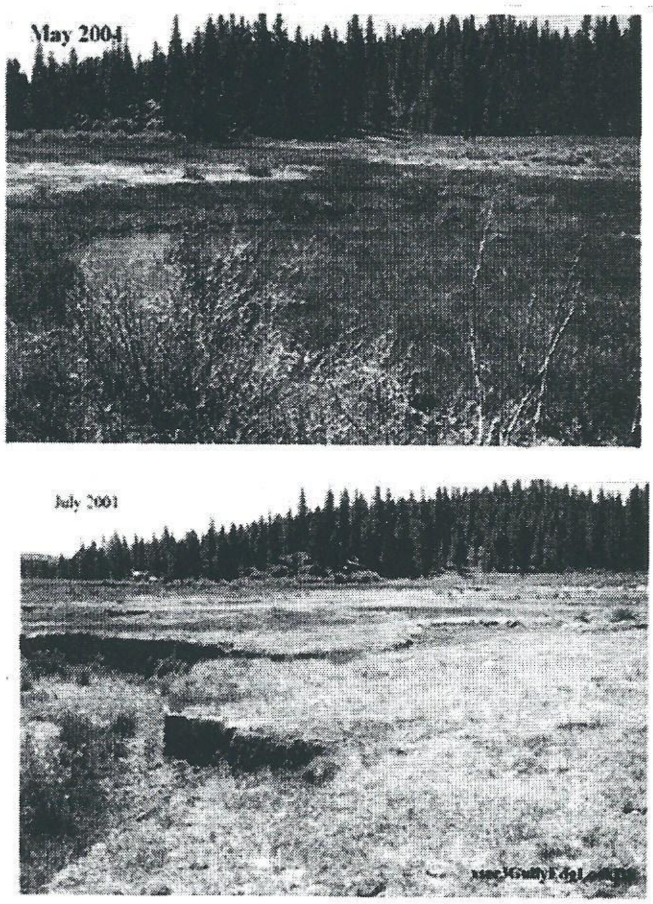


Illustration 2:

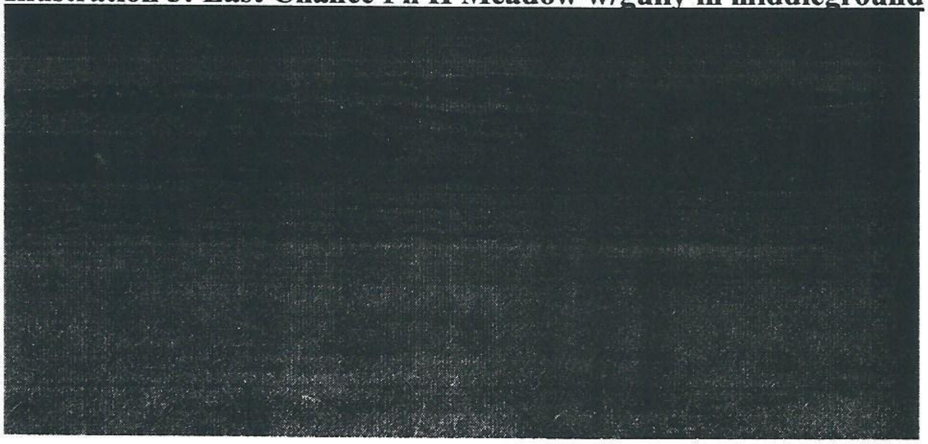


This project, funded by Stanford and the National Science Foundation, is also scheduled for completion by the end of 2005.

A third effort, just getting underway, is to sample existing monitoring well water for stable naturally-occurring isotopes. Tracking changes in isotope concentrations and occurrence potentially will further our understanding of seasonal variations of the surface/sub-surface water exchange related to restored meadows. This study is being conducted by Burkhard Bohm, a consulting geohydrologist, and FRCRM staff, it has been initially funded by Plumas County through the Water Forum Monterey Settlement program.

Summary: The Feather River CRM is committed to restoring watershed functions, particularly those that adversely affect timing of flows. Restoring the remaining 9-mile segment of Last Chance Creek above the Doyle Crossing station is a very high **priority**. **Ilustration** 3 show the desertified meadow above Doyle Crossing Completion of this segment, estimated to cost approximately $3,500,000, would incontrovertibly demonstrate whether meadow restoration at the landscape scale appreciably affects timing of flow and water temperature. Similar, ongoing funded projects on Red Clover Creek and elsewhere will continue to advance the knowledge and understanding of these processes and their influence on the watershed system as a whole.

Illustration 3: Last Chance Ph II Meadow w/gully in middleground



The Genesee Valley Integrated Resources Management Project

The Feather River Land Trust is a private, non-profit organization founded by residents of the Feather River region. Our mission: To conserve, restore and manage land in the Feather River region in cooperation with willing landowners for the benefit of current and future generations. Lands in the Feather River region are irreplaceable. The Feather River Watershed, the largest Watershed in the Sierra Nevada. It includes all of Plumas County and portions of Sierra, Lassen and Butte counties.

"The 884-acre Heart K Ranch and 80-acre Taylor Lake, in Genesee Valley, are the most recently protected lands in the Feather River watershed. The Nature Conservancy and Feather River Land Trust joined forces to protect this very special property that contains alluvial bottomlands and surrounding uplands that include black oak woodland, aquatic, riparian and wet meadow habitats. These habitats support a rich assemblage of rare wildlife and plant species, including four threatened or endangered species and twenty-two species of special concern. The Heart K Ranch also contains spectacular scenery, provides important wintering and breeding habitat for the Sloat mule deer herd, and provides a migratory corridor for numerous other wildlife. Taylor Lake, one of three sacred Maidu Indian lakes, is one of the few natural lakes in this area of the northern Sierra Nevadas." (www.frlt.org)

An early priority for this property is to identify and evaluate water management alternatives to increase instream flows, improve irrigation efficiency, improve groundwater recharge, lower stream water temperatures, increase overstream vegetative cover and increase fish (and wildlife) habitat. This is anticipated to eventually involve dedicating a portion of the irrigation water to instream flows in Indian Creek that will be saved through fixing the headgate system at Taylor Lake and by losing less water in the leaky flume ditch, and through better "on ranch" irrigation practices.

Another immediate management priority would be to begin passive restoration of two and a quarter (2.25) miles of Indian Creek by installing/repairing riparian fencing on bothsides of the creek (approximately 5 miles) to permanently exclude livestock and by replanting riparian vegetation to enhance stream shading. Improving the existing flood irrigation system in order to eliminate the need for stock water access to Indian Creek is an immediate necessity. In the future, we may want to develop a more active irrigation water management program involving cross-fencing in the irrigated meadow and recontouring natural swales in meadow terraces to enhance groundwater infiltration and sub-irrigation. Through the redevelopment of vernal pools and seasonal wetlands, we hope to reduce our summer irrigation diversion needs from Indian Creek, thereby leaving more stream flows in the creek during summer peak heating periods. We may also want to experiment with placing instream trout habitat structures such as rootwads, logs, boulders and vanes along the streambanks of Indian Creek to enhance pool/riffle development and cold water refugia for trout.

A first year pilot project budget would fund riparian fencing, alternative sources of livestock water where needed, and the installation of wildlife- friendly cross-fencing, where needed, to prevent over-grazing of meadow habitat by livestock. Baseline fishery and water quality assessments and some groundwater baseline assessment work could be part of the first year's activities as well.

Ongoing upper watershed restoration in the Red Clover, Indian and Last Chance Creeks above Genesee Valley has the potential to moderate historic flood damage in this incised reach downstream of Flournoy Bridge where the topography changes from canyon to alluvial valley. It may be informative to build in some data collection and instrumentation on the Heart K Ranch to measure flood peak changes in order to better document the flood damage resistance that this project can achieve with permanent livestock exclusion combined with accelerated re-vegetation of the riparian corridor. Enhanced re-vegetation would also aid the development of a lower stream width in this reach. In 1993 this stream reach was measured as 300ft. wide, and flat bottomed sand- without pools or riffles. The FR CRM has identified the beaver as a "keystone species" fro watershed processes in the Feather River watershed. Evaluating beaver activity in a livestock excluded riparian corridor may be a research project of future interest.

<u>The Watershed Plan and Environmental Assessment for the Indian Creek Watershed Project</u> (SCS, 1993) states, on page 15, that *"the primary limiting factors for fish (particularly trout) abundance in Indian and Genesee Valley are high water temperatures, lack of cover and streambank vegetation, and a low percentage of pools."*

"The benefits of fencing and planting are most consequential in Genesee Valley. It is the area most impacted by grazing and is not limited in recovery potential by channelization or restricted stream flows. (SCS, 1993:30) *"Detailed data were collected from the upper two miles of Genesee valley and analyzed for suitable trout habitat using US Fish and Wildlife Service Habitat Suitability Index (HIS) Raleigh, 1984) and methods from Flosi and Reynolds, 1991. These HSI values are different than those generated with the COWFISH model.... It has been estimated from stream surveys that there are only 18 to 25 catchable (over 127mm) rainbow trout per mile at present. A potential number of catchable trout is estimated to be about 300 per mile."*(SCS, 1993:35)

In summary, this project has the best potential in the EBNFFR system to answer the following question number 10 of the "12 Questions". Question number 10 asks for the *development of information on the incremental benefits over time from rehabilitation treatments such as livestock exclusion, streamside re-vegetation, meadow re-watering, etc.*

The estimated project cost is $150,000. $50,000 is needed for fencing and $100,000 is needed for steam corridor re-vegetation and water and land management planning and assessment, and including maybe installing one or more fishery habitat enhancement features or offstream water for livestock, or cross-fencing, as experiments.

APPENDIX A-5: ECONOMIC CONSIDERATIONS

Defining the values, as well as the benefits and costs
What is Sierran and Feather River water worth anyway?

Looking Downstream
Butte County has been working to improve public understanding of aquifer dynamics in the Butte Basin. Isotope data from the Lawrence Livermore Laboratory indicates that the Tuscan formation, a 27 million acre foot (MAF) confined groundwater basin, that underlies the Butte Basin and five northern Sacramento Valley Counties, is recharged from the Sierras (Craddock, Beeler). This is not surprising since the 3.2 million acre Feather River watershed yields 3.2 MAF of "firm (surface water) yield" annually, to Lake Oroville from a landscape that is 4% meadow (250,000 acres), approximately 2% open water in rivers and lakes, and almost 94% upland forest that overlies fractured bedrock in shallow and deep forest soils (Benoit). Surface water yields are typically a small fraction of groundwater yields in fractured bedrock, Groundwater recharge to surface waters is created by a combination of shallow meadow aquifer recharge from surface and subsurface flood flows in alluvial floodplains, and deep aquifer recharge into, over, and from, upland bedrock formations.

Forest understory vegetation management for improving forest health and reducing forest fuels may also provide quantifiable benefits in the both the quality and timing of water draining to receiving streams and aquifers. The Oak Ridge National Laboratory conducted a preliminary study of seasonal water yield effects from implementing the

Quincy Library Group forest thinning program. The WRENSS model predicts that summer runoff would increase by 3/4 of a percent for west slope forest stands just from reduced evapotranspiration and not including groundwater-related streamflow augmentation.

The Feather River Coordinated Resource Management (FRCRM) group has been implementing over 40 stream bank erosion control and meadow re-watering projects since 1985 in the upper Feather River watershed on Plumas National Forest and private lands. Project monitoring combined with modeling-based predictions (Bond,1997; Kattlemen,1987) suggest that meadow and stream restoration in combination with upland vegetation management could reduce flood peaks by 5% for the first 24 to 36 hours of a severe winter storm under a specific range of conditions, while enhancing summer flows by 7%. Dr. Romm, an economist a UC Berkley conducted a cursory survey of the value of environmental services from the Feather River watershed in 1999 and concluded that "in certain conditions, riparian and meadow restoration can actually enhance water storage more efficiently than dam augmentation". These assessments are promising but not conclusive, as indicated by the April 1996 study by CH2MHill titled Reinvestment Opportunities for the Feather River Watershed and the 1999 study by the Planning and Conservation League Foundation, titled The Benefits of Watershed Management: Water Quality and Supply A Report. Literature Review and Economic Benefits Discussion With an Emphasis on the Sierra Nevada. To move forward (with predicting and realizing local and downstream watershed benefits; coordination of modeling, monitoring and project implementation needs to be strengthened.

Looking Upstream

The Organic Administration Act of June 4th, 1987 created the National Forests. The Act describes the purposes of the National Forest system as follows: *"No National Forest shall be established except to improve and protect the forest within the boundaries, or for the purposes of securing favorable conditions of water flows and to furnish a continuous supply of timber for the use and the necessities of the citizens of the United States."*

The Sierra Nevada range is a significant source of water for the cities and farms of California and Nevada. A 1994 report by the Wildland Resources Center states that, *"Computer modeling by the Department of Water Resources suggests that...In 1989, roughly 38 million acre feet (MAF) of surface water were applied to agricultural (31MAF) and municipal and industrial uses (7MAF) in California.... Approximately 19 million acre-feet of this total originates in National Forest watersheds"... [A value of $10 dollars per acre-foot is equivalent to]... " $190 million which is comparable to recent (1994) NF timber receipts..."*

National Forests in California are the headwaters for much of the municipal water used by the south state's urban populations. In recognition of National Forest contributions to downstream municipal water needs, *the Forest Service Manual FSM 2500 "Watershed and Air Management WO Amendment 2500-90-1 Chapter 2540* provides the following management direction. *"Show municipal supply watersheds as special management areas in Forest Plans when management intensity and timing differs from other areas.*

Forest plans shall include a statement of objectives for managing the water resources on or flowing from the watershed. Include water quality, quantity and timing criteria for the water resource.... "

The benefits of restoring "conditions of favorable flows" to unhealthy and fire prone Sierran watersheds are potentially significant. The Sierra Nevada Ecosystem Project (SNEP) produced a 1996 report on existing conditions in the Sierra Nevada. According to Bill Stewart, author of the investment chapter in SNEP, the Sierra Nevada ecosystem produces direct resource values of $2.2 billion annually in commodities and services. Sixty percent of the 2.2 billion-dollar total value is water. Total resource values include the substantial recreation and gaming economy of the Lake Tahoe region of the Sierra Nevada. Other Sierra Nevada commodities account for 20% and services account for another 20% of the 2.2 billion dollar value total in the mid 1990s. Only about 2 percent of these resource values were captured and reinvested in ecosystems or communities and this level of reinvestment is inadequate to ensure *"sustainable utilization of the ecosystem"* (Stewart 1996:976).

Looking local

The Herger-Feinstein Quincy Library Group Forest Recovery Act authorized the Quincy Library Group Pilot project on the Plumas and Lassen National Forests and on the Sierraville Ranger District of the Tahoe National Forest. That legislation included the following language under the "Final Report" section, *"The report shall include, but not be limited to the following....(B) An assessment of watershed monitoring data on lands treated pursuant to this section. Such assessment shall address the following issues on a priority basis: timing of water releases, water quality changes; and water yield changes over the short-and long-term in the pilot project area... "*

Since 1990, FR-CRM projects injected nearly $10,000,000.00 into the local area through the wages and salaries of contractors, their employees, local consultants and FR CRM staff. These projects provide additional opportunities for grading contractors and their operators to supplement their normal road building, land development and utility installation activities with contracts that utilize their skilled operator training and experience. This effort has coincided with diminished road building associated with the reduction in timber harvesting region-wide. Over the past 11 years, this has translated into 110 industry- standard jobs. These jobs have typically spanned 1-3 months with operator wages compensated at State Prevailing Wage or Federal Davis-Bacon wage rates. In order to implement these projects, studies and CEQA/NEPA investigations are required. These activities have provided numerous consulting contracts for local professional biologists, botanists, hydrologists, engineers and archaeologists to work in their fields and in their community. The FR-CRM program alone has supported a 2-3 person staff full-time for over a decade to coordinate and implement this program, including supervising the local workers and contractors engaged in project construction. (Wilcox, 2000)

Investing in watershed management provides benefits at multiple scales, to both local and distant economies. Other alternatives being considered for improving water quality and coldwater fisheries enhancements in the North Fork Feather River, may improve some environments at the expense of others, or may externalize costs to third parties. Somehow, the net benefit of the proposed alternatives needs to be reconciled at multiple levels (local, regional and national) in order to be a part of a truly equitable, effective, and sustainable solution to water and fish impairments in the NFFR.