APPENDICES TO

COUNTY OF BUTTE, CALIFORNIA'S COMMENTS ON THE DRAFT ENVIRONMENTAL IMPACT REPORT FOR RELICENSING OF THE OROVILLE FACILITIES, FERC PROJECT NO. 2100

(SUBMITTED TO THE DEPARTMENT OF WATER RESOURCES)

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APPENDIX A

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SOCIOECONOMIC IMPACTS OF THE OROVILLE FACILITIES PROJECT ON BUTTE COUNTY, CALIFORNIA

PREPARED BY FMY ASSOCIATES INC.

JANUARY 2006

SOCIO-ECONOMIC IMPACTS OF THE

OROVILLE FACILITIES PROJECT

ON

BUTTE COUNTY, CALIFORNIA

PREPARED BY FMY ASSOCIATES INC.

JANUARY 2006

BOARD OF SUPERVISORS

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February 14, 2006

The Honorable Arnold Schwarzenegger
Governor
State of California
State Capitol
Sacramento, California 95814

Re: **Operational Impacts of Lake Oroville on the Citizens of the County of Butte**

Dear Governor Schwarzenegger,

The Board of Supervisors for the County of Butte submit the attached reports regarding the impacts the Lake Oroville Project continues to have upon the citizens of Butte County:

1. Report on the Operational Impacts of the Oroville Facilities Project on Butte County, prepared by the Office of the Chief Administrative Officer, Butte County, California (February 2006) (Operational Impacts Report); and

2. Report on the Socio-Economic Impacts of the Oroville Facilities Project on Butte County, California, prepared by FMY Associates Inc. (January 2006) (Socio-Economic Report).

Lake Oroville is the jewel of the California State Water Project and is owned and operated by the State of California through the Department of Water Resources. While this Project supports billions of dollars in annual commerce, the reports document that this commerce comes at the significant expense of the citizens of Butte County.

Our reason for bringing these reports to your attention is based, in part, upon our recognition that the County's current subsidization of the Project—through the provision of law enforcement, criminal justice, fire and rescue, communications, public works/roads, emergency operations center, and health and human services to the Project and over 1.7 million annual visitors to the Project (including an average peak period population of 5,720 daily visitors to the Project who do not reside in Butte County)—combined with DWR's lack of payments, cannot be sustained during the upcoming relicensing period. **As indicated in the Operational Impacts Report, the estimated net cost impact of the Project on Butte County—after deducting the value of benefits received from the Project such as sales and transient oriented tax revenues paid by Project Visitors and contract payments made by DWR—is $4,560,345 in annual costs and $10,544,252 in one-time costs.** The County's use of its resources to serve the needs of non-County residents using the Project Area is diverting necessary discretionary dollars from the County budget, compromising the County's ability to meet its primary obligations to its over 210,000 citizens.

The Board of Supervisors greatly appreciates the partnership your administration has formed with local government and the fairness with which you approach that relationship. We ask that the same fairness be extended to the citizens of Butte County and that you direct the Department of Water Resources to stop imposing these very real impacts on our community without providing for mitigation of those impacts.

The Department of Water Resources is currently in the process of applying to renew the operating license for Lake Oroville through the Federal Energy Regulatory Commission. As the Board of Supervisors, representing the People of the County of Butte, we ask that the State of California use this license renewal as an opportunity to address the issues identified in the attached reports.

We trust that you will agree that the State has a moral responsibility to ensure that no segment of the State be treated disparately; to do no harm. We ask only that Butte County be treated in a manner that is fair and equitable.

Sincerely,

Curt Josiassen, Supervisor District 4
Chairman

Bill Connelly, Supervisor District 3
Vice Chairman

Jane Dolan, Supervisor District 2

Mary Anne Houx, Supervisor District 3

Kim Yamaguchi, Supervisor District 5

Attachments

Cc: The Honorable Sam Aanestad, State Senator
The Honorable Doug LaMalfa, State Assemblyman
The Honorable Rick Keene, State Assemblyman
The Honorable Dianne Feinstein, U.S. Senator
The Honorable Barbara Boxer, U.S. Senator
The Honorable John Doolittle, Member of Congress
The Honorable Wally Herger, Member of Congress
Mike Chrisman, Secretary, Resources Agency
Lester Snow, Director, Department of Water Resources
Jim Keene, Executive Director, California State Association of Counties
Brent Harrington, Executive Director, Regional Council of Rural Counties

CONTENTS

ACRONYMS AND ABBREVIATIONS

Defined Term	**Definition**
BOE	California Board of Equalization
Commission	Federal Energy Regulatory Commission
DCF	Discounted cash flow
DWR	California Department of Water Resources
Facilities	Oroville Project
FERC	Federal Energy Regulatory Commission
LADWP	Los Angeles Department of Water and Power
Lake	Oroville Reservoir
Lake Oroville	Oroville Reservoir
Oroville Project	Oroville Project
PG&E	Pacific Gas and Electric Company
PILOT	Payments in lieu of taxes
Project	Oroville Project
The County	Butte County

I. INTRODUCTION AND SUMMARY

The Oroville Project ("Oroville Project," "Project" or "Facilities") is a 762 MW hydroelectric generating plant located in Butte County, California, which is currently operating under a 50-year license from the Federal Energy Regulatory Commission ("FERC" or "Commission"). The FERC license for this Project (FERC Project No. 2100) was issued by FERC's predecessor agency, the Federal Power Commission, to what is now the California Department of Water Resources ("DWR") in 1957 and is due to expire on January 31, 2007. The DWR is seeking a new 50 year operating license for the Project, and submitted its application to FERC in January, 2005.

This report has been commissioned by Butte County ("the County") to assess some of the major socio-economic impacts of the Project on the County, both in historical terms and for the new 50-year license period requested by DWR.

Butte County has a population of over 210,000 people, about half of whom live in unincorporated areas of the County. Butte County and its citizens are directly affected by the Project and its operations because the Oroville Facilities are located entirely within the County, utilize County natural resources and existing infrastructure (e.g. roads, bridges and traffic controls), and rely on the County for such local government services as law enforcement, fire protection, emergency services and "first responder" services. The impact of the Project on Butte County is highly significant because in California county governments are responsible for providing almost all of the services required to meet the health and welfare needs of county residents, and are responsible for the public safety of all citizens living in unincorporated areas as well.

Although the Project has substantial environmental, land management, water use and social impacts on the County and its constituents, this report primarily addresses the socio-economic impacts of the Project that are caused and can be directly attributed to the existence of the Project and its operation and are further exacerbated by (i) DWR's failure to pay taxes or make payments in lieu of taxes ("PILOT"); and (ii) DWR's failure to make any low-cost power from the Project available to County residents, businesses and industry. This Report will examine the relationship between the Project and the community to see if there is a fair balance between Project costs and benefits and if there are adverse Project impacts that can be eliminated or mitigated.

From an historical perspective, it is important to note that in the 1950's many promises were made to Butte County by the Water Project Authority, other proponents of the Oroville Facilities and the State Water Project in order to sway public and political opinion in favor of development of the Project.[1] Expectations were established that the construction and later operation of the Project would bring jobs and prosperity to Butte County and its citizens, as well as provide water, recreation and flood control benefits to much of the population of California. The proponents of the Project argued that the loss of local lands and the improvements thereon, and the resultant loss of tax base that was to occur from the transfer

[1] The original licensee of the Project was the Water Project Authority of the State of California, which in 1956 was abolished by the legislature and then succeeded by DWR.

of properties and development rights to DWR, would at most have a short-term negative impact on the County and would be more than compensated for later on by the economic prosperity that the Project would bring to Butte County and California. As stated by then Secretary of Agriculture Benson in a letter to the Chairman of the Federal Power Commission supporting and approving the Project, "While substantial loss to the community would result from inundation of these lands and other values, it does not seem large in terms of the gain to the State which would accrue from the project."[2] In addition, in the FERC license application the licensee even committed to FERC and the County that: "Provision will be made to make payment for or replace improvements destroyed or injured by the proposed works."[3]

Looking back at the last fifty years, and assessing the impact of the Project on the surrounding area, it is easy to see that rather than providing substantial benefits to the County, the Project has been a source of significant and ongoing negative impacts. Our findings indicate that Butte County has absorbed almost all of the negative consequences of the Project from its very beginning, when "farms, mines, homes, schools, roads and trails of a 'golden historical past' were inundated"[4] to create the Project. Even today the County struggles to provide the local government services that are required to accommodate the Oroville Facilities and the burdens they impose. In addition, DWR has never compensated the County for lost taxes on improvements it destroyed, including Big Bend[5], a pre-existing 70 MW hydro power plant. The negative consequences of the Project will be examined later in this report.

The Oroville Project continues to have a substantial negative impact on the County. Based on our findings, it appears that the loss of tax revenues from the substantial acreage and improvements taken for Project purposes, the lack of a property tax revenue stream emanating from the operation of the Facilities and the Project's failure to provide low-cost power for local residents has imposed an ongoing financial burden that, over time, has resulted in a downward spiral in the economic well being of Butte County.[6]

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2 Letter from Secretary of Agriculture E. T. Benson to Thomas C. Buchanan, chairman of the Federal Power Commission, as published in The Mercury. The letter identifies impacts of the project on fire protection, grazing values, timber values, forest service improvements and other community improvements and values (including significant impacts on the local transportation system of roads and railroads).

3 Application for license for Feather River Project, Project No. 2100, at Schedule F, page 37 (1952).

4 FERC Order on Revised Recreation Plan, September 22, 1994.

5 Until its operation was terminated and the facility was dismantled prior to inundation, Big Bend served as the economic and social epicenter for the small but vibrant community of Las Plumas. A compelling history of Big Bend and the community is attached to this report.

6 A downward spiral resulted from the initial loss of property tax revenues and lack of low cost power supplied to the County residents. As a result of such losses, the County government and the affected residents cut back on their expenditures, leading to further cuts in tax revenues for the government and lower incomes for the local businesses and residents, which in turn led to lower expenditures on the part of the public. The initial impact flows through the local economy a number of times, leading to this downward spiral. Accordingly, the eventual long term total impact will be much greater than the initial impact.

Not only were the expectations of economic development created by the Project's sponsors not realized, but instead, Butte County has experienced chronic and lasting deterioration and decline, accompanied by persistent high unemployment, below average household incomes and a degradation of the quality of life in general. The cycle of economic decline in the County, and the resulting further loss of revenues for County government, has left its public agencies and institutions unable to fully cope with the ongoing demand for services. This demand for public services has been greatly increased due to the Oroville Facilities. As discussed below, although many factors have influenced Butte County's decline, there is no doubt that the root cause for much of this economic deterioration is the Project and the lack of any meaningful compensation from DWR to the community for all of the Project's negative impacts.

The list of demonstrable harms suffered by the County due to the Oroville Project is long; however the most serious effects can be summarized as follows:

- Due to DWR's failure to make tax or other payments in lieu of taxes for the over 41,000 acres of County land that is within the Project Boundary and for the Facilities, the County has lost substantial tax revenues over the 44 years that the Project has been under construction and in operation;

- The County continues to lose property tax revenues as a result of the Project, totaling over **$6.87 million annually**;

- The Project has caused a shift in demographics to a more dependent populace resulting in more stress on the local government, schools and community services;

- None of the residents, businesses or industry in the County receive an allocation of low-cost power from the Project, representing as much as **$30 million in lost benefits annually;**

- The resulting loss of tax revenues and high electricity costs have made the County less attractive to businesses, resulting in job losses and an inability to attract new industry;

- Although the County is not receiving the economic benefits it was promised when the Project was developed and licensed, it still bears most of the government service and other costs associated with supporting a Project which occupies a large share of County land and uses a large proportion of the local infrastructure.

- The long term impact of the Project on the County and its residents has been, and will be for the term of the relicense period, much larger in magnitude than the figures stated here. This is because losses resulting from the negative impacts of the Project flow through the local economy a number of times and accumulate over time. This is often referred to as a multiplier effect. The dollar size of the local economy in 1999 is **in excess of $1.1 billion smaller** than a comparable average same size economy in California which was not saddled with the negative impacts of the Project.

We find the unequal distribution of benefits associated with the Project difficult to understand. The Oroville Facilities provide 762 MW's of extremely low cost power (less than $0.0163/kWh or 1.63 cents/kWh) that is either sold or used for the purpose of implementing the water supply, flood control, environmental and recreational aspects of the Project, yet almost all of these benefits are enjoyed by Californians outside of the County. The local community hosting the Project receives only a very small share of the overall benefits while providing all of the local government services required to support Project operations.

Although the Oroville Facilities must be considered one of the major sources of prosperity in California, the community that makes this benefit possible has some of the lowest standards of living in the State. These are the same people who continue to pay for the success of the Project by providing the government services, property and water used by the Project. The County services provided to the Project include police, fire, criminal justice system, the full range of "first responder" services, roads, traffic control and other government services. To further underscore this hardship, Butte County is forced to cover Project related costs with the lowest per capita general purpose revenues of any county in the State of California.[7]

Substantial changes have occurred in California since the Project was originally licensed. The State's population has grown from 15 million to 34 million people and the economy now represents the world's fifth largest economic unit.[8] The downstream benefits of low cost water supply for both urban and rural communities, flood control and improved environmental and recreational attributes and opportunities, are now enjoyed by over 23 million Californians, compared to approximately 10 million people when the Project was first built. Thus, Project benefits have greatly increased in importance and value over the first license term but few of these benefits have been shared with Butte County and its residents. In fact, the main burden of hosting the Project remains on Butte County.

The relicensing process provides an opportunity for all parties to assess Project impacts and take required action to eliminate or mitigate harms and inequities in the future. There are a number of ways to bring the resources of the community and DWR together to reimburse Butte County for its costs and to provide the prosperity and quality of life that were promised to the community when the Project was developed. On the basis of our findings, we present our recommendations for license conditions in the last section of this report.

II. BACKGROUND OF THE OROVILLE FACILITIES PROJECT

The 762 MW Project is located in Butte County, California in the foothills of the western slopes of the Sierra Nevada and consists of the Oroville Reservoir ("Lake Oroville" or "Lake"), the Thermalito Forebay, the Thermalito Afterbay, and the Thermalito Diversion, all located on the Feather River. The Oroville Facilities encompass 41,100 acres, approximately 9,000 acres of which are in the Plumas and Lassen National Forests. The Lake itself has a surface area of 15,810 acres at its normal maximum operating level. The Oroville Dam is the

7 Legislative Analyst's Report, May 7, 1998, Why County Revenues Vary: State Laws and Local Conditions Affecting County Finance

8 CAL Facts, Legislative Analyst's Office, December 2002

highest earthfill dam in the U.S., rising 770 feet above streambed elevation and is over a mile long between abutments.

The primary purposes of the Oroville Facilities are to (i) supply water to urban and agricultural water users; (ii) provide flood control and (iii) produce electricity. The electric power generation aspect of the Project is significant as it provides much of the energy, either directly or through swaps and sales, required to move water throughout the State Water Project System. This system extends for some 600 miles from Northern to Southern California and provides water to two-thirds of the State's population and irrigates 755,000 acres of farmland. The Lake Oroville Facilities represent almost one-percent of all the hydroelectric generation in the U.S.

In 1945, the California Legislature authorized an investigation into statewide water resources. Out of this study came legislative authorization for the Oroville Division in 1951 and on January 31, 1952, the original application for a license to construct the facilities was filed with the Federal Power Commission, predecessor to the Federal Energy Regulatory Commission. The license for Project No. 2100 was originally issued on December 14, 1956, for a term of 50 years to the then Water Project Authority of the State of California (16 FPC 1340). On January 14, 1957, Cal Water Resources informed the Commission that by Act of the California Legislature (Cal. Stats. 1956, Ch. 52), effective July 5, 1956, the Water Project Authority was abolished and that Cal Water Resources had succeeded to and been vested with all of the powers and duties of the former entity, including authorization to construct and operate the Feather River Project. Accordingly, the Commission rescinded the order issuing the license to the Water Project Authority (17 Project No. 2100-052) and issued a new license to what is now the DWR.[9]

The Oroville Dam and Lake Oroville were formally transferred from construction status to operating status on December 17, 1969 and approved on December 19th of the same year.

III. STATE OF THE ECONOMY IN BUTTE COUNTY

The development of the Oroville Project has affected the local environment, employment, land use and development, and the financial conditions and lives of the County populace more than any other event or development in the history of the County. Unfortunately, the current state of the economy in Butte County shows that the Project has financially harmed this community. Today, Butte County is one of the poorest counties in California, with limited potential for economic growth. A review of the socio-economic statistics for Butte County shows that in general, and in many categories, the communities within the County are faring worse than the average community in California.[10]

This Section is devoted to an assessment of the state of the economy in the County at the present time. The following measures of community well being are considered: income,

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9 CA. Dept. of Water Res., 61 FERC ¶61,001 (1992) at footnote 2.

10 The information for this section is derived from public sources, among others, publications and websites by the United States Bureau of Labor Statistics, the United States Census Bureau, and local governmental authorities.

poverty levels, employment and housing.[11] In addition, we will look at both direct and indirect costs, including the multiplier effect that occurs when monies are added to or taken from the local economy.

A. Employment and Unemployment

The two factors, which together define the status of jobs and employment in the economy, are the unemployment rate and the labor force participation rate. The unemployment rate is measured as the percentage of the labor force classified as "unemployed."[12] The labor force participation rate in simple terms is the percentage of the general population who are in the labor force. Persons 16 years of age and older who are either employed or are categorized as unemployed but seeking employment are considered to be in the labor force. The percentage of the U. S. population in the labor force in 1999 was 63.9 percent. Of the persons in the labor force in the United States in 1999, 5.8 percent were categorized as unemployed.

The State of California fared somewhat worse than the Nation as a whole in both of these categories. The labor force participation rate in 1999 in the State of California was 62.4 percent. This lower rate may be due to the more advanced age of the population, worse economic conditions in the referenced area or due to the "discouraged worker" phenomenon.[13] The unemployment rate in the State for the same year was 7.0 percent, again significantly higher than the national average.

The employment situation in Butte County in 1999 was much worse than that of California. The labor force participation rate in Butte County in 1999 was 56.8 percent and the unemployment rate was 9.3 percent, both significantly worse than the statistics for the State and the national average.

The table below summarizes these employment statistics for 1999.

1999	United States	State of California	Butte County
Labor Force Participation Rate	63.9%	62.4%	56.8%
Rate of Unemployment	5.8%	7.0%	9.3%

11 For consistency, all information in the following paragraphs is from Census 2000 and report figures for the year 1999.

12 In order to be classified as unemployed, one has to be in the labor force. Those who are not in the labor force are not counted as "unemployed," even though they do not hold a job. Therefore, retired persons, those under 16, the institutionalized, members of the armed forces and those who do not actively seek employment are not considered to be in the labor force.

13 Discouraged workers, in simple terms, are those who have stopped searching for employment because they do not think they will be able to secure desired and appropriate employment under the circumstances present at the time.

These two factors affect not only the people who are unemployed or out of the labor force, but have a major impact on the fiscal state of the local governments. Fewer people in the labor force, and/or a higher unemployment rate, puts pressure on local governments by requiring them to spend more on subsidies and assistance programs, while at the same time depriving the community of the benefit of higher tax and spending revenues that would result if people who are either unemployed or out of the labor force were in fact working.

B. Poverty

Another measure of the welfare of the community is the percentage of families and individuals in the community living below the official poverty line. In 1999, the percentage of families living below the poverty level in the United States was 9.2 percent, the percentage of individuals living in poverty was 12.4 percent and the percentage of families with related children under 18 living below the poverty level was 16.1 percent.

As with the employment data, the State of California fared worse than the Nation as a whole in this category. The percentage of families living below the poverty level in the State of California was 10.6 percent, the percentage of individuals living below the poverty line was 14.2 percent and the percentage of poor families with related children under 18 was 19.0 percent.

With respect to this measure of well being, Butte County again fared much worse than the Nation and the State of California in all categories. The percentage of families living below the poverty level in Butte County was 12.2 percent, the percentage of individuals living below poverty was 19.8 percent and the percentage of poor families with related children under 18 was 23.8 percent.

The table below summarizes the poverty statistics as described above for 1999.

1999	United States	State of California	Butte County
Families Living below Poverty	9.2%	10.6%	12.2%
Individuals Living below Poverty	12.4%	14.2%	19.8%
Families with Related Children under 18 Living below Poverty	16.1%	19.0%	23.8%

Some of these issues can be directly traced back to the impact of the Project on the local community. Many of the jobs that are created in connection with the Project are seasonal and low paying, such as jobs in the tourism industry built around the Project. As such, they contribute to the level of poverty prevalent in the local economy due to the low paying nature of these jobs during the peak tourist season and the lack of income during the off-peak season. An additional impact of this phenomenon is the heavy burden on the local governments to provide support to such workers, including those who go onto the public assistance rolls even while working in the low paying, seasonal jobs.

In short, Butte County has some of the worst poverty statistics in the State. It is important to note here that these poverty statistics demonstrate the additional pressures that are placed on local governments. The impact on the County is again two fold; it has a much higher burden to provide public assistance, housing and other services to the people in need, and at the same time County revenues are negatively impacted by the lack of earnings and incomes for these families and individuals.

C. Income

There are a number of different measures of income, which is another determinant of economic well being for a community. We considered three such measures; median household income, median family income and per capita income.[14]

Median household income in the United States for 1999 was $41,994, while median family income was $50,046 and per capita income was $21,587. The median household income, median family income and per capita income for the State of California for the same year were $47,493, $53,025 and $22,711 respectively. Butte County, however, had figures that were much lower than the national and State figures, with median household income of $31,924, median family income of $41,010 and per capita income of $17,517.

The income figures follow the pattern shown in the employment, unemployment and poverty categories developed above for Butte County. The income levels in Butte County are between 23 percent and 33 percent below State levels.

The following table presents statistics for various income measures for the year 1999.

1999	United States	State of California	Butte County
Median Household Income	$41,994	$47,493	$31,924

14 The United States Census Bureau defines income as "the sum of the amounts reported separately for wages, salary, commissions, bonuses, or tips; self-employment income from own non-farm or farm businesses, including proprietorships and partnerships; interest, dividends, net rental income, royalty income, or income from estates and trusts; Social Security or Railroad Retirement income; Supplemental Security Income (SSI); any public assistance or welfare payments from the state or local welfare office; retirement, survivor, or disability pensions; and any other sources of income received regularly such as Veterans' (VA) payments, unemployment compensation, child support, or alimony", Per capita income is defined as "average obtained by dividing aggregate income by total population of an area," Family is defined as "a group of two or more people who reside together and who are related by birth, marriage, or adoption," and household as "all the people who occupy a housing unit as their usual place of residence." Finally, median income is defined as follows: "the median income divides the income distribution into two equal groups, one having incomes above the median, and other having incomes below the median."

Median Family Income	$50,046	$53,025	$41,010
Per Capita Income	$21,587	$22,711	$17,517

The disturbing pattern indicated in this incomes approach, again, demonstrates the hardship imposed on the local governments due to the dual impact of receiving lower revenues due to a lower income tax base and higher expenditure levels to support that portion of the population in need of support due to low income levels. Not only the members of the community suffer due to the lower income levels indicated here, the local governments also suffer with a multiplier effect on the community as a whole.

D. Housing

Housing is one of the most basic needs in any community and provides another important measure of the welfare of the community. We have looked at two different aspects in this category; vacant housing rates and home ownership.

The vacant housing units category measures the presence or lack of equilibrium in a community. It measures how expectations about occupancy and affordability do or do not match reality. The vacant housing units in the United States in 1999 represented 9.0 percent of all housing units. The figure for the State of California was 5.8 percent and for Butte County 7.0 percent. The more relevant markets to compare against each other in terms of vacancy rates are the State of California and Butte County. Again, the results here are consistent with those shown above and show that Butte County fared worse than the State of California in this regard.

Another measure of the welfare of the community is the ratio of owner occupied to renter occupied housing units. The higher the ratio, the more people who are able to afford the down payment and the mortgage required to purchase a house. The ratio of owner occupied to renter occupied units in 1999 for the United States, the State of California and Butte County were 1.96, 1.54 and 1.32 respectively. Consistent with the pattern, Butte County fared worse than both the Nation and the State of California in this category.

The table below summarizes the housing statistics for the year 1999.

1999	United States	State of California	County of Butte
Vacant Housing Units	9.0%	5.8%	7.0%
Ratio of Owner Occupied to Renter Occupied	1.96	1.54	1.32

It is highly significant that the housing stock of Butte County (and related demand for government services) is still affected by the original construction of the Project. During Project construction, low quality housing was built for use by workers at the Facilities, then one of the largest construction projects in the world. Once the Project was completed, many workers moved away, resulting in a glut of low cost and low quality housing. According to local residents, many of these houses were abandoned or sold at very low prices. This housing glut led many low income people to move into the community and take over these abandoned or unoccupied properties. Once there, people who were attracted by the low cost housing found there were inadequate employment opportunities. The result was that an enormous social service burden was placed on Butte County.

Consider the following example. In the three years following the opening of the Project, the population of Butte County increased by less than one percent. However, over this same period, Butte County subsistence payments increased by 58.1% and the number of people receiving such payments increased by 56.1%.[15] Thus, construction of the Project caused a direct, quantifiable and unmitigated impact on the County. This significant increase in demand for government services immediately following completion of the Project occurred at the same time the County was dealing with reduced property tax revenues due to all of the property taken by the Project and the failure of DWR to make tax or PILOT payments to compensate for the new burdens it was placing on the County. Together, these effects started the County down a path of economic decline. This effect continues to the present with, as shown above, Butte County experiencing poverty levels, unemployment rates and social service costs that rank among the highest in the State.

E. Additional Considerations Regarding the Fiscal Health of Butte County

The evidence that Butte County has suffered and continues to suffer severe fiscal problems is extensive. In 1989, an independent audit commissioned by the State Department of Finance confirmed Butte County's dire fiscal situation and qualified the County for emergency assistance funding in order to avoid a bankruptcy declaration by the County.

Again in 1996, Butte County received a 12-month finding of significant financial distress from the Commission on State Mandates, which found the County had annual unmet needs of $17.6 million. This finding was later extended to a three year term. Butte County was one of only six counties in the State to receive this finding. On November 30, 1999 the Commission on State Mandates found once again that Butte County could not pay for basic County services and concluded that the County government had $17.3 million in annual unmet needs. Butte County was the only county in California in 1999 to receive such a finding.

In 2005 the County filed to establish that due to the decline in the amount of funds available in the general fund balance and the increases in costs being experienced by the County, it would experience unmet needs of $56.9 million for the next year. Recently, and based on an exhaustive analysis by staff from the California Commission on State Mandates, State Treasurer's Office, Department of Finance, and State Controller's Office, the Commission on State Mandates completed its process under SB 1033 and issued a finding of significant financial distress for Butte County for the period September 1, 2005 through August 31, 2006.

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15 Based on data provided by the Public Welfare in California, Annual Statistical Report, Statistical Series AR 1.

It is clear that Butte County's economic condition remains poor, relative to that of the State and the Nation as a whole, and that Butte County requires additional funding to make up for a shortfall in tax revenues and service costs that its citizens and businesses cannot afford to fund. The County has had to turn repeatedly to the State for determinations of need and subsequent stop-gap funding to prevent bankruptcy or other dire financial consequences.

We believe that this shortfall is largely due to the costs imposed on the County by the Oroville Project. The County seems to be going through what is sometimes referred to in the economics literature as a "death spiral". The initial shock to the local economy was caused by the loss of tax revenues received by the County as a result of the large quantity of lands taken for the Project and by other tax generating property being displaced by the Project, such as DWR's removal of a tax-paying power plant.

The second shock to the local economy was the large number of low-quality and low-cost homes abandoned or sold below cost by Project workers at the end of the construction phase. This in turn led to an influx of low-income people to buy or take over this housing who then increasingly relied upon the County for subsistence payments and a broad range of government and social services. Further, for each year that the Project has operated the County has been called upon to provide road, fire, police and other government services to the Project. No tax or PILOT payments have been made by DWR to offset these additional County operating costs or to offset the loss of tax revenues associated with the permanent loss of approximately 41,000 acres of County land and certain tax generating assets, such as the aforementioned power plant. Together these impacts have had a devastating financial impact on Butte County, which as noted above has had to rely on the State for ever larger emergency payments in order to prevent financial failure.

Looking at the status of the local economy today and comparing how the County has fared over the decades compared to similar communities in California, one cannot help but conclude that the process of decay started with the loss of taxes received by the County governments once the Project commenced, and worsened over time due to the death spiral effect.

The initial loss of government revenues had two direct effects on the local economy. First, the County had to reduce its expenditures in order to accommodate the loss of revenues; such reduction in expenditures necessarily meant a reduction in the labor force hired by the County, a reduction of incomes within the County due to this loss of employment and a reduction of expenditures in the County due to reduced incomes by the residents. Second, a reduction in County expenditures meant the quality of life in the community declined, gradually making Butte County a less desirable place in which to live, especially for younger generations in the labor force with expectations of higher incomes and better living standards.

Thus, the initial impact of the loss of tax revenues due to the Project was a reduction in government services, lower countywide incomes and expenditures and an exodus of some labor force participants to more desirable places with higher government revenues and better services. This initial impact later led to more negative consequences for the County. Taking into account the multiplier effect, particularly over time, the loss of revenues and income levels in the County resulting directly from the loss of tax revenues by County governments resulted in a further reduction in incomes and expenditures by local residents. Lower incomes and expenditures necessarily caused an additional round of revenue losses for local governments, leading to a decline of local government expenditures, loss of jobs and incomes in the local community and further loss of expenditures and incomes for County residents. Unfortunately, this was not a one time or transitory event; the County did not lose a part of its revenues for one year, but rather it lost revenues permanently, with recurring impacts every year. Today the situation has worsened to the point that the County has been found to be in significant financial distress three times, a record not matched by any other County in California.

What we see today is that every quantitative measure of well being shows that the County is suffering significant financial distress, and that this situation is getting worse. Labor force participation and employment in the County are at some of the lowest levels in California. Poverty statistics show that in every category Butte County is faring worse than any similar community and the State as a whole. Various income figures for Butte County are also some of the lowest in California. And the housing statistics further confirm all of these adverse impacts. The current situation results from decades of negative impacts associated with the lack of tax and other payments by the Project and has been exacerbated further by the absence of any payments in lieu of taxes or low cost power to partially compensate the County residents for the losses they incurred due to the existence of the Project. As we will show later, the impact on the County is very substantial today and could well be worse over the relicense term if the current situation is not changed.

IV. ESTIMATES OF FINANCIAL IMPACTS

Butte County is in severe financial distress and cannot afford to pay for the essential services needed by its citizens and demanded by the Project itself. This situation has been and continues to be exacerbated by the Project, which consumes County resources by creating a demand for services which the County is responsible to provide, and by displacing other uses of the land and water resources used by the Project that could generate tax revenues.

It is beyond dispute that tax revenues are a vital element of every community's socioeconomic well-being. In the case of Butte County, this vital element has been severely restricted for almost half a century. Initially the harm was caused by DWR not paying property taxes or making payments in lieu of property taxes on the real and personal property that was taken for the Project or on the Facilities that were subsequently constructed and operated. This has produced the secondary and tertiary effects of an inadequate tax base, which in turn has led to reduced services and a shifting of the tax burden to others. The Project's failure to pay its fair share of taxes has placed the County in a chronic condition of under-funded budgets due to lack of tax revenue, inadequate tax base and increased demand for services. The long term effects of this imbalance are that reduced County services make the County less attractive than surrounding communities that are able to collect property taxes from all of their businesses and lands and thus can provide adequate government services.

Throughout this Report we will discuss revenues added or taken away from Butte County due to the Project and how this affects the community. In addition to the immediate effects of such financial gains or loses there is also a greater if less immediate effect, which is commonly referred to as the multiplier effect. The multiplier theory, a well known economic theory, states that for every dollar injected into the economy by an economic agent, a multiple of that one dollar will be created in the economy as expenditures or income through people spending and re-spending that original dollar, or portions thereof.

The general multiplier for the economy as a whole is quite large, but for our purposes we assume that the county wide multiplier is in the range of 3.0. A study published by the University of California, Davis titled "The Measure of California Agriculture 2000," Internet Release, Chapter 5 by Nicolai V Kuminoff, Daniel A Sumner and George Goldman estimated the multiplier effect to be 3.99 for California and 3.41 for the counties located in the Sacramento valley, including Butte, Colusa, Glen, Sacramento, Shasta, Solano, Sutter, Tehama, Yolo and Yuba in 2000. In the case discussed here, the multiplier is likely to be higher, due to the fact that an injection of $1.00 into the local government coffers will be passed on, almost 100%, to the local community, which will re-spend based on its own propensity to spend. In contrast, an extra dollar injected into the agriculture sector may not be completely re-spent in the local community. We feel that the University of California study is representative of the realities of the local economy, but for the sake of using a conservative estimate, we have chosen to assume a multiplier of 3.0 for our analysis. We would note that in a similar study, conducted on behalf of the New York Power Authority in support of its application at FERC for the renewal of its license for the Robert Moses Niagara Power Project, a multiplier of 3.9 was used in the socioeconomic report filed by the New York Power Authority (NYPA Socioeconomic Report).

A multiplier of 3.0 in the instant context means that an extra dollar spent in the Butte County economy, perhaps because the local government collects this extra dollar to compensate for lost taxes associated with the Project, will be spent and re-spent (wholly or partially) in the local economy, resulting in a final addition to the local economy's income and expenditures equal to $3.0. Similarly, one dollar lost by an economic agent is assumed to eventually result in a loss of $3.00 for the local economy in Butte County.

In this section, we quantify the lost tax revenues to Butte County that result from DWR's failure to make tax or PILOT payments and the large footprint the Oroville Facilities occupy in the County, thus displacing the many potential uses of the land by tax paying entities. We also quantify the harm caused by the Project's failure to provide any low cost power to the host community and, conversely, the value that such a low cost power allocation would represent to the citizens and businesses of Butte County. Because these results are based on assumptions that differ in certain respects from those presented by DWR in the license application that it filed at FERC in January, 2005, notably in Chapter 6, Developmental and Economic Analysis, we will also review some of the application's underlying assumptions.

The following scenarios have been analyzed to quantify some of the impacts of the Oroville Facilities on Butte County's financial condition.

A. Lost Taxes Assuming Project Was Never Built

One approach to quantifying the harm to Butte County due to DWR's failure to make tax or PILOT payments is to assess what the County would be receiving in tax revenues if the Oroville Facilities had never been constructed. The underlying assumption is that the benefits and burdens associated with alternative development of the area encompassed by the Oroville Facilities would be no different than those associated with the Project. The difference is that there would be tax revenue flowing from the 41,100 acres encompassed by the Project, if it had not been taken over by DWR.

If one were to assume that the Project had never been constructed, then there would be property taxes flowing from the assessed value of the land and homes, commercial buildings and industrial facilities encompassed by the Oroville Facilities Project area. As it is impossible to accurately construct exactly what might have transpired on the 41,100 acres of land currently under DWR's control, one can only make certain reasonable assumptions.

One possible scenario is that the land encompassed by the Oroville Facilities would have developed over the past 50 years generally in the same fashion as the County as a whole. The following table shows the current assessed tax valuations county-wide. [16]

	Number of Properties	Average Value	Total Value	Percent of Total

[16] Table values were provided by, or derived from data provide by, Mr. Aranguren, Butte County GIS Division Manager.

Residential	85,789	$89,545	$7,681,917,928	95.16%
Commercial	3,875	$504,395	$1,954,530,625	4.30%
Industrial	487	$624,275	$304,021,925	0.54%
Total	90,151	$110,265	$9,940,470,478	100%
County (acres)	1,068,800 acres	$9,300/Acre		

Thus all developed properties have an assessed value of $9.94 billion. Because Butte County is 1,068,800 acres in size, the average per acre valuation for the County is $9,300/acre. Assuming the same characteristics for properties encompassed by the Project as those for the County as a whole yields a value for the area encompassed by the Oroville Facilities (net of the National Forests[17]) of $298,548,936, and at the current 1% property tax rate would yield approximately $3 million per year in lost tax revenue. If this value is allowed to escalate at 2.0 percent per year[18], the lost property tax revenues over the new 50-year license period would be $267,966,590.

Another approach to determining how much property tax revenue would be generated if the Project had not been constructed is to focus on the property development that was in place prior to constructing the Oroville Facilities. We know from the records that a 70 MW hydroelectric power plant known as Big Bend or Las Plumas was owned by Pacific Gas and Electric Company ("PG&E") and was then purchased by DWR and inundated as Lake Oroville filled.[19] Thus it is possible to determine a value for Big Bend as if it were still operating today. To do this, one must develop a property value for Big Bend in line with the methodology used by the California Board of Equalization ("BOE"), which has had the responsibility since 2002 of assessing the value of power generating facilities of greater than 50 MWs.

The BOE uses the fair market value of the generating facility for assessment purposes. In general, for newer plants BOE relies on the replacement value concept of property valuation. For older plants, it uses the discounted cash flow methodology to determine fair market value. For this assessment, we use the discounted cash flow, or income capitalization, approach to determine a likely assessed value.

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17 Of the 41,100 acres that are encompassed by the Project, approximately 9,000 acres are within the Plumas and Lassen National Forests.

18 The assumed value of properties that might today exist where the Project is currently located has been escalated over the new 50-year license period to reflect that property values tend to increase over time. Through a separate analysis of data provided by Butte County, it has been determined that land values in Butte County have increased at an average annual rate of 4.2% over the initial license period. An escalation rate of 2 percent has been used and is conservative as it assumes there would be no future sales/transfers/revaluations of property, thus property tax increases would be limited to the Proposition 13 cap.

19 Butte Historical Society "Diggins", Volume 11, No.3, Fall 1967.

For the discounted cash flow ("DCF") approach we assumed a generation level of 224.9 million kWh per year[20], a net value of 4.73 cents/kWh (see below for an explanation of how this value has been determined) for the energy, and a discount rate of 20.22 percent for present value calculations.[21] The discounted cash flow method, using the above assumptions, yields a present value of $63.1 million for the Big Bend Project.[22] Further, assuming a tax rate of 1.0 percent for property tax purposes, the annual taxes due on Big Bend, as determined by the DCF method, would be $631,151. Lost tax revenues over the 50-year new license period due to the destruction of Big Bend would be approximately $31.6 million[23].

If we assume that the area encompassed by the Oroville Facilities had only the Big Bend power project as a property improvement, then the balance of the land not associated with Big Bend could be assumed to have the value today of other areas of the County or $9,300 per acre[24] as shown above. Again, using the area of the Oroville Facilities less the National Forests and deducting the area assumed to be encompassed by the Big Bend facilities[25], we assign a conservative value to the remaining area of approximately $263.4 million, which at a 1% tax rate would yield an additional $2,634,337 per year of taxes. If the land value is allowed to escalate at 2 percent, then foregone taxes would equal $236.4 million over the proposed 50-year license period.

The table below summarizes the lost property tax revenues that would be paid to Butte County from the area currently occupied by the Oroville Facilities under these two different approaches and thus represents a conservative range of potential lost tax revenues.

Lost Tax Revenues		
Approach Used	**Annual (2004)**	**50-Year License**
Alternate Use of Property	$2,985,489	$267,966,590

20 The amount of energy generated per MW of capacity has been assumed to be the same as for the Oroville Facilities, as discussed below.

21 The discount rate was calculated in accordance with BOE's "Unitary Valuation Methods" handbook revised March 2003 and BOE's "Capitalization Rate Study" dated March 2005.

22 As recently as August 2000, PG&E valued its hydroelectric power plants (approximately 3900 MW's) at $2.8 billion or an average value of $718/kW. This average value per kW would yield a value for the Big Bend plant of approximately $50 million.

23 According to conversations with representatives of the BOE, 100% of the property taxes collected from power generating facilities greater than 50 MWs remain with the locality in which the assessed asset exists; in this case Butte County.

24 Based on land values provided by Mr. Bailey, Senior Appraiser, Butte County Assessor's Office.

25 We have assumed the land associated with Big Bend is proportional to the size of Big Bend compared to the Oroville Facilities, thus 70MW/762MW = 9.186% and 9.186% of 41,100 acres (area encompassed by the Oroville Facilities) is equal to 3,776 acres. The net area used above is then 41,100 less 3,776 less 9,000 or 28,324 acres.

Big Bend Hydro Retained (BOE valuation) and Alternate Use of Excess Property	$3,265,488	$268,006,030

B. Lost Taxes Assuming Project Owned by Private Third Party

Another approach to determining the tax revenues lost by Butte County due to the Project is to consider the tax revenues that would be paid if the same facilities were owned by an investor owned utility as a non-rate base asset or other privately owned unregulated power producer.

In analyzing the effect of the tax exempt status of the Facilities, we developed a property value in line with the methodology used by the California Board of Equalization ("BOE"). Again, for this analysis we used the discounted cash flow valuation method

For the discounted cash flow approach we determined a cash flow for the Project. Thus we developed revenue and expense values. Revenue is the amount of energy produced times the unit price at which the energy is sold. We assumed a generation level of 2,448 million kWh (2,448 GWh) per year as this is the 20-year average energy production from the Oroville Facilities (1982-2001)[26]. In determining a value for the energy on a kWh basis, we used the average annual wholesale cost of energy, as determined by the California Independent System Operator, for the period 2002 through 2004 of $0.0496[27]. Please note that the wholesale price of electricity in California has recently been in excess of 10.0 cents/kWh, making our analysis quite conservative. We then added $0.0099 (20% of the average wholesale cost) to conservatively approximate the benefit that the Oroville Facilities would achieve by selling much of the energy during peak periods, just as DWR currently does.[28] From the total revenue per unit of energy generated of $0.0595/kWh, we then subtracted expenses.

In this case, we used the operations and maintenance, capital improvement/additions, and environmental/recreation costs that DWR has indicated apply to the Oroville Facilities.[29]

26 Table B.4.4-1 of Exhibit B of DWR's application to FERC, January 2005.

27 Calculated from information contained in the California Independent System Operator's 2004 Annual Report on Market Issues and Performance.

28 This appears to be a very conservative assumption as the State Water Resources Development System, Management's Discussion and Analysis report, June 2004 indicates that power from the Project was sold over the 2002 – 2004 period at an average price of $0.0898/kWh. Further confirmation of the conservative assumption for cost of energy is that Pacific Gas and Electric reported an average cost of purchased power for 2004 of $0.082/kWh.

29 Table D.4.5-1of Exhibit D of DWR's application to FERC, January 2005. We did not include the cost of relicensing the Oroville Project or the levelized bond cost as the discount rate addresses this cost of capital element. We point out here that the levelized bond costs included as a Project cost in DWR's application apply to all of the outstanding DWR Series A through Y water bonds with a total value of $153,700,000. However,

Spreading the above costs, as determined by DWR to be $29.9 million per year, over the 2,448 GWh of energy produced, yields expenses of $0.0122/kWh. The net cash flow value per unit of generation is then 4.73 cents/kWh. We then assumed a discount rate of 20.22 percent for present value calculations. The discounted cash flow method, using the above assumptions, yielded a present value of $687 million for the Project. Thus, further assuming a tax rate of 1.0% for property tax purposes, the annual taxes due for the Project would be approximately $6.87 million. Lost tax revenues over the 50-year new license period would be approximately 343.5 million. The table below summarizes the effects of DWR's tax exempt status in terms of lost revenue to the County using the DCF valuation methodology.

Tax Revenues – DCF		
Approach: Privately Owned-DCF	**Annual (2004)**	**Over 50-Year License**
Discounted Cash Flow	$6,870,535	$343,526,743

The analysis and results presented above regarding the property taxes that would be paid by a private owner of the Facilities would be the same if the Facilities were owned by a California municipality located outside Butte County. Article XIII, Section 11 of the California Constitution generally provides that lands, water rights and any interests in any lands owned by a local government that are located outside its boundaries are taxable if they were taxable when acquired by the local government. As an example, the Los Angeles Department of Water and Power ("LADWP") owns land and related improvements in Inyo County. At this time, LADWP pays Inyo County over $3 million a year in property taxes and an additional $3 million in payments into the general fund and water and recreation funds. Thus again, but for the form of entity owning the Facilities, Butte County would currently be receiving substantial property tax revenues from the Project.

Note that all of the above figures are indicative of the first round of impacts on the County and its government resulting from nonpayment of taxes by the Project. Over time these first round impacts result in secondary and tertiary impacts on the County governments and residents making the impact larger every year, as well as causing an accumulation of adverse impacts over time. This financial harm will only become more pronounced and severe if allowed to continue during the relicense period.

DWR's footnote explanation of this amount states that it "**includes** (emphasis added) funding of past improvements to the Oroville Facilities", thus it appears not all of the outstanding debt is related to the Oroville Facilities. Given that the outstanding balance in 1994 of the original debt issued for the Oroville Project was approximately $35.2 million, it is likely that only a relatively small percentage of the currently outstanding $153.7 million is associated with the Project. However, the entire cost of amortizing this debt is considered a cost of the Project in the application.

C. Financial Harm Due to Failure to Provide Low Cost Power

We have used several different approaches to calculate the potential tax revenues that will be lost by the County during the proposed 50-year new license period if the status quo is allowed to persist. In this section of the report, we will quantify the costs to the citizens and businesses of Butte County due to DWR's failure to provide a low-cost allocation of Project power. We will also assess the impact on the local economy of DWR not making this recognized method of compensating local communities where large, invasive infrastructure projects (particularly hydroelectric generation projects) are constructed and operated available to the residents and businesses of Butte County.

The cost to the residents of Butte County due to DWR's failure to provide a low-cost allocation of power from the Project that is located in their community, and which is wholly dependent upon their local resources, is extremely high. To arrive at an estimate of this cost, we estimated that the total Butte County residential consumption of electricity is approximately 390.6 million kWh per year, based on an average demand of 4,553 kWh/residential unit/year[30].

Currently, Butte County residents pay a retail rate for electricity that is made up of several components, primarily distribution charges, transmission charges and energy charges. We have assumed for simplicity that all charges to the retail customer would stay the same as they are today except for the energy charge. We have also assumed that a low cost allocation of power from the Project would be provided by DWR at its cost. According to DWR's application to FERC, this cost would consist of the operations and maintenance, capital improvement/additions, environmental/recreation, relicensing, and levelized bond costs of $0.0182/kWh. Because the average wholesale cost of power for the California Independent System Operator was $0.0496/kWh over the 2002 – 2004 period, we can assume that the value of a low-cost power allocation from the Project would at a minimum equal the difference between the wholesale cost of generation and DWR's cost of producing power, or $0.0313/kWh. To be conservative, we have made such assumptions about the value of the power, despite the recent wholesale price of power being in excess of 10.0 cents/kWh in California

Because there are approximately 85,789 residential units in Butte County the community loses approximately $12.2 million a year in electricity costs due to DWR's failure to provide a low cost power allocation. The negative impact does not stop there, as every dollar taken out of the local economy due to the loss of low cost power will cause further rounds of losses to the local economy, with the final impact being much larger than the original funds taken out of the economy. As discussed above, if one applies a multiplier of three to these lost savings, the total annual loss to the community from this effect of Project operations is approximately $36.7 million per year. Over the 50-year license period this would equate to almost $1.8 billion in foregone savings.

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[30] U.S. Department of Energy, Energy Information Association, Form EIA-861 Database for 2003 (data for PG&E, main local provider, were used).

In addition to the direct quantifiable costs associated with Butte County citizens having to pay power rates much higher than the cost of Project power, the indirect costs to the County from this loss are also extremely high. Had low cost power been made available to Butte County for commercial and industrial businesses, there is no doubt that significant additional economic development would have occurred. Using an average total demand (i.e. residential, commercial and industrial loads) for power per residential unit of 11,203 kWh[31], the County as a whole loses annual savings of $30.1 million, Further, by applying the same multiplier as above, over $90 million of annual savings are foregone. Thus, over a 50-year license period the County would lose over $4.5 billion in savings.

The loss of tax revenues and lack of low cost power to compensate for such lower tax revenues has made the County a less desirable place to live or locate a business. With fewer people and businesses sharing the burden of supporting the local government expenditures, each remaining business or resident has had a larger tax burden, while at the same time receiving lower quantities and qualities of government services due to the lack of funds available for the County government. Businesses logically have preferred to locate where the tax burden might be lower, government services superior and local customers more plentiful and better able to purchase their products. This additional spiral effect can also be attributed to the existence of the Project and its impact on the local government as well as residents and businesses in the County.

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[31] U.S. Department of Energy, Energy Information Association, Form EIA-861 Database for 2003 (data for PG&E, main local provider of power, were used).

The table below summarizes the economic impact on the citizens of Butte County due to DWR's failure to provide a low cost power allocation.

Low Cost Power Allocation	Annual(2004)	Annual With Multiplier	50-Year License	50-Year License With Multiplier
Residential Only	$12,230,960	$36,692,880	$611,548,000	$1,834,644,000
Residential, Commercial & Industrial	$30,092,662	$90,277,986	$1,504,633,100	$4,513,899,300

It is when one focuses on the value of receiving a low cost power allocation from the Project and the increased economic activity that would result from the associated savings, which is estimated by applying the multiplier, that the economic harm of losing these benefits can be fully appreciated. Not only would the citizens of Butte County be economically better off individually but such an allocation would, over time, cause tax revenues and the tax base to grow as businesses move into the area, attracted by the availability of low cost power and the increased buying power of County residents due to lower cost power. Thus, the County's finances would also substantially improve if Project power were made available to the community. This line of reasoning is not only supported by economic theory, but can be observed in practice. In fact, research and analysis performed by the author in other states indicates that these two factors, namely low cost power and a healthy local government, contribute substantially to the vitality of the whole community.[32]

V. LIKELY IMPACT OF THE PROJECT ON BUTTE COUNTY OVER THE PROPOSED LICENSE TERM

Butte County will be greatly harmed if the status quo is allowed to continue into the second license period. The County has already lost hundreds of millions of dollars of tax revenue since Project inception, and that loss has had multiple negative effects on the community which will take many years to reverse. The lack of tax base and lost tax revenues, together with the loss of land, lack of robust tourism and failure to receive a low-cost power allocation, have kept the County on the brink of financial insolvency for years.

Butte County will continue to suffer economic decline if measures are not taken to mitigate the Project's continuing adverse impacts during the new license period. Considering the range of financial losses shown above, tax revenues of $6.87 million per year and increased electricity costs of $30.1 million per year, over the term of a 50-year license the cumulative

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[32] Analysis performed by FMY Associates, Inc. with respect to the impact of low cost power and local government finances in the case of Niagara Power Project and its impact on Niagara County in New York.

direct harm experienced by the County would be approximately $1.85 billion.[33] In addition, this harm would be exacerbated by the multiplier effect, resulting in total losses to the County over the proposed 50-year license period equal to approximately $5.5 billion.

The analysis in this report shows clearly that: (a) the County, its residents and its government have suffered tremendous losses over the first license period, (b) the County has gradually but consistently over the term of the existing license been driven into a cycle of decline to the point of severe financial distress. Butte County remains one of the poorest counties in California and in general ranks near the bottom of all economic measures commonly used to assess economic well being. Realistically there is little the County and its residents can do to improve this situation, as long as the status quo with DWR and the Project continues. In fact, the County and its residents are likely to see this economic decline intensify over time, just as it has since the Project was developed. It seems that the only way out of this economic decline and death spiral would be for the Project to provide financial assistence and low cost power. Without such assistence from DWR, the County will continue to suffer the consequences of the Project's existence within its borders.

VI. CONCLUSIONS AND RECOMMENDATIONS

Over the initial license period, the Oroville Project has provided substantial economic benefits to DWR, all the recipients of low cost water supply and flood protection attributes and to the State of California in general. The past direct value of these benefits could possibly be calculated by valuing the water delivered and the property protected by the Facilities since installation, but the calculated value would pale in comparison to the signficance of the Oroville Project to the economic development of California over the past 50 years. The very phenomenon of California's robust agricultural production and the economic vitality of its urban areas are due in some large measure to the presence of the Facilities. Perhaps the strongest proof of how central the Oroville Facilities are to the economic well being of the State is to simply contemplate the reaction from stakeholders if the Facilities were in fact not relicensed. Butte County is not suggesting such a measure but is instead requesting that those bearing the burden of the Project be fairly compensated going forward. The cost of that compensation would simply be another operating cost to DWR and DWR would pass that cost on to the Water Authorities it serves who would then pass the cost down to the eventual end-users. In others words, compensation to Butte County would be paid by those parties that have received and will continue to receive the benefits of the water and flood protection the Facilities provide.

As additional development takes place in the future and more pressure is placed on the available water supply, the value of the benefits delivered by the Project will only increase over the term of a new license. In contrast, however, Butte County, which has suffered ongoing and severe financial losses, and other significant adverse impacts as a result of the Project operating within its area, will likely face additional negative impacts in the future. As demand for water increases due to economic and population growth elsewhere in the State, there will be increasing pressure to manage the Oroville Facilities to best accommodate

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33 As shown in Section IV, the DCF valuation method resulted in cumulative lost taxes of $343 million and the loss of a low cost power allocation will result in a cumulative loss of $1.505 billion in benefits.

those demands as opposed to ongoing recreational and environmental requirements. To the extent this is allowed to occur, even greater negative consequences will be suffered by Butte County.

Although the Oroville Project will continue to take advantage of the resources offered by the County, DWR does not propose to provide any compensation in the form of property taxes or equivalent payments. Moreover, the failure to provide local residents and businesses with any of the low-cost power produced by the Project will continue to result in a large outflow of community revenues in the form of higher energy payments. Because Butte County has already suffered many negative economic consequences as a result of the Project, with low income levels, high unemployment rates, and high poverty levels, it is vital that this downward spiral be halted in any new license term.

Through the relicensing process, DWR should be required to accept responsibility for mitigating the ongoing harm that is being experienced by the community in which the Project is located. One need only compare the value extracted from Butte County by the Project with the County's unmet funding requirements and record of economic decline to understand the disparity and unfairness that characterizes the existing relationship between the Project and Butte County.

There are a number of ways DWR should address the Project's adverse impacts and assure that the public interest is protected. No one has a stronger claim to receive low cost power than the County that hosts the Project. Therefore, as the first step, DWR should provide a fair share of the electricity generated by the Project to the local community at cost-based rates. Total annual load for all classes of service in the unincorporated areas of the County is about 19.2% of the average annual generation of the Facilities. A fair allocation of low cost power to the County for its use would probably be one half of the annual load for the unincoprporated portion of the County, namely approximately 235 million kWh on an annual basis. It is easy to imagine the benefits that would begin to accrue locally to the extent some of this low cost power was made available to new industries locating in the County as an economic development incentive. This would allow the multiplier effect which has been so devasting for so long, to begin working to the benefit of Butte County and its residents. The power of the death spiral would be undone as every dollar generated by these new businesses would yield up to a three-fold increase in economic activity.

In addition DWR should compensate the County for the direct costs and adverse effects of having the Project in the community by paying local taxes or making equivalent payments. Considering the calculations made in Section IV of this report, the payments in lieu of taxes should be in the range of S3.0 million to $6.87 million per year in 2004 dollars, increasing by 2.0% per year. By increasing the tax revenues available to the County more and better services will be available. This will not only rectify a serious inequality, but improve the lives of county residents and encourage new businesses to locate in the area, again serving as a means to break out of the vicious cycle of decline.

REFERENCES

ATTACHMENT A –
QUALIFICATIONS OF FARAMARZ MARK YAZDANI, PH.D.

Faramarz Mark Yazdani, Ph.D.
146 Main Street, Suite 404
Los Altos, California 94022
(650) 941-3850 (Tel)
(650) 941-1835 (Fax)

PROFESSIONAL EXPERIENCE

President — **1994 - Present**
FMY Associates, Inc.

Provide financial, economic, and regulatory advice and support to clients participating in various aspects of the electric power industry.

- As leading ex-pat negotiator, designed strategy and implementation plan, was involved in all aspects of the restructuring program and completed renegotiation of 27 power purchase contracts and over 11,000 MW worth of IPP capacity, on behalf of PLN, the government owned national electric utility in Indonesia. The negotiations involved international IPP's, private and government owned oil and gas companies, private international lending institutions, government sponsored insurance and lending institutions such as OPIC, USEXIM and JBIC, governmental entities and other participants in the IPP industry in Indonesia. These successful negotiations, involving projects of 60 MW to 1320 MW capacity, resulted in billions of dollars of savings for the various parties involved and avoided lengthy and costly litigation which would have ensued upon failure of such negotiations.

- Performed research and prepared report titled The Impact of the New York Power Authority's Robert Moses Niagara Power Project on the County of Niagara and Its Constituents for the County of Niagara, New York and its constituents. This report contributed to a successful outcome for the host communities of this 2,400 MW hydro power project.

- As principal strategist, restructured all aspects of power projects, in light of economic, political or social changes, by renegotiating power contracts on behalf of utilities or clients selling power to their respective utilities within the U.S. power sector.

- As lead negotiator, successfully conducted contract buyout negotiations with major California utilities; obtained regulatory approval from the California Public Utilities Commission, provided substantial upside to the clients, restructured related contracts to provide additional benefits to clients and lending institutions.

- Represented numerous international clients in acquiring or selling power generating facilities. FMY's role included marketing, financial evaluation, negotiation and due diligence.

- Actively participated in California Public Utilities Commission's proceedings to design and implement California's electric industry restructuring, filed testimony and testified before the Commission on behalf of consumer groups regarding stranded costs, customer protection, industry design, competition and divestiture issues.

- As lead negotiator, conducted negotiations on behalf of clients with utility purchasers or industrial customers in the Dominican Republic, Yemen, Turkey, Pakistan, Ireland, Mexico, Bolivia, Honduras and other developing countries to negotiate power contracts leading to development, construction and operation of power plants.

- Assisted utility and non-utility clients in developing strategies designed to reduce their electric power costs. Developed and compared costs associated with various scenarios to find the least cost approach achievable for such clients.

- Performed due diligence analysis and provided litigation support related to disputes between utilities and independent power producers. Negotiated settlements of regulatory and civil complaint cases to the satisfaction of the clients, obtained regulatory approval for the settlements.

- Assisted clients with avoided cost methodology and calculations in various jurisdictions in the United States and other countries. Developed long and short term avoided costs.

- Filed testimony regarding avoided cost calculations before the California, Hawaii and Pennsylvania Public Utilities Commissions, testified before various commissions to support clients' positions.

Senior Project Manager **1992 - 1994**
MRW & Associates, Inc.

Assisted non-utility clients in dealing with their respective utilities in California and negotiated existing and prospective power contracts with utilities.

Program and Project Supervisor **1989-1992**
California Public Utilities Commission

Managed CPUC branch section in charge of reviewing hundreds of long-term power contracts for the major electric utilities in California.

Program Specialist **1986 - 1989**
Regulatory Analyst **1985 - 1986**
California Public Utilities Commission

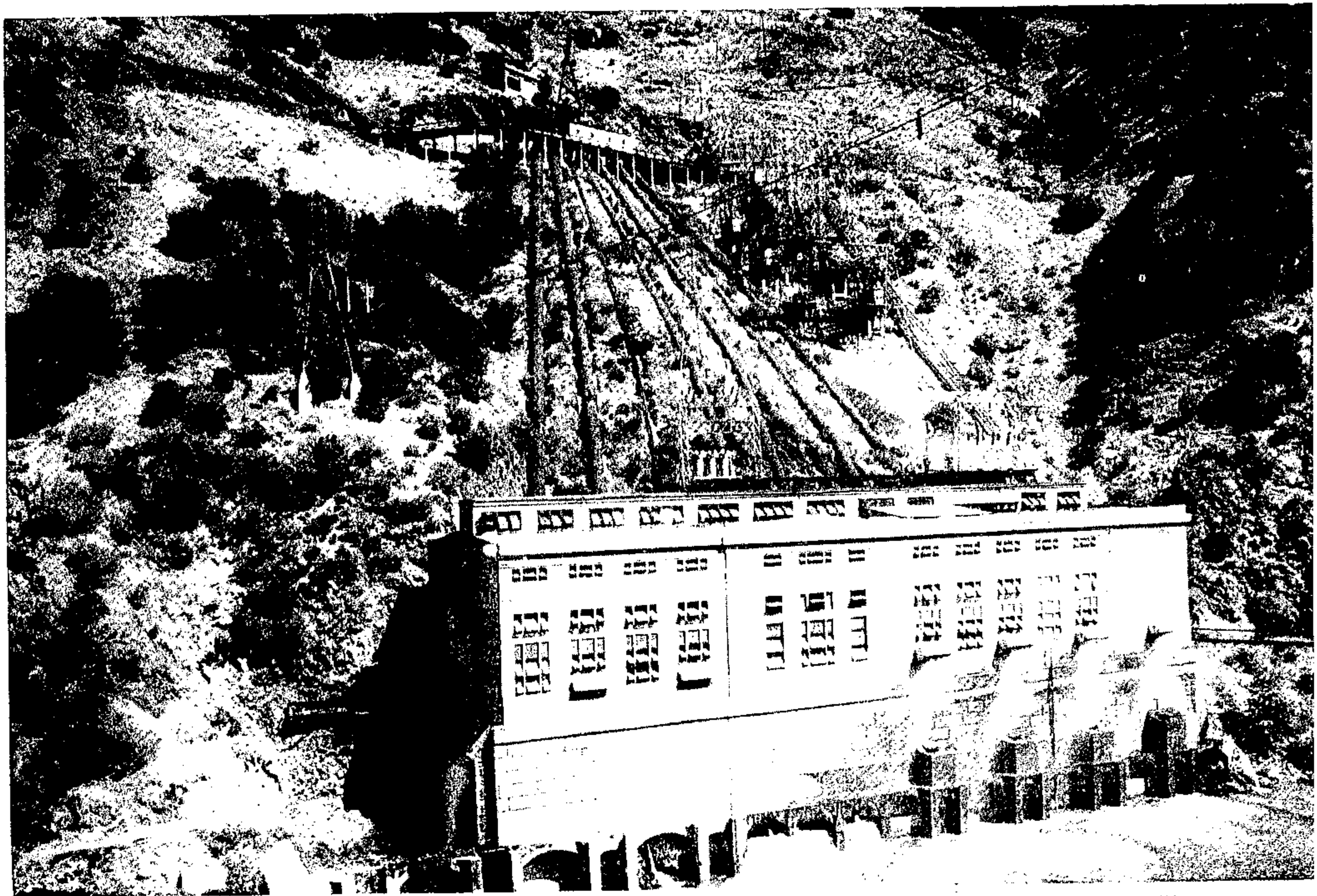
Supervised branch section in charge of modeling and econometrically estimating total factor productivity for local exchange telephone companies and electric utilities in California, and provided sales and revenue forecasts for such utilities.

EDUCATION

Ph.D., Economics and International Finance, Stanford University, 1985.

- Dissertation in Asian Financial Development Theory and Practice
- Areas of specialization: International Finance, Game Theory and Development.

ATTACHMENT B -
"HISTORY OF BIG BEND POWERHOUSE AND THE COMMUNITY OF LAS PLUMAS"



Heavy machinery was moved across Feather River by aerial tramway to build Big Bend Powerhouse, in 1908 largest hydro operation west of the Mississippi.

With the site for a magnificent storage lake in its hands, the new company could not proceed until location for one or more powerhouses had been secured and a plan of development formulated. A survey of the Feather River led the engineers to Big Bend, 16 miles above Oroville and 65 miles downstream from Big Meadows. Here was a spot to delight the builder of hydroelectric powerhouses, with an essential part of the project already partly completed.

Big Bend was so named because of an oxbow in the stream's channel some 12 miles in length, with a neck of land only 3 miles wide separating the beginning and end of the bend. Big Bend had a long history of riches gained and fortunes lost. In the early days the stream bed had yielded plentiful gold to the placer miners. Below Big Bend at Cape Claim, $600,000 had been recovered in 40 days in 1865. The Union Cape placer paid $275,000 in one season, and Toland Bar gave up more than a million dollars in 1856 and 1857. Miners believed that if the stream flow could be diverted from the Big Bend channel, another great fortune could be recovered from its gravel.

Dr. Ray V. Pierce, Buffalo manufacturer of the widely advertised medicinal pills that bore his name, became interested in a scheme submitted to him in 1880 to drive a diversion tunnel through the neck of the Big Bend oxbow. With Major Frank P. McLaughlin and Colonel J. C. Logan, he organized the Big Bend Tunnel and Mining Company and the Eocene Placer Mining Company, the first to drive the tunnel and the second to operate the mining venture.

The tunnel was bored, found to be too small, and was then enlarged to 16 feet by 12 feet, 12,000 feet long. It was completed in 1887 at a cost of $750,000. The Sprague Electric Company installed a water-powered electric generating plant to operate pumps and hoists for mining.

Like many another post-gold-rush mining venture, Dr. Pierce's project failed. The elaborately equipped plant was placed in operation, but the expected gold was not found in paying quantity.

Soon after the formation of the Western Power Company, Dr. Pierce ordered Major McLaughlin, his Pacific Coast agent, to incorporate the Eureka Power Company. This was done July 3, 1902, and word spread that the new company would use the Big Bend tunnel to supply water for a large hydroelectric plant. The result, perhaps, was precisely what Dr. Pierce anticipated; E. T. Earl and his brother saw that they would have to acquire the Big Bend properties. It would be folly to go on with the water-storage project at Big Meadows while an alien power plant on the lower river stood ready to reap the benefit.

At about this time, promoters Frank L. Brown and Harley P. Wilson of San Francisco were called in to assist the Earls in launching their project. Brown and Wilson arranged for purchase of the Eureka Power Company's holdings at Big Bend, and an option was given to Western Power Company.

Cornell's Golden State Power Company still was to be reckoned with. Unknown to the Earls, the Golden State group had filed claim to the waters of the Feather at the intake of the Big Bend tunnel and had acquired from the Central Pacific Railroad some 3,000 acres of land along the river above the Bend.

The time had come to find the millions that would be needed to build a powerhouse at Big Bend, a dam at Big Meadows, and a transmission line to carry electric power to the San Francisco Bay cities. The year 1903 passed without any progress; that was the time of the "rich man's panic" on Wall Street and capital was still nursing its burned fingers. In 1904 Brown was commissioned to arrange for the sale of $5,000,000 in Western Power Company bonds, but he reported that Eastern investors were reluctant to buy California bonds. He and Wilson did succeed, however, in interesting Edwin Hawley of New York, who through his connection with the Western Pacific Railroad knew something of the wealth of water power hidden in the Feather River Canyon. Hawley was joined by a group of New York and Boston financiers who formed a syndicate, first, to investigate and then to invest if the outlook was promising.

They were a distinguished group: Colonel Frank H. Ray, vice-president and organizer of the American Tobacco Company; A. C. Bedford, who rose from a position as clerk in a wholesale dry goods firm to president of Standard Oil of New Jersey in 1916; James H. Wallace, president of Central Trust Company of New York; Phillip Stockton, a young industrial engineer of Boston who, after his graduation from Harvard and Massachusetts Institute of Technology, became president of the Old Colony Trust Company when he was thirty-six and director of a dozen or more banks and utility companies.

These men were formally known as syndicate managers in the transactions that resulted in formation of Great Western Power Company. They were joined by other investors, including multimillionaire Clarence Mackay, son of John W. Mackay who made his fortune from the Comstock Mines in Virginia City, Nev. Clarence Mackay was then in the first years of a career which brought him fame as head of the Postal Telegraph Company and associated cable companies. Another prominent syndicate man was H. J. Pratt, one of the Eastern Standard Oil group and member of a family long identified with John D. Rockefeller and oil development.

Few electrical projects have been given the exhaustive examination that was devoted to the Earls' Feather River enterprise. The Eastern engineering firm of Viele, Cooper and Blackwell was engaged to make a field survey of the entire undertaking. Their report covered every element of a well-rounded hydroelectric development. John R. Freeman and Emil Kuichling, eminent hydraulic engineers, made a study of water storage and supply. Engineers Sargent and Lundy reported on possible competition from steam-operated electric plants. Dr. Thomas Addison of General Electric Company submitted a survey of available power markets. The work required about 18 months to complete.

Calling attention to the favorable volcanic character of the terrain and the 4,000-foot drop in elevation between Big Meadows and Big Bend, the engineers concluded: "No other water power in California can be so economically developed." They recommended that a $4,000,000 generating plant be built at Big Bend and outlined plans for other powerhouses to be built at sites between the Bend and the storage reservoir which was to be constructed later.

Even before the engineers' final report was submitted, the syndicate managers, confident of their position, had signed an agreement with Brown to organize a company which would purchase control of the Earls' Western Power Company and its valuable rights and properties. While all this was going on, the promoters of the Golden State Power Company, seeing that the Earl project would be financed, gave up their contest in 1906 and sold their holdings to Western Power Company. Lloyd P. Cornell, son of the pioneer originator of the project, eventually joined the engineering staff of the Great Western Power Company and, subsequently, the P. G. and E. He retired January 1, 1947.

The fire and earthquake of April 18, 1906, nearly wrecked the entire Feather River project. On the evening of April 17, Guy C. Earl and W. H. Spaulding, who had assisted in charting the legal path of the enterprise, met in Earl's office for a conference. At last, after four years of effort, the way seemed to be clear.

The next morning they awakened to view the ruins of San Francisco and the possible collapse of all their plans. When the Eastern financiers read the news of the disaster, they decided there was no use to go on if the metropolis of Northern California had been destroyed. They telegraphed Earl to call off all negotiations. They were not prepared to risk more of their money on so perilous a venture. They were through.

But Guy Earl would not admit defeat. With Spaulding's help he composed a fervent reply, written in long hand because there were no stenographers available. The Feather River project had not lost a dollar because of the San Francisco earthquake. In fact, it was in a better position because the city's electric facilities had been wrecked. San Francisco would be rebuilt. The prospects for success of the hydroelectric development were better, not worse, than before the disaster.

His appeal, written with the sincerity of desperation, had immediate effect. The Eastern financiers were reassured and wired back they would not withdraw.

There followed a welter of agreements, contracts, incorporations, and stock and bond issues, typical of the financial methods of the 1900–1910 decade. Out of the seeming confusion emerged the Western Power Company of New Jersey, a holding company incorporated August 23, 1906, in which the syndicate held the controlling stock interest. H. P. Wilson, who had shared with Brown in promotion of the plan, became a director and secretary of the New Jersey company. Under California laws, the Great Western Power Company was incorporated September 18, 1906. All but directors' shares were held by the New Jersey holding company.

In the California company was vested ownership of the rights, contracts, and properties acquired by E. T. and Guy C. Earl and their associates. Great Western was capitalized for $25,000,000 and a bond issue in that amount was authorized. The New York syndicate subscribed for $6,967,000 of the company's bonds.

The Earls and their associates received $1,500,000 in stock of the New Jersey Western Power Company and $1,000,000 in Great Western Power bonds. Brown and Wilson, who had carried the burden of promotion, received in commission for their work a total of $473,000 in stocks and bonds of the New Jersey and California companies.

After the organization of the Great Western company, Edwin Hawley was elected president and Guy C. Earl, vice-president. Bedford and Ray were named to the executive committee of the board of directors. Within a few months the number of directors was increased from nine to eleven and E. S. Pillsbury, San Francisco attorney, J. Downey Harvey, San Francisco capitalist, Henry E. Huntington, railway builder of Los Angeles, and William G. Henshaw of Oakland were elected directors. E. T. Earl, Frank L. Brown, and H. P. Wilson also were made directors and Wilson was appointed secretary of the company.

With funds in its treasury the company immediately began construction of Big Bend, its first power plant. The site was on the steep south bank of the Feather opposite the present Western Pacific railroad station, Las Plumas. (The Spanish name of the Feather River was El Rio de las Plumas.)

Camps were established to accommodate a thousand workmen. The Western Pacific Railroad, then under construction, had not yet reached the powerhouse site and all the early hauling was over the steep mountain roads by lumbering freight wagons. Toward the end of the construction period, however, the rails had been laid to Las Plumas station and the problems of the builders were simplified. The heavy machinery, steel, and other materials then were brought in by rail to the station across the river from the powerhouse. Two aerial cable tramways were erected to span the 1,200-foot chasm between the river banks, and over them enormous tonnages were moved across the river. One of these cable crossings still is in operation, offering a dizzying and thrilling ride to uninitiated visitors.

For about two years the big work continued. Dr. Pierce's old tunnel was enlarged and extended to provide a fall of 465 feet. A timber diversion dam was constructed. It was replaced in 1910 by a larger concrete dam designed by Engineer John R. Freeman.

The generating station is a massive, imposing structure of steel and concrete rising from foundations set deep in the bedrock of the precipitous riverbank. In continuous operation for nearly half a century, it still produces electric power for beneficial use in the distant cities of Northern California.

The first 10,000-kilowatt generating unit of Big Bend Powerhouse was placed in operation December 23, 1908. Five additional units were placed in succeeding years to bring the total capacity to 70,000 kilowatts, its present rating. The *Electrical World* of the period said: "The project is on a grander scale than any of the transmission plants on the Pacific Coast." At the time, the plant was the largest hydro operation west of the Mississippi.

W. G. B. Euler, now executive vice-president of P. G. and E., started his career in utility company operation at Big Bend Powerhouse. Graduated from the University of California in 1905, Euler joined the General Electric Company's staff and gained a thorough experience in electrical construction and installation in Northern and Southern California. He came to Great Western Power Company in 1910 as division superintendent in charge of powerhouse operation and transmission, and then as general superintendent. When he joined the P. G.

and E. staff, successive promotions brought him to the post of vice-president and general manager of P. G. and E. in 1947 and to his present position three years later.

At one time during construction of Big Bend, the builders gave thanks for their Eastern financial sponsorship. At the height of the money panic of 1907, when cash went into hiding and clearinghouse certificates were issued in San Francisco to be used in place of currency, the work went on without interruption. Many other California building projects were closed down temporarily for lack of cash, but Great Western payrolls were met by gold. Coin was necessary because in Oroville, where the Big Bend men spent their days off and their money, clearinghouse certificates were not accepted. To provide the weekly payroll cash, Wilson, then in New York, arranged with the United States Subtreasury there to telegraph a credit payable in gold at the San Francisco Subtreasury. This was not done without much labor on Wilson's part. The Subtreasury refused to order coin delivered in San Francisco unless coin in equal amount was deposited in New York. Currency was not acceptable. To satisfy this requirement, Wilson would make nightly rounds of theaters, hotels, and other places where he was known and collect gold coins sufficient for deposit in the New York Subtreasury to meet the California payroll. And regularly during the crisis Charles E. Mynard, the first Great Western auditor and assistant treasurer, would draw the coin in San Francisco and, with a guard, transport it to the Big Bend works.

The power output of the plant was transmitted on a steel tower line to Brighton Substation at Sacramento and thence to Oakland. Power was transmitted at first at 60,000 volts, and November 1, 1909, the pressure was raised to 100,000 volts, another advance in the long struggle of electrical engineers toward the high tension goal of 220,000 volts.

Hydroelectric power from Big Bend was flowing into Oakland. The next step in Great Western's ambitious plans was to provide steam-operated stand-by generating facilities to ensure continuous delivery. For this purpose, the California Electric Generating Company was incorporated November 23,

1908. A site was secured on the Oakland estuary and a plant erected there with a generating capacity of 10,500 kilowatts.

Financing of the steam plant project was accomplished by a complicated series of corporate transactions, all backed by the New Jersey holding company. Pacific Securities Company, a new organization, built the powerhouse and sold it to the California Electric Generating Company, which in turn leased it to the Great Western Power Company. The Oakland steam plant was placed in operation November 27, 1909.

When the Great Western Power Company entered Oakland it was compelled to sell its Big Bend electric output to the recently organized Pacific Gas and Electric Company. The Earls' utility had no distribution system, no franchises, and no access to the San Francisco power market, but it was going to have these facilities. Great Western had only begun to fight.

Seven years had passed since Julius M. Howells had told E. T. Earl of his vision of a great hydroelectric system on the Feather River. His plan for a storage reservoir at Big Meadows had not yet materialized, but the power project at last was under way. Great Western Power was to become a hard-hitting rival to P. G. and E., which was then struggling to get on its corporate feet. For a score of years the courses of the two utilities ran on parallel but hotly competing lines.

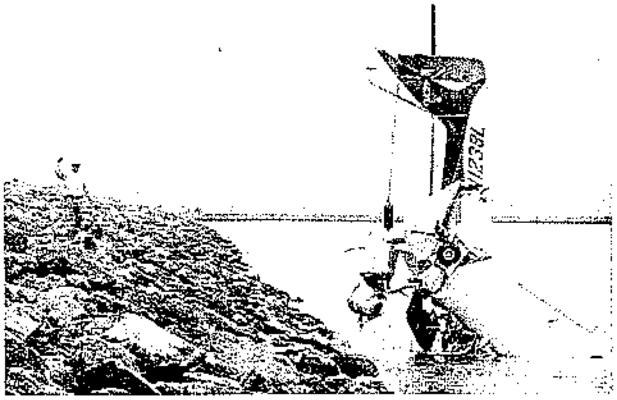
APPENDIX B

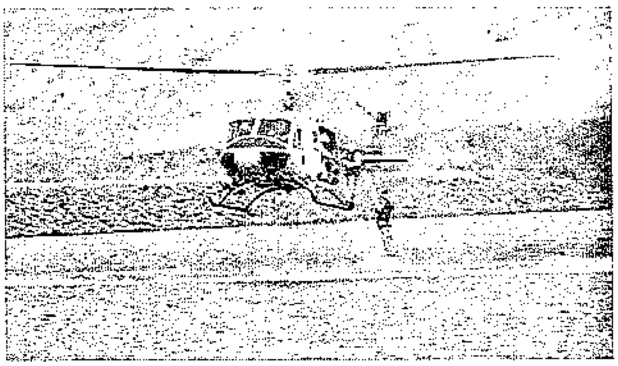
APPENDIX B

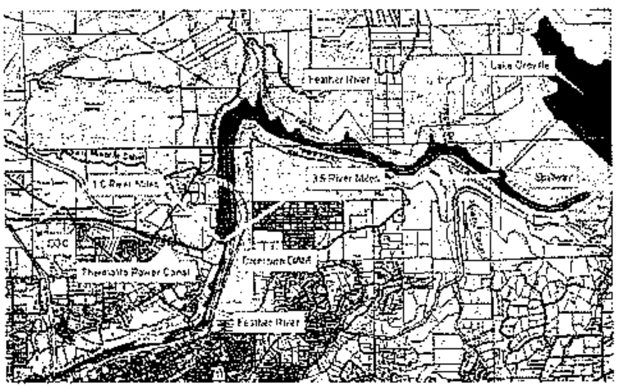
OPERATIONAL IMPACTS OF THE OROVILLE FACILITIES PROJECT ON BUTTE COUNTY

PREPARED BY OFFICE OF THE CHIEF ADMINISTRATIVE OFFICER

FEBRUARY 2006







Operational Impacts of the Oroville Facilities Project on Butte County

Office of the Chief Administrative Officer

February 2006

BUTTE COUNTY, CALIFORNIA

Report on Operational Impacts of the Oroville Facilities Project on Butte County

February 2006

Office of the Chief Administrative Officer

PRINCIPAL AUTHOR

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fax: 530-538-7120

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TABLES

FIGURES

EXHIBITS

ACRONYMS AND ABBREVIATIONS

Defined Term	Definition
AFPA	American Fire Protection Association
Afterbay Patrol Contract	The Licensee has contracted with the Butte County Sheriff's Office since 1992 to enforce boating & waterways laws, provide education, boating safety and vessel inspections at the Afterbay
Application	Federal license to operate the Project in January 2005
Area of Highest Use	The area that experiences the most significant Project impacts, as further described in Appendix A of this Report, defined by the arterial and collector roads that lead to the Project Area; in other words, the primary routes (roads) used by visitors to get to the Project.
BCAG	Butte County Association of Governments
CAD	Computer Aided Dispatch System
CalTrans	California Department of Transportation
CDF	California Department of Forestry and Fire Protection
Central Communications, or Division	Central Communications Division of the County's Information Systems Department
cfs	Cubic feet per second
Commission	Federal Energy Regulatory Commission
County	Butte County
DA	District Attorney
DART	Dive and Rescue Team
DFG	California Department of Fish and Game
Division, or Central Communications	Central Communications Division of the County's Information Systems Department
DWR	California Department of Water Resources
EOC	Emergency Operations Center
EOD	Emergency Ordinance Disposal team
Fire Department	Butte County Fire Department
HazMat Team	County's Interagency Hazardous Materials Team
Hdl Companies	Companies that Butte County contracts with via Hinderliter de Llamas and Associates to determine its sales tax revenues (additional information regarding The HDl Companies can be found at http://www.hdlcompanies.com.)

Defined Term	Definition
IDLH	Conditions "immediately dangerous to life and health"
Licensee	California Department of Water Resources
move-up and cover	Back-up or partial response by Fire Department and Rescue Services in the Area of Highest Use
MPO	Metropolitan Planning Organization
msl	Mean sea level
MW	Megawatt
NIMS	National Incident Management System
Non-Resident Visitor Population	The population of non-residents visiting the Project
Non-Resident Visitors	Visitors from other locations drawn to Butte County that are not Butte County residents
NRV Factor	The proportion of Non-Resident Visitors to the Total Population Served, derived by dividing the Non-Resident Visitors Population by the sum of the Total County Population and the Non-Resident Visitor Population
NRV-AHU Factor	Non-Resident Visitor Use Within the Area of Highest Use Factor
OSHA	Federal Occupational Safety and Health Administration
OWA	Oroville Wildlife Area
Percentage of Total Population	The proportion of Non-Resident Visitors to the total population served by Butte County. The factor is derived by dividing the Non-Resident Visitors Population by the Total County Population plus the Non-Resident Visitors Population (the Total Population Served).
PM&E	Protection, mitigation and enhancement
POST	Peace Officers Standards and Training
Primary Tourist Lodging and Purchases Area	Defined by the arterial and collector roads that lead to the Lake Oroville Project Area; in other words, the primary roads used by visitors to get to the Project.
Project	Lake Oroville Project
Project Visitors	Approximate average peak daily population of visitors drawn to Butte County due to the Project
PSAPs	Public Service Answering Points
Public Works	Public Works Department
Report	Report on the Operational Impacts of the Oroville Facilities

Defined Term	**Definition**
	Project on Butte County
Resident Visitors	Approximate number of annual Project Visitors from Butte County
SEMS	Standardized Emergency Management System
STIP	State Transportation Improvement Program
SWAT	Special Weapons and Tactics team
TANF	Temporary Assistance to Needy Families – welfare payments formerly known as Aids to Families with Dependent Children (AFDC)
TOT	Transient occupancy tax (commonly known as a "hotel tax" or "room tax")
Total County Population	The total number of County residents
Total Population Served	The Total County Population plus the Non-Resident Visitors Population
Two-in and two-out rule	Situations where firefighters must enter an atmosphere that presents conditions IDLH
UCR	Uniform Crime Report

1.0 EXECUTIVE SUMMARY

The following Report on the Operational Impacts of the Oroville Facilities Project on Butte County ("Report") was prepared by the Office of the Chief Administrative Officer for Butte County (the "County"). The Report describes the primary services provided to the Oroville Facilities Project (FERC Project No. 2100) (the "Project") by the County and quantifies the service impacts of this Project on Butte County. This Report is not intended to describe all of the costs and other adverse impacts of the Project on the County but rather focuses on the primary service impacts of the Project that represent an ongoing cost and harm to Butte County and its over 210,000 residents. This Report was prepared by County personnel with responsibility for the specific areas mentioned, under the direction of Mr. Paul McIntosh, Chief Administrative Officer, and pursuant to authority from the Butte County Board of Supervisors.

Originally licensed by the Federal Power Commission in 1957, the Project, a 762-megawatt ("MW") hydroelectric project, has been in operation since 1968. The Project, further described in Section 2.0, includes Oroville Dam and Reservoir, three power plants, Thermalito Diversion Dam, the Feather River Fish Hatchery and Fish Barrier Dam, Thermalito Power Canal, Oroville Wildlife Area, Thermalito Forebay and Forebay Dam, Thermalito Afterbay and Afterbay Dam, transmission lines, as well as a number of recreation facilities. The Project encompasses 41,100 acres—all located within the unincorporated areas of the County.

The California Department of Water Resources ("DWR" or, the "Licensee"), the current licensee for the Project, applied for a 50-year renewal of its federal license to operate the Project in January 2005 (the "Application" see FERC Accession Nos. 20050126-4020 through -4032; 20050128-0066 through -0079). The proposed new license term is to commence in 2007. The application filed by the Licensee with the Federal Energy Regulatory Commission (the "Commission") indicates that DWR receives electricity revenues from the Project in excess of $100 million each year,[1] and in addition both DWR and its water contractor beneficiaries receive other electricity and water benefits from the Project worth hundreds of millions of dollars per year. The Application includes some potential expenditures for protection, mitigation and enhancement ("PM&E") measures, however, the proposed actions are insufficient to mitigate the significant impacts on Butte County government and services, and to protect the public safety and health of County residents and the over 1.7 million annual visitors to Butte County attracted by the Project.

Relicensing the Project, as proposed by the Licensee in its Application, will result in substantial service-related costs to the citizens of Butte County and their government. The purpose of this Report on the Operational Impacts of the Oroville Facilities Project on Butte County ("Report") is to identify the annual service costs incurred by Butte County because of the Project. The Project's impact on Butte County is highly significant because, in California, county governments are responsible for providing a broad range of government services to all persons within the county, whether in the unincorporated or incorporated areas of the County, and including recreational visitors and tourists visiting Project-related facilities.

1 Application, Preliminary Draft Environmental Assessment, at Table 6.4-1.

Upon review of the Licensee's Final Existing Recreation Use Report (R-12), it is projected that the Project draws an approximate average peak period population of 11,334 daily visitors to Butte County (the "Project Visitors"). See Appendix A.[2] Of the Project's over 1.7 million annual visitors, DWR has estimated that approximately 53.5% are from Butte County ("Resident Visitors") while the remainder come from other locations (the "Non-Resident Visitors"). See id. Significantly, although Butte County provides many governmental services to the Project, the Project does not reimburse these expenses, pays no taxes, makes no payments in lieu of taxes to the County, and provides none of the low-cost power produced at the Project to local residents, industry or governments. Thus, although the Project provides hundreds of millions of dollars in annual water and electricity benefits to the Licensee and others, none of these revenues or benefits are shared with the County or its residents.

The Licensee is thereby forcing the local government and its taxpayers to subsidize Project operations. The County is mandated to respond to public safety threats within its community, whether from calls for police assistance, boating accidents, vehicle fires, dangerous roadways, flood events, or other hazards, regardless of whether the Project provides revenues to fund such services. Thus, the County must use its limited discretionary budget funds to subsidize these services within the Project Area. The County—which suffers from high unemployment rates and a depressed economy—must divert resources away from other important governmental services, such as health and human services, to pay for the costs of responding to Project-related medical emergencies, rescues, crimes on Project lands, flood events, road maintenance, and the like.

Butte County is responsible for providing public services to all Project Visitors, including Non-Resident Visitors, in the primary areas summarized below and described more fully in this Report. The service costs discussed herein are not the total costs incurred by Butte County, but rather reflect only that portion of the County's identified service costs that are incurred due to Project demands and the service demands of the Non-Resident Visitors to the Project.

- ***Law Enforcement/Criminal Justice Services***, including general police response, investigation and patrol services; special police operation unit services (e.g., emergency ordinance disposal team, special weapons and tactics team, canine unit, aviation unit, dive and rescue team, and narcotics task force); jail services; prosecution services; probation department services; and public defender services;

- ***Fire and Rescue Services***, including all rescue services (e.g., emergency medical response, rescue teams, vehicular accident responses, water rescue response, and animal rescue); general fire department services (including responding to structural, grass, refuse, and vehicle fire events); and specialized services, including responses by the County's Interagency Hazardous Materials Team ("HazMat Team"), Technical Rescue Team, Drowning Accident Rescue Team, Vehicle Extraction Team, and the Critical Incident Stress Debriefing Team;

2 The County believes that DWR has greatly under-counted the number of Project Visitors. However, because the Licensee did not agree to revise its study methodologies when the County raised such concerns during the alternative licensing process, the County relies upon these recreational studies as the only data currently available.

- ***Communications Services***, including the equipment and technology that allow the various safety-related agencies to respond to requests for assistance at the Project;

- ***Public Works - Road Services***, including the construction and maintenance of roads serving the Project and responding to increased air quality and water pollution impacts due to this road usage;

- ***Emergency Operations Center ("EOC") and Services***, including EOC services and the provision of facilities used by County, state and federal agencies to respond to threatened and actual floods and other disaster events; and

- ***Health and Human Services***, including, but not limited to, welfare payments and services, medical payments for children and the elderly, and assistance to families.

In addition to the cost of providing these services to Non-Resident Visitors, as individual demand is presented, it is important to note that the Project requires that public safety and rescue services, including manpower, training and equipment, be available to the Project 24 hours per day, 365 days per year, so that those services might be immediately deployed as demand arises.

This Report is organized into five major sections. Sections 1 and 2 provide an Executive Summary and Introduction. Section 3 identifies tourism revenues that could be associated with the Project. Section 4 identifies cost impacts of the Project on Butte County by service category, both direct and indirect. Section 5 provides a summary of estimated cost impacts and closing remarks. Appendix A discusses general assumptions used to develop the Report. The calculations used to develop the cost impacts defined herein were based on actual Project demands for County services, using conservative assumptions and estimates based on past and present demands. Unless otherwise noted, **all cost statements herein are based upon 2005 dollar values.** Appendix B discusses methodologies for use in determining the escalation of such costs over the proposed license term.

Section 4 of this report identifies the following Project-related cost impacts by service category:

- ***Law Enforcement/Criminal Justice Services*** - $2,035,416 direct annual costs to serve the Project, plus $1,032,000 of one-time costs to enable provision of such services.

- ***Fire and Rescue Services*** - $393,267 direct annual costs to serve the Project, plus $1,309,478 of one-time costs to enable provision of such services.

- ***Communications Services*** - $351,143 in one-time costs to enable provision of services to the Project.

- ***Public Works – Road Services*** - $791,351 in annual costs related to Project use, plus $5,306,136 of one-time costs to enable provision of such services.

- ***EOC Services*** - $2,545,495 in one-time costs to move the existing EOC facility out of the Project-created flood zone so that EOC services can continue to be provided to the Project and community.

- ***Health and Human Services*** - $1,837,983 indirect annual costs, related to Project impacts.

Annual Project-related service costs incurred by Butte County greatly exceed both the County's and Licensee's estimate of fiscal benefits received by Butte County in association with the Project. These estimated benefits include $306,672 in projected annual tourism revenues and, at present, the payment by the Licensee of $191,000 to the County Sheriff's Office.[3] This Report identifies $3,220,034 of direct annual Project-related costs, $1,837,983 of indirect Project-related costs, and $10,544,252 of Project-related, one-time mitigation and/or initial fixed costs. ***The total net Project-related service cost impact to Butte County is at least $4,560,345 per year.***[4]

Other than these limited tourism related benefits and the small payment made by the Licensee to the Sheriff's department, the Licensee and Project make no other payments to the County. The Project does not reimburse the County costs, does not make any tax payments to the County, although it uses over 41,000 acres of County land, nor does the Licensee or Project make any payments in lieu of taxes to the County. Similarly, the Project does not provide any of the low cost electricity produced by the Project to any County residents, businesses or governments. The Project uses local land, water and other natural resources in Butte County to produce low cost electricity and to provide water to persons residing in other counties. While this arrangement greatly benefits the Licensee, the County as the host community is forced to subsidize the Project by providing a full range of government and community services to the Project, its employees and Project Visitors.

3 Although presented in this Report as an ongoing Project "benefit," the annual payment by the Licensee to the County's Sheriff's Department for services provided at the Thermalito Afterbay is set by a short-term contract that could be terminated by the Licensee at will during the proposed new license term.

4 See Table 5.0-1. The County has used conservative estimates to develop the annual Project impact amount used in this Report and has only considered the primary services provided and primary Project service impacts on the County.

2.0 INTRODUCTION

The purpose of this Report is to identify the primary annual costs incurred by Butte County to provide County services to the Project. The calculations used to develop the cost impacts defined herein were based on actual Project demands for County services, using conservative assumptions and estimates of costs that will be incurred during the new license period and based upon past and present Project demands. The Project's impact on Butte County is highly significant because, in California, county governments are responsible for providing a broad range of government services to all persons within the county. It is important to note, as well, that the presence of the Project requires the availability of public safety and rescue services, including manpower, training and equipment, at all times in order to be ready to meet both expected and emergency situations, as they are presented.

Butte County is located in the Northeastern portion of the Sacramento Valley with boundaries extending from the Sacramento River on the west to the foothills and mountains of the Sierra Nevada and Cascade ranges on the east. Contained within a total land area of 1,675 square miles are over 1,380 miles of county-maintained roads and over 350 bridges. Approximately eight percent (8%) of the total county land area is located within incorporated areas, while 92% remains unincorporated and under the jurisdiction of Butte County for the provision of local services, including, but not limited to, public safety and criminal justice services, fire and rescue services, communications services, public works services, emergency services, and health and human services. Butte County's population is over 210,000, of which 56% is located within incorporated jurisdictions and 44% within unincorporated areas. Four cities and one town are located in the County—Chico, Oroville, Gridley, Biggs, and the Town of Paradise—as well as the unincorporated areas of Richvale, Durham, Thermalito, and Palermo.

The mountain areas and foothills in the eastern portion of the County are cut with deep canyons. The combination of canyons and high Sierra mountain ranges creates some of the County's most attractive and visually stunning landscapes while presenting a variety of unique challenges in the areas of law enforcement services, fire and rescue services, and public works services provided by the County. The foothill and mountain areas constitute 25 and 30 percent of the total county area, respectively. The Town of Paradise is located within this region, as well as several unincorporated communities, including Forest Ranch, Cohasset, Magalia, Stirling City, Berry Creek, Forbestown, Concow, and Cherokee.

The Project Area, as described in the Licensee's Application, includes Oroville Dam and Reservoir, three power plants, Thermalito Diversion Dam, the Feather River Fish Hatchery and Fish Barrier Dam, Thermalito Power Canal, Oroville Wildlife Area ("OWA"), Thermalito Forebay and Forebay Dam, Thermalito Afterbay and Afterbay Dam, transmission lines, as well as a number of recreation facilities. The entire Project Area lies within the unincorporated area of Butte County and covers 41,100 acres, or approximately 64 square miles. To provide geographical perspective, the Project Area happens to be nearly the same size as Washington, D.C., which is 68 square miles.

Lake Oroville is the second largest reservoir in California. It has 167 miles of shoreline and more than 15,500 surface acres. At 770 feet, the Lake Oroville Dam is the tallest dam in the

United States. Built from 1962 through 1967, its crest is more than one mile long and it was made with more than 80 million cubic yards of earthen materials. The Project is a predominate feature in Butte County.

3.0 PROJECT-RELATED TOURISM AND OTHER REVENUES

As discussed in Section 1.0, the Project attracts approximately 11,334 peak period daily visitors, of which 4,534 are Non-Resident Visitors to Butte County each year. While these tourists travel through the County, they often make purchases from local retailers, hotels, restaurants, and service providers. Butte County collects sales tax and transient occupancy taxes from these transactions. These tourism-related revenues (sales and occupancy tax revenues), plus a small contract payment made by the Licensee to Sheriff's Department, are the fiscal benefit that the County receives from the Project. Such benefits provide a minor offset to the high annual costs incurred by the County as a result of the Project. This section of the Report discusses such revenue sources and quantifies the approximate annual benefit received by the County as a result of such revenue collection. This information should be considered in context with estimated cost impacts, as described in Section 4.

3.1 Analysis of Tourism-Related Revenues

Tourism spending has been assumed to include all purchases made by a traveler at the point of sale while visiting the Project's "Primary Tourist Lodging and Purchases Area," as shown in Figure 3.1-1 on the next page. The County collects two types of revenues from such transactions: sales tax revenues and transient occupancy tax revenues.

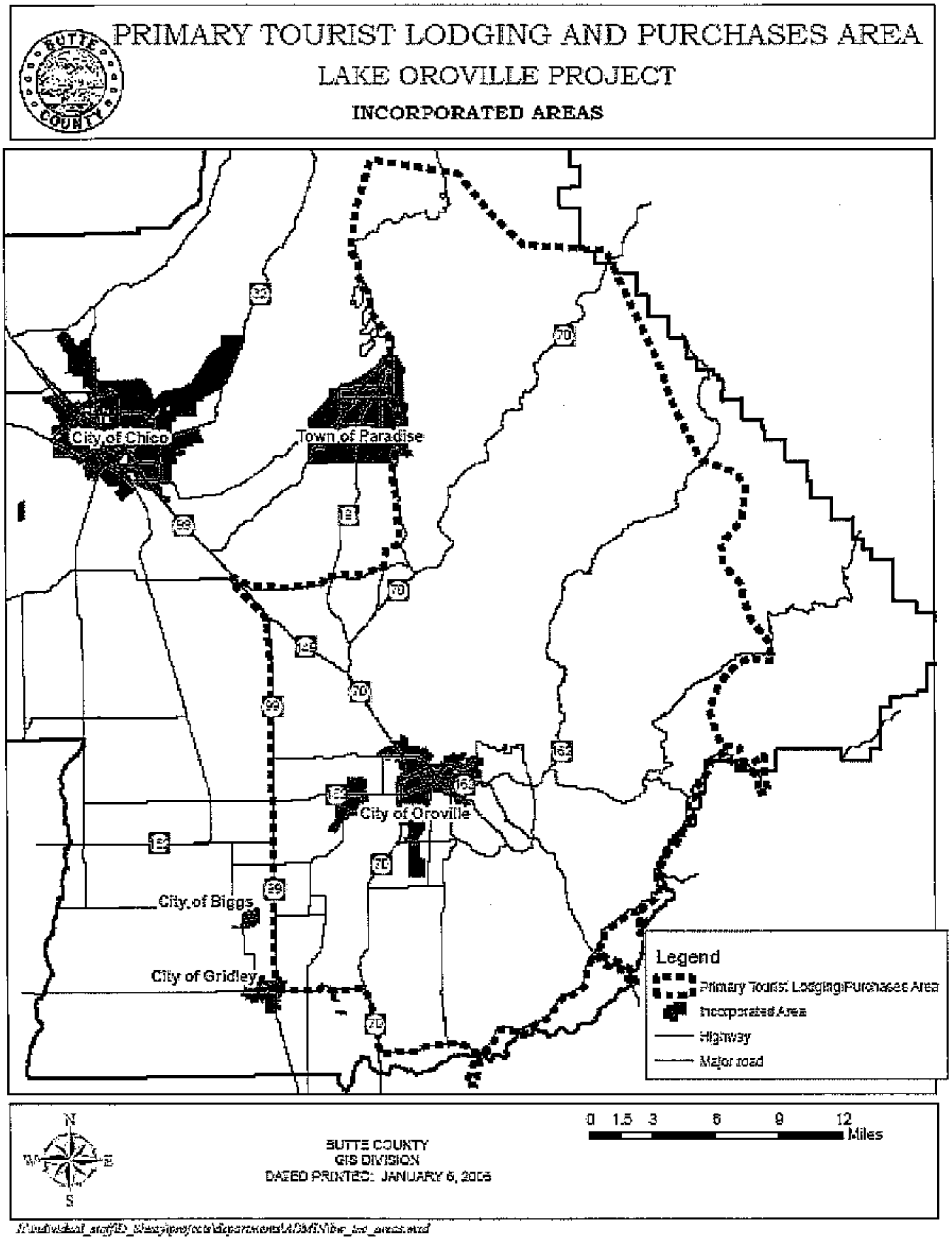
3.1.1 Primary Tourist Lodging and Purchases Area

The Primary Tourist Lodging and Purchases Area, as shown in Figure 3.1-1, is used herein to define the primary geographic area where visitors to the Project stay in lodgings and make point of sale purchases. It is also comparable to the area that experiences the most significant Project impacts (e.g., roads, traffic, emergency services) (the "Area of Highest Use," as further described in Appendix A of this Report). The Primary Tourist Lodging and Purchases Area is defined by the arterial and collector roads that lead to the Lake Oroville Project Area; in other words, the primary roads used by visitors to get to and from the Project.

Arterial roads generally link urban areas (with a population of 25,000 or more) and are primarily used for through traffic on a continuous route. Arterials often connect urban centers with outlying communities, employment, or shopping centers and link to collector roads.

Collector roads consist of surface streets providing land access and traffic circulation within residential, commercial, and industrial areas. They typically provide service to any county seat not on an arterial route, to the larger towns not directly served by the higher systems (i.e., freeways and arterial roads), and to other traffic generators of equivalent intra-county importance (i.e., the Project Area), nearby larger towns or cities, or with routes of higher classification (i.e., freeways and arterial roads). Collector roads provide land access to major land uses such as shopping centers, large industrial parks, major subdivision, and community-wide schools and recreation facilities (i.e., the Project Area).

Figure 3.1-1


PRIMARY TOURIST LODGING AND PURCHASES AREA
LAKE OROVILLE PROJECT
INCORPORATED AREAS
City of Chico
Town of Paradise
City of Oroville
City of Biggs
City of Gridley
Legend
Primary Tourist Lodging/Purchases Area
Incorporated Area
Highway
Major road
0 1.5 3 6 9 12
Miles
N
S
W
E
BUTTE COUNTY
GIS DIVISION

3.1.2 Sales Tax and Transient Occupancy Tax

Sales Tax. In Butte County, a 7.25% State of California sales tax is applied to most sales and use transactions.[5] However, the County receives only one percent (1.0%) of gross receipts for sales and use transactions that occur in the unincorporated area and receives no sales tax revenues associated with sales and use transactions in incorporated towns and cities.

Butte County contracts with Hinderliter de Llamas and Associates (The Hdl Companies)[6] to determine its sales tax revenues. The HdL Companies are dedicated to helping cities, counties, redevelopment agencies and special districts maximize revenues through allocation audits, financial and economic analysis and provision of related software products. The companies serve approximately 300 local governments in six states. The analysis conducted by HdL, using the County's actual financial data, determined that in fiscal year 2004-2005 Butte County received $297,487 in sales tax revenue from all sales and use transactions generated within the Primary Tourist Lodging and Purchases Area.[7] See Exhibit 1.

Transient Occupancy Tax. Butte County also collects a transient occupancy tax ("TOT") for the unincorporated areas of the County, commonly known as a "hotel tax", or "room tax." The current rate for TOT in the unincorporated areas of Butte County is 6.0% of the gross room receipts. TOT operators are required to report and remit payments to the County Treasurer-Tax Collector on a quarterly basis.

In developing this Report, the County Treasurer-Tax Collector's Office provided information for TOT revenues collected from lodging businesses located within the Primary Tourist Lodging and Purchases Area. In fiscal year 2004-2005, the County received a total of $9,185 in TOT revenue from establishments located within the Primary Tourist Lodging and Purchases Area.

Combined Total – Sales Tax & TOT. *The combined total for sales tax revenue and TOT revenue received by the County in fiscal year 2004-2005 from the Primary Tourist Lodging and Purchases Area is $306,672.*[8] **It is reasonable to assume that the County would have received some portion of this tourism-related revenue even if the Project did not exist. However, in order to develop a conservative estimate for use herein, the County has applied the full amount received as a cost-offset to calculate net annual Project-related service cost impacts to Butte County.**

5 Certain exceptions apply, such as the purchase of some food items.

6 Additional information regarding The HDl Companies can be found at http://www.hdlcompanies.com.

7 The sales tax figure excludes auto dealerships because auto sales have no apparent relationship to tourism activity.

8 The Licensee's R-19 Report for fiscal year 2002-2003 estimated total revenues to the County of $220.4 million.

3.2 Licensee's Contract with Sheriff

The Licensee has contracted with the Butte County Sheriff's Office since 1992 to enforce boating and waterways laws, provide education, boating safety and vessel inspections at the Afterbay. The current three-year contract expires on June 30, 2006. The total amount of the current contract is apportioned by fiscal years as follows: fiscal year 2003-04 - $185,000; fiscal year 2004-05 - $191,000; and fiscal year 2005-06 - $197,000.

Although the Sheriff's Office is responsible for the entire Project area, the "Afterbay Patrol Contract" provides full-year funding for one full-time deputy assigned to the Afterbay. This Deputy Sheriff is a certified diver and responds to all water-related calls for service on the Afterbay.

4.0 PROJECT COST IMPACTS ON BUTTE COUNTY SERVICES

Based on the known service demands generated by the Project, the County is able to identify the primary annual costs incurred by the Butte County as a result of the Project. This section of the Report describes service cost impacts of the Project on Butte County by major category of expenditure. Detailed spreadsheets documenting calculations are referenced and included within the attached exhibits.

The methodology used in this Report first calculates total costs incurred by the County to provide the described services and then estimates what portion or percentage of that total cost is incurred due to the Project. The percentage attributed to Project services is calculated or verified in three primary ways. First, County data is used to calculate or estimate actual Project demands on County services such as law enforcement, fire and rescue, emergency services and other public safety services. Second, to account for those Project-related costs that cannot be readily or fully documented (e.g., police and fire departments do not break down all of their reports based on whether incidents occur inside or outside of the Project Area), the County determines the cost of providing services to that portion of the annual Visitor population at the Project that is associated with Non-Resident Visitors. Although all Project Visitors place demands on County services, it is assumed that the County would provide services to its residents even if the Project did not exist. Third, to check the accuracy of this result and to fully account for the Project-related costs associated with these Non-Resident Visitors, the County then reviewed the service costs incurred by towns of comparable size located in the Project Area to calculate the cost per citizen to provide the same services. Because the frequency and types of services provided to the Non-Resident Visitor population at the Project are similar to the frequency and types of services provided to the population of an equivalent-sized town in the area, comparing these amounts provides a reliable cost estimate that also acts to substantiate the County's own calculations.[9]

Percentage of Total Population – The "Percentage of Total Population" is the proportion of Non-Resident Visitors to the total population served by Butte County. The factor is derived by dividing the average number of daily peak period Non-Resident Visitors (5,270) (the "Non-Resident Visitor Population") to the Project by the sum of the total County population (210,022) (the "Total County Population") plus the Non-Resident Visitors Population (5,270) (the "Total Population Served"). See Appendix A. Based on this calculation, described further below in Tables 4.0-1 and 4.0-2, 2.45% of the Total Population Served by the County is comprised of Non-Resident Visitors (the "NRV Factor"). As discussed in Appendix A, the number of Project Visitors, and the percentage of that population who are Residents and Non-Residents is based on data included in DWR's Application as filed before the Commission.

As discussed more fully herein, this Report considers peak period Project Visitor numbers to calculate annual costs because many of the County's Project-related costs are annual as facilities and staffing (particularly for emergency services) must be based on peak period demands.

9 This comparison may well act to under-calculate total costs incurred by the County because, as discussed in this Report, due to the rugged terrain and remoteness of Project areas, it takes far more time and additional services and equipment to respond to calls for assistance at the Project than to respond to service calls in a town or rural setting.

Additionally, the level of County services to the Project does not vary significantly by season. See, e.g., Appendix A.2.

Table 4.0-1
Variables Used in the Calculation of "Non-Resident Visitor Factor" (NRV)

Variable Description	Variable Calculation (if applicable)	Variable Value
Project Population (includes Resident Visitors and Non-Resident Visitors) – Assumptions Section – Appendix A	N/A	11,334
Percentage (%) of Project Population that are Non-Resident Visitors – Assumptions Section - Appendix A	N/A	46.5%
Project Non-Resident Visitor Population	46.5% * 11,334	5,270
Total County Population – California Department of Finance estimate for 2003	N/A	210,022
Total Population Served	210,022 + 5270	215,292

Table 4.0-2
Calculation of Non-Resident Visitor Factor

Calculation Detail
11,334 * 46.5% = 5,270 210,022 + 5,270 = 215,292 5,270 / 215,292 = 2.45%

4.1 Law Enforcement/Criminal Justice Services

Public Safety and Criminal Justice Services are a core function of local government and critical to the safety, health, and well being of Project Visitors. Butte County's fiscal year 2005-2006 Proposed Budget includes approximately $50.4 million for criminal justice services. Most of the funding for these services comes from the County's General Fund. From these appropriations, the County funds the Sheriff's Office and other law enforcement programs that provide a wide array of services to County Residents and Project Visitors. Detail for services provided by each of these law enforcement programs is discussed in the following sections.

4.1.1 Sheriff's Office – Law Enforcement Services

The Sheriff's Office provides front-line law enforcement and public safety services to suppress crime and to protect life and property in the 41,100 acre Project Area. The provision of police services within the Project Area is a challenge because of the large size of the Project (64 square miles total area; 164 miles of shoreline), steep canyons, dense vegetation, poor radio contact due to geographic area, poorly maintained roads, and areas that are inaccessible by patrol vehicles. The Sheriff's Office provides services to the Project through regularly dispatched vehicle patrols, response to service calls from Project Visitors and Project employees, waterway patrols in the Afterbay (utilizing boats, jet skis and 4-wheel drive vehicles), search and rescue services, aviation services, investigative services, coroner services, and special operations services.

Sheriff Deputies train with diving equipment for evidence and body recovery in the Project Area, as well as with repelling equipment for rescues and contraband recovery within the Project's steep canyons. The Sheriff's Office operates or provides personnel in special operations units that provide services to the Project, such as the Emergency Ordinance Disposal ("EOD") team, Special Weapons and Tactics ("SWAT") team, a Canine Unit, Aviation Unit (fixed wing aircraft and helicopters), Dive and Rescue Team ("DART") and the Butte Interagency Narcotics Task Force.

4.1.1.1 Project Related Demand for Law Enforcement Services

The Sheriff's Office responds to hundreds of calls for service within the Project Area each year from Resident and Non-Resident Visitors and from outside agencies including the California Highway Patrol, State Parks and Recreation, and the Department of Fish and Game requesting mutual aid. The Sheriff Deputies are trained to manage specific incidents under a variety of challenges and settings and to handle various equipment required to bring incidents to a successful conclusion.

The calls for law enforcement services in the Project Area are diverse. The Sheriff's Office incident logs were reviewed to identify the types of calls the County receives for service within the Project Area. Examples of such calls for service include, but are not limited to: suspicious persons and/or vehicles, theft, vehicle accidents, watercraft accidents, reports of damaged property, public drunkenness, family disturbances, acts of vandalism, disturbance of the peace, battery, drunk driving, search and rescue, coroner investigations, criminal assault, trespassing, vehicle recovery, illegal discharge of firearms, burglary, evidence and body recovery, homicide, explosive ordinance disposal, and plane crashes. Details for several of the incidents are summarized below to provide the reader with an understanding of the kinds of service demands that are imposed by the Project.

- On October 10, 2005, a single engine aircraft departed the Oroville Airport in what appeared to be a routine takeoff. The plane suddenly stalled and fell into a pasture located within the Oroville Wildlife Area. The aircraft was consumed by fire on impact, and the pilot and passenger were killed. This incident required a high level response; approximately ten (10) Sheriff's Office and Fire Department personnel had to be deployed. The Sheriff's helicopter also provided aerial support.

- On May 4, 2005, an anonymous reporting party advised that he worked for the United Nations and that a "Capitalist Party Member" was at the Forebay "cutting and gutting" a female subject. The reporting party advised that the female was screaming that she was going to be killed. The Sheriff's Office dispatched two (2) patrol vehicles and searched the area for several hours. Fortunately, no victims were found but a significant number of man-hours were expended by the Sheriff's Office before this incident could be cleared.

- On August 21, 2004, a single engine airplane equipped with flotation landing gear attempted to take off from the Afterbay but crashed after ascending approximately thirty feet above the water. Both the pilot and passenger were trapped in the wreckage and died. Approximately fifteen (15) Sheriff Office personnel were required to respond to this incident.

- On August 3, 2004, a boat struck the shore of the north fork of Lake Oroville. The boat driver was ejected by the impact and the boat received heavy damage. Upon further examination of the boat's interior, a deceased female was found. She had suffered severe head trauma. Ten to fifteen (10-15) Sheriff's Office personnel were required to respond to this incident.

- On June 1, 2004, a physical altercation occurred between a father and son at the Larkin Road boat ramp at the Afterbay. The father died at the Oroville Hospital the following day as a result of the incident. One (1) Sergeant and four (4) Deputy Sheriffs were required to respond to this incident.

- On May 8, 2004, a deceased male adult was found in the water at the Forebay. The Sheriff's Dive and Rescue Team responded to this incident.

- During the past eight years, the Sheriff's Office has performed at least seven complex investigations and/or Coroner's investigations related to crimes or accidents in the Project Area. All coroner cases require an autopsy to be performed. Each autopsy costs the County a minimum of $1,750.

- On April 28, 2001, a factory representative from a boat company was demonstrating personal watercraft at the Monument Hill launch ramp at the Afterbay. Several untrained operators were given brief instructions and were allowed to operate the watercraft. One of the operators was ejected from the craft, was run over by one of the other operators and killed. Approximately five (5) Sheriff's Office personnel were required to respond to this incident.

- On September 28, 1998, the Sheriff's Office investigated a homicide that occurred on the Nelson Avenue Bridge that crosses over the Forebay. Approximately five (5) Sheriff's Office personnel were needed to respond to this incident.

- Since 1992, the Sheriff's Office has responded to over 173 search and rescue calls for assistance conducted within the Project Area. Several of these call-outs lasted for several days and countless man-hours were expended. Many of these events required use of the Sheriff's helicopters and boats, which is very costly to the County.

From October 2004 through October 2005, Butte County Sheriff's Deputies responded to over forty (40) calls for back-up or other assistance in the Project Area, in addition to providing their regular patrols and responses to visitor calls in Project areas. In responding to these calls for assistance, the Sheriff deployed fifty-nine (59) deputies, five (5) canine units, conducted five (5) arrests, and towed three (3) vehicles. This is a conservative estimate as these calls are difficult to query due to the manner in which information is logged into the Sheriff's Office database system. In comparison, State Parks and Recreation Department personnel responded to 87 calls during this same period of time. See Exhibit 2. This suggests that the State Parks and Recreation and others refer approximately 50% of all the requests for police services at the Project to the Butte County Sheriff's Office.

In addition, although the majority of visitors to the Project come during the summer months, the demands on County law enforcement personnel do not vary substantially by season, remaining relatively constant throughout the year. This is because outside of the summer months there are far fewer personnel and/or contractor support from the State Parks & Recreation Department, or other agencies, to assist the County in providing law enforcement services at the Project. Thus, although the total demands for law enforcement services at the Project are generally lower in non-summer periods, the County is required to respond to a far higher percentage of those service demands and referrals that arise during these non-peak periods.

Due to the large area and rugged terrain at the Project, it is both more difficult and more expensive for the County to provide law enforcement services at the Project than for other areas in the County. Access to areas of the Project can require Sheriff Deputies to travel 45 minutes or longer. Handling and resolving an incident may take significantly longer, depending upon the issue, its severity, and the number of agencies and other parties involved. In some cases, subjects are transported by Sheriff Deputies to the Butte County Jail, which requires additional in-processing time. The Sheriff's Office estimates that many calls for service related to the Project require two or more hours of a Deputy Sheriff's time. This diminishes the Sheriff's ability to deploy these resources to other law enforcement calls in the County. These Project demands also cause delays in response time to other County demands and thus increase the safety risks experienced by all other residents of the unincorporated areas of Butte County.

The Sheriff's Office must also support special events at the Project, including the annual 4th of July fireworks celebration on Lake Oroville, fishing tournaments and many other events. At least nine (9) Deputies and one (1) helicopter are normally deployed for the July 4th event. In addition, bass tournaments conducted on Lake Oroville also cause increased traffic and visitors, which generates calls for the Sheriff's Office. The California Department of State Parks and

Recreation issues permits for these events and a representative from this agency indicated that fifty (50) bass tournaments were conducted on Lake Oroville in 2005.

Flooding and other weather events also place a heavy demand on County law enforcement services. When heavy rains bring the Lake Oroville level to possible overflow conditions, it triggers major flood management operations at Oroville Dam. When this occurs, the Sheriff's Office must deploy its resources to ensure the safety of County citizens and Project Visitors by modifying its operations schedule to afford maximum deployment of personnel and resources. Often the majority of the department personnel must prepare for and/or become involved in planning, evacuations, search and rescue, and anti-looting enforcement. The Sheriff has dedicated hundreds of hours of helicopter and special equipment to these emergencies. These types of operations have occurred in 1994, 1995, 1997 and 2005. Even though the operational period for these unplanned disaster protection events can last for several days or more, the Licensee does not reimburse the County for any of the costs associated with these operations.

During the 1997 flood event, 25 inches of rain fell in the Feather River basin in an eight-day period leading up to January 3rd, and inflows to Lake Oroville exceeded 300,000 cubic feet per second ("cfs") during a 16-hour period. The County developed an evacuation plan for the City of Oroville and residents located further south along the Feather River. The Sheriff's Office helped to coordinate a multi-jurisdictional effort to implement the evacuation plan.

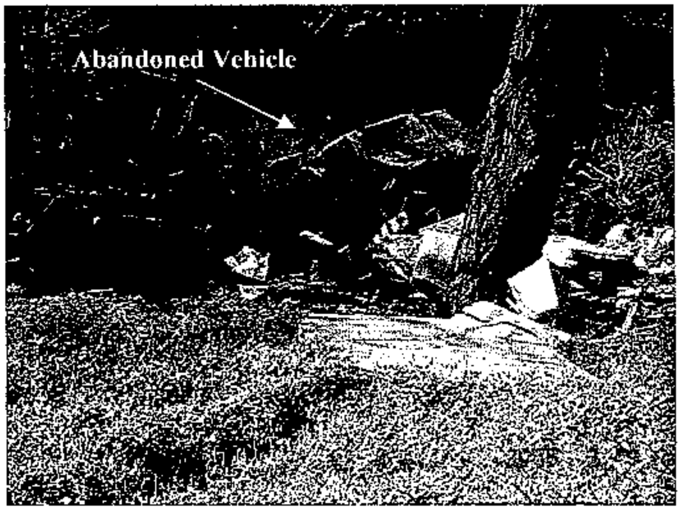


Figure 4.1.1.1-1 – Abandoned vehicle in OWA(3/9/05)

Some Project areas are poorly maintained, resulting in more criminal activity and both unsafe and unsightly conditions that threaten both Project Visitors and County residents. For example, the County has to expend significant law enforcement and other County resources in one portion of the Project Area—the OWA—beyond that required elsewhere. The OWA includes approximately seven (7) miles of Feather River frontage, as well as the Afterbay. Due largely to its close proximity to urban areas, the relative abundance of cold water fishing, "primitive" campgrounds, and boating recreation available on the Afterbay, OWA receives approximately 318,462 visitors each year, as reported in Table 5.1-1 of the Licensee's Final Existing Recreation Use Report (R-9). The OWA is located within a few miles of commercial and residential areas and it is easy to find secluded spots within this area of the Project. In addition, as illustrated by the photos on this and following pages, the OWA is poorly maintained, with trash, abandoned vehicles, and other conditions that attract a criminal element to the area. The OWA has experienced a relatively high, ongoing amount of criminal activity, including violent crimes and gang activity.

County law enforcement must spend substantial resources responding to calls for service in the OWA, arresting, prosecuting, and incarcerating offenders. Some examples of serious violent crimes in the OWA include four (4) gang rapes (1997-98), an assault with a deadly weapon (2005), numerous drug offenses, assaults, batteries, and other criminal activity. The prosecution of the gang rape cases alone, which involved an extradition from Minnesota, an appeal to the California Court of Appeals, and interviews with a large number of out-of county-witnesses, spanned a two-year period and consumed significant Butte County resources.

Figure 4.1.1.1-2 – Abandoned vehicle in OWA (3/9/05)

One of the major reasons why this Project area imposes significant impacts on County law enforcement is because the California Department of Fish and Game (DFG) departed the OWA in April 2004 and ceased its management because of the lack of funding. The OWA is a FERC-designated Project recreation area managed by DFG for DWR. Although well aware of DFG's funding problems and DWR's obligations under the 1994 FERC Order mandating the recreation area, DWR refused to provide any funding support to DFG. The lack of a presence by DFG game wardens and Project employees in the OWA area has resulted in an increase in crime, vandalism, and unlawful dumping activities. The cessation of regular refuse disposal service has caused piles of trash to accumulate periodically in the area of the Afterbay outlet to the River. There has been a general degradation of the appearance of the entire OWA area as shown in Figures 4.1.1.1-1, 4.1.1.1-2, and 4.1.1.1-3. Documented evidence shows that unfavorable environmental conditions such as proliferations of dumped trash, abandoned vehicles, dilapidated facilities, and graffiti attract criminal activities such as numerous types of gang activity, vandalism, and more serious crimes.[10] This crime activity not

Figure 4.1.1.1-3 Refuse and Waste in OWA (3/9/05)

[10] Numerous articles have been written concerning the "broken window syndrome" and descriptions of the largely successful crime eradication efforts undertaken by then-New York City Mayor Rudolf Giuliani in the 1980's, which were based upon beautification of the City and graffiti eradication. See, e.g., Clines, Francis X, "Candidates Attack the Squeegee Men," The New York Times (Sept. 26, 1993); Harcourt, Bernard E., "Policing Disorder," Boston Review, online at http://www.bostonreview.net/BR27.2/harcourt.html; Morgan, Richard E., "Free to Strip? Opponents of Mayor Giuliani's Campaign to Close Sex Shops Say It Violates the First Amendment. They're Wrong: It Doesn't," City Journal (Spring 1999); Testimony of Rudolph W. Giuliani:

only requires County law enforcement to spend more time in the OWA, but the poor conditions also serve to attract criminal elements that then commit crimes throughout the County.

Due to the County's financial problems, the FY 2005-2006 budget provides only minimal funding to maintain critical operations provided by the Butte County Sheriff's Office in the Project Area and unincorporated areas of the County. At times, the Sheriffs patrol coverage in the unincorporated areas of the County is limited to four (4) Deputy Sheriffs. This means that each Deputy is providing services to the equivalent of 419 square miles of territory (1,675 – total square miles of County, divided by four (4) Deputy Sheriffs). Thus, when Deputy Sheriffs are deployed to the Project for two or more hours it creates coverage problems and delayed response times for Butte County residents.

In June 2005, the California Commission on State Mandates validated Butte County's need to add fifty-five (55) Deputy Sheriff positions, eight (8) Sergeant positions, eight (8) Public Safety Dispatcher positions, and eight (8) support staff positions.[11] This finding demonstrated the need for a total of seventy-nine (79) sworn and non-sworn positions in the County. Butte County's application referenced the 2002 Uniform Crime Report ("UCR"), stating that the California average ratio of sworn officers per 1,000 people is 2.77.[12] The Commission on State Mandates acknowledged that Butte County's ratio is only 1.18 sworn officers per 1,000 people. The adverse effects of these resource limitations is compounded by the fact that the patrol services of the Sheriff's Office are regularly directed away from service demands in Butte County's unincorporated areas to respond to or assist with calls in the Project Area. This means that the failure of the Project to reimburse the County for providing law enforcement services results in inadequate law enforcement staffing for the Total Population Served, and less protection and slower response times for County residents. If the Project paid for the law enforcement services that it utilizes, the County could afford to hire the additional officer personnel recommended by the State and provide adequate law enforcement services to both the Project and County residents.

4.1.1.2 Cost of Providing Law Enforcement Services to Meet Project Related Demand

A reasonable way to estimate the costs of law enforcement services related to the Project is to consider the cost of meeting those demands as if the services were being provided to a stand-alone community. In reviewing data provided by the Licensee's Final Recreation Surveys Report (R-13), approximately 53.5% of the survey respondents who visited the Project were residents of

Hearing on "The Government Performance and Results Act" Before the H. Comm. on Government Reform, 1997 Leg. (March 13, 1997).

11 California Commission on State Mandates. Final Statement of Decision (June 10, 2005). The finding of the Commission is based upon an exhaustive analysis by staff from the California Commission on State Mandates, State Treasurer's Office, Department of Finance, and the State Controller's Office. The Commission on State Mandates completed its process under SB 1033 and issued a finding of significant financial distress for Butte County for the period September 1, 2005 through August 31, 2006. Butte County previously received this designation in 1996 and 1999.

12 Non-sworn positions, such as Public Safety Dispatchers and support staff are not considered by the UCR California average ratio of sworn officers.

Butte County and 46.5% were visitors from outside the County.[13] Therefore, the average daily peak period service demand for Non-Resident Visitors was estimated to be 5,270.[14]

The Sheriff's Office handles approximately 50% of all requests for law enforcement services at the Project. One-half of the peak service demand for Non-Resident Visitors equates to an average daily population of 2,635. This creates an adjusted estimated population of 2,635, for which the Sheriff's Office needs to provide police services on a 24/7, year-round basis.

The cost of providing police services in the nearby communities of Red Bluff (13,550 population), Oroville (13,350), Marysville (12,800), Anderson (10,050) and Gridley/Biggs (7,585) were reviewed to obtain data on the cost of providing law enforcement services. The average law enforcement staffing and operation costs per 1,000 people were then computed for these towns. These communities were selected for the survey due to their small population size and close-proximity to the Project.

The average number of law enforcement employees per 1,000 people in the above jurisdictions in 2005 was 2.84. The average cost per 1,000 people in 2005 was $258,698. See Exhibit 3. The projected cost estimate also considers fixed costs that would be incurred to establish and maintain these services, as indicated in Exhibit 3.

Using a staffing ratio of 2.84 per 1,000 in population (considers sworn and non-sworn positions), the Sheriff's Office requires seven (7) positions to provide a reasonable level of police services to the Non-Resident Visitor Population of the Project on a 24/7, year-round basis. Five (5) of these positions should be "sworn positions" and two "non-sworn" positions. Applying the average cost per 1,000 people ($258,698) to the Non-Resident Visitor Population of 2,635 results in a Project service cost calculation of $681,670 per year. This amount is approximately 1.35% of the County's total budget for law enforcement and criminal justice services. In addition, fixed costs, such as vehicles, training, equipment, and supplies are estimated to be an additional $542,000.[15]

Table 4.1.1.2-1
Calculation of the Average Annual Cost of Providing Law Enforcement Services for Non-Resident Visitors

Calculation Detail
2,635 / 1,000 = 2.635
2,635 * $258,698 = $681,670

[13] See Appendix A.1.

[14] The exclusion of Project Visitors that are County residents results in a very conservative estimate of cost impacts since providing rescue, fire and other County assistance on the remote and rugged Project areas is much more time consuming and expensive than providing the equivalent services in a town or rural setting.

[15] For example, the Sheriff's Office has indicated that the cost to recruit, hire, train, and equip one Deputy Sheriff is approximately $70,000.

The annual operating cost to provide Law Enforcement Services to Non-Resident Visitors within the Project Area is estimated to be $681,670, as further described in Exhibit 3. The one-time costs to enable such law enforcement support are estimated to be an additional $542,000.

4.1.2 Criminal Justice Services

As noted above, the County is responsible for making arrests when it responds to criminal activities that occur within its boundaries. The County's responsibilities do not end with arresting the suspect. Arrests are followed by the provision of County jail, District Attorney, Probation Department, and Public Defender services. These other criminal justice services are provided to both Resident and Non-Resident Visitors to the Project and include persons arrested by other State agencies as well as arrests made by County Law Enforcement personnel.[16]

4.1.2.1 Project Related Demand for Criminal Justice Services

When arrests are made on Project lands by County law enforcement or State agencies, the arrestees are incarcerated in the County Jail, prosecuted by the County District Attorney's office, a court report is prepared by the County Probation Department, and in many cases, the County's Public Defender provides a legal defense to the defendant. Following trial, the Probation Department also provides court-directed supervision to adults and juveniles.

The District Attorney's office investigates and prosecutes criminal cases filed by all enforcement agencies in Butte County. Pursuant to State law, no criminal complaint can be filed without review by the District Attorney, who must determine whether evidence of a crime is sufficient to bring the complaint to trial, which often requires involvement by DA Investigators as well.

The Probation Department supervises convicted felons, both adults and juveniles, who are placed on probation by the court. The Department also prepares reports recommending sentencing after a conviction, operates the Juvenile Hall, manages the victim witness/assistance program, and participates in a variety of collaborative programs with schools, law enforcement agencies, County departments, and private agencies to prevent crime.

The Public Defender Consortium is comprised of sixteen (16) private attorneys under contract with the County that provide legal assistance to indigent clients in criminal cases. Federal and State constitutions require the provision of competent counsel to those who are unable to retain a private attorney to defend him/herself.

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16 The County's estimated costs to provide criminal justice services is based on extremely conservative assumptions because although County Law Enforcement personnel must respond to approximately 50% of all Project-related service demands, the County must incarcerate and provide criminal justice services for all persons cited or arrested at the Project, whether the arrest was made by County personnel or by other State and Federal agencies.

The Incarceration Division of the Sheriff's Office is mandated by law to provide for the care, safety, security, and welfare of persons incarcerated in Butte County correctional facilities. The Division provides transportation of inmates to court, medical and dental appointments, and state prisons.

The Butte County Superior Court is a separate governmental entity and its operational costs are funded entirely by the State of California. Therefore, this report does not consider Project-related operational impacts to the Butte County Superior Court to try criminal defendants.

4.1.2.2 Cost of Providing Criminal Justice Services to Meet Project Related Demands

To determine cost estimates for these Criminal Justice Services related to the Project, the Non-Resident Visitor ("NRV") Factor was applied. As described earlier, the NRV Factor is the proportion of Non-Resident Visitors to the Total Population Served. The factor is derived by dividing the average daily Non-Resident Visitors Population (5,270) by the sum of the Total County Population (210,022) and the Non-Resident Visitor Population (5,270). Based on the calculation, 2.45% of the Total Population Served is comprised of Non-Resident Visitors.

The NRV Factor of 2.45% was applied to actual expenditures incurred by the County in fiscal year 2004-05 for the following budget units: District Attorney–Criminal, Probation Department, Public Defender, and Sheriff–Incarceration. The following table provides detail for these calculations.

Table 4.1.2.1-1
Calculation Detail for Other Criminal Justice Costs

	FY 2004-05 Actual Exp.	Project Cost	% of Total
District Attorney - Criminal	$6,661,086	$163,197	2.45%
Probation Department	$6,448,554	$157,990	2.45%
Public Defender	$2,167,108	$53,094	2.45%
Sheriff - Jail	$11,849,152	$290,304	2.45%
	$27,125,900	**$664,585**	2.45%

The total estimated annual operating cost for Criminal Justice Services attributable to the Project is $664,585.

4.1.3 Crucial Asset and Community Threat – Demands and Costs

Butte County recognizes that the Project could potentially be the target of terrorist activity. Lake Oroville Dam is ranked Number 130 on the 2004 California Crucial Asset List distributed by the California Office of Homeland Security and developed by the California National Guard. Lake Oroville Dam is the highest-ranking critical asset north of Folsom Lake (No. 63 on the Crucial Asset List). Areas of the City of Oroville are located only two miles away from the Lake

Oroville Dam with an estimated population of 13,500.[17] However, the State of California currently provides minimal security for this potential target. One of the first security measures taken after the September 11, 2001 terrorist attacks at the World Trade Center was the creation of an off-limits area along the face of the Dam. The Butte County Sheriff's Office has advised that this rule is frequently violated, and that the State's security guards are unarmed and often difficult to find or contact in this sensitive area. Therefore, current security arrangements are not adequate either to protect Butte County residents and Visitors or to protect the Oroville Dam itself from potential terrorist or other threats.

Butte County recognizes the potential threat exposure to both its residents and Project Visitors due to the location of the dam near populated areas and proposes the use of Sheriff's personnel to better guard the Lake Oroville Dam. The Sheriff's Office has advised that staffing of a minimum of six (6) Deputy Sheriffs and one (1) Sergeant would be needed in order to arrange patrols to guard the Lake Oroville Dam 24 hours per day, assuming one officer on duty per shift, with increased staffing for higher activity periods.

Table 4.1.3-1
Shift Detail to Provide Minimal Coverage 24 Hours Per Day*

Shift	Wed	Thur	Fri	Sat	Sun	Mon	Tues
0600-1600	Dep. #1	Dep. #1	Dep. #1	Dep. #1; Dep. #4	Dep. #4	Dep. #4	Dep. #4
1400-2400	Dep. #2	Dep. #2	Dep. #2	Dep. #2; Dep. #5	Dep. #5	Dep. #5	Dep. #5
2200-0800	Dep. #3	Dep. #3	Dep. #3	Dep. #3; Dep. #6	Dep. #6	Dep. #6	Dep. #6
Sergeant/Backfill			Dep. #7	Dep. #7	Dep. #7	Dep. #7	

* "Dep." as used herein represents each individual deputy assigned to provide shift coverage. Due to labor laws, to provide deputy patrol over a 24-hour period, several deputies must be hired in order to staff the three daily eight-hour shifts.

17 This population estimate does not consider residents located in the unincorporated area of the County.

Table 4.1.3-2
Estimated Cost to Provide Minimal Coverage 24 Hours Per Day

Description	Estimated Cost ('05$)
Annual Cost of 6 Deputy Sheriff Positions ($79,866 each)	$479,198
Annual Cost of 1 Sergeant Position	$95,189
Overhead and supplies[18]	$114,774
Cost to hire, train, and equip[19]	$490,000
Total	**$1,179,161**

Total estimated annual operating costs to provide coverage for Crucial Asset and Community Threat risks created by Project facilities are $689,161 as shown in the table above. Initial fixed costs are estimated to be $490,000. This estimated cost would provide for at least one deputy on duty 24 hours per day, with increased numbers during higher activity periods.

[18] Represents 20% of estimated salary and benefits, which is consistent with the Sheriff's Operations budget for fiscal year 2005-06.

[19] This cost estimate was provided by the Sheriff's Office and considers the following: application, interview, and selection process; Peace Officers Standards and Training ("POST"), and the Sheriff's 14-week Field Training Officer Program.

4.2 Fire and Rescue Services

The Butte County Fire Department ("Fire Department") provides fire and rescue services in the Project's Area of Highest Use (as described previously in the Report and in Appendix A). The Fire Department responds to a variety of incidents for Project Visitors including, but not limited to, the following service needs: emergency medical, rescue, vehicular accidents, water rescue, public assistance, animal rescue, and fire (structural, grass, refuse, vehicle fires). In addition, the Fire Department provides specialized services to the Project through the County's Interagency HazMat Team, the Technical Rescue Team (includes the Drowning Accident Rescue Team), the Vehicle Extraction Team, and the Critical Incident Stress Debriefing Team. Staffing levels and service levels for each response vary depending upon the classification of a geographic area (i.e., urban vs. rural) and the type of call (i.e., structural fire vs. public assist).

4.2.1 Project Related Demand for Fire and Rescue Services

Calls from the Lake Oroville Project Area are likely to be rescue-related and typically require more Dispatch time than calls from local residents for the following reasons:

- Callers from the Project are typically on a cell phone, with poor reception, and are therefore more difficult to locate.
- Callers from Lake Oroville do not usually know where they are on the lake and cannot describe their location to Dispatch.
- State Parks and the California Highway Patrol sometimes get the initial calls and typically do not question the caller thoroughly to identify what specific fire/rescue services are needed.
- Callers with medical emergencies on boats often tell Dispatch they will come into a certain launch ramp and then go to another launch ramp, requiring multiple responses to multiple sites.

Specific examples, but by no means an exhaustive list, of incidents directly related to the Project include:

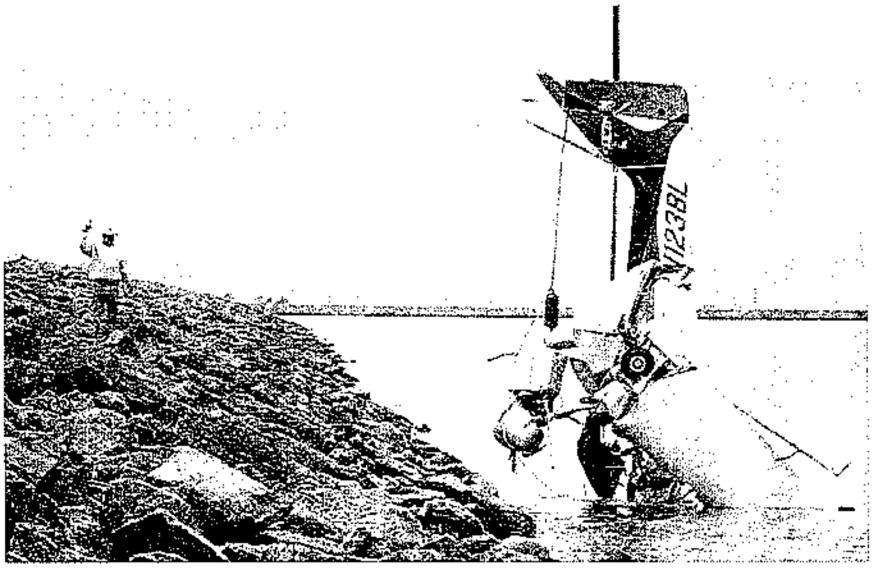
- Each year, from 1997 through 2005, County Fire personnel responded to more than 25 calls during the 4th of July holiday alone, including fires, medical assistance, and traffic collisions.
- In 2005, the Fire Department personnel responded to various fire and rescue calls on the Project, including, but not limited to:
    - A boat fire at Potter Ravine, including the rescue of victims that were in the water;
    - A boat fire on the Lake caused by electrical problems;

  - A suicidal subject at the Middle Fork floating campsites;
  - The rescue of a vehicle and its passengers when the vehicle ran off the edge of Lime Saddle Road; and,
  - A dive rescue for a capsized boat off of the Monument Hill Launch Ramp at the Afterbay.

- In 2005, there were multiple emergency medical responses by the Fire Department to the Project, including, but not limited to:
  - A head injury at Lime Saddle Marina;
  - A request for medical assistance in the water near the Dam;
  - A partial leg amputation at Lime Saddle Marina;
  - An unconscious woman at the Lime Saddle Group Camp;
  - A hand stuck in a boat motor on the Lake near Bidwell Marina;
  - A seizure at Bidwell Marina;
  - An arm fracture at Bidwell Canyon Launch Ramp;
  - A heart attack, associated with a murder attempt, at the Afterbay;
  - A finger laceration at Bidwell Canyon Launch Ramp; and,
  - A rib injury at the Spillway Launch Ramp.

- In 2004, emergency responses by the Fire Department included:
  - A victim came in contact with an active boat propeller and died as a result.
  - A more than 2,000-acre vegetation fire in the Oregon Gulch area of the Project.
  - A houseboat sank in Bidwell Marina, triggering an oil spill that required a response by the County's HazMat Team.

Figure 4.2.1-1 Plane Crash in Afterbay – August 21, 2004



Source: Oroville Mercury Register

Figure 4.2.1-2 Drowning Accident Rescue Team Response to Afterbay – August 3, 2004

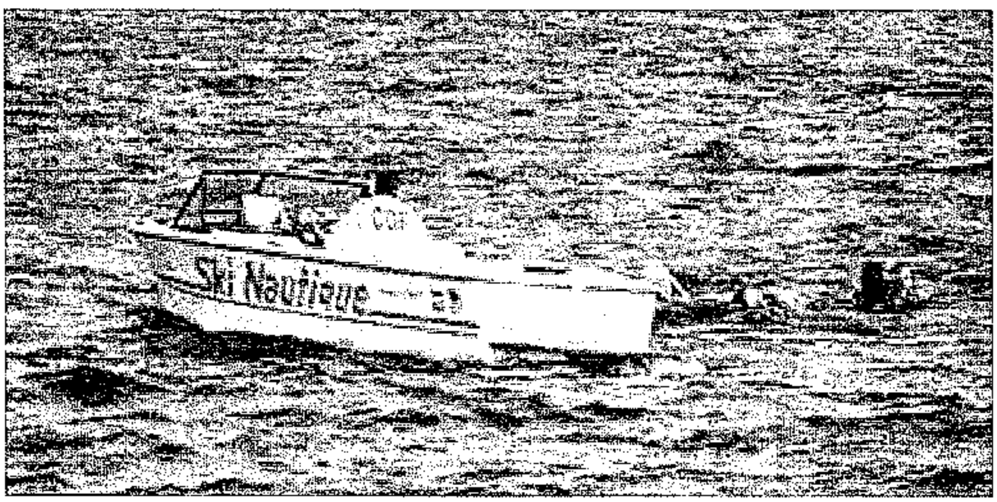
Source: Oroville Mercury Register

Figure 4.2.1-3 Short-haul Rescue of Kayaker in Distress at Afterbay – April 10, 2004

Source: Oroville Mercury Register

- In 2003, Fire Department responses included:
  - A vegetation fire at the Bidwell Campground and a water rescue at the Thermalito Afterbay.

Figure 4.2.1-4 Two Persons Rescued from Water Accident – Thermalito Afterbay – 2003



Source: Oroville Mercury Register

- In 2002, Fire Department responses included:
  - Responding twice in the same day to the South Fork of the Feather River. The first call was for an emergency medical response for a groin laceration. The second call required response by the County's Drowning Accident Rescue Team .
  - A crushing injury at Bidwell Marina that turned out to be fatal.
- In 2001, Butte County Fire Department responses included:
  - A heart attack victim on his boat. The response saved the victim's life.
  - A post-9/11 anthrax scare that required a HazMat response to the shore of Lake Oroville by the County.
- Prior to and including 2000, examples of responses include:
  - In 2000, there was a hydraulic fuel spill from Lime Saddle Marina that required a HazMat response by the County.
  - In 1997, the Drowning Accident Response Team provided two separate responses to Lake Oroville. In addition, the Fire Department and DART responded to a seaplane crash in the middle of Lake Oroville that required a major rescue response, including divers.
  - In 1995, a DWR dredger sank near the Oroville Dam, causing an oil spill which required a response by the County's HazMat Team.
  - In 1980, the Fire Department responded to a fire involving multiple houseboats. This incident is referred to as a houseboat conflagration where fire burns from houseboat-to-houseboat. A total of six houseboats burned in the incident.

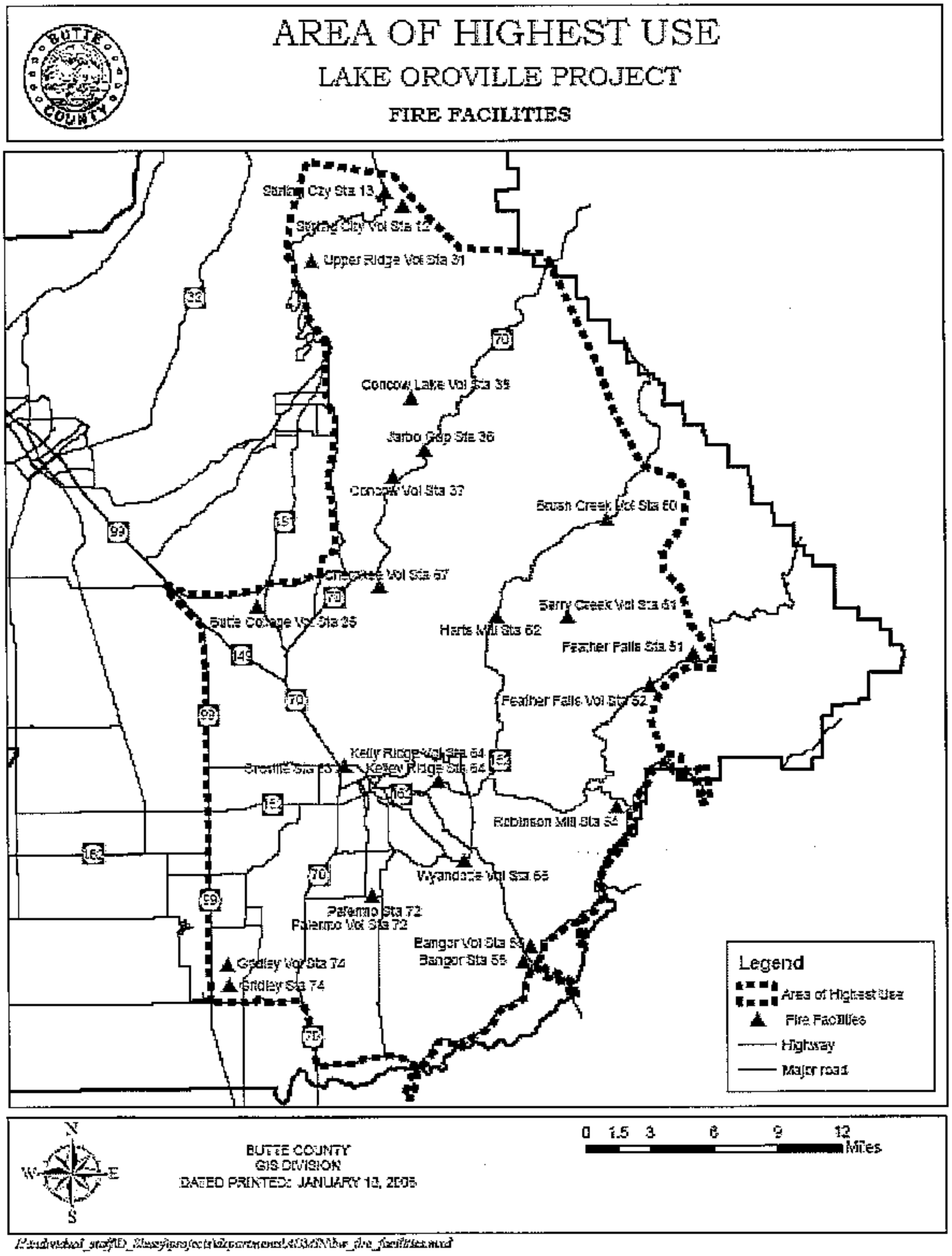
Project Visitors expect that the Fire Department will be available to respond to emergencies that occur within the boundaries of the County, including within the Project Area. Because the Fire Department is usually the first to arrive on scene to a 911 call, Project Visitors look at the fire service as a *de facto* provider of emergency medical services. The County Fire Department staff are trained and staffed to provide basic life support only and must call in local ambulance companies when advance life support and transportation to a hospital is needed. Due to the large geographic span of the Project and the area surrounding it, arrival of an ambulance takes considerable time. Until the ambulance arrives, Fire Department personnel are responsible for the care of the person in need of medical assistance, pulling County fire staff away from their station and, in many situations, requiring an engine and fire staff to be moved from elsewhere to cover the vacant station.

There are specific regulatory mandates that must be met by any fire department providing structural fire protection. These mandates include a range of requirements such as breathing apparatus protection, staffing levels, and equipment/clothing. One of the most significant regulations impacting required staffing levels in fire departments was implemented by the Federal Occupational Safety and Health Administration ("OSHA") in 1999; it is known as the "two-in and two-out" rule. The expression refers to situations where firefighters must enter an atmosphere that presents conditions "immediately dangerous to life and health" ("IDLH"). A minimum of two firefighters is required to conduct entry and two other firefighters must remain outside of the structure. The Fire Department staffs all of its stations with one engine with two-person staffing. Therefore, the "two-in and two-out" requirement impacts a minimum of two stations whenever the department responds to a structural fire. The minimum requirement of the Fire Department for responding to a one-alarm fire is three engines, requiring, once again, that engines and personnel be moved from elsewhere to cover the vacant stations.

The Fire Department operates in an emergency status any time a station is uncovered. Appropriate efforts are made to cover open stations through "move-up and cover" and/or "call-backs." When resources are available, it is the objective to have all fire stations covered. A fire station is considered uncovered when fire engines in a particular area are unavailable for more than 30 minutes. The Fire Department classifies each station into one of four priority levels (color codes) for station coverage. A station designated as red is the highest priority for coverage, followed by yellow, green, and blue (lowest priority). Stations designated blue are typically in a "move up and cover" status on a daily basis, in order to maintain fire engines in the red and yellow stations.

The Fire Department allocates its resources throughout the unincorporated areas of the County. Stations are positioned based on population distribution, asset values, geographical distribution, and other local factors. Not all stations serve the Project; for the purposes of this study, the County has identified an "Area of Highest Use" to define where visitors to the Project utilize County services. The Area of Highest Use is defined by the arterial and collector roads that lead to the Project Area; in other words, the primary routes (roads) used by Project Visitors to get to the Project. The Area of Highest Use has been discussed previously in the report and is further explained in Appendix A – Assumptions and Definitions and illustrated in Figure 4.2.1-5.

Figure 4.2.1-5


AREA OF HIGHEST USE
LAKE OROVILLE PROJECT
FIRE FACILITIES
Upper Ridge Vol Sta 31
Jarbo Gap Sta 36
Harts Mill Sta 62
Feather Falls Sta 51
Robinson Mill Sta 54
Palermo Vol Sta 72
Bangor Sta 55
Gridley Sta 74
Legend
Area of Highest Use
Fire Facilities
Highway
Major road
BUTTE COUNTY
GIS DIVISION
0 1.5 3 6 9 12
Miles

There are twenty-two (22) fire stations with response areas that fall within the Area of Highest Use, as reflected in Figure 4.2.1-5, above. Of these stations, nine (9) are Butte County Volunteer Fire Stations, four (4) are California Department of Forestry and Fire Protection ("CDF")/Butte County "Amador" Stations, eight (8) are Butte County Fire Department Stations, and one (1) is a CDF station. The types of fire stations are distinguished as follows:

1. Butte County Volunteer Fire Stations consist of stations owned and maintained by the County. County costs associated with Volunteer Fire Stations include maintenance of the facility, payment of stipends to volunteers, and training costs for volunteers.

2. CDF/Butte County "Amador" Stations consist of stations owned by the State of California. The State provides full staffing and operational funding for five months (fire season) out of each year. CDF employees receive Emergency Response Pay in addition to their base pay rate for providing 24-hour coverage and responding to emergencies. During the remaining seven months (non-fire season), the County continues to pay the additional Emergency Response Pay for the CDF firefighters that then respond to County emergencies.

3. Butte County Fire Department Stations consist of stations and apparatus owned and operated by the County. Firefighters that are assigned to County stations are State employees working under contract with the County through a Schedule A contract with California Department of Forestry and Fire Protection. All staffing and overhead expenses are run through the Schedule A contract and are fully funded by the County.

4. CDF Stations consist of stations owned and operated by the State, including all staffing and overhead costs.

Listed in Table 4.2.1-1 are total incident data from 2004 for the Fire Department and CDF/Butte County "Amador" fire stations that respond to calls at the Project and within the Area of Highest Use. In addition, the priority level of station coverage, as discussed previously, has been included. The table reflects that Stations 33, 64, 72, 73, or 74 (red or yellow priority) must be covered either by other County stations (green or blue priority) and/or other local fire jurisdictions (i.e., cities), when the assigned engines and staff are called out for longer than 30 minutes.[20]

20 Butte County Fire Department, CDF/BCFD Station Cover Plan (Winter) and CDF/BCFD Station Cover Plan (Summer) (2005-2006).

Table 4.2.1-1
Total Calls by Station and Priority Level in Project Area of Highest Use - 2004

Stations	Calls	Fire	Medical	Other
Butte County Stations (priority level)				
33 – Upper Ridge (red)	664	56	457	151
45 – Durham (green)	327	45	198	84
64 – Kelly Ridge (red)	1,002	57	769	176
63 – Oroville (blue)	659	35	520	104
71 – Richvale (blue)	101	17	56	28
72 – Palermo (yellow)	916	101	666	149
73 – Biggs (yellow)	151	29	81	41
74 – Gridley (red)	470	80	280	110
CDF/Butte County "Amador" Stations (priority level)				
35 – Paradise (green)	422	41	198	183
62 – Harts Mill (green)	220	20	122	78
54 – Robinson Mills (green)	260	17	204	39
36 – Jarbo Gap (green)	241	32	141	68

Source: Butte County Fire Department – Year End 2004 Statistics by Station and Incident Type (data from Computer Aided Dispatch (CAD) System)

Provided in Table 4.2.1-2 are the 2004 statistics for "move-up and cover" station coverage by the Butte County and CDF/Butte County "Amador" fire stations located within the Project Impact Area.

Table 4.2.1-2
Total Runs to Cover Other Stations in Project Area of Highest Use - 2004

County Stations (priority level)	Total "Move up and cover" Runs
33 – Upper Ridge (red)	0
45 – Durham (green)	35
63 – Oroville (blue)	198
64 – Kelly Ridge (red)	3
71 – Richvale (blue)	179
72 – Palermo (yellow)	28
73 – Biggs (yellow)	50
74 – Gridley (red)	63
CDF/Butte County "Amador" Stations (priority level)	
35 – Paradise (green)	163
36 – Jarbo Gap (green)	20
54 – Robinson Mills (green)	37
62 – Harts Mill (green)	73

Source: Butte County Fire Department – Station Coverage Logs

Diverting the County's limited Fire Department resources to respond to time-consuming calls for assistance within the Project Area of Highest Use has a significant adverse operational impact on the County's ability to provide adequate fire service coverage to Butte County residents at all times.

4.2.2 Cost of Providing Fire and Rescue Services to Meet Project Related Demand

The total fiscal year 2005-2006 budget for the County's Fire Department is $14,177,791 (including operations and equipment replacement). The cost calculations below are only based on the costs of operating stations and replacing stations and equipment. They do not include costs for non-Project-related activities, such as planning, building permit review or fire prevention.

County costs for providing Fire and Rescue Services to the Project were calculated based on one of two factors: 1) the Non-Resident Visitor Factor ("NRV Factor"- described earlier in the Report) or 2) the Non-Resident Visitor Use Within the Area of Highest Use Factor (or, "NRV-AHU Factor"), as described below.

Non-Resident Visitor Use Within the Area of Highest Use Factor – The NRV-AHU Factor is the proportion of Non-Resident Visitors to the Total Population Served within the Area of Highest Use. The factor is derived by dividing the Non-Resident Visitors Population (5,270) by the sum of the Total County Population Within the Area of Highest Use (56,596) and the Non-Resident Visitor Population (5,270). Based on this calculation, 8.52% of the total population served in the

Area of Highest Use is comprised of Non-Resident Visitors. Table 4.2.2-1 summarizes this calculation.

Table 4.2.2-1
Variables Used in the Calculation of "Non-Resident Visitor Use Within the Area of Highest Use Factor" ("NRV-AHU Factor")

Variable Description	Variable Calculation (if applicable)	Variable Value
Project Population (includes Resident Visitors and Non-Resident Visitors) – [see Assumptions Section – Appendix A]	N/A	11,334
Percentage (%) of Project Population that are Non-Resident Visitors– [see Assumptions Section – Appendix A]	N/A	46.5%
Project Non-Resident Visitor Population	46.5% * 11,334	5,270
Total County Population Within Area of Highest Use – [2000 Census Data by Census Tract]	N/A	56,596
Total Population Served in Area of Highest Use	56,596 + 5,270	61,866

Calculation Detail

11,334 * 46.5% = 5,270
56,596 + 5,270 = 61,866
5,270 / 61,866 = 8.52%

For Fire and Rescue Services, the cost calculations for stations that provide partial response in the Area of Highest Use or provide backup ("move-up and cover") to stations that respond directly to the Project utilize the NRV Factor (2.45%). The cost calculations for stations that respond directly to the Project (i.e., that include the Project Area within their station service boundaries) utilize the NRV-AHU Factor (8.52%).

Fire Services – Operational Costs

The County's share of the fiscal year 2005-06 operating and staffing costs for each of the types of stations with response areas that fall within the Area of Highest Use is detailed in Exhibit 5. Costs are calculated by multiplying the annual cost to operate the stations by the appropriate cost factor, either the 2.45% or 8.52% cost factors described above. Table 4.2.2-2 summarizes the information provided in Exhibit 5 and reflects the calculation of the portion of annual cost to provide Fire and Emergency Services attributable to the Project. The Project's annual share of costs equals **$393,267**.

Table 4.2.2-2
Total Operating Costs for Stations that Serve the Area of Highest Use ('05$)

Station Type	Response Level	Cost Factor	Operating Costs	Number of Stations	Total Operating Costs	Cost Attributable to the Project
Butte County Volunteer Station	Direct Response	8.52%	$29,796	5	$148,980	$12,693
Butte County Volunteer Station	Partial Response/ "Move up and Cover"	2.45%	$29,796	4	$119,184	$2,920
CDF/Butte County "Amador" Station	Partial Response/ "Move up and Cover"	2.45%	$152,460	4	$609,840	$14,941
Butte County Station	Direct Response	8.52%	$826,603	4	$3,306,412	$281,706
Butte County Station	Partial Response/ "Move up and Cover"	2.45%	$826,603	4	$3,306,412	$81,007
TOTAL					**$7,490,828**	**$393,267**

Fire Services – Facilities

Over the proposed 50-year life of the license, the County will have to replace all eight (8) County fire stations within the Area of Highest Use. The current approximate replacement cost for a fire station in California is $2.1 million.[21] Based on total current costs of $16,800,000 (8 * $2,100,000) to replace eight (8) fire stations, and after applying the NRV-AHU Factor of 8.52% to the four (4) stations that respond directly to the Project and 2.45% to the four (4) that partially serve the Area of Highest Use or serve as backup to the other four stations, the Project's share of the one-time costs would be **$921,480**. On an annual basis, assuming replacement of all eight (8) stations within ten (10) years, the Project's share of costs would be **$92,148 per year for ten years** ($921,480 / 10). See the calculations in Tables 4.2.2-3, 4.2.2-4 and 4.2.2-5 below for details.

[21] See Exhibit 5. The last station that was built in Butte County was built by the California Department of Forestry and Fire Protection in 2001-02 and cost $1.5 million.

Table 4.2.2-3
Project Related Cost of Replacing a Station That Responds Directlyto the Project

Calculation Detail
4 * $2,100,000 = $8,400,000 $8,400,000 x 8.52% = $715,680 *Annualized Cost over a ten-year period =* *$715,680 / 10 = $71,568*

Table 4.2.2-4
Project Related Cost of Replacing a Station That Partially Serves the Area of Highest Use or Provides Backup to Other Stations

Calculation Detail
4 * $2,000,000 = $8,400,000 $8,400,000 x 2.45% = $205,800 *Annualized Cost over a ten-year period =* *$205,800 / 10 = $20,580*

Table 4.2.2-5
Total One-Time Costs Attributed to Project for Replacing Eight Fire Stations

Calculation Detail
$715,680 + $205,800 = $921,480 *Annualized Cost over a ten-year period =* *$921,480 / 10 = $92,148*

Fire Services – Equipment

Based on the age of equipment used by the stations that serve the Project and the Area of Highest Use, the County will need to replace some vehicles twice over the 50-year license period and others will need to be replaced once. Exhibit 6 details the total replacement costs and the Project's portion of costs. Replacement of the necessary vehicles during the 50-year cycle of the license will cost **$387,998**. Assuming replacement of vehicles in 2007 and 2037 for those vehicles needing replacement twice during the cycle of the license, and replacement in 2037 for those vehicles needing replacement once during the cycle of the license, the annual cost for Fire and Rescue Services demanded by the Project would be **$12,933 per year for thirty (30) years** ($387,998 / 30).

Industry standards for equipment replacement in fire services (as defined by American Fire Protection Association ("AFPA"), Section 1901, Standards for the Replacement of Automotive Fire Apparatus) are not based on either mileage or age, but rather on life expectancy of fire apparatus that is dependent upon a number of factors such as quality of the maintenance program, quality of mileage (i.e., on- or off-road), and general environmental conditions. The Fire Department strives to follow the replacement criteria of the CDF, which is 15 years for engines, with an assessment inspection at 12 years. The life span in Butte County for fire engines is typically 15-20 years, with the older engines assigned to volunteer fire stations after serving as reserve units.

The estimated annual cost for Fire and Rescue Services operations demanded by the Project is $393,267.

The estimated one-time fixed costs for Fire and Rescue Services demanded by the Project over a 30 year license term are $1,309,478 ($921,480 for station replacement and $387,998 for equipment replacement).

On an annual basis, for ten (10) years, the Project's portion of costs for fire station replacement would be $92,148.

On an annual basis, for thirty (30) years, the Project's portion of costs for equipment replacement would be $12,933.

4.3 Communications System Services

In order to respond to police, fire, rescue demands and other emergency situations at the Project, as well as for the County as a whole, the County maintains and operates communications systems for public safety agencies. The Central Communications Division of the County's Information Systems Department ("Central Communications," or "Division") provides and maintains the equipment and technology that serves the voice communications infrastructure for Butte County public safety departments and agencies that respond to service demands within the Project Area and Area of Highest Use.

Central Communications is responsible for all radio and related communications for Butte County public safety and general government radio networks, the voicemail system, and is the 911 Coordinator for the County's Public Service Answering Points ("PSAPs"). The PSAPs are the cornerstone of emergency communications between all public safety entities in the County. The Division also provides and manages telephone equipment and lines, special service circuits (electronic data and networking), cellular, Nextel (radio), and pager services.

4.3.1 Project Related Demand for Communication System Services

Many of the calls received from within the Area of Highest Use for public safety and rescue services involve Project Visitors. Due to the steep and mountainous nature of the terrain in the Area of Highest Use, communication into the area from dispatch or other safety and rescue personnel is difficult and sometimes impossible. These areas are referred to as the "black holes" of the County's communication system. As reflected in Figure 4.3.1-1, the eastern two-thirds (2/3) of the County, which contains the Project Area, has numerous "black holes," putting County safety personnel and victims alike in jeopardy in emergency situations. In many instances, radio contact with safety personnel at or around the Project is limited or non-existent.

Figure 4.3.1-1
Butte County Radio Transmission System – Percentage of Coverage

100% coverage (Depicted in White) **0% coverage (Depicted in Black)**
Source: Butte County Information Systems Department

The majority of Butte County's radio and microwave systems (which are the backbone for emergency communications) were acquired between the years of 1963 and 1976. All of the equipment is old technology and has become increasingly unreliable. The County has been proactive in its preventative maintenance efforts to help in reducing the amount of system failures and has partnered with other entities to extend the ability and the life of the County's system. Butte County has studied in-depth the costs associated with replacing the County's antiquated radio system with the improved technology necessary to provide dependable public safety dispatch and radio services to County agencies, which are defined in the next section.

Due to the nature of the Project (water and related sports) and the mode of transportation used to get to the Project (vehicle), there are increased needs for safety and rescue services by Project Visitors. Dispatch of, and communication with, public safety personnel in the Project Area is done via the County's radio and microwave systems, which are virtually non-existent in the eastern portion of Butte County that contains Lake Oroville. Again, this lack of ability to communicate within the Project Area puts safety personnel and victims at risk.

4.3.2 Cost of Providing Communication System Services to Meet Project Related Demand

The total fiscal year 2005-06 budget for the Central Communications Division is $2,196,863 for operations. Due to the County's severe economic problems, there are no budgeted funds available for equipment replacement. Estimated Project related costs were calculated utilizing the NRV-AHU Factor (8.52%), as previously defined in Section 4.2.2. The Project's share of costs related to the impacts on the system from the Project would defray 8.52% (NRV-AHU

Factor) of the total cost to upgrade the system. Based on an anticipated cost of $4,121,398,[22] as estimated in the "Butte County Radio System Study" (Exhibit 7) completed by MACRO Corporation in 2002, the Licensee would be responsible for $351,143. This one-time cost of upgrading the infrastructure does not include the ongoing operating expenses that the County will incur each year nor does it include a cost escalator over time.

It is reasonable to expect that a similar system upgrade will be required every seven to ten (7-10) years during the license term, and at prices that will escalate similar to price escalations in the economy generally.

Table 4.3.2-1
Summary of Required Communication System Upgrade Costs

Description	Estimated Cost ('05$)
Placement of radio repeaters, microwave links, and related equipment	$3,082,178
Addition of Public Works channel	$112,340
Addition of District Attorney channel	$112,340
Addition of local government channel	$194,540
Replacement of all Sheriff's Department mobile radios	$620,000
TOTAL Replacement Cost	$4,121,398

Table 4.3.2-2
Calculation of Project Related Cost of Communication System Upgrade

Calculation Detail
$4,121,398 * 8.52% = $351,143

Total one-time costs related to the Project to upgrade the County's radio and microwave systems are $351,143.

22 MACRO Corporation, "Butte County Radio System – Final Recommendations Report" (April 2002). See Exhibit 7 (excerpts from the MACRO Corporation's report).

4.4 Public Works – Road Services

The Public Works Department ("Public Works") is the County agency responsible for the transportation infrastructure within the Project's Area of Highest Use, including construction and maintenance of County roads and bridges used by Project employees, contractors and Visitors.

Public Works has identified three levels of impacts from the Project on the local transportation infrastructure. The first and most direct impact is the increased maintenance required on County roads due to the vehicle trips generated by the Project. The second impact is the degradation of air quality and the increased water pollution from Project Visitors' use of certain dirt and gravel roads owned by the County but used exclusively by Project Visitors. The third impact relates to the inadequate capacity and maintenance of certain State-owned highways that lead Project Visitors through Butte County and to the Project.

4.4.1 Project Related Demand for County Road Services

4.4.1.1 Maintaining County Roads in the Area of Highest Use

The Project's Area of Highest Use is defined by the arterial and collector roads that lead to the Project Area. As previously explained in the Section 4.2 and further defined in Appendix A – Assumptions and Definitions, these are the main roads that visitors travel to reach the Project. Given the average peak daily population of 11,334 Project Visitors, 5,270 of whom are Non-Resident Visitors, the Project generates thousands of vehicle trips for Non-Resident Visitors each day in the Project Area and primarily along these County roads. The County has historically had to absorb the annual maintenance costs of all County roads that lead to the Project throughout the Area of Highest Use.

To understand the fiscal issues that surround local road maintenance, one must understand how local road maintenance is funded in the State of California and the history of how the funds are split between the State and local agencies. Funding for road maintenance stems from the various gas taxes collected at the pump by the State. Prior to 1980, the money generated by the gas tax was almost evenly split between the State and local agencies. Even though the tax per gallon of gas has risen over time, the State has reallocated the split such that local agencies (i.e., counties) now receive only one-third (1/3) of the money collected. The California Street and Highways Code, Sections 2104 through 2122, provides a formula for the distribution of funds to local agencies, including Butte County. While several factors are involved, the majority of money is allocated to counties based upon the number of registered and exempt vehicles resident in the county.

The allocation method described above penalizes the local population when a destination, such as Lake Oroville and other Project areas, are included in a rural county, such as Butte. In such a case, a large number of out-of-area vehicles pass over the local roads, wearing and damaging those roads, yet the County does not receive any funds for the maintenance costs of the roads they damage from the State, and receives nothing from the Project itself. Because Non-Resident Visitors are in Butte County solely for the purpose of accessing Project facilities, the Project should be responsible for helping to maintain these roads.

4.4.1.2 Cost of Providing County Road Services to Meet Project Related Demand

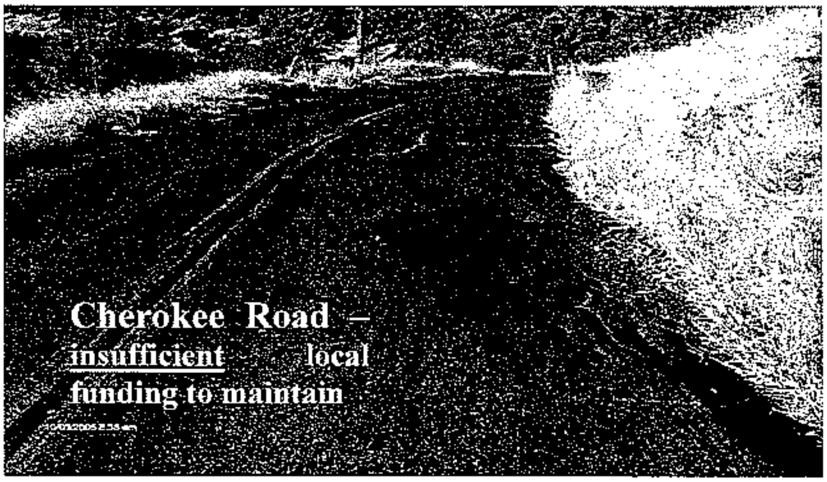
The total fiscal year 2005-06 budget for the County infrastructure portion of the Public Works Department is $13,865,282. Based on the August 25, 2005 Recreational Road Maintenance Plan Cost Estimate (Exhibit 8) provided by the Butte County Public Works Department, the maintenance cost on only arterial and collector roads within the Area of Highest Use of the Project (identified in Figure 4.2.1-5) averages $4,198,519 per year to maintain approximately 293.56 miles of road. Maintenance includes chip sealing (developing a water supply, traffic control, materials for chip seal), cape sealing (developing a water supply, traffic control, materials for chip seal, materials for slurry seal), and asphalt concrete overlays (surface grinding, developing a water supply, traffic control, materials for 0.17" asphalt concrete). Applying the NRV-AHU Factor, it can be assumed that 8.52% of the people using the roads are Project Visitors. Thus, the Project's share of these costs would be $357,714 annually for costs incurred by the County to maintain the roads used by Project Visitors.

Table 4.4.1.2-1
Calculation Detail for Costs of County Road Maintenance for Project Visitors in the Area of Highest Use

Calculation Detail
$4,198,519 * 8.52% = $357,714

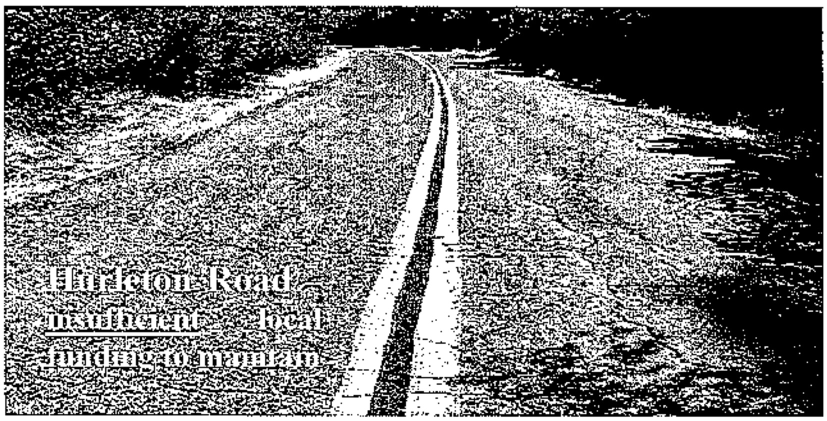
The first two photos (Figures 4.4.1.2-1 and 4.4.1.2-2) below depict examples of roads leading to the Project Area for which the County does not have sufficient local road maintenance funding. In contrast, the third picture (Figure 4.4.1.2-6) reflects the County's standard level of road maintenance, which would be applied to such roads were sufficient funding provided by the Project.

Figure 4.4.1.2-1



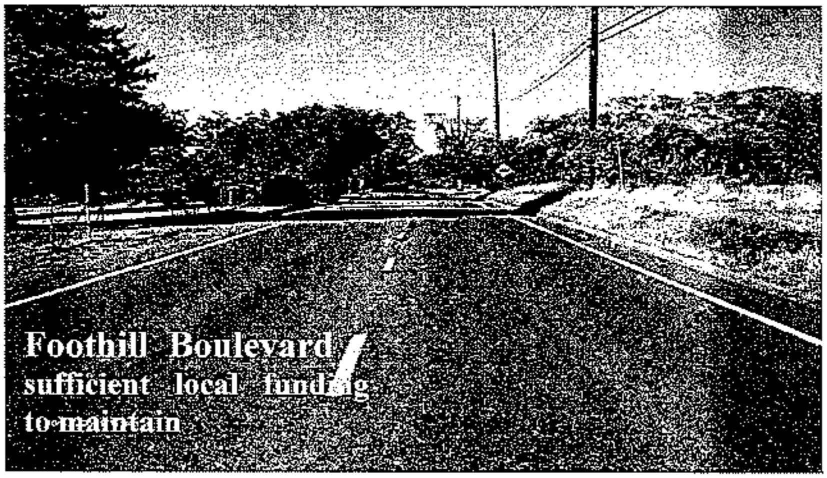
Source: Photo Taken on 10/3/2005 at 8:38 AM by Tom Odedirk, Public Works

Figure 4.4.1.2-2



Source: Photo Taken on 9/30/2005 at 1:42 PM by Tom Odekirk, Public Works

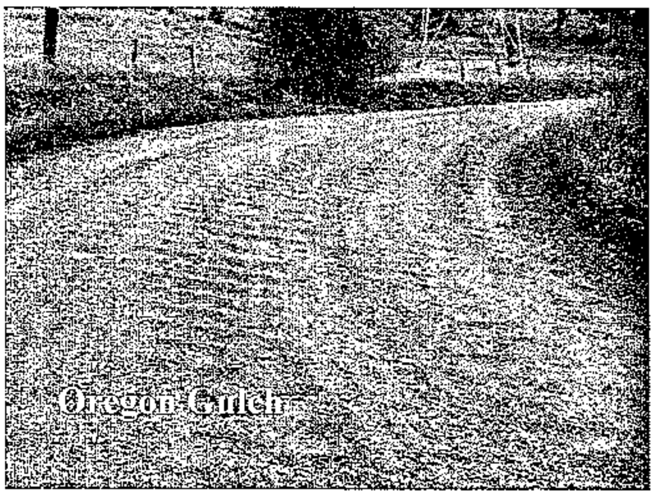
Figure 4.4.1.2-3



Source: Photo Taken on 10/3/2005 at 9:17 AM by Tom Odekirk, Public Works

4.4.2 Environmental Impact Costs Caused by Need for Project Related Road Services

Some visitors to the Project use County-owned, dirt and gravel roads to access the Project Area. These roads do not lead anywhere except to the Project Area. In other words, they are not needed by the general population of the County to reach homes, businesses, or any other type of structures or functions, nor would they be used if it were not for the Project.

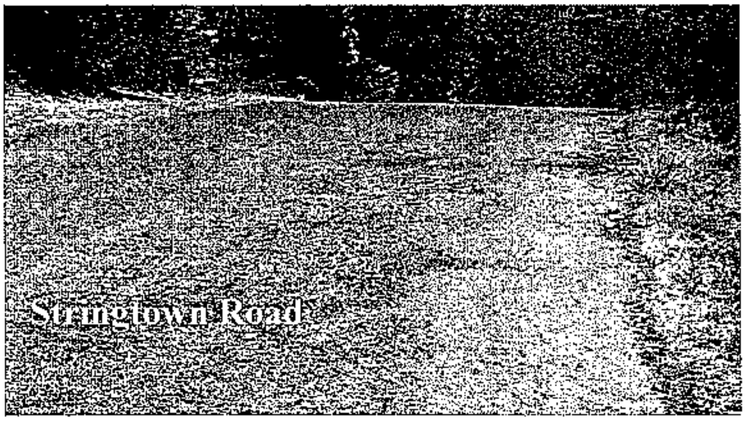


Source: Photo Taken on 10/3/2005 at 8:28 AM by Tom Odekirk, Public Works

Areas on the extreme north end of Lake Oroville contain ultramafic rock; the parent rock to serpentine rock, in which naturally occurring asbestos is known to exist. Other roads around the Project Area, including Stringtown Road (Figure 4.4.2-2) to Forbestown Road and Hurleton

Road to Lake Oroville are in areas that contain this naturally occurring asbestos rock.[23] Cars that utilize the gravel roads leading to the Project Area disturb the rocks and soils that contain naturally occurring asbestos, releasing it into the air and increasing toxic air pollution and increased water pollution in the area. To the County's knowledge, the Licensee has not studied this Project-imposed environmental impact.

Figure 4.4.2-2



Source: Photo Taken on 9/30/2005 at 1:29 PM by Tom Odekirk, Public Works

Asbestos is a known carcinogen and inhalation of asbestos may result in the development of lung cancer or mesothelioma. The California Air Resources Board has regulated the amount of asbestos in crushed serpentinite used in surfacing applications since 1990, such as for gravel on unpaved roads. In 1998, based on concerns about possible health hazards, the California Air Resources Board revised its asbestos limit for crushed serpentinite and ultramafic rock in surfacing applications from 5% to less than 0.25% and adopted a new rule requiring best practices dust control measures for activities that disturb rock and soil containing naturally occurring asbestos.[24]

The California Air Resources Board has identified "Unpaved Road Dust" as the No. 1 emission leading to the Sacramento Valley's (Butte, Colusa, Glen, Tehama, and Shasta Counties) non-attainment of state standards for "coarse" (PM10) particulate matter measures and the #No. 3 emission leading to "fine" (PM2.5) particulate matter measures in the air. When inhaled, particulate matter can lodge deep in lung tissue or enter the bloodstream and reach internal organs, causing health problems.[25]

23 See Exhibit 9.

24 Department of Conservation, California Geological Survey (2006), "Asbestos" Article, available online at .http://www.conservation.ca.gov/CGS/minerals/hazardous_minerals/asbestos/index.htm.

25 California Air Resources Board and the Great Valley Center, "Assessing the Region Via Indicators – The Environment (2000-2005)", November 2005.

To meet the California Air Resources Board's requirement to reduce toxic air pollution from naturally occurring asbestos, as well as to meet the State's PM10 and PM2.5 standards for other particulate matter, it would be necessary to convert existing gravel roads serving the Project Area to paved or chip sealed roads. The County does not have adequate funding to make the necessary road conversions to paved or chip-sealed roads. This issue is discussed in detail in Butte County's Protection, Mitigation, and Enhancement report (PM&E) No. 8, dated April 7, 2003 (Exhibit 9).

Based on Preliminary Cost Estimates provided by the Butte County Public Works Department (Exhibit 10), it would cost the County approximately $5,306,136 to convert the eight gravel/dirt roads currently used by visitors to the Project Area to paved or chip-sealed roads. Since the increased toxic air pollution is solely related to use of the Project, it would be appropriate for the Project to fully fund the upgrading of these roads to the level needed to meet the Air Resources Board requirements.

Assuming the roads are upgraded, there will be an annual cost of $433,637 to the County to maintain them, which should also be funded by the Project. See Exhibit 10. This estimate is based on the miles of road that would need to be maintained (30.32 miles) multiplied by the average annual cost per mile for maintenance ($14,302) as reflected in Exhibit 8.

Table 4.4.2-1
Calculation of Costs to Upgrade of Unpaved Roads to Reduce Environmental Impacts

Calculation Detail
30.32 * $14,302 = $433,637

Total annual mitigation required by the Project for road maintenance costs on existing County-maintained roads used exclusively by the Project is $357,714.

One-time cost to the Project to upgrade gravel roads used exclusively by the Project to paved or chip-sealed roads is $5,306,136. Annual costs to the Project for road maintenance costs on these newly paved or chip-sealed roads would be $433,637.

4.4.3 Impacts Due to Inadequate State-Owned and Maintained Highways

The Project has had severe impacts on the quality and capacity of roads leading to the Project, including State Routes. The main access points to Butte County for visitors of the Project are State Routes 70 and 162. State Route 70 is a two-lane highway from the City of Marysville to the City of Oroville and State Route 162 is a two-lane highway for its total road miles. During the peak seasons for Project Visitors, the traffic on both State Routes becomes more than the two-lane highway can safely accommodate, leading to backups and traffic collisions, all of which interfere with the ability of County residents to drive to and from work, school, shopping, and to go about their other daily activities.

It should be noted that Butte County is a partner in the only Metropolitan Planning Organization ("MPO"), as legislatively defined in the *California Transportation Agencies Listing*, that is an urbanized area without a four-lane highway to serve it. The agency that serves as the MPO for Butte County is the Butte County Association of Governments ("BCAG").

Once again, it is important to understand how road infrastructure in the State of California is funded. The California Department of Transportation ("CalTrans") is the state agency responsible for maintenance of State highways. As a state agency, it has a limited amount of resources (federal funds and gas taxes) that may be expended on road construction and maintenance. In fact, due to budgetary issues at the State level, funds that used to be allocated through the State Transportation Improvement Program ("STIP") to transportation planning agencies e.g., the BCAG) for local projects are now used primarily by the State to improve the State Highway System. Expansion of State Routes 70 and 162 by CalTrans would lead to needed funding being redirected from other regional priorities (local roads); there is a limited amount of transportation funding available through BCAG and CalTrans.

According to staff from the County's Public Works Department and the Director of BCAG, the specific short-term improvement needed on State Route 70 between the City of Marysville and the City of Oroville is an increased number of dual-purpose passing lanes; this means passing lanes simultaneously on both sides of the highway.

As described by the BCAG website,[26] in the long-term and in order to meet growing traffic demand, State Route 70 should be a four-lane freeway with a standard median width. According to a recent BCAG report, "[t]his portion of SR 70 is a two-lane highway with increasingly heavy commuter, **recreational**, and agricultural use. Forecasted future demands are significantly in excess of what the current facility (highway) is capable of sustaining."[27] The BCAG report includes the following statements about the deficiencies of the current highway, on its webpage:

> As a result of the high number of frontage properties along SR 70, conflicting movements to and from the highway are creating operational deficiencies as well as safety concerns. Deficiencies are recognized by the lack of left turn pockets, inadequate sight distance at side roads, and long stretches of two-lane roadway where passing opportunities are not available.
>
> The Marysville/Yuba City, Oroville, and Chico areas are among the very few urbanized areas in California without a modern freeway connection.

Due to the high costs associated with these necessary improvements, CalTrans has shelved the project and there is no indication of the project being put back on the table any time soon.

According to BCAG and the County's Department of Public Works, State Route 162 between the City of Oroville and Lake Oroville needs to be widened to four lanes with turn lanes, for traffic flow and safety purposes. Deficiencies on State Route 162 are similar to State Route 70: a lack

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26 See information available at BCAG website: http://www.bcag.org.

27 See BCAG, "SR 70 Marysville to Oroville Freeway Bypass" (2006), available online at: http://www.bcag.org.

of left turn pockets; inadequate sight distance at side roads; and due to the suburban setting, an even higher number of frontage properties than State Route 70. The project has not been identified as a priority for CalTrans, so cost estimates are not available at this time.

The County has not estimated any specific amount that the Project should provide to help mitigate the adverse impacts on County residents associated with Project related traffic and traffic congestion over these roadways. As the population increases over the new license term, both due to increased Project visitors and County population growth, it can be expected that stress on these roadways will greatly increase, potentially to the breaking point. It would seem reasonable that the Project should have an obligation to help eliminate or reduce these current and expected adverse impacts on the community.

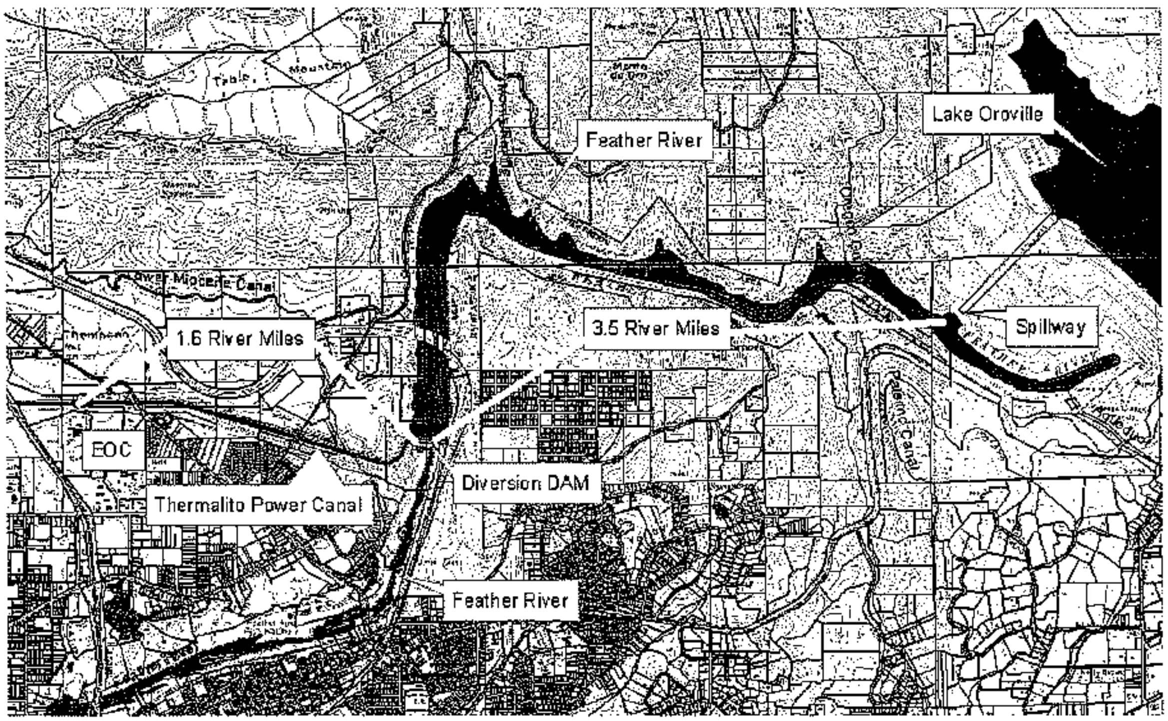
4.5 Emergency Operations Center (EOC) Services

California counties are required to provide emergency operations facilities and staff to respond to natural disasters, such as floods, earthquakes, acts of terrorism/sabotage and other emergencies. The County's EOC is the primary service provider that must respond to citizen and Project Visitor needs in the event of a threatened or actual natural disaster, as well as to any event that leads to damage or failure of the Project facilities.

4.5.1 Project Related Demand for Emergency Services

Butte County's current EOC faces significant flood risks because of the Project. The EOC, located in the basement of the Sheriff's Office, was built before the construction of the Project generated new and substantial flood risks within the County. Significantly, construction of Project facilities resulted in a change in topography that put the EOC, for the first time, within a flood zone. Project construction also put the Dam and Thermalito Canal proximate to both the EOC and County population centers. The EOC is located approximately five miles downstream from the Dam and approximately 150 yards from the Thermalito Power Canal. Prior to the Project's development, the EOC was not subject to flooding because it is distant from the Feather River and was protected by the surrounding topography. The illustration below shows the location of the EOC in relation to the Thermalito Power Canal and the Feather River.

Figure 4.5.1-1
EOC Proximity to Project Facilities



Because a potential flood event is characterized as the most probable and detrimental emergency risk within the County, this presents the possibility of serious operational failure in the event of flood events, as well as a breach of the Dam.

Recent hurricane and flood events in the United States have illustrated the importance of well-coordinated responses to disasters at all levels of government. To manage the complexities of large-scale disaster events such as floods, the County must have a secure and operable EOC, insulated from flood threat to the greatest degree possible. The EOC not only allows the County to manage its own response and recovery efforts, but allows coordination with state and federal agencies as well as non-governmental entities. Such coordination is not only sound practice but is required in California through the Standardized Emergency Management System ("SEMS"). Moreover, the federal government has mandated coordination in multi-agency or multi-jurisdictional emergencies through National Incident Management System ("NIMS"). During a disaster, the EOC must be activated to manage the event from beginning to end.

The County EOC faces two types of flood risks because of the Project:

1. Failure or overflow of the Dam. Scenarios generated by DWR in its flood plain analysis indicate a large geographic area below the Dam would be inundated if the Dam failed.[28] As depicted in DWR's Oroville Dam Failure Inundation Map (October 2000) (Exhibit 11), because of its proximity to the Project's spillway, diversion dam, and canal, the EOC lies directly in the path of initial impact within the flood plain affected by dam failure or overflow events.

2. Uncontrolled flow to the Thermalito Power Canal. As designed by DWR, water not sent down the Feather River is diverted via the Thermalito Power Canal (part of the Project) which is located approximately 150 yards from the EOC. During a flood event, excess water from uncontrolled release from the Dam will flow through the canal. Since no flow controls exist on the canal, the EOC faces significant risks in any major flood event.[29]

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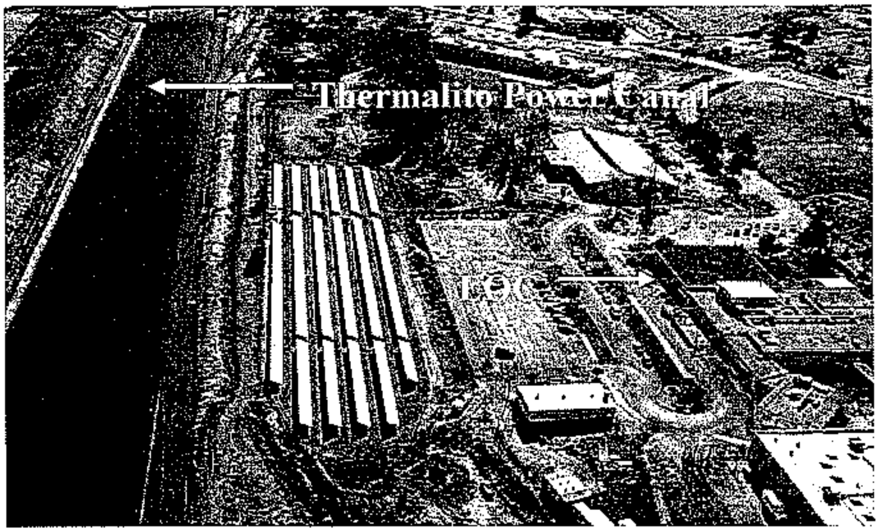
28 Exhibit 11: DWR. Oroville Dam Failure Inundation Map (October 2000).

29 Edell, Stuart, Deputy County Surveyor and Registered Professional Engineer, Memorandum to Paul McIntosh, Butte County Chief Administrative Officer, December 5, 2005.

Figure 4.5.1-2
Photograph of EOC and Thermalito Power Canal



In 1997, a major flood caused significant property damage to areas down river of the Project and illustrated the risk to the Butte County EOC. Over an eight-day period leading up to January 3, 1997, a total of 25 inches of rain fell in the Feather River basin. The inflows to Lake Oroville stayed at record levels for more than 16 hours and peaked at over 300,000 cfs on New Year's Day.[30] On January 2, 1997, a levee approximately 40 miles from the Dam broke inundating parts of Yuba County destroying hundreds of homes and businesses.[31] During this period, DWR advised the County that the EOC would be under water by the next morning due to uncontrolled releases over the emergency spillway of the Dam. The County faced the difficult decision to either (a) move the EOC, the Sheriff's operations and the inmates in the adjacent jail without suitable facilities to house them, or (b) continue its operations and face significant flood risks. After a careful analysis, a decision was reached not to evacuate, and fortunately, the EOC was not flooded the next morning. However, the threat of flooding caused significant operational problems in the EOC and demonstrated the need for its relocation.

Northern California routinely experiences flood events that threaten persons and property. Just recently storms within the area caused serious flooding and damage. In Butte County, there were localized flooding events in addition to elevated flows on the Feather River that caused the activation of the EOC on December 31, 2005. Key County staff monitored river levels for potential risk to Butte County residents and Visitors, jail inmates, County personnel and property.

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30 DWR. DWR News Online. "Battling Raging Water – The Floods of 1997," (Spring 1997); available at http://www.news.water.ca.gov/1997.spring/raging-waters.html

31 "Collapse of Levee No Surprise, Expert Says Break Occurred Just 1,500 Feet from Spot Palo Alto Engineer Pinpointed in '91 Testimony," *San Francisco Examiner*, January 12, 1997, available at http://www.stanford.edu/~meehan/flood/sfexam.html

4.5.2 Cost of Providing Secure, Relocated EOC Facility

The only way to assure a fully functional EOC in all emergency situations in Butte County is to build a new facility outside the flood plain of the Project Area. Based on the California Office of Emergency Services' guideline for staffing the EOC,[32] the new facility should be at least 3,450 square feet. The County estimates such a facility would cost $2,545,495 to construct (Exhibit 12). This would accommodate the County EOC staff and representatives from outside agencies who would be present during a major emergency situation.[33] Additionally, it would accommodate additional staff during a shift change where briefings need to take place.

The construction of a new EOC facility is necessary because the Project has generated significant unmitigated flood risks to the County EOC, and the Licensee should bear the full cost of $2,545,495 for this new facility.

32 California Office of Emergency Services. Standardized Emergency Management System (SEMS) Guidelines, at [pages 3-9], available at http://www.oes.ca.gov/Operational/OESHome.nsf/PDF/SEMSGuidelines/$file/1CLOCA_1.pdf.

33 See Exhibit 13 for detailed Butte County EOC staffing outline

4.6 Health and Human Services

Butte County provides County residents a wide range of Health and Human services (including, but not limited to, welfare payments, foster care, child welfare, medical payment assistance, case management for children with serious medical issues, services for the elderly and disabled, and adoption assistance), including demands for these services that are created by the Project. A significant portion of demand for the County's Health and Human Services ("HHS") is related to the Project, presented by people who came to the County for employment at the Project and either are no longer employed by the Project or are not working at the Project at a level to provide sustainable income throughout the year.

The Project and Project-related tourism provides jobs that are largely seasonal and low paying (at or near minimum wage). Because people receiving County public assistance are allowed to earn some monies before losing some or all HHS benefits, many residents who take these low paying and seasonal jobs remain on County assistance even while they are employed by the Project or in Project-related tourism positions (such as fast food and other restaurants, marinas, motels, stores, and so forth). Thus, while the Project does create some tourism related jobs, which brings additional income to these individuals, it does not appear to materially benefit the County by generating tax revenue or by reducing Health and Human service expenses.

As noted below, and in the Report prepared by FMY Associates Inc., the failure of the Project to pay taxes or make payments in lieu of taxes, the failure to share Project benefits (such as low-cost power) with the County, and the many unreimbursed service-related costs imposed on the County by the Project has helped create a more economically depressed and dependent population in Butte County. For example, the County has HHS caseloads well above the State's average. Although Project-related tourism does bring some revenue into the County, and this helps certain individuals and businesses, it does not appear to reduce the County's HHS expenses or other costs. These tourism-related jobs may even serve to keep the County's HHS obligations at levels well above the State's average because the ability of many County recipients of HHS services to earn a little money at or due to the Project, while retaining public benefits, allows these individuals to "get by" financially, thereby making it easier for them to remain in the County and on the HHS rolls rather than, for example, moving to a location that could offer better job opportunities. Additionally, Project-related tourism does not provide enough income or job opportunities to move these workers off of the County's HHS rolls.

Moreover, since the Project was built, in addition to construction workers who helped construct the Project facilities, thousands of people came to the County to take advantage of the houses that were abandoned or sold below cost after Project construction ended. Because there were no jobs for these individuals, many became dependent, and remain dependent, on the County's Health and Human Services.

In fiscal year 2004-05, the County expended a total of $170,726,473 for Health and Human Services. Of this total, the costs attributable to the Project borne by the County were approximately $1.8 million, which represents an indirect Project-related cost impact.

Historically, Butte County has been financially stressed with a combination of low revenues and high expenditures. This is due to the weak economic situation in Butte County and the high demand for poverty-related services. Table 4.6-1 illustrates the median household income in Butte County from 1998 to 2002.

Table 4.6-1
Median Household Income (in dollars)[34]

	1998	1999	2000	2001	2002
Butte County	30,464	30,536	31,963	31,342	32,124
California	41,003	43,924	46,836	47,064	47,323
U.S.	38,885	40,696	41,990	42,228	42,409

Per the above chart, the median household income in Butte County was 78.3% of the U.S. median and 74.3% of the California median in 1998. The gap grew to 75.7% of the U.S. median and 67.9% of the California median in 2002, which was the last year that data was available through the U.S. Census Bureau. The data shows, that from 1998 to 2002, the median household income in Butte County increased a modest 5.5%. In contrast, the increase was 9.1% for the U.S. and 15.4% for California as a whole.

The low median household income has a direct revenue impact on Butte County. With lower income, residents in Butte County own less expensive property and pay proportionally lower property taxes than other jurisdictions. County residents also have less disposable income. Hence, the County receives lower sales tax revenues.

Not only does Butte County have lower tax revenues compared to other jurisdictions, it has to devote a higher percentage of its limited resources to pay for Health and Human Services due to the higher poverty level. The following table illustrates the percentage of people living in poverty in Butte County:

Table 4.6-2
Percentage of People Living in Poverty[35]

	1998	1999	2000	2001	2002
Butte County	19.4	18.0	17.2	16.7	16.4
California	14.9	13.7	12.7	12.9	13.3
U.S.	12.7	11.9	11.3	11.7	12.1

It is important to note that California is one of handful of states that administers Health and Human Services at the county level; in most other states, these services are provided directly by the state. California requires counties to pay a share of mandated services for programs such as:

[34] U.S. Census Bureau, Small Area Income & Poverty Estimates – Butte County (2000); available at http://www.census.gov/hhes/www/saipe/. The actual 2000 U.S. Census figures differ from the Census Bureau estimates for 2000. Since the actual census is taken every 10 years, estimates from the U.S. Census bureau are used in this Report to look at trends.

[35] Id.

- Foster Care
- Child Welfare Services
- California Children's Services – medical payment assistance and case management for children who have serious medical issues
- In-Home Supportive Services – house keeping and medical services to the elderly and the disabled so they can stay in their own homes instead of being institutionalized
- Adoption Assistance Program
- Temporary Assistance to Needy Families ("TANF") – welfare payments formerly known as Aids to Families with Dependent Children ("AFDC")
- Administrative costs of various entitlement programs

Moreover, California counties are responsible for 100% of costs to provide medical services to indigent adults and cash payments to those who are not qualified under TANF (known as General Assistance). In addition, California counties are responsible for operating community-based mental health programs and providing institutions or group homes to the seriously mentally ill.

4.6.1 Project Related Demand for Health and Human Services

Both the Project and Project-related tourism impose significant demands for Health and Human Services on the County. Although the effect of the Project on such costs may be relatively small, as a percentage of the County's total HHS expenditures, it is still a very significant cost for the County. The Project has brought and continues to bring a substantial number of low income residents to the County that rely on Health and Human Services from the County. As discussed below, this migration started when Project construction ended and thousands of construction worker houses were either abandoned or sold at very low prices. Once individuals and families moved into the County to take advantage of these abandoned or low-cost houses, however, they found there were few jobs available and hundreds then migrated to the County's welfare rolls and/or increased their demand on County funded Health and Human Services. The impacts of this effect continue today, with many of those former Project workers and those acquiring abandoned/low-cost construction housing, as well as their families, remaining in need of County Health and Human Services. The impacts are also felt through the low paying and seasonal jobs created by the Project and Project-related tourism.

4.6.2 Cost of Providing Health and Human Services to Meet Project Related Demand

In fiscal year 2004-05, Butte County expended $170,726,473 for Health and Human Services. While state and federal revenues paid for much of these mandated services, the County nevertheless committed $36,759,669 of its local revenues as its required share.

To determine the impact of the Project in Health and Human Services, the percentage of the current Butte County population attributable to the Project was estimated and applied to the County's share of Health and Human Services costs. According to a study conducted by the

DWR, the Project employed 3,300 workers at the peak of its construction in 1966.[36] The total population connected to the Project, such as family members of the construction workers, those who came to open new businesses, work crews who built housing for the surge in population, and others reached an estimated 14,000 in 1966 and 1967.[37] Based on the total Butte County population of 101,300 in 1967, the percentage of the population attributable to the Project was 13.8%.

After the height of Project construction in 1966 and 1967, the Butte County population decreased slightly to 100,200 in 1968 and 100,000 in 1969 before starting an upward trend in 1970.[38] This indicates that many workers and their families chose to remain in the area. Moreover, according to California Employment Development Department, unemployment increased sharply after the construction of the Project from 3,750 in 1968 to 6,775 in 1975.[39] The Oroville Dam was one of the last major water projects constructed in California, which may explain why so many workers remained in Butte County after its completion thus contributing to increased unemployment figures.

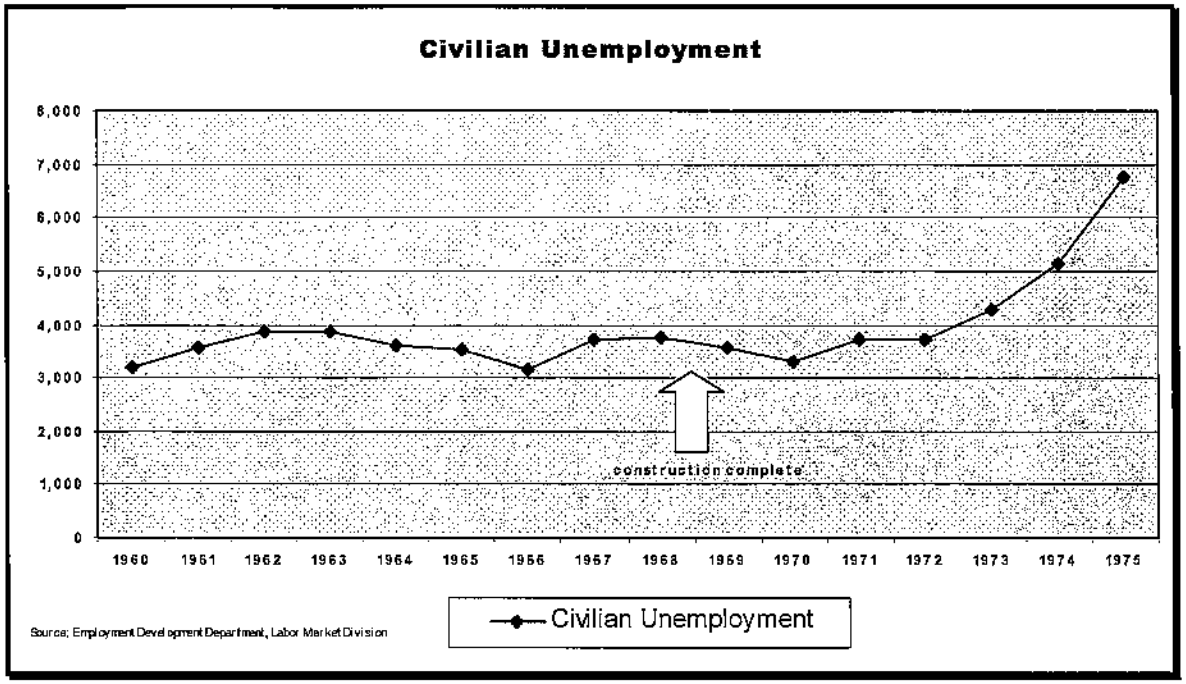
36 DWR, *Economic Impact Study, Oroville Area*, October 1972, at p. 7

37 See id., at p. 14

38 California Department of Finance, Demographic Research Unit. 2005. July Intercensal Estimates of Total Population for California Counties, 1947-1970, with 1940, 190, and 1970 Census Counts; July Intercensal Estimates of Total Population for California Counties, 1970-1979, with 1970 and 1980 Census Counts; available at http://www.dof.ca.gov/HTML/DEMOGRAP/I47-69.htm.

39 Daniel, Brandy. Local Market Consultant, California Employment Development Department; personal correspondence with Jennifer Macarthy, Manager – Program Development, September 2005. See Exhibit 14.

Figure 4.6.2-1
Butte County Unemployment Levels (1960-1975)



Since precise data relating current County residents to Project construction is unavailable, a conservative figure of 5% (or about one-third of the 1967 percentage) was used to estimate the impact of the Project on the County's costs of providing Health and Human Services. The County's share of Health and Human Services cost in fiscal year 2004-05 was $36,759,669, and the amount attributable to the Project is approximately $1.8 million, based on the 5% population assumption.

Butte County 2005 Population	210,022
Percentage of Project Population Compared to Butte County Population	5%
Butte County's Share of H&HS ('05$)	$36,759,669
"Base Year" Project Impact on H&HS	$1,837,983

The total projected cost for the Project's share of Health and Human Services programs is $1,837,983 for fiscal year 2004-05.

5.0 CONCLUSIONS

Annual Project-related costs incurred by Butte County greatly exceed the $306,672 in annual County tourism revenues that can be associated with the Project and the current payment by DWR to the County Sheriff of $191,000 per year. This Report identifies $3,220,034 of direct annual Project-related service costs, $1,837,983 of indirect Project-related service costs, and $10,544,252 of Project-related one-time mitigation and/or initial fixed costs for providing these County services.

The total net annual Project-related cost impact to Butte County is $4,560,345. The calculations used in developing the cost impacts defined herein were based on conservative assumptions, and estimates, and based on actual Project related demands.

Table 5.0-1
Summary of Estimated Cost Impacts

DESCRIPTION	ANNUAL COST ('05$)	ONE-TIME COSTS ('05$)
Law Enforcement/Criminal Justice Services		
Sheriff – Police Services	$681,670	$542,000
Other Criminal Justice Services	$664,585	N/A
Crucial Asset and Comm. Threat	$689,161	$490,000
Subtotal =	**$2,035,416**	**$1,032,000**
Fire and Rescue Services	**$393,267**	**$1,309,478**
Communications Services	**N/A**	**$351,143**
Public Works - Road Services		
Road Maintenance	$357,714	N/A
Road Improvements	$433,637	$5,306,136
Subtotal =	**$791,351**	**$5,306,136**
EOC Services	**N/A**	**$2,545,495**
Health and Human Services	**$1,837,983**	**N/A**
TOTAL COSTS =	**$5,058,017**	**$10,544,252**
Less: Project-Related Revenues	**(306,672)**	**N/A**
DWR Payment to Sheriff	**(191,000)**	
Net Project Impact =	**$4,560,345**	**$10,544,252**

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Appendix A: Assumptions and Definitions

To assess Project cost impacts for Butte County government services it was necessary to utilize a set of assumptions and definitions to ensure accuracy and consistency. A listing of general assumptions used in the Report follows. Further assumptions, specific to various categories of expenditure, are included within sections describing those specific Project cost impacts.

A.1 Cost Factor for Project Area

The peak service demand population is an estimate of the peak number of Non-Resident Visitors the County is expected to serve because of the Project. To assess the Non-Resident Visitor demands for County services, this Report reviews services that are routinely provided to Non-Resident Visitors. The County relates the Non-Resident Visitor Population served to the Total Population Served by the County, over 215,000 persons. The County uses this ratio to determine the percent of its actual costs that are attributable to Non-Resident Visitor demands.

This cost calculation first requires a determination of the Project Visitor Population. To establish this number, the County looked at the recreation studies that were prepared by the Licensee as the best available data regarding Project Visitors. The Licensee's Final Existing Recreation Use (R-9) report analyzes the Project's current recreational usage in recreation or visitor days. The R-9 report's Table 5.1-1, page 5-2, compiles the results of DWR survey conducted during the period May 15, 2002, to May 14, 2003, by recreation or visitor days in the Oroville Facilities study area and found an average daily population ranging from 2,837 visitors on weekdays during the off-season (September 16, 2002, to May 14, 2003) to 9,874 visitors on weekends during the recreation season (May 15, 2002, to September 15, 2002). During this survey period, the average lake level was 775 feet above mean sea level ("msl").[40] However, this lake level is not representative of the 26 year average as the survey period occurred during a drought period. The Descriptive Statistics table in the Licensee's Final Projected Recreation Use (R-12) report, page B.c-1, identifies the 26-year mean lake level as 818.1138 msl with a Standard Deviation of 46.47822 feet. The lake elevation at one standard deviation is 864.59 msl (818.1138 + 46.47822). Elevation 864.59 is 89.59 feet above 775 msl or an 11.56% increase in lake level over the survey period's average lake level. The R-12 report at page B-17 calculates that for each 1% increase in lake level, there are an additional 12,325 Visitors to the lake per year. Therefore, an 11.56% increase in lake level would result in 142,477 additional Visitors to the Project per year (11.56 x 12,325). Although Project-related service demands on the County do not vary greatly by season, the peak demand on County services occurs on weekend days during the recreation season. From Table 5.1-1, the ratio between total weekend visitor days to the total recreation season visitor days is 394,949 to 959,774 (or 41%). This means that 58,416 Project Visitors are added to the base weekday visitor rate to determine peak demand (142,477 x 41% = 58,416). The recreation season weekend total was 394,949. Adding the 58,416 weekend visitors results in an adjusted weekend total of 453,365. The recreation season reviewed in the R-12 report reviewed 40 weekend days, so 11,334 (453,365 / 40 = 11,334) is the daily average number of Project Visitors for high lake-level peak usage. In other words, the Project has a peak service demand approximately equal to a community of 11,334 in population.

40 The Licensee used 40 days to calculate the average daily weekend visitor days during the recreation season as reported in Table 5.1-1 of Final Existing Recreation Use (R-9), page 5-2.

The community of 11,334 people surveyed includes both Resident and Non-Resident Project Visitors. In the Licensee's Final Recreation Surveys (R-13) report, Table F-2, page F-2, identified that 53.5% of the on-site survey respondents primarily resided in Butte County. Therefore, this report will utilize a Visitor composition of 53.5% Resident Visitors and 46.5% Non-Resident Visitors, or 5,270 Non-Resident Visitors (11,334 x .465 = 5,270) as a base line for measuring Non-Resident Visitor service demand.

One approach to determine the cost of meeting this additional out-of-County peak service demand is to treat the 5,270 Non-Resident Visitors as a stand-alone community. The Department of Finance's estimate of the County's 2003 countywide population, when the bulk of the DWR survey was performed, was 210,022. Using the County's 2003 countywide population number, the peak population for which the County would need to provide services would be 210,022 plus 5,270, or 215,292. Thus, the additional 5,270 Non-Resident Visitors represent 2.45% of the Total Population Served by the County.

Calculation Detail
11,334 * 46.5% = 5,270
214,119 + 5,270 = 215,292
5,270 / 215,292 = 2.45%

A.2 Peak Service Demand

Even though recreational use of the Project varies on a seasonal basis, it is necessary for the County to plan and establish service levels to accommodate peak service demand periods caused by the Project, primarily from the end of May to the beginning of September, each year. Although some of the costs are seasonal, many are annual costs as discussed below.

1) It is not feasible for the County to hire and train seasonal help (part-time workers) to provide services to the Project. For example, public safety positions, which are predominantly affected by the Project, require months of training and experience before an employee can perform duties independently. Training and recruitment costs for these types of positions are extremely expensive and the County continues to compete with other jurisdictions to retain these types of positions.

2) Much of the equipment required to provide the services impacted, such as emergency vehicles and equipment and road maintenance equipment, is simply too specialized to rent and must be purchased on a regular, ongoing basis. Fleets of vehicles and inventories of other equipment must be regularly updated, in order to maintain stringent safety standards required by federal and State regulations.

3) The four-month duration of the Project's peak service demand period precludes the County's ability to stretch its already scarce resources. This resource limitation is compounded by the fact that Sheriff patrol services are routinely directed away from service demands in Butte

County's unincorporated areas to provide backup and/or assist with calls in the FERC Project Area. This causes significant impacts and creates significant risk for all residents in the unincorporated areas of Butte County.

4) Butte County serves as the "first responder" for all emergency services within the Project service area. As first responder, Butte County departments must be staffed and equipped for 24/7 service levels.

5) The Project requires the availability of public safety and rescue services, including manpower, training and equipment, to the project on a 24 hour per day, 365 days per year basis, whether or not those services are deployed.

In addition, the County law enforcement services required by the Project are relatively constant throughout the year. This is because in the non-summer months there are far fewer State Parks and Recreation Department and other agency staff to respond to Project emergencies and Visitor calls for assistance. Thus, although total Project Visitor numbers drop substantially in the winter months, the County must respond to a far higher percentage of the total number of calls for assistance and emergencies at the Project that do arise.

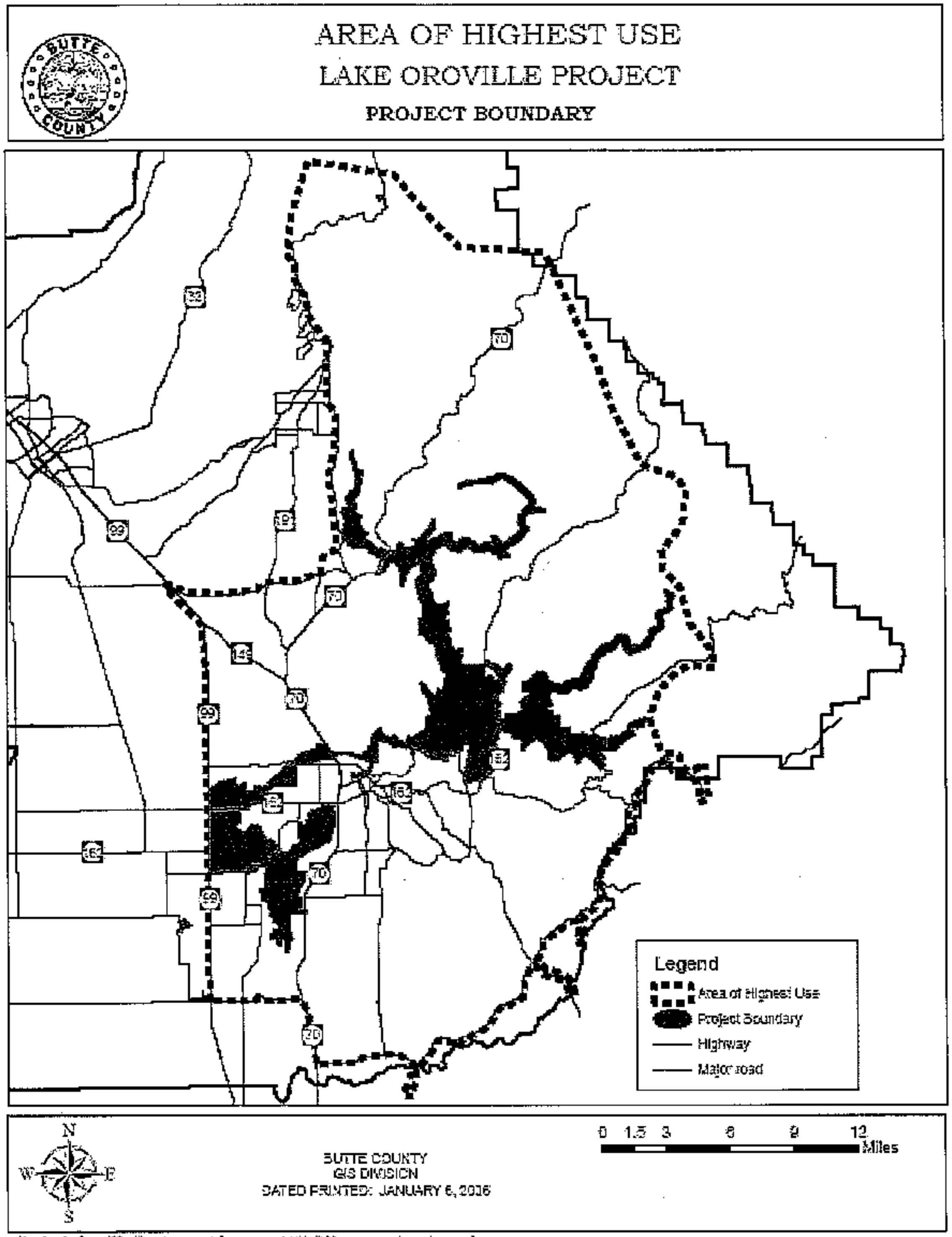
A.3 Area of Highest Use

While project-related impacts are countywide, impacts for fire/rescue services, communications and County transportation infrastructures are impacted to a higher extent within the "Area of Highest Use." The Area of Highest Use is defined by the arterial and collector roads that lead to the Project Area; in other words, the primary routes (roads) used by visitors to get to and from the Project. The Project Area includes Lake Oroville, the Forebay, the Afterbay, and the OWA.

Arterial roads generally link urban areas of 25,000 or more population and are primarily for through traffic on a continuous route. Arterials often connect urban centers with outlying communities and employment or shopping centers and link to collector roads.

Collector roads consist of surface streets providing land access and traffic circulation within residential, commercial, and industrial areas. They typically provide service to any county seat not on an arterial route, to the larger towns not directly served by the higher systems (i.e., freeways and arterial roads), and to other traffic generators of equivalent intra-county importance (i.e., the Project Area), nearby larger towns or cities, or with routes of higher classification (i.e., freeways and arterial roads). Collector roads provide land access to major land uses such as shopping centers, large industrial parks, major subdivision, and community-wide schools and recreation facilities (i.e., the Project Area).

The Area of Highest Use is also used by the County to extract tourism-related revenue data (sales tax and TOT) that may be associated with the Project.


AREA OF HIGHEST USE
LAKE OROVILLE PROJECT
PROJECT BOUNDARY
BUTTE COUNTY
Legend
Area of Highest Use
Project Boundary
Highway
Major road
0 1.5 3 6 9 12
Miles
N
W
E
S
BUTTE COUNTY
GIS DIVISION
DATED PRINTED: JANUARY 6, 2006

Appendix B: Tools for Projection of Future Expenses Not Considered by this Report

Unless otherwise noted, the cost statements used in this Report are based upon 2005 dollar values. The Licensee proposes a new license term of 50 years. Because costs will not remain constant during this long period, it is necessary to apply cost escalators to project the actual costs that will incurred by the County in the out years in order to meet the on-going demands for services within the Project Area. This Appendix B describes two cost escalators that should be applied to calculate future year costs.

B.1 Cost of Living Adjustment

The purpose of this Report is to identify the annual costs incurred by Butte County to provide services to the Project. It is reasonable to assume that Butte County's cost to provide a constant level of service to a constant number of outside visitors will increase over time. One approach to estimate future costs is to apply the average annual inflation rate for past years. The Licensee applied for a 50-year renewal of its federal license to operate the Project. The average National Consumer Price Index (CPI) rate of inflation over the 50-year period of 1954-2004 is 4.05%. Other indexes were reviewed, including the West Urban CPI (4.8% 50-year avg.) and the San Francisco – Oakland – San Jose CPI (4.3% 50-year avg.). Cost of living adjustment information was obtained from U.S. Department of Labor, Bureau of Labor Statistics.[41] Utilizing an annual cost escalator of 4.05% would be a conservative approach because it represented the lowest annual inflation rate for the Project area during the past 50 years.

B.2 Growth of Project Visitors in Future Years Due to Increased Tourism

Just as costs will not remain constant over time, it is also anticipated that projected population growth within Northern California will impact the number of Non-Resident Visitors that will be attracted to the Project over time. One approach to estimate a future cost associated with the growth of Non-Resident Visitors is to apply an average population growth rate.

Table F-2, on page F-2, of the Licensee's Final Recreation Surveys Report (R-13) provides information regarding the on-site survey respondents' county of primary residence. This table indicates that visitors from Sacramento, Sutter, Placer, Contra Costa, Yuba, Solano, Santa Clara, Alameda, Sonoma, and Yolo counties represent 64.9% (30.2% / 46.5% = 64.9%) of on-site respondents from counties other than Butte County.

It is reasonable to assume that the number of Non-Resident Visitors to the Project will increase as populations grow in these counties. The California Department of Finance provides population projections for California and its counties by decade from the year 2000 to 2050. The average annual growth for the ten counties described is 1.48%.

[41] U.S. Department of Labor, Bureau of Labor Statistics. Cost of Living Adjustment – National Consumer Price Index available at - – http://www.bls.gov.

Appendix C: Other State and Federal Revenues

Butte County's budget for fiscal year 2004-2005, totaling $320.9 million, was funded from a variety of sources including $145.8 million in categories labeled "state revenues" and $70.77 million in categories labeled "federal revenues." Anyone who is not familiar with California county budgets could reasonably question whether or not the costs of services provided to the Project are not in some way covered in those State and/or federal revenues. Unfortunately, such is not the case.

C.1 State-County Fiscal Relationship

Butte County serves as an agent of the State of California and the federal government in the delivery of a variety of State and federal entitlement programs to residents within the County's jurisdiction. Allocation of State and federal funds, captured in the County's budget under those headings, along with required matches of county funds, provide the basis for those programs. Every dollar received from the state and/or federal government is restricted in its use, and the County is routinely audited to ensure that those dollars are in fact used solely for the purposes intended.

In fact, the notion that unspecified State and/or federal revenues might in some manner supplant the subsidy to these programs provided by Butte County is even more remote considering that Butte County must use its discretionary revenues to pay for mandated State and federal programs. In fiscal year 2004-2005, Butte County was required to expend over $36 million in its local revenues to operate programs mandated by the State or federal government but which were not funded or reimbursed by the State or federal government. Moreover, the State routinely requires local governments to "contribute" to solve its budget deficits. For example, Butte County was required to pay $1.9 million in property tax revenues to the State in fiscal year 2004-05 to make up for State budget shortfalls. Statewide, local governments gave over $1.3 billion in property taxes to the State in addition to the billions of dollars they were already contributing. The State also deferred $500,000 of payments due to Butte County for operating a variety of other mandated programs in fiscal year 2004-05. This was in addition to the $3.8 million the State deferred in FY 2003-04.

Although Butte County's budget reflected $216.57 million in State and federal revenues in fiscal year 2004-2005, those revenues were all designated to specific programs and, in fact, were millions of dollars short of covering the actual costs incurred by the County when acting as the agent of the State during that fiscal year. Any claim that any of these funds could have possibly been used to offset the direct service impacts of the Project is simply erroneous.

C.2 Findings of the California Commission on State Mandates

The impacts of the loss of revenues due to State mandates or diversions resulted in Butte County once again being designated a county with "significant financial distress" by the California Commission on State Mandates on May 26, 2005.[42] The Commission's findings were made in accordance with legislation enacted by California in 1993, which added section 17000.6 to the California Welfare and Institutions Code. That section authorizes a county board of supervisors to take certain actions to reduce general assistance (financial aid to indigents who are not qualified for TANF) standard of aid if the Commission on State Mandates finds compelling evidence of significant financial distress. The statute makes clear that the Commission shall not make a finding of significant financial distress unless the county has made a compelling case that basic county services, including public safety, cannot be maintained. Butte County had previously received similar findings of significant financial distress in October 1996 and December 1999.

In February 2005, Butte County filed an application for a finding of significant financial distress with the Commission. The basis for the application was that the ongoing fiscal situation in the County had seriously impacted the ability of departments to provide services and meet increasing demands. To determine the extent of Butte County financial difficulties, staff from the California Commission of State Mandates, California Department of Finance, and California State Controller's Office performed thorough audits of the county's finances.

Commission staff issued its Staff Analysis of the Application in May 2005, finding trends to support the County's claim of unmet needs and recommended approval if the County provided more current information to support their underlying assertions. After a response from the County, which included the additional information sought by the Commission, the Commission conducted a fact-finding hearing in Oroville to hear testimony from county officials.

Based on the evidence and testimony provided and in accordance with California Welfare and Institutions Code section 17000.6, in June 2005 the Commission made findings that, among other things:

1. The County's FY 2004-05 Final Budget totals $320.9 million, with a General Fund contingency appropriation of $5.6 million. While this represents increased financing requirement of approximately $2 million from prior year, the General Fund contingency is expected to decrease by $400,000.
2. The County's discretionary expenditure flexibility is constrained both by fund restrictions and by State and federal mandates, leaving $70.4 million, of the $320.9 million in Final Budget appropriations, as theoretically, available for discretionary use.
3. The full $70.4 million cannot be considered truly discretionary inasmuch as 35 percent, or $24.7 million, is directed toward State mandated costs and State established required maintenance of efforts.

[42] California Commission on State Mandates. County of Butte - SB 1033 Application. Commission Case Number 05-SB1033-01. Final Statement of Decision Pursuant to Welfare and Institutions Code Section 17000.6; and Title 2, California Code of Regulations, Article 6.5, Section 1186.5 et seq (adopted June 10, 2005; effective July 2, 2005).

4. The County's total available discretionary resource for FY 2004-05 is projected to decline by $4 million from $74.4 million in FY 2004-05.

The Commission concluded that the County had unmet needs in basic county services, including public safety, in the amount of $17,459,947.

It should be noted that Butte County was the only county in California that received the "financially distressed county" status by the Commission in 1999 and 2005.

APPENDIX C

APPENDIX C

BUTTE COUNTY SHERIFF'S OFFICE INTERDEPARTMENTAL

MEMORANDUM OFFICE OF THE SHERIFF

PREPARED BY PERRY L. RENIFF, SHERIFF-CORONER

DECEMBER 16, 2005

LETTER TO PAUL MACINTOSH

PREPARED BY PERRY L. RENIFF, SHERIFF-CORONER

NOVEMEBER 16, 2006

BUTTE COUNTY SHERIFF'S OFFICE
INTERDEPARTMENTAL MEMORANDUM
OFFICE OF THE SHERIFF

TO: Paul McIntosh, CAO

FROM: Perry L. Reniff, Sheriff-Coroner

SUBJECT: Service Impacts to the Sheriff's Office Caused by the Lake Oroville Project

DATE: December 16, 2005

The Sheriff's Office provides front-line public safety services including patrol, court security, search and rescue, coroner services, civil process, jail operations, counter drug enforcement and waterway safety. The Sheriff's Office also operates or provides personnel in special enforcement such as School Resource Officers, a Special Weapons and Tactics (SWAT) team, a Canine Unit, and the Butte Interagency Narcotics Task Force. Many of these services are extended to visitors at the Lake Oroville Project Area.

The provision of services within Butte County is made quite challenging by the variety of terrain, climates, and population characteristics located within its 1,675 square mile area. Service demands require staff to be knowledgeable and trained in a full spectrum of services, as well as adequately equipped to provide the required services in a safe and efficient manner. Sheriff Deputies respond to bomb incidents, plane crashes, hostage and barricaded suspects, civil disturbances, hazardous material incidents, search and rescue events, and natural disasters such as flood and fire. Not only are Deputies trained to handle specific incidents, but also they are trained with various equipment needed to bring the incident to a successful conclusion under a variety of challenges and settings. Sheriff Deputies train with diving equipment for evidence and body recovery in the many waterways and lakes within the County, as well as repelling equipment for rescues and contraband recovery within steep canyons.

Butte County is located in the North Eastern portion of the Sacramento Valley with boundaries extending from the Sacramento River on the West to the foothills and mountains of the Sierra Nevada's and Cascade Range on the East. Butte County's current population is estimated to be 214,119. Three major State routes pass through Butte County including Highways 99, 32, and 70. Two major rivers run through Butte County: the Sacramento River, a navigable waterway on the west bordering Glenn County and Colusa County, and the Feather River which flows into Lake Oroville. The Lake Oroville Project Area is a widely used recreational area in the County with a shoreline of 164 miles. Many visitors come from outside the area to enjoy recreational facilities provided by the Project.

The Sheriff's Office responds to calls from citizens and mutual aid requests from outside agencies including; the California Highway Patrol, State Parks and Recreation, and the Department of Fish and Game, for assistance in the Lake Oroville Project Area, which includes Lake Oroville, the Forebay, Afterbay, and the Oroville Wildlife Area. These calls include: Search and Rescue, Coroners investigations, complex criminal investigations, and routine back-up support. A percentage of these services are difficult to query due to the manner in which they are logged into the Sheriff's system.

- ***Search and Rescue Services*** - From 1992 to present, the Sheriff's Office has responded to over 173 search and rescue call outs on Lake Oroville. Several of these call outs lasted for several days and countless man-hours were expended. Equipment such as the Butte County Sheriff's helicopters and boats were used in many of these operations. Current operational cost for one (1) hour of helicopter time, including pilot, maintenance, fuel, insurance and hanger rental is approximately $300 per hour.

- ***Coroner/Investigative Services*** - September 10, 1992, two recreational boaters were navigating the waters of the Oroville South Afterbay when a wave washed over the small craft swamping the boat. The passenger/witness swam to shore and summoned aid. The driver of the boat was found several days later. The occupants of the boat were not wearing personal floatation devices at the time of the incident. It is difficult to estimate the amount of actual man hours dedicated to these investigations. However, this particular incident incurred well over twenty (20) hours of the Chief Deputy Coroner and his staff's time.

    - September 28, 1998, Butte County Sheriff's Office investigated a homicide that occurred on the Nelson Avenue Bridge that crosses over the Forebay.

    - April 28, 2001, a factory representative from Polaris Motor Sports was demonstrating personal watercraft at the Monument Hill launch ramp at the Oroville South Afterbay. Several untrained operators were given brief instructions, personal flotation devices and were allowed to operate the craft. The watercrafts were operating in close proximity. One of the operators was ejected from the craft and was run over by one of the other operators and was killed.

    - May 8, 2004, a deceased male adult was found in the water in the Forebay.

    - June 1, 2004, a fight occurred between father and son at the Larkin Road boat ramp at the Afterbay. The father died as a result at Oroville Hospital the following day.

    - August 3, 2004, a patio boat struck the shore on the north fork of Lake Oroville. The boat received heavy frontal damage. The driver of the boat was discovered on shore a short distance from the boat. The driver was apparently ejected from the boat. Upon further examination of the boat's interior, a deceased female was located. She suffered from obvious head trauma.

    - August 21, 2004, a single engine airplane equipped with flotation landing gear landed north bound on the Oroville South Afterbay. The plane turned south and began a take off run. The aircraft left the water and ascended approximately thirty to forty feet above the water when it suddenly fell without explanation to the water. Both the pilot and passenger were trapped in the wreckage and died.

    - October 10, 2005, a single engine aircraft was departing the Oroville Airport in what appeared to be a routine take off, when the plane suddenly stalled out and fell nose first into a pasture. The aircraft was consumed by fire on impact. The pilot and passenger were killed. The aircraft came to rest in the Oroville Wildlife Area.

- ***Calls for Assistance by other Jurisdictions*** - From October 2004 through October 2005, Butte County Sheriff's Deputies have responded to forty calls in the Lake Oroville Project Area, which are in addition to their regular call area. This diminishes our ability to deploy these resources to other county calls. Of the forty calls, two were self-initiated due to suspicious activity seen by the Deputy and thirty-eight were responses to requests for assistance by other agencies. As stated previously, this will not fairly represent the actual amount of calls for service in the designated area due to the internal method of data entry. In responding to these calls, the Sheriff deployed fifty-nine (59) deputies, five (5) K-9 units, conducted five (5) arrests, towed three (3) vehicles, and utilized more than twenty-three (23) man-hours.

- ***Waterway Safety and Enforcement*** - The Butte County Sheriff's Office Marine Unit is funded from the Department of Boating and Waterways and contract enforcement with funds from the State Department of Water Resources. This unit has made more then 3,312 contacts at the Afterbay and surrounding area. These contacts include personal assistance, vessel assistance, verbal warnings, arrests, accident investigations and death investigations.

- ***Special Events*** - The Butte County Sheriffs Office supports special events, such as the annual Fourth of July firework celebration on Lake Oroville. In past years, nine Deputies and one helicopter were deployed. Bass tournaments bring an increase in traffic and people, which also generate calls for the Sheriff's Office.

- ***Natural Disasters*** - Heavy rain seasons bring the water level up to overflow levels at Oroville Dam. When this occurs, literally all hands are on deck. The Sheriff's Office changes the operations schedule to afford maximum deployment of personnel and resources. The County Office of Emergency Service opens the Joint Operation Center which is manned by trained Sheriff's personnel. Often times the majority of the department personnel are involved in evacuations, search and rescue and anti-looting enforcement. The Sheriff has dedicated literally hundreds of hours of helicopter and special equipment to these emergencies. This type of operation occurred in 1994, 1995 and 1997. The operational period for the unplanned disasters lasted for several days.

BUTTE COUNTY SHERIFF

November 16, 2006

Paul McIntosh, CAO
Butte County Administration
25 County Center Drive
Oroville Ca 95965

Dear Mr. McIntosh:

The California Highway Patrol, Department of Fish and Game, State Parks and Recreation and the Butte County Sheriff's Office share law enforcement responsibilities within the FERC project area. These agencies maintain a good working relationship with each other and the Department of Water Resources. This relationship is essential due to the fact that all of these law enforcement agencies are short staffed; some of the state agencies are critically short staffed.

I have reviewed the material submitted by the county to FERC, as it relates to law enforcement and coroner's issues, and those impacts to the county. I concur that there have been considerable costs to the county over the past 40 (approximate) years. I have been with the Sheriff-Coroner's Office for over 34 years, and I can recall several major cases that have occurred within the project area. Those cases include: drugs labs, rapes, robberies, homicides, suicides, and numerous types of accidents (involving aircraft, motor vehicles, and watercraft).

I can assure you that the Sheriff's Office has expended literally thousands of hours on those investigations and body recoveries, and we will continue to do so, regardless of whether or not we are reimbursed for the costs. We have a duty to the survivors of the victims to bring those responsible for the crime to justice, and for those that have lost loved ones to make a recovery, so that the closure process can begin.

In the state of California, the Sheriff is a Constitutional Officer and the Chief Law Enforcement Officer in the county in which they are elected. As such, regardless of which agency has a primary function in a given area, it is ultimately my responsibility to ensure the safety of the people in the county.

We live in a dangerous world which appears to have become more dangerous with each passing year. We must be ever vigilant against those that would do us harm, and there are many. Recently, I received a briefing on a number of Foreign Nationals who have been in this country for years, and who are bent on terrorism and the destruction of our society.

A few years ago I convened a meeting with state law enforcement agencies and the DWR to discuss how to increase the security at Oroville Dam. We have made considerable progress, but there is much left to be completed. The Regional Terrorism Task Force is in the process of completing a Security Assessment at Oroville Dam. Upon completion of this assessment, I would request that FERC review the documents and make it a condition of the relicensing that ANY and ALL recommendations made by the Terrorism Task Force be implemented. This will significantly add to the protection of that facility and help to enhance the safety of people living downstream from the dam.

Sincerely,

Perry L. Reniff
Sheriff Coroner

PR:lf

APPENDIX D

APPENDIX D

SUPERIOR COURT OF CALIFORNIA, COUNTY OF BUTTE

MEMORANDUM FROM ANDREA NELSON,

ASSISTANT COURT EXECTIVE OFFICER

PREPARED BY ANDREA NELSON

AUGUST 1, 2007

SUPERIOR COURT OF CALIFORNIA, COUNTY OF BUTTE

MEMORANDUM FROM ANDREA NELSON, ASSISTANT COURT EXECUTIVE OFFICER

Date: **August 1, 2007**

To: **Sean Farrell, Deputy Administrative Officer**

Re: **DUI (23152a CVC) fine breakdown**

As requested, below is the fine breakdown for a first offense 23152a CVC violation, Driving under the Influence.

DUI Fine Breakdown			
Fine	**County***	**State**	**Total**
Base Fine	$440.00	$0.00	$440.00
PC 1464	$0.00	$440.00	$440.00
PC 76000	$308.00	$0.00	$308.00
GC 70372(a)	$0.00	$220.00	$220.00
DNA	$0.00	$88.00	$88.00
20% Surcharge	$0.00	$88.00	$88.00
PC 1463.16	$50.00	$0.00	$50.00
CVC 40508.6	$10.00	$0.00	$10.00
PC 1202.4	$0.00	$100.00	$100.00
PC 1465.8	$0.00	$20.00	$20.00
Totals	$808.00	$956.00	$1,764.00
% of Monies Received	46%	54%	
* Does not include additional fee ($25 or $10) pursuant to PC 1463.07			

Please do not hesitate to contact me if you need any additional information.

Andrea Nelson

ONE COURT STREET λ OROVILLE, CA 95965 λ (530) 532-7108

APPENDIX E

APPENDIX E

STATISTICS ON STATE PARKS ARRESTS

PREPARED BY MIKE THOMPSON, I.S. ANALYST SENIOR,

BUTTE COUNTY SHERIFF'S OFFICE

FEBRUARY 2, 2007

Farrell, Sean

From: Thompson, Mike

Sent: Friday, February 02, 2007 9:31 AM

To: Farrell, Sean

Subject: stats

Sean,

Here is the spreadsheet for the State Parks arrests. I took ¼ of the total for 2005-2006 calendar years. The average length of stay is real low. They do a ton of DUI arrests.

Hope this helps!

Mike Thompson

I.S. Analyst Senior
Butte County Sheriff's Office

INCIDENT_ID	BOOKING_ID	ARREST_REASON	BOOKED_BKD-RLSD	ARREST_DATE	RELEASE_DATE	BOOKING_NUMBER	ARREST_LOCATION	ARREST_DATE	OCCURANCE_LOCATION
0IHZNRJ000BCS0IU	0IHZN47000BCS0IU	BATTERY	BOOKED	6/12/2005	6/14/2005	5163024	PARADISE	2005061302:00:00-420	PARADISE
0ILWJES000BCS0LM	0ILWJBE000BCS0LM	BATTERY	BKD-RLSD	8/27/2005	8/27/2005	5239042	LOAFER CREEK	2005082804:24:00-420	LOAFER CREEK, OROVIL
0IKGX50000BCS0LM	0IKGX4I000BCS0LM	CHILD CRUELTY	BOOKED	7/30/2005	8/3/2005	5212003	MONTGOMERY/OLIVER	2005073106:55:00-420	OROVILLE
0IHMU0Z000BCS0IU	0IHMTYX000BCS0IU	DOMESTIC VIOLENCE	BKD-RLSD	6/5/2005	6/6/2005	5156017	C/S 45 LOAFER CREEK	2005060603:00:00-420	OROVILLE
0IMADPO000BCS0LM	0IMADB1000BCS0LM	DOMESTIC VIOLENCE	BOOKED	9/4/2005	9/4/2005	5247034	STRINGTOWN ROAD	2005090415:18:00-420	OROVILLE
0I9R7J7000BCS0IV	0I9R7IU000BCS0IV	DRUGS	BOOKED	1/3/2005	1/19/2005	5003035	BUTTE COUNTY	2005010401:25:00-480	F4ERNWOOD & LAWSEN
0IEG68K000BCS0IU	0IEG60L000BCS0IU	DRUGS	BKD-RLSD	4/4/2005	4/5/2005	5095002	SOUTH FOREBAY, OROV	2005040504:59:00-420	SOUTH FOREBAY, OROV
0IG5534000BCS0IU	0IG551W000BCS0IU	DRUGS	BOOKED	5/7/2005	5/23/2005	5127041	NOTRH FOREBAY-LOSR/	2005050803:30:00-420	OROVILLE
0IWR9GG000BCS0O6	0IWR9D2000BCS0O6	DRUGS	BKD-RLSD	3/26/2006	3/26/2006	6085034	SPILLWAY	2006032703:20:00-480	OROVILLE
0IZZ9ZG000BCS0OU	0IZZ9KI000BCS0OU	DRUGS	BOOKED	5/28/2006	5/28/2006	6148020	SOUTH FOREBAY	2006052819:23:00-420	SOUTH FOREBAY
0J2TMTZ000BCS0OU	0J2TMS5000BCS0OU	DRUGS	BKD-RLSD	7/22/2006	7/22/2006	6203028	CONCOW	2006072301:17:00-420	CONCOW
0J6EO9V000BCS0OU	0J6EO6P000BCS0OU	DRUGS	BKD-RLSD	9/30/2006	9/30/2006	6273028	LIME SADDLE CAMPGRC	2006093016:21:00-420	LIME SADDLE CAMPGRO
0IFVZPU000BCS0IV	0IFVZJP000BCS0IV	DUI	BKD-RLSD	5/2/2005	5/3/2005	5122022	BIDWELL MARINA KIOSK	2005050305:38:00-420	BIDWELL MARINA KIOSK
0IGT70N000BCS0IV	0IGT6ZB000BCS0IV	DUI	BKD-RLSD	5/20/2005	5/21/2005	5140060	LOSRA	2005052104:14:00-420	LOSRA
0IHZMAK000BCS0IU	0IHZM5Q000BCS0IU	DUI	BKD-RLSD	6/12/2005	6/12/2005	5163023	PARADISE	2005061301:44:00-420	PARADISE
0IHZQRY000BCS0IU	0IHZQNZ000BCS0IU	DUI	BKD-RLSD	6/12/2005	6/12/2005	5163028	BIDWELL MARINIA	2005061303:28:00-420	BIDWELL MARINIA
0IIPM2I000BCS0HW	0IIPM1H000BCS0HW	DUI	BKD-RLSD	6/26/2005	6/26/2005	5177031	BIDWELL BOAT RAMP	2005062703:01:00-420	OROVILLE
0IJ0WHL000BCS0IG	0IJ0WGP000BCS0IG	DUI	BKD-RLSD	7/2/2005	7/3/2005	5183035	LIMESADDLE MARINA	2005070304:25:00-420	OROVILLE
0IJ1AB3000BCS0HT	0IJ1A7K000BCS0HT	DUI	BKD-RLSD	7/3/2005	7/3/2005	5184014	MINERS RANCH & HWY '	2005070307:08:00-420	OROVILLE
0IJQKN2000BCS0IV	0IJQKLJ000BCS0IV	DUI	BKD-RLSD	7/16/2005	7/17/2005	5197037	SPILLWAY LOT/LOSRA	2005071701:55:00-420	SPILLWAY LOT/LOSRA, (
0IJQW8D000BCS0IV	0IJQW79000BCS0IV	DUI	BKD-RLSD	7/16/2005	7/17/2005	5198002	BIDWELL LAUNCH RAMF	2005071706:12:00-420	OROVILLE
0IK1WNG000BCS0LM	0IK1WL0000BCS0LM	DUI	BKD-RLSD	7/22/2005	7/23/2005	5203053	LOAFER CREEK DAY US	2005072304:45:00-420	OROVILLE
0IKGP60000BCS0LM	0IKGP4L000BCS0LM	DUI	BKD-RLSD	7/30/2005	7/30/2005	5211027	BIDWELL/LOSRO	2005073102:27:00-420	LAKE OROVILLE
0ILYEV1000BCS0LM	0ILYEU6000BCS0LM	DUI	BKD-RLSD	8/28/2005	8/29/2005	5240037	OROVILLE	2005082901:49:00-420	BIDWELL CANYON, ORO'
0IQL7JI000BCS0LL	0IQL7IT000BCS0LL	DUI	BKD-RLSD	11/26/2005	11/27/2005	5331002	HWY 162/WARD	2005112706:05:00-480	OROVILLE
0J002PC000BCS0OU	0J002OI000BCS0OU	DUI	BKD-RLSD	5/28/2006	5/29/2006	6149002	BIDWELL KIOSK	2006052905:44:00-420	OROVILLE
0J12NW1000BCS0OU	0J12NUU000BCS0OU	DUI	BKD-RLSD	6/18/2006	6/19/2006	6169032	LOAFER CREEK	2006061902:22:00-420	OROVILLE
0J12RUT000BCS0OU	0J12RTX000BCS0OU	DUI	BKD-RLSD	6/18/2006	6/19/2006	6169035	NELSON BAR	2006061903:46:00-420	OROVILLE
0J1QXJS000BCS0OU	0J1QXIU000BCS0OU	DUI	BKD-RLSD	7/1/2006	7/2/2006	6182025	LAKE OROVILLE, OROVI	2006070204:30:00-420	LAKE OROVILLE, OROVIL
0J2EWSC000BCS0OU	0J2EWHR000BCS0OU	DUI	BKD-RLSD	7/14/2006	7/15/2006	6195031	LAKE OROVILLE, CA	2006071502:50:00-420	LAKE OROVILLE, CA
0J58WAO000BCS0OP	0J58W6C000BCS0OP	DUI	BKD-RLSD	9/7/2006	9/8/2006	6250035	BIDWELL CANYON	2006090803:22:00-420	OROVILLE
0J25J77000BCS0OU	0J25J5H000BCS0OU	DUI/NEGLIGENCE	BOOKED	7/9/2006	7/10/2006	6190032	LIME SADDLE MARINA L(	2006071001:50:00-420	OROVILLE
0IGDZDT010BCS0IU	0IGDZ8Q000BCS0IU	FALSE ID	BKD-RLSD	5/12/2005	5/12/2005	5132028	SPILLWAY LAUNCH RAM	2005051223:12:00-420	SPILLWAY LAUNCH RAM
0IVAHLP000BCS0LM	0IVAHBV000BCS0LM	FIREARMS	BOOKED	2/26/2006	3/21/2006	6057017	RIVER ROAD, OROVILLE	2006022615:46:00-480	RIVER ROAD, OROVILLE
0IJSGB5000BCS0IV	0IJSGA4000BCS0IV	NEGLIGENCE	BOOKED	7/17/2005	7/20/2005	5198024	LIME SADDLE MARINA	2005071801:25:00-420	LIME SADDLE MARINA, O
0ICDR7P000BCS0IV	0ICDR6Q000BCS0IV	PAROLE HOLD	BOOKED	2/23/2005	2/24/2005	5054035	LAKELAND DAY USE	2005022401:10:00-480	OROVILLE
0IFFGMM000BCS0IV	0IFFGJX000BCS0IV	PAROLE HOLD	BOOKED	4/23/2005	4/29/2005	5114004	CANYOND DR @ 185 CAI	2005042406:50:00-420	OROVILLE
0IUHG6S000BCS0LL	0IUHG42000BCS0LL	PAROLE HOLD	BOOKED	2/10/2006	2/15/2006	6041032		2006021100:00:00-480	LIME SADDLE CG #36
0J47T6A000BCS0OU	0J47T23000BCS0OU	PAROLE HOLD	BOOKED	8/18/2006	8/25/2006	6230051	BIDWELL CANYON	2006081902:40:00-420	BIDWELL CANYON
0J69WEK000BCS0OU	0J69W7S000BCS0OU	WARRANT	BOOKED	11/5/2006	11/8/2006	6309031	ENTERPRISE BOAT RAM	2006110602:40:00-480	OROVILLE

APPENDIX F

APPENDIX F

INTEROFFICE MEMORANDUM

PREPARED BY GEORGE MORRIS, DEPUTY FIRE CHIEF

AUGUST 16, 2007

Interoffice- Memorandum

TO: *Shari McCracken, Deputy CAO* *Phone: 538-7111*

FROM: *George Morris, Deputy Fire Chief*

SUBJECT: Primary Public Safety Answering Point (PPSAP)

DATE: *August 16, 2007*

When an emergency occurs and someone dials 911 to ask for help, a Primary Public Safety Answering Point (PPSAP) will receive the call. For nearly all areas of the Lake Oroville Project those PPSAP's are either the California Highway Patrol (CHP) (for cell phone 911 calls) or the Butte County Sheriff's Office (for calls from hard-wired phones). In both cases, if a call originates from the Project area that requires a fire department response (fire, medical emergency, rescue, hazmat, etc.), the call is immediately transferred to the Secondary PSAP, the Butte County Fire Department Emergency Command Center (ECC). For emergencies in small areas of the Lake Oroville Project that fall within the city Limits of Oroville the PPSAP is Oroville Police Department (hard wired phones only). Any calls on the project within the city limits needing a fire response would also be forwarded to the Butte County Fire Department ECC.

After receiving the information from the reporting party the ECC dispatches the appropriate fire department response for the emergency reported. The ECC, per current practice with the Department of Parks and Recreation (DPR), then notifies the DPR dispatch center located in the Sacramento area. The DPR dispatch center then notifies DPR personnel on call. Butte County Fire Department resources or co-responders (which means the County bears the cost, either directly or through mutual support of other agencies), are the first responders, unless DPR is the one calling 911 requesting the additional resources.

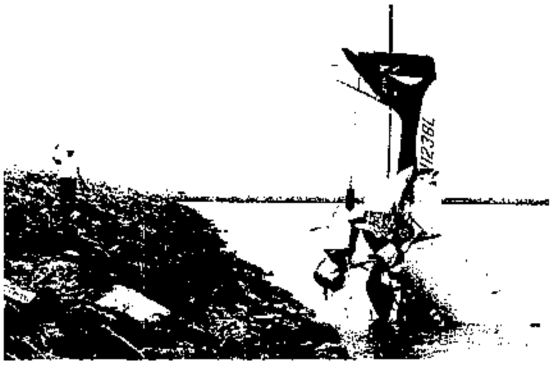
APPENDIX G

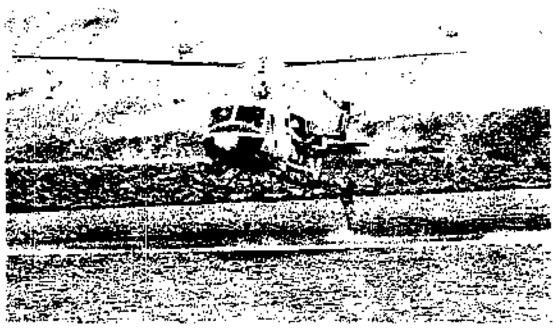
APPENDIX G

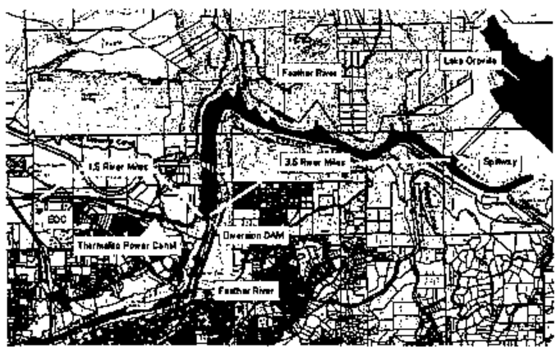
BUTTE COUNTY, CALIFORNIA'S RESPONSE TO THE MAY 2006 REPORTS OF CH2M HILL AND TCW ECONMICS

PREPARED BY OFFICE OF THE CHIEF ADMINISTRATIVE OFFICER

JUNE 2006







Butte County, California's Response to the May 2006 Reports of CH2M Hill and TCW Economics

Office of the Chief Administrative Officer
June 2006

CONTENTS

TABLES

EXHIBITS

Exhibit 1	Memo from Dr. Jon Ebeling to Paul McIntosh, Butte County Chief Administrative Officer, dated June 20, 2006
Appendix A	Maps of County Road Surrounding the Project Area

1.0 INTRODUCTION

Originally licensed by the Federal Power Commission in 1957, the Oroville Facilities Project (FERC Project No. 2100) (the "Project"), a 762-megawatt ("MW") hydroelectric facility, has been in operation since 1968. The Project includes Oroville Dam and Reservoir, three power plants, Thermalito Diversion Dam, the Feather River Fish Hatchery and Fish Barrier Dam, Thermalito Power Canal, Oroville Wildlife Area, Thermalito Forebay and Forebay Dam, Thermalito Afterbay and Afterbay Dam, transmission lines, as well as a number of recreation facilities. The Project encompasses 41,100 acres—all located within the unincorporated areas of Butte County ("County").

As the Host Community and first responder to any emergency arising at the Project, Butte County prepared and filed two studies documenting the primary operational and socioeconomic impacts the Project presents to the County on an annual basis. The studies were filed with Federal Energy Regulatory Commission (FERC) on February 15, 2006 and are titled:

> *Operational Impacts of the Oroville Facilities Project on Butte County*, Office of the Chief Administrative Officer, February 2006 ("*Operational Impacts Report*"); and,
>
> *Socio-Economic Impacts of the Oroville Facilities Project on Butte County, California,* FMY Associates, Inc. January 2006 ("*Socio-Economic Impacts Report*").

In response to those studies, the Metropolitan Water District of Southern California ("MWD") contracted with an engineering consulting firm, CH_2M Hill to prepare a study disputing the findings of the County's studies ("CH_2M Hill Report").[1] In addition, the California Department of Water Resources ("DWR") contracted with TCW Economics[2] ("TCW") to prepare a study addressing "the effects of the Oroville Facilities on the economic well-being of the residents of Butte County…"[3]

It must be pointed out that neither CH_2M Hill nor TCW Economics gathered any additional data nor did they perform any additional studies to arrive at the conclusions found in their reports. CH_2M Hill did not contact Butte County to verify data or to obtain

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1 *Operational, Socioeconomic, and Fiscal Impacts of the Oroville Facilities: A Critical Assessment of the analyses Conducted by Butte County*, CH_2M Hill, May 2006 found as Attachment A to the Response of the State Water Contractors and the Metropolitan Water District of Southern California to Interventions, Terms and Conditions, Prescriptions, and Settlement Comments, May 26, 2006.

2 DWR contracted with Thomas Wegge dba TCW Economics, Sacramento, California.

3 *Economic and Fiscal Effects of the Oroville Hydroelectric Facilities Operations: A Local Perspective*, TCW Economics, May 24, 2006 found as Attachment A to the Response of the California Department of Water Resources to Recommendations, Terms and Conditions, Prescriptions, and Settlement Comments, May 26, 2006, Page 1 ("TCW Report").

additional information regarding Butte County's cost estimates or analysis. TCW visited Butte County once related to a narrow question on visitor days. Hence, neither report is based on empirical data and in large measure only represent these consultants' opinion. In several instances, the reports attribute economic values to claimed Project benefits that are made from whole cloth.

Butte County has now had the opportunity to evaluate the quality of the reports and finds the conclusions upon which DWR, MWD and the State Water Contractors ("SWC") rely to be both inaccurate and baseless. This analysis examines each report and addresses the significant shortcomings and flawed assumptions found in each report.

2.0 BUTTE COUNTY'S ANALYSIS OF THE CH_2M HILL REPORT

This analysis is prepared in response to CH_2M Hill's Report and identifies the significant errors and shortcomings of that assessment. In sum: the CH_2M Hill Report fails to accurately measure or assess the effects of this Project on Butte County.

The CH_2M Hill Report does not appear to understand basic municipal finance or the nature and cost of criminal justice services that a California County government in a suburban/rural setting is required to provide.[4] By contrast, the County's *Operational Impacts Report* and this Response were prepared by and under the direction of Butte County's Chief Administrative Officer, a county executive with over 25 years of local government experience, including 20 years of experience with Northern California counties.[5]

Setting the record straight on these issues is important because SWC, and MWD, have used this assessment in support of their "*Response of the State Water Contractors and the Metropolitan Water District of Southern California to Interventions, Recommendations, Terms and Conditions, Prescriptions, and Settlement Comments*" filed with FERC on May 26, 2006.

This Response critiques four main aspects of CH_2M Hill's Report:

1. Butte County properly used figures generated by DWR to estimate the number of non-County visitors to the Project. Rather than correcting material flaws in the estimates made by DWR, however, CH_2M Hill's Report has attempted to give novel interpretations to the data in an effort to undercount and undervalue Project impacts on Butte County.

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[4] Although CH_2M Hill is a leader in full-service engineering services, construction and operations, a review of the firm's website does not list any experience or expertise in municipal finance and criminal justice services, particularly in California county government. To the extent the firm has this expertise, it is not reflected in the Report.

[5] The Chief Administrative Officer, Mr. Paul McIntosh, has a master's degree in public administration with an emphasis on public finance and public management and is recognized by the International City/County Management Association as a "credentialed manager."

The following analysis demonstrates the flaws in these new DWR/MWD/SWC assessments and shows that Butte County used the most conservative of three reasonable approaches for determining the level of Project demand for County services.

2. The CH_2M Hill Report diminishes the value of property taken or inundated by the Project and ignores the actual tax payments that are lost by Butte County each year due to the Project's failure to make any tax payments or payments in lieu of taxes ("PILOT") to the County. In addition, CH_2M Hill's Report ignores the fiscal impacts of the loss of the Big Bend Power Plant, a pre-existing hydro project owned by Pacific Gas and Electric and taken from the County's tax rolls when DWR purchased and submerged it under Lake Oroville. CH_2M Hill's Report also fails to recognize the loss of entire Butte County communities – such as Las Plumas, Enterprise, and Bidwell Bar – due to the construction of the Project.

   This analysis examines the flaws in CH_2M Hill's data and assumptions, and challenges the use of a federal formula for calculating lost property tax revenue impacts.

3. CH_2M Hill's Report undervalues the benefits of a low-cost power allocation to the County by substituting business location statistics for the actual savings that low cost power provides to established businesses, enabling them to grow, and giving the County the ability to attract quality new jobs to the region.

   This analysis reviews the loss of financial opportunity to Butte County due to the export of <u>all</u> low-cost power produced by the Project.

4. CH_2M Hill's Report vastly over-inflates the claimed benefits of the Project to Butte County and attempts to offset the actual, annual fiscal impacts by substituting unsubstantiated and "what if" benefits.

   This analysis examines the claimed Project benefits to the community in the DWR/MWD assessments and shows that their value and ability to offset the operational cost impacts of the Project is greatly exaggerated or non-existent. Many of the claimed Project benefits are either contradicted by DWR's own studies or are demonstrably false.

ANALYSIS

2.1 The CH_2M Hill Report Relies Upon Flawed Data And Analysis.

2.1.1 Number Of Non-Resident Visitors To The Project.

The first "critical assessment" offered by the CH_2M Hill Report is that Butte County has over-estimated the number of non-resident visitors and, hence, their impact on local government services. (CH_2M Hill Report Section 2.1.1 Estimation of the Number of Non-Resident Visitors, p. 7) Butte County and its consultants[6] have consistently noted serious flaws in DWR's statistical analysis, as used in DWR's filed "SP-R18 Recreation Activity, Spending, and Associated Economic Impacts, Final Report" ("DWR Report R-18") and "SP-R19 Fiscal Impacts, Final Report" ("DWR Report R-19") and repeated in CH_2M Hill's analysis. These flaws act to substantially undercount Project visitors and their economic impact on the County.

First, the County's *Operational Impacts Report* measures the number of visitors, and where those visitors came from, based on the studies conducted by DWR and filed at FERC in support of its license application.

Second, Butte County documented the methodology used to calculate the non-resident visitor days in its cost analysis (see *Operational Impacts Report*, Appendix A), and the logic behind its approach. In fact, to further validate the approach used, the County compared the actual costs incurred by similar sized communities in the Northern California region to provide the same services as those provided by Butte County to the Project. This comparison helped validate the County's approach and findings. Additionally, the County sought to avoid dispute by using conservative assumptions. Based upon the statistical surveys conducted by DWR, **Butte County could have justified non-resident visitor days that would have produced cost impact estimates <u>three</u> <u>times</u> the amount actually used in the County's *Operational Impacts Report.***

Third, the County was surprised by CH_2M Hill's attack on the County's use of 'recreation days' rather than 'visitor days' in the County's analysis of Project visitors. (See CH_2M Hill Report at p. 3) DWR itself measured "recreation days" in its relicensing surveys and defines recreation days as "equal to participation in recreation at a site during a single day by one person for any length of time," and also uses "recreation days" as a surrogate for usage throughout DWR's filed "SP-R9 Final Report: Existing Recreation Use" ("DWR Report R-9") and "SP-R12 Final Report: Projected Recreation Use" ("DWR Report R-12"). The County used this same definition and based its analysis on DWR's "recreation day" numbers. Further, DWR itself stated that a "recreation day" is "interchangeable with 'visitor day' "in one of its relicensing filings to FERC:[7]

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6 *See* The issue was also discussed in the County's prior filing. *See* Comments of Dr. Jon S. Ebeling Regarding DWR's Economic Analysis, filed as Exhibit C to Butte County's Motion for Leave to Intervene and Comments on Application for New License, March 30, 2006.

7 *See, e.g.*, DWR's April 15, 2005 filing entitled "Fifth Biennial Recreation Report" (FERC Accession No. 20050427-0275) at p. 3 & n. 1. In footnote 1 DWR clarified that "a 'recreation day' [is used] interchangeabl[y] with 'visitor day,' [and] is defined as a visit by one person for recreation purposes for all or part of a 24-hour day." The two key DWR Reports in which recreational activities at the Project are measured (namely, Reports R-9 and R-12), both use "recreation day" throughout.

These estimates of total attendance are generally consistent with the annual "1.7 million visitor days" reported for the period during which Relicensing studies were conducted.

Additionally, where DWR does differentiate between "visitor days" and "recreation days," it fails to adequately justify its conversion between them. Thus, the very premise for the CH_2M Hill analysis of the County's estimated number of Project visitors is seriously flawed.

2.1.2 The Country's Cost Calculations Are Conservative.

The following illustrates the more aggressive cost calculation approach that the County could have used, based on DWR data, and represents the upper range of the service cost impact numbers for the County due to the Project:

1. DWR's Report R-19, *Fiscal Impacts*, analyzed two categories of the Project's fiscal impacts on local government service costs:

   "***Visitor-driven costs***," which includes fire, law enforcement, and road maintenance costs generated solely by non-residents who visit the Project; and

   "***Indirect (growth-related) costs***," which includes "fire, law enforcement, and road maintenance costs, indirectly generated by the population growth spurred by [1] visitor spending and [2] O&M spending." (DWR's Report R-19, p. 4-2) These are County residents who, for example, use County roads year-round.

Table 2.1-1
Percentage of Net Fiscal Impacts

R-19 Table and page #	Type of Effect	Net Fiscal Impact to County	Percentage of Net Fiscal Impact ($503,800)
Table 5.1-1, p. 5-2	Visitor-driven Fiscal Impacts	($149,500)	29.7%
Table 5.1-2, p. 5-2	Indirect Effects due to Visitor Expenditures	($240,100)	47.6%
Table 5.1-3, p. 5-3	Indirect Effects due to O&M Expenditures of the Oroville Facilities	($114,200)	22.7%
Totals:		($503,800)	100.0%

DWR's R-19 Report determined that Butte County incurred adverse net fiscal impacts from the Project equal to $503,800 per year, as demonstrated in the above table.[8]

[8] Table 3-1 of the TCW Report shows increases in the net visitor-driven fiscal impacts (i.e., direct impacts) on the County from ($149,500) per year in R-19 Table 5.1-1 to ($386,900) per year -- a 159% increase. Applying the same 159% increase to the other amounts in Table 5.1-2 would increase the DWR-admitted fiscal impacts to the County to ($1,304,842) per year, instead of ($503,800) per year. Again, contrary to CH_2M Hill's assertions, the County's cost estimates are quite conservative.

2. Visitor-Driven [Direct] Fiscal Impacts – Out-of-County Visitors to the Project.

   a. There is no dispute that Out-of-County visitors have a direct adverse fiscal impact on Butte County services and infrastructure. The disagreement is over how that impact should be calculated. The County's *Operational Impacts Report* shows net annual direct fiscal impacts of $2,722,362 (excluding "indirect" costs).[9] The direct visitor-driven fiscal impacts found in DWR's Report R-19 are included in the County's direct fiscal impact numbers.

   b. In DWR's Report R-19, DWR provides data suggesting that 76.4% of visitors to the Project originated from outside of Butte County. The County, however, based its analysis on the more conservative 46.5% measurement justified in its *Operational Impacts Report*. How DWR derived this 76.4% number can be seen below from the following abbreviated version of DWR Report R-19, Table 4.4-1, "Allocation of current (FY 2002-03) visitor days for assigning public service costs in the fiscal impact model."[10] Additionally, DWR's Table 4.4-1 appears to be seriously flawed, as it bases its results on data pertaining to where in Butte County Project visitors originated, not solely on whether visitors were from outside Butte County. Again, the County's analysis of the adverse impact to the County from visitors originating outside Butte County is more accurate than the analysis relied upon by CH_2M Hill and TCW Economics.

Table 2.1-2

Summary of DWR-produced Table Showing In-County and Out-of-County Visitors

	Out-of-County Visitors Potentially Affecting Jurisdiction	In-County Visitors Potentially Affecting Jurisdiction	Total Visitors Potentially Affecting Jurisdiction
Butte County	533,130	164,844	697,974
Percentage Breakdown for County	76.4%	23.6%	100.0%
Total for All Jurisdictions	1,306,169	516,241	1,822,410
Percentage Breakdown for All Jurisdictions	71.7%	28.3%	100.0%

   c. In Appendix A of the *Operational Impacts Report*, Butte County assessed the financial impact of Out-of-County Project visitors on it services and operations by assuming that only 46.5% of the Project's total visitors were from outside of the County. This was based upon DWR's "SP-R13 Final Report: Recreation Surveys" ("DWR Report R-13") field survey numbers, and represented a very conservative approach. If the County had used DWR's Out-of-County visitor percentage of 76.4% instead, the Project's fiscal

9 *See Operational Impact Report*, at Table 5.0-1, p. 58.

10 Table 4.4-1 can be found at page 4-27 of DWR Report R-19.

impacts on the County would increase by 64.3% ((76.4% - 46.5%)/46.5%) and show that the County's net annual direct costs are equal to $4,472,841. This is a reasonable approach and represents the upper range of direct service cost impacts based on DWR data.

3. In-County Residents Resulting from Project's Indirect (Growth-Related) Effects.

   a. The County's *Operational Impacts Report* does not include a fiscal impacts category based upon the adverse fiscal impact effects from DWR Report R-19's "indirect population" of County residents because DWR refused to provide the actual indirect population number used and provided very little information on how the indirect population was determined. The County has made verbal and written requests to DWR to provide the County information about the "indirect population" that creates these indirect effects, *i.e.*, the actual size of the indirect population. However, DWR has continually refused to provide this information.

   b. Absent DWR's information, one reasonable method of determining net indirect fiscal impacts to the County from the Project is to use the ratio of net direct fiscal impacts to net indirect fiscal impacts found in the "Percentage of Net Fiscal Impacts" table above (and based on DWR's Report R-19 of direct effects to indirect effects fiscal impacts). The ratio derived is 1:2.37 (149,500:354,300). If you apply the 1:2.37 ratio to the County Report's net annual direct costs of $2,722,362,[11] as adjusted to $4,472,841 based on DWR's Report R-13 (as discussed in Paragraph 2c above), then the Project's Indirect Effects Net Fiscal Impact on the County would total $10,600,633 per year.

4. The County's one-time costs for equipment and facility replacements and upgrades of $10,544,252, if financed over 30 years at 6% interest (DWR's assumed financing period and interest rate in PDEA Table 6.1-2), would have an annual debt payment of $766,028.

5. DWR conducted a visitor survey from May 15, 2002, to May 14, 2003 to calculate the number of visitors to the Project.[12] Unfortunately, calendar year 2002 was a low reservoir level year. In Appendix A to its *Operational Impacts Report*, the County made an 11.56% adjustment upward to reflect average reservoir levels. This adjustment recognizes the fact that Project visitor numbers are significantly lower when reservoir levels are low.

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11 *See Operational Impacts Report*, at p. 55, Table 5.0-1. The $2,722,362 total represents the Law Enforcement/Criminal Justice Services amount of $2,035,416, plus Fire and Rescue costs of $393,267 plus Public Works-Road Services of $791,351.

12 The results were reported in Table 5.1-1, page 5-2, of DWR Report R-9. The R-9 Table 5.1-1 numbers were used in Appendix A of the County's *Operational Impacts Report*.

DWR states that its 2002-03 visitor day survey numbers were already adjusted upward to better reflect average reservoir levels. However, DWR Reports do not appear to properly reflect this adjustment. Attachment 5 to the minutes of the June 24, 2004 Recreation and Socioeconomic Work Group meeting shows unadjusted visitor totals for various locations within the Project, as well as visitor totals that have been adjusted upwards by 9.8% to reflect the low reservoir levels.[13] For instance, Attachment 5 shows an unadjusted total number of visitors for Bidwell Canyon BR/DUA/Marina of 195,457, and an adjusted total number of visitors of 214,613. Similarly, Attachment 5 shows an unadjusted number of visitors for Lime Saddle BR/DUA/Marina of 153,540, and an adjusted total number of visitors of 168,588. However, only unadjusted numbers are shown on Table 5.1-2 of DWR's Report R-9, at p. 5-5 (see last column entitled "Combined Seasons Total").

While no adjusted total for the Lake Oroville sites is given in Attachment 5, it was reasonable for the County to have adjusted the Lake Oroville numbers to reflect the depressing influence of low reservoir levels on visitor levels. Thus, the proper number of visitor days for the Lake Oroville sites (adjusted by 9.8%) would be 911,183 x 1.098%, or 1,000,479 visitor days. In other words, the DWR Report R-9 reflects unadjusted visitor numbers for the Lake Oroville sites, and the County was correct in adjusting visitor day numbers to better reflect average reservoir levels.[14]

The CH_2M Hill Report argues that the visitor numbers should be adjusted upwards by only 9.8% to reflect the lower-than-average reservoir levels from calendar year 2002. Whether a 9.8% adjustment is more accurate than an 11.56% adjustment is not material, however the County believes it is more accurate based on its own experience. Either way, the County was correct in adjusting visitor day numbers upwards in its analysis to account for the lower reservoir levels in 2002.

6. In its analysis, Butte County chose to use only non-resident visitors to calculate the impacts of the Project on the County. It could reasonably be argued, however, that all visitors to the Project create impacts on the County that would not otherwise have occurred had the Project not been built.[15] Certainly the law enforcement, rescue, fire protection, roads and other costs incurred by the County

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13 Attachment 5, entitled "*Adjusted Lake Oroville Sites Base numbers (+9.8%)*", can be found at http://orovillerelicensing.water.ca.gov/pdf_docs/06-24-04_rec_att5.pdf.

14 The County applied its reservoir level adjustments to all Project sites because low reservoir levels at Lake Oroville depress visitorship to all Project locations, even those where the reservoir levels do not vary appreciably.

15 For instance, a resident of Butte County needing medical assistance while recreating at the Project is likely to consume more County resources then if the resident remained at home, due to geography, distance from County resources, etc. The "what goes on in Mexico stays in Mexico" phenomenon also affects many vacationers. *See* TOBY KEITH, Stays in Mexico, on GREATEST HITS VOL. 2 (Dreamworks Nashville 2004).

to serve resident as well as non-resident Project visitors are all actual costs that would not be incurred by the County if the Project did not exist. By excluding these residents, Butte County's analysis expresses a conservative cost estimate. If the cost to serve all Project visitors are considered, then the annual service costs incurred by the County due to the Project would amount to over $6.7 million.

7. The following table summarizes the above information and provides a comparison of fiscal impacts to Butte County:

Table 2.1-3
Total Adverse Fiscal Impacts of the Project on Butte County

Type of Effect	① DWR Report R-19	② Adjusted[16] DWR R-19 Numbers	③ County's *Operational Impacts Report* with one-time costs amortized
Visitor-Driven Fiscal Impacts	($149,500)	($4,472,841)	($2,722,362)
Indirect Effects due to Visitor Expenditures	($240,100)	($10,600,633)	($1,837,983) Health & Human Services Costs only
Indirect Effects due to O&M Expenditures of the Oroville Facilities	($114,200)		
County's One-Time Cost of $10,544,252 Amortized at 6% over 30 years		($766,028)	($766,028)
Total Adverse Fiscal Impacts	($503,800)	($15,839,502)	($5,326,373)

8. DWR has acknowledged in several instances that their data collection methodologies contain "significant shortcomings and deficiencies,"[17] particularly in the use of traffic counters as a means to determine visitor days. Not only is traffic counter data unreliable, it also fails to count the number of users per vehicle. A Chevrolet Suburban carrying eight teenagers to a beach party would be counted the same as a Honda Civic carrying a single fisherman to a site. Traffic counter data also does not disclose the residency of the visitors.

As demonstrated in the *Operational Impacts Report* and explained above, Butte County's calculation of the Project's direct and indirect fiscal impacts is more conservative than if the results of the County's fiscal impacts calculations were adjusted to incorporate the out-of-county visitor percentage and indirect population effects used by DWR in its own R-19 Fiscal Impacts Report. Additionally, the County did not calculate indirect fiscal impacts (other than health and human services costs) from the Project although they are clearly a significant cost.

16 This column represents the cost figures had Butte County used DWR's higher (76.4%) out-of-county visitor percentage (*see* paragraph 2c above) as a factor in determining the ratio of direct and indirect costs and amortizes one time costs.

17 *See*, for instance, Department of Water Resources *Fifth Biennial Report Summary of Attendance Data*, March 2005, page 1.

Contrary to the contention of CH_2M Hill, Butte County has used a conservative estimate of the actual fiscal impacts of non-resident visitors to the Project, based upon the range of numbers presented by the surveys utilized by DWR to support its license application. The actual impact of non-resident visitors could be further refined by a more accurate, statistically valid analysis, but the approach used in the County's *Operational Impacts Report* represents a reasonable, middle-range cost assessment of direct service impacts.

2.2 The Use Of Flawed Data Causes The Assessment To Underestimate The Impacts On County Service Impacts. Untenable Alternatives To Providing Public Safety Services Are Offered By The CH_2M Hill Report.

After using flawed data to support a lower estimate of non-resident visitor days to the Project, the CH_2M Hill assessment then criticizes Butte County's analysis of service impacts, yet offers no empirical evidence to dispute the County's findings.

1. CH_2M Hill's Report states that Butte County erred when assuming that the level of demand on the County's criminal justice system caused by non-resident visitors is the same as the demand caused by residents, stating that the assumption is not supported by empirical evidence.[18] (Significantly, CH_2M Hill offers no empirical evidence to support its own claims.) Butte County's estimates are based upon information and data supplied by the elected Sheriff and District Attorney of Butte County, both experts in criminal justice administration.

   Further, there is a wholly unwarranted assumption in CH_2M Hill's assessment that Butte County is overstaffed in its public safety departments. This is in direct conflict with the findings of the State's Commission on State Mandates, which as discussed below, found that the County is seriously understaffed in its public safety departments due to severe budget constraints.[19] Further, the CH_2M Hill Report incorrectly assumed that Butte County does not already utilize both mutual and automatic aid agreements with surrounding jurisdictions to reduce its costs, and that Butte County public safety departments do not already utilize over-time, temporary personnel and reserve officers/personnel to the fullest extent possible. This is completely incorrect and shows the lack of research conducted by the consultant before making its claims. Due to personnel shortages, the County must actually leave some areas of the County unprotected (by both fire and law enforcement) when responding to many incidents at the Project.

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18 CH_2M Hill Report at p. 9.

19 *Final Statement of Decision, Application for a Finding of Significant Financial Distress Pursuant to Welfare and Institutions Code Section 17000.6*, California Commission on State Mandates, June 10, 2005 (available at http://www.csm.ca.gov/sb1033/sod.pdf).

Section 2.1.3.1 of CH_2M Hill's Report is critical of Butte County's sizing of its fire and emergency response facilities and services discussed in Appendix A to the County's *Operational Impacts Report* in proportion to the peak demand for those services. The Butte County Fire Department is a full-service fire, emergency services and rescue provider, operating 24 hours a day, 7 days a week and 365 days per year. Moreover, the cost figures provided by the County for fire protection services is based on the actual costs it incurs to serve Project demands, not as the CH_2M Hill criticism suggests, based on performing fire protection services that are in fact provided by others. Although Butte County is geographically divided between Local Responsibility Areas (LRA), State Responsibility Areas (SRA) and Federal Responsibility Areas (FRA), a significant portion of the Project lies strictly within the LRA. That portion consists of the Project's Forebay and Afterbay. Further, although Lake Oroville itself lies within the SRA, it remains the County's responsibility to respond to structural fires (including houseboats) and medical emergencies (including drowning accidents, vehicular collisions, rescues, and medical response) at Lake Oroville, as well as at all other areas in the State Responsibility Area and Federal Responsibility Area.

The mission of the California Department of Forestry and Fire Protection (CDF) within the State Responsibility Area is to provide protection of natural resources, which is primarily related to wildfires. The primary need for fire and rescue services within the Project area is for medical and emergency response, which falls under County responsibilities through the Butte County Fire Department and its cooperative partnerships with other local safety agencies. For these reasons, Butte County Fire stations are found within the State Responsibility Area in order to respond quickly to structural fires and other emergencies experienced by both residents and visitors to Butte County.

The fire protection system for the Project and Butte County relies on the cooperation of Butte County Fire with all other fire companies serving the area, including fire departments from surrounding counties. To ensure this system works smoothly, Butte County Fire has mutual aid and/or automatic aid agreements with all surrounding jurisdictions, whether they are city, county, state, or federal entities.

In addition to mutual aid and automatic aid agreements that help protect the Project and community, the Butte County Fire Department participates in a number of joint efforts with other jurisdictions including, but not limited to:

- The Hazmat Joint Powers Agreement
- Joint training and exercises with other local emergency first-responders
- The Butte County Fire Chief's Association
- The Interagency Rescue Group (includes many of the teams that respond to the Project area, previously discussed in the *Operational Impacts Report*)
- Emergency radio frequency coordination

- Direct communication between all dispatch centers in Butte County
- Agreements between all dispatch centers to assume dispatching in the case of a failure in any one of them.

Through the cooperative and integrated system discussed above, the fire and rescue services expected by residents and Project visitors alike are provided.

In contrast to CH_2M Hill's statement that there would be "excess capacity and personnel", the Fire Department is currently understaffed given its workload. Over the past five years, the Department has responded to over 15,300 calls on average each year, requiring constant shifting of resources throughout the County. When looking at the years individually in Table 2.2-1, the growth in the number of calls has been supported by the same number of positions, and in some years with fewer positions, allocated to the Butte County Fire Department. There is not a time that existing personnel are either not responding to an incident, or providing backup coverage in an area whose engine has been called out.

Table 2.2-1
Annual Responses and Full-Time Equivalents (FTEs) Butte County Fire Department

Fiscal Year	Number of Responses	Number of FTE	Number of Responses per FTE	FTE per capita (County population)	FTE per square mile
2000	14,430				
2001	15,349	96.5	159.1	.00047	.0589
2002	15,593	96.5	161.6	.00047	.0589
2003	15,362	94.5	162.6	.00045	.0576
2004	15,888	94.5	168.1	.00044	.0576

Source: Butte County Fire Department/CDF and California Department of Finance

In comparison to Butte County's fire service staffing, the County of Riverside, California's numbers show a lower number of responses per FTE (45% lower), as well as a higher FTE per capita (19% higher) and per square mile (110% higher). For 2002, the following comparisons are provided.[20]

Table 2.2-2
Comparison of Butte County Fire Service Staffing to Riverside, California's County's Fire Service Staffing

Number of Responses	Number of FTE	Number of Responses per FTE	FTE per capita (County population)	FTE per square mile
Butte / Riverside	Butte / Riverside	Butte / Riverside	Butte / Riverside	Butte / Riverside
15,593 / 96,524	96.5 / 865	161.6 / 111.6	.00047 / .00056	.0589 / .1235

[20] Riverside County, Butte County Fire Department/CDF, and California Department of Finance, available at http://www.rvcfire.org.

Due to financial constraints, Butte County fire stations are staffed with two on-duty personnel per piece of equipment (also known as 2:0 staffing), although National Fire Protection Association (NFPA) guidelines recommend a higher level. The NFPA 1710, "*Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Career Fire Departments" – 2004 Edition,"* recommends a minimum of four on-duty personnel per piece of equipment (also known as a company), whether that is an engine, truck or ladder company. The NFPA *Standard* also recommends a minimum of five or six on-duty personnel per company in jurisdictions with tactical hazards, high hazard occupations, high incident frequencies, geographical restrictions, or other pertinent factors. The Project should be considered a geographical restriction due to its large size and the need to drive long distances to respond to emergency situations.

Butte County also endeavors to meet, at a minimum, the guidelines recommended by the NFPA for *Volunteer Fire Departments* (NFPA 1720), which incorporate response times into recommended staffing levels. Instead of setting a guideline per company (or vehicle), the NFPA 1720 guidelines recommend that, in Suburban areas,[21] there should be 10 personnel on-site within 10 minutes at least 80% of the time. To meet this minimum recommendation requires Butte County Fire to dispatch five apparatus (the equivalent of five stations) to respond to each incident, thus leaving areas of the County uncovered. While the companies are responding to the incident, an area of the County will be left uncovered due to the "move up and cover process" discussed in the County's *Operational Impacts Report* at pages 29, 31, and 32. In Rural areas,[22] the standard is to have a minimum of six personnel on site within 14 minutes at least 80% of the time. To meet this guideline, the County must dispatch a minimum of three apparatus (the equivalent of three stations), causing the same "move up and cover" process, and again leaving some areas in the County uncovered.

When station staff are unavailable, staff from another station are used to backfill using unplanned overtime. Both planned overtime (due to MOU requirements) and unplanned overtime (due to the need for extra personnel at any given time) are included in the actual costs of providing fire services in Butte County. The following Table outlines the overtime costs for the Butte County Fire Department over the past five years.

Table 2.2-3
Overtime Budget for Butte County Fire Department

Fiscal Year	Unplanned Overtime	Planned Overtime
2001-2002	$235,383	$643,737
2002-2003	$235,383	$674,577

21 A "Suburban" area as defined by the National Fire Protection Association (NFPA) is an area with between 500 and 1,000 people per square mile, as defined by the U.S. Census Bureau.

22 A "Rural" area as defined by the National Fire Protection Association (NFPA) is an area with fewer than 500 people per square mile, as defined by the U.S. Census Bureau.

2003-2004	$530,883	$1,105,772
2004-2005	$457,896	$2,097,596
2005-2006	$544,593	$2,805,216

Source: Butte County Fire Department/CDF

The CH_2M Hill suggestion that temporary personnel can be used at the Project ignores the fact that it is difficult to hire temporary firefighters, due to the high level of training required for a firefighter. Year-round life and fire protection requires permanent staffing. Permanent personnel are better trained and able to meet the fire and life protection needs of County residents and visitors alike. Needs for additional personnel at all emergencies, beyond available permanent staff, are met by utilizing volunteers that work under the supervision of the Butte County Fire Department. California Department of Forestry and Fire Protection retired annuitants may also be used to backfill permanent positions, when minimum levels of service are at risk due to vacancies.

The Butte County Fire Department's volunteer force includes 405 allocated positions. Due to the intensive federal, state, and local training requirements for volunteer firefighters, the Butte County Fire Departments continues its extensive recruitment and retention efforts to fill the positions. The five-year history of the actual strength of the County's volunteer firefighting force is shown below:

Table 2.2-4
Butte County Fire Department Volunteer Firefighting Force

Fiscal Year	Number of Volunteer Positions Filled
2001-2002	266
2002-2003	217
2003-2004	188
2004-2005	168
2005-2006	177

Source: Butte County Fire Department/CDF

2. CH_2M Hill maintains that the Emergency Operations Center ("EOC") does not need to be relocated because an Army Corps of Engineers study dating back to 1970 placed it out of the floodplain.[23] This ignores the fact that DWR recommended that the EOC be evacuated on New Year's Day of 1997, during a major storm. The County's emergency response would be severely compromised if it was forced to evacuate (or consider evacuating) its emergency control center at the very time it is needed the most. CH_2M Hill's criticism also fails to seriously consider that DWR may choose to direct high water flows into the Thermalito Power Canal, which is less than 150 yards from County offices, the jail, courts and EOC; and runs through the Town of Oroville. Due to DWR's decision to not build the Marysville Dam, during high water periods it must divert large volume

[23] *See* Response of the State Water Contractors, at n. 123 (citing U.S. Army Corps of Engineer's August 1970, *Report on Reservoir Regulation for Flood Control*).

flows into the Thermalito Canal, thereby subjecting the local population and County facilities to a flood risk.

3. The CH_2M Hill Report maintains that the paved roads in the Area of Highest Use, identified for maintenance purposes, and the unpaved roads in the Project area, identified by Butte County that are in need of paving or of a treatment to inhibit dust, are all used by County residents to access residences and businesses and therefore do not represent a Project-related expense. However, its Report presents no evidence to support these claims. Rebuttal of the CH_2M Hill claims about Project impacts on roads can be broken into two sections: paved and unpaved. This is because the contribution required of the DWR differs between these two types of roadways.

   As an initial matter, the CH_2M Hill Report, and DWR studies, all significantly underestimate the costs of routine road maintenance because they fail to recognize State and federal accepted practices and required levels of maintenance. For example, the CH_2M Hill assessment continues to use a cost per mile for road maintenance, derived from DWR's R-19 Report, of $6,670 per mile. This estimate is wholly inaccurate, as the County told DWR several times when the R-19 Report was in draft form. Generally accepted standards for road maintenance, as established in GASB34, estimates the cost of road maintenance at $35,000 per mile. The County conservatively utilized an estimated road maintenance cost of $14,300 per mile.

   a. **Paved Roads:** The County's study did not request that the Project assume responsibility for the cost of <u>all</u> maintenance of paved roads near the Project. The County request is only for that portion of road maintenance that is attributable to road use by non-resident Project visitors. As noted in the County's *Operational Impacts Report* (section 4.4.1.2 at p. 42), the annual cost for maintenance of the arterial and connector roads to the Project's Highest Area of Use is approximately $4.2 million. Of those total expenditures, the County only requests that $357,714 of County costs be reimbursed each year by the Project. This amount represents a conservative estimate of the County's annual road maintenance expenses that are associated with the non-resident visitors to the Project.

      As stated in the *Operational Impacts Report*, this reimbursement request assumes the County will pick up the maintenance costs associated with County residences going to and from the businesses, residences, and to the Project area on the routes identified. The County at no time requested full cost recovery for maintenance of its paved roads.

      - The County's Project impact analysis also does not include non-visitor travel on the roads related to the Project including, but not limited to: garbage trucks, service vehicles, medical/rescue vehicles, law enforcement vehicles, tow trucks, and DWR or State staff providing direct services to the Project.

- The County analysis of Project related costs also does not take into account the greater burden on the roads from the heavier vehicles used by Project visitors, including boat trailers with boats and recreation vehicles.

- The County only included major arterial and connector roads in calculating the costs caused by the Project. There are many smaller County-maintained roads used by Project visitors that were not included in the calculation.

- The County estimate sought only a road maintenance reimbursement from the Project equal to the non-resident visitor's share of roadway use, even though, as described above, such non-resident Project visitors disproportionately degrade the County's roads.

Based upon the Equivalent Single Axle Loads (ESAL) method for measuring the connection between the amount of wear a road experiences and the load applied by a vehicle, a car or pickup truck has an ESAL of 0.007. On the other extreme is a large truck pulling a semi-trailer, similar to the trucks that haul gas to the fueling stations at the Project, or the garbage trucks and septic waste trucks used at the Project, which have an ESAL of approximately 0.39. What the ESAL analysis shows is that a semi rig causes the same amount of damage to a roadway as 557 cars and an SUV pulling a boat causes the damage equivalent of two cars. Thus, although the additional wear caused by the larger trucks providing services and deliveries throughout the Project (the 1:557 ratio) were not factored into the maintenance calculations, it would be reasonable to do so because the County assessment represents the low end of the cost of service range.

b. **Unpaved or Substandard Roads:** A primary reason for the inaccuracies in the unpaved/substandard road criticisms advanced by CH_2M Hill is that its analysis was done without extensive knowledge of the specific roads identified. For purposes of clarification, CH_2M Hill's footnote 4, in Section 2.1.2.3 brings up a good point. The eight sections of road that the County has requested DWR improve are not all unpaved, at least for their entire length. The correct description would be "unpaved or substandard." The County's assessment that all of these unpaved or substandard roads are either exclusively or predominantly used by Project visitors and personnel is correct.

Provided below is additional information that discusses the types of road sections in question, a description of the extent of residential or business use on or near the specific section of road, and the General Plan designation for the area around each road section.

To address CH_2M Hill's statement that "...to argue that only the sections of the unpaved roads within the Project area should be paved while those outside should not is unreasonable: all unpaved sections create emissions of particulate matter (dust) that has adverse air quality effects."[24] The County never proposed paving only unpaved roads within the Project area to address air pollution issues. Since the intention of the County's Report was to address Project-specific impacts, it would have made no sense to include a discussion of what the County does with unpaved roads that are not within the Project area. Since the question has been asked, however, a response is provided.

The County receives $25,000 per year in grant funding for road improvements. The cost to chip seal[25] one mile of road is approximately $50,000, thus the County chip seals bi-annually to reduce costs. The County continues to seek other forms of funding to decrease the number of gravel roads throughout the County. To put the conservative request of the County in perspective, it costs approximately $50,000 to chip seal one mile of a road and approximately $1.5 million to pave that same distance. If the County's request was excessive, it would have been for the Project to be responsible for paving versus chip sealing the eight stretches of road in question, at a cost of approximately $45.5 million. The current request from the County is for the Project to chip seal the roads at an estimated cost of $5.3 million.

There is not one road on the County's list that is used primarily by local residents. The roads identified in the *Operational Impacts Report* are main Project access roads or, in some cases, the only land access to certain portions of the Project, including the Afterbay, Forebay, Stringtown, Potter Ravine, and Bloomer Primitive Area. The primary use of all unpaved or substandard roads specified in Butte County's *Operational Impacts Report*, Exhibit 10, is for access by visitors and Project personnel to the Project area.

For reference, maps of the following areas are included in Appendix A.

> Map 1 in Appendix A provides a birds-eye view of the roads in question and their proximity to the Project. As noted by the lack of other roads near the eight stretches of roadway listed in Exhibit 10 of the County's Operational Impacts Report, the unpaved and substandard roads are not in populated areas. Most of them are in areas where parcels range from 20 acres to 500+ acres, and many of the adjoining parcels are not improved.

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24 CH_2M Hill Report at p. 10.

25 "Chip sealing" is a form of road cover that consists of an asphalt emulsion (water and asphalt) and rock chips. The asphalt is the glue that holds the chips together on the road. Chip sealing is used for two major road maintenance purposes: 1) an asphalt road ages from the top side down. The surface exposed to the air oxidizes, getting brittle and cracking. Cracks allow water to get into and under the asphalt surface, accelerating the decay of the road. When a road is chip sealed, the emulsion is sprayed on the road and the chips are spread over the emulsion. The emulsion gets into the small cracks, filling and sealing them up while the chips give a new running surface to the road; and 2) In the case of gravel roads, chip sealing gives a more stable surface that reduces dust in the dry months and mud in the winter months. Chip sealing gravel roads also reduces the development of potholes and ruts, as the vehicles traveling over it move around gravel.

Map 2 in Appendix A provides a birds-eye view of the same area, with an overlay of General Plan designations, to illustrate the rural nature of the areas surrounding the stretches of roads under discussion.

Map 3 in Appendix A provides a copy of the map the DWR provides on its website, which clearly shows Cherokee Road, Nelson Road, Wilbur Road, Hurelton Road, and Stringtown Road leading to key recreational areas on the Project.

Eight roads were listed in Revised exhibit 10 to Butte County's *Operational Impacts Report* (submitted to FERC by Butte County on April 27, 2006). Additional details about these roads are provided below in order to rebut the conclusions in the CH_2M Hill Report.

a) Cherokee Road (Oroville City limits to Highway 70) – this stretch of road is narrow, winding, and substandard and is used primarily by visitors to the Project to access the Bloomer Primitive Camp Area. In addition, Cherokee Road is the only connection to Oregon Gulch Road (#4 – Exhibit 10), and is part of the only land access to the Potter Ravine area.

   Cherokee Road winds through two major General Plan designations; Grazing and Open Land (GOL) and Agriculture-Residential (AR), as reflected in Map 2. Parcels range in sizes from 1 to 120+ acres. There are very few residents along Cherokee Road and no businesses.

b) Hurelton Road (Stringtown Road to Forbestown Road) – this stretch of road is substandard and is used primarily by visitors to the Project to connect to Stringtown Road (#5 – Exhibit 10). This is a major route of access to the Stringtown area of the Project.

   Hurelton Road runs through Agriculture-Residential (AR) areas, with some Grazing and Open Land designations. Parcel sizes range from 1 to 120+ acres. There are some residents along this stretch of Hurelton Road and no businesses.

c) Nelson Road (Highway 99 to end of pavement) – this stretch of road is gravel, with very few houses and no businesses located on it. Visitors to the Project use it to access the Forebay. The other stretch of Nelson is paved and maintained by the County for use by its residents.

d) The section of Nelson Road under discussion is surrounded by Grazing and Open Land designations. Out of the approximately 22 parcels that front the stretch of Nelson Road, thirteen are over 100 acres, three are between 20 and 100 acres, and the remaining six are 5 acres or under. There are very few residents and no businesses on or near this stretch of road.

e) Oregon Gulch Road (Cherokee Road to Cherokee Road) – this stretch of road is gravel and the only connector road to Potter Ravine Road, and the only land access to the Potter Ravine area.

   The road is bordered on the west by Grazing and Open Land and on the east by Agricultural-Residential (AR) designations. Parcel sizes range from 1 acre to 300+ acres. There are very few residents and no businesses on this road.

f) Stringtown Road (Hurelton Road to Lake Oroville) – this stretch of road is narrow, winding, and substandard and is used primarily by visitors to the Project to access the Stringtown area of the Project.

   The road winds primarily through Agricultural-Residential areas, with some Grazing and Open Land to the northwest. Approximately 25% of the roadway is bordered on the north by Lake Oroville and State-owned land. Parcels along Stringtown Road range in sizes from 1 to 100+ acres. There are some residents and no businesses along this road.

g) Toland Road (Hwy 99 to end of pavement) – this road dead ends at a locked gate owned by DWR. It is primarily used by visitors to the Afterbay and/or by DWR employees. The road is surrounded by Grazing and Open Land, has no residents or businesses on it, and is used for the sole purpose of accessing the Afterbay.

h) Wilbur Road (Thermalito Afterbay to Hwy 162) – this stretch of Wilbur Road is gravel and is the most heavily populated of the other stretches of roads discussed. This stretch of road is used to access the Afterbay from Hwy 162.

   This stretch of Wilbur Road is surrounded by Agricultural-Residential (AR), with parcel sizes ranging from 1 to 150+ acres.

The growth along this stretch of road is spurred by people wanting to live near the Afterbay for easier access to the water and is thus a direct impact of the Project. There are no businesses on this road.

i) Wilbur Road (Tres Vias Road to Nelson Road) – this stretch of Wilbur Road is gravel and has no residents or businesses. It is used to access the Afterbay from Nelson Road.

This stretch of Wilbur Road is surrounded by Grazing and Open Land, where parcels are 100+ acres each. There are five (5) parcels along this stretch of road. Residents that live on the southerly stretch of Wilbur Road, between the Afterbay and Hwy 162, travel on the maintained Hwy 162 to reach their homes. The stretch of Wilbur Road between Tres Vias and Highway 162 is paved and maintained by the County for the residents that live north of Hwy 162.

3. The CH_2M Hill Report criticizes Butte County's inclusion of security services necessary to protect the citizens of Butte County from the potential impacts of a terrorist attack on the Project; foreign or domestic. In fact, the CH_2M Hill Report states that "there is no indication that the level of security services provided at the facilities is inadequate." (CH_2M Hill Report at p. 10) The County respectfully disagrees. The County's *Operational Impacts Report* details the inadequacies of the current security situation on pages 13-23, focusing on the threat posed by terrorism on pages 21-23. Importantly, the CH_2M Hill Report dismissed the County's conclusions in less than a paragraph, even while acknowledging that a catastrophic dam failure (due to operator error, terrorism or earthquake) would inundate the County's Emergency Operations Center, as well as large portions of the Town of Oroville. (CH_2M Hill Report at p.10) The CH_2M Hill Report provides no expert testimony, additional factual evidence, or detailed analysis to support its claims that the current level of security provided at the Project is adequate.

By contrast, Butte County's estimates were based upon analysis by the Butte County's Sheriff's Department using personnel trained who are experienced in security and knowledgeable as to the availability or non-availability of qualified State and Federal security personnel to also provide security services for the Project.

Although it may be easy for DWR or other non-residents to dismiss the danger to County residents, the reality is that: (a) Lake Oroville Dam is ranked No. 130 on the 2004 California Crucial Asset List and is located only two miles from the Town of Oroville; (b) at present there are wholly inadequate security measures in place—the area is not patrolled 24 hours per day and the security personnel are unarmed; (c) although there is an off-limits area along the face of the dam the Butte County Sheriff's office has advised that this restriction is frequently violated; and (d) the Butte County Sheriff's Office also advises that the State's unarmed security guards are often difficult to even find or contact in this sensitive area.[26] In the face of this wholly unacceptable level of security, and DWR's repeated failures to address these issues, the County needs to use extra personnel to secure and protect this area and the adjacent residents. In the opinion of the County's law enforcement experts, the cost recovery requested represents the bare minimum coverage needed to secure the area and protect County residents, Project personnel and visitors. Leaving the dam unprotected because it is "somebody else's job" is not an option for Butte County.

5. CH_2M Hill suggests that all low-paying businesses in Butte County should help support its health and human service agencies because they support low wage jobs. This contention fails to note that these businesses already support the health and human service agencies of the County by paying taxes. If the Project were owned by an investor-owned utility (or other tax paying entity), it would be the largest taxpayer in Butte County and would provide sufficient tax revenues to the County to support its social service costs.

   The CH_2M Hill Report also fails to acknowledge the overriding role the Project plays in creating and maintaining high social service costs in the County. These high costs have their roots in the construction of the Project and these effects continue to the present. At the time of its construction, the Oroville Dam was one of the largest construction projects in the country, attracting construction workers from all over the United States. At peak construction in 1960, DWR estimated that the Project added a net impact of 14,580 new residents to Butte County, a 22% increase in the population.[27] Housing was built in the region to support those workers. When the Project was completed, most of the workers moved on to other projects, leaving a huge inventory of low-cost, available housing on the local market. Low-income individuals looking to the local economy for work quickly occupied these low-cost or abandoned homes. When they realized that jobs were not available locally, they transitioned to Butte County social service programs. Additionally, some unemployed Project workers remained in the County, and also transitioned onto the social service rolls.

   The table below demonstrates the social service caseloads before and after completion of the Project. As this table shows, the effect of the Project on increased subsistence payment obligations is clear. In 1962, the County had a population of 91,000, the per capita subsistence payments were approximately $14,000, there were 701 subsistence cases, and the per capita subsistence cases were 7.71 percent. In 1967, the year the Project was completed, the

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26 *See Operational Impacts Report* at Section 4.13.

27 *Economic Impact of the Construction of Oroville Dam and Power Plant Upon the Oroville Area,* Department of Water Resources, October 1956, Page 10, Table 5.

population was 101,000, the subsistence payments were approximately $24,000, the number of cases was 1,206, and the per capita number of cases equaled 11.90. Since 1967, the year Project construction ended, the number of subsistence cases, and per capita cases has increased dramatically. For example, in 1975 the County's population, at 119,000, had not increased significantly but the per capita payments equaled over $57,000 per year, there were 2,354 subsistence cases in the County and the per capita rate was 19.72. Thus, in just eight years after the Project was completed individuals and families in the County receiving subsistence payments more than tripled and the total financial burden on the County from such payments increased from $2.4 million to $6.8 million per year; a 184% increase in subsistence payments. This impact was largely due to the Project and continue today.

Table 2.2-5
Butte County Subsistence Caseloads
1960 to 1975

Year	Population	Subsistence Payments	Payments Per Capita	Cases	Per Capita
1960	83,200	1,340,146	16,107.52		
1961	87,000	1,338,980	15,390.57		
1962	90,900	1,294,234	14,238.00	701	7.71
1963	93,700	1,540,427	16,439.99	816	8.71
1964	95,800	2,058,345	21,485.86	1032	10.77
1965	97,300	2,381,670	24,477.60	1194	12.27
1966	99,900	2,462,004	24,644.68	1246	12.47
1967	101,300	2,406,346	23,754.65	1206	11.91
1968	100,200	2,600,864	25,956.73	1268	12.65
1969	100,000	3,067,742	30,677.42	1521	15.21
1970	101,969	3,804,760	37,312.91	1882	18.46
1971	104,300	4,400,406	42,189.89	1905	18.26
1972	108,300	4,567,680	42,176.18	2002	18.49
1973	112,100	4,834,494	43,126.62	2116	18.88
1974	116,000	5,696,458	49,107.40	2221	19.15
1975	119,400	6,828,797	57,192.60	2354	19.72

Source: California Department of Social Services
Note: The highlighted year, 1967, is the year the dam was completed.

2.3 The CH_2M Hill Report Misrepresents The Level Of Demand For Public Safety Services.

The CH_2M Hill Report incorrectly claims that Butte County has over-estimated the demand for services caused by non-resident visitors because Butte County has based that demand on peak levels of service. This assessment maintains that Butte County should instead rely upon mutual aid agreements, over-time, hiring temporary personnel, and also call upon reserve officers and personnel to cover peak demand periods at the Project.

Again, it is relevant to note that CH_2M Hill did not conduct any independent research or in any other way authenticate these claims.

1. The idea that Butte County could rely upon mutual aid from adjoining agencies to meet peak demands ignores the fact that Butte County already fully utilizes both mutual and automatic aid agreements with surrounding jurisdictions. It also ignores the fact that Butte County public safety departments already utilize over-time, temporary personnel and reserve officers/personnel to the fullest extent possible. In addition, most, if not all, of those agencies have demands peaking at the same time that Project facilities are also experiencing increased use. For example, two of the peak periods of demand in the Project area are the Fourth of July and Labor Day holidays. For the Fourth of July, virtually every community in Northern California has scheduled events such as parades and fireworks displays that demand the presence of their public safety personnel. Additionally, Labor Day has historically been a high-peak demand for tubing on the Sacramento River, requiring the diversion of law enforcement from all over the North State to meet the demand of those events.[28] All areas in the region experience peak demands for law enforcement, fire and other personnel at the same time that the Project experiences peak demands for these same County services. Thus, it is completely inaccurate to claim that mutual aid, overtime or officer reserves can meet this need. These resources are already deployed.

2. The CH_2M Hill suggestion that Butte County can rely on overtime, hire temporary personnel and/or call upon reserve officers and personnel also ignores the limited staffing levels Butte County currently suffers due in large part to the financial drain the Project imposes upon Butte County. It also ignores the extensive training required of public safety personnel.

3. At 2.1.3.2, the CH_2M Hill Report states "*Given that many visitors to the Facilities remain less than eight hours and do not stay in the area overnight, the demand they place on County services would be significantly less than that of a full-time county resident.*" This statement is not correct and there are significant discrepancies in the data relied upon to support the claim:

    - The statement that "For all visitors to Lake Oroville, 89% stay less than 8 hours, 61% stay less than 5 hours, and 22% stay 2 hours or less" is supported nowhere in DWR's R-13 Report. If CH_2M Hill manipulated that data to reach such a conclusion, it neglected to explain how. Instead, the data CH_2M Hill quotes appears to be from DWR's R-13 Report and pertain to only those survey respondents staying in the Project area for one day or less. The actual length of visit for all visitors to Lake Oroville is that 47.9% of visitors stay for 1 day or less, and 52.1% of visitors stay at

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28 *See*, for instance, *Labor Day Weekend an Expensive Party for Hundreds of Revelers*, Chico Enterprise-Record, September 3, 2003.

the Project for more than 1 day, as reported in DWR Report R-13 at Table 5.1-2.

- Further, the percentages stated in the CH_2M Hill analysis discuss visitors to the Oroville Facilities (Project-wide data) on the one-hand and then discuss only visitors to Lake Oroville, on the other. This has the effect of excluding information about visitors to other areas of the Project. Specifically, the statement that "For visitors to the Oroville Facilities who reside outside of Butte County and adjacent counties, 25% visit for one day or less" has no connection to the statement that follows it regarding the breakdown by hours of people visiting Lake Oroville for one day or less.

- The CH_2M Hill Report also ignores the findings that the length of visits to portions of the Project that have campground facilities are significantly longer than visits to portions of the Project without these facilities. The CH_2M Hill Report inappropriately conflates these findings.

4. **Impact On Fire Services (And Other Emergency Service Providers)**: The mere fact that Lake Oroville exists in Butte County, along with the Afterbay and Forebay, increases the likelihood of calls for emergency assistance for vehicular and non-vehicular incidents alike, well above the likelihood that would exist absent the Project. The increased odds of vehicular accidents are tied to the following: 1) visitors driving rural roads that were not built with the intention of handling heavy or frequent traffic; 2) visitors driving roads they are unfamiliar with; and 3) visitors driving RV's and pulling boats they may drive or pull infrequently so that their driving skills are not honed. Further, many accidents that occur related to water sports on Lake Oroville and at the Afterbay and Forebay would not occur if the Project did not exist.

   a. The very nature of boating, swimming, and other water-related activities add to the increased odds that rescue or emergency medical services will be needed by Project visitors. Though visitors will be in the County less time than residents, the activities the visitors are taking part in have an increased risk, and thus create a larger demand for rescue and other County services than the activities that County residents are engaged in on an everyday basis.[29]

   b. Additionally, there are extra demands placed on law enforcement, fire, and other County rescue personnel due to the high incidence of visitors (particularly boaters) drinking during the day and then getting in their vehicles to drive elsewhere, due to the lack of overnight accommodations at the Project. Even without alcohol consumption, boaters are already statistically at a higher risk of injury than non-boaters.

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[29] *See*: State of Washington, Washington Parks and Recreation, "Adventures in Boating", Chapter 5: Boating Emergencies. Available at http://www.boat-ed.com/wa/course/p5-1_riskmgmt.htm.

c. Risks of water-related accidents are not confined to the summer months. In the non-summer months, when fishing is still a favorite past time, there is increased risk of hypothermia when visitors to the Project fall into cold water:[30]

> It only takes 3-5 minutes for 'cold shock' to set in. . . . In 3-30 minutes, swim failure can occur. The muscles and nerves in the arms and legs cool quickly. Manual dexterity, handgrip strength, and speed of movement can all drop by 60-80%. . . Long-term immersion hypothermia sets in after 30 minutes. . . . Hypothermia eventually leads to loss of consciousness and death, with or without drowning [and] Post-immersion collapse occurs during or after rescue. Once rescued, if you have been immersed in cold water you are still in danger from collapse of arterial blood pressure leading to cardiac arrest.

Additionally, according to Gordon Smith, Associate Professor in Health Policy and Management at the Johns Hopkins School of Public Health, "82% of adolescent drownings occur in remote – and usually unsupervised – places such as lakes, rivers, canals and oceans."[31]

5. Throughout its report, CH_2M Hill suggests that Butte County's study would provide a higher level of staffing and personnel availability than currently used by Butte County. This completely ignores the fact that the current level of availability is based upon the severely depressed financial condition of Butte County and is not adequate. The County would note that this is a condition largely caused and perpetuated by the Project's failure to pay for the County resources it utilizes every day.

6. The fiscal plight of Butte County during the decade of the 1990's is well documented.[32] Butte County's fiscal plight was confirmed by an independent audit, commissioned by the State Department of Finance in 1989. In 1996, Butte County was one of the few California counties to be designated "fiscally distressed" under the provisions of Welfare and Institutions Code § 17000.6. In December 1999 the Commission on State Mandates found that Butte County was "significantly financially distressed" and extended that certification through

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30 *Id.* The State of Washington's boater safety course discusses the stages of hypothermia that occur and reflects the importance of timely rescue.

31 KidSource On-Line, "Johns Hopkins: Drowning Rates are Highest in Summer, and Teens Have Greatest Risk." Available at http://www.kidsource.com/kidsource/content/news/drowning.html.

32 *See* for instance "*California Counties on the Fiscal Fault Line: A Study of the Financial Condition of California Counties*," California Counties Foundation, November 1990, pages 1-3.

December 28, 2002. Some of the highlights the Commission noted in their report, include (emphasis added):

> *Although Butte County's economic condition was improving from the early 1990's, even if the economy continues to improve the County* ***would still face unmet needs in essential county services, particularly in public safety programs.***
>
> *The County's discretionary expenditure flexibility is constrained both by fund restrictions and by state and federal mandates, leaving (in 1999) $34.1 million, of the $218.8 million in Proposed Budget appropriations, as theoretically available for discretionary use.*
>
> *The full $34.1 million cannot be considered truly discretionary inasmuch as 67 percent is directed toward funding public safety services, and much of the remainder is used to support such essential County services as: funding to meet maintenance of effort requirements in receiving state revenue for public safety and health services; leverage for receiving other state and federal revenue; coverage of non-state funded court costs; and, the provision of building inspection and planning services not covered by fee revenue.*
>
> ***The County has unmet needs in basic county services, including public safety, in the amount of $17,308,596.***
>
> *This amount represents the approximate county portion of costs associated with basic county needs. The identified unmet needs were both compellingly basic in character and convincingly established in amount. In addition, a majority of these unmet needs represent ongoing costs that will continue for at least the next three years.*

Butte County again filed for distressed county status under California Senate Bill 1033 in 2005 and was granted that status in June 2005 for the period of September 1, 2005 through August 31, 2006. In other words, as this response is written, Butte County is the only county in California to hold the "distressed county" designation bestowed by the California Commission on State Mandates. In its findings, issued in June 2005, the Commission found that Butte County had $17,459,957 in unmet needs for public safety programs.[33]

What these State findings show is that any analysis of Project impacts on Butte County, which uses the County's current budget as a basis for

[33] *Application for a Finding of Significant Financial Distress Pursuant to Welfare and Institutions Code Section 17000.6, Final Statement of Decision*, Commission on State Mandates, State of California, Adopted June 10, 2005.

determining necessary program levels and impacts is inaccurate. Such an analysis would begin with the false assumption that current County budget reflects actual demands and needs.

2.4 The CH_2M Hill Report Under Reports The Loss Of Property Taxes By Ignoring The Removal Of A Major Hydro Project And An Established Community From The Tax Rolls, As Well As Unsupported Speculation As To The Development Potential Of Butte County Land

In critiquing Butte County's study regarding the loss of property taxes due to the Project, CH_2M Hill ignores the fact that in constructing this hydro facility and acquiring the necessary property, DWR purchased the Big Bend Power Plant hydro facility[34] from Pacific Gas and Electric Company (PG&E), a tax-paying investor-owned utility, taking Big Bend from the Butte County tax rolls, and without providing any compensation to the County. This loss of tax revenues was not a one-time or prior period loss, each year the County loses the over $631,151 in tax revenues associated with the destruction of this tax-paying asset, a loss of approximately $131.6 million in tax revenue payments to the County over the Project's requested 50-year license renewal period.[35] Despite the fact that DWR pledged to "*make payment for or replace all improvements destroyed or injured by the proposed work*"[36] it has never provided any compensation to Butte County for the loss of the County's single largest taxpaying entity. In addition, to construct the Project the communities of Las Plumas, Enterprise, and Bidwell Bar[37] were also evacuated and destroyed. DWR has never replaced or compensated the County for any of these destroyed improvements.

Further, the CH_2M Hill Report also fails to base any of its tax analysis on empirical data, relying instead on baseless speculation concerning what development would have occurred along the Feather River and within the 41,100 acres occupied by the Project, had the Project not been built. Significantly, much of this speculation is completely inaccurate, again reflecting the analyst's lack of knowledge concerning Butte County.

Finally, the CH_2M Hill report mistakenly applies the formula used by the federal government to allocate payments in lieu of taxes to local governments for certain land that is owned by the federal government. Butte County has never asserted nor maintained that any payment to the County for the loss of taxes resulting from the Project should be modeled after a federal program that has no relevance to a developed hydro

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34 *See "History of Big Bend Powerhouse and the Community of Las Plumas"* in Attachment B to the "*Socio-Economic Impacts of the Oroville Facilities Project on Butte County, California,*" FMY Associates, January 2006.

35 *See Socio-economic Impacts Report* at p.18-19.

36 Water Project Authority of the State of California (precursor to DWR) Application to the Federal Power commission for License for the Feather River Project, January 31, 1952, p. 37.

37 *See Socio-economic Impacts Report* at p. 18-19.

facility or other economic resource. Rather, Butte County's proposed license condition would provide for a payment in lieu of taxes based on the actual loss of tax dollars resulting from the Project, as determined by the FMY Associates Study[38]; this Study calculated the tax payments that would be paid if the Project were owned by an investor-owned utility or any other power generating entity making tax or PILOT payments in exchange for the opportunity to develop and use County resources to operate a hydroelectric power project. Moreover, contrary to the CH_2M Hill analysis, the *Socio-Economic Impacts Report* prepared by FMY Associates was based on well documented, empirical evidence.

The federal program for allocating certain minimal payments to local governments for land owned by the Federal Government has no bearing on this Project or on this relicense proceeding. Certainly the minimal payments made under this federal formula have nothing to do with compensating the host community for the actual services that it provides to the Project, including law enforcement, fire protection, rescue services, roads, social services and government infrastructure. These payments also have no analogy to a taking of land and other resources from the community in order to develop an energy resource that will inure to the financial benefit of a select group of entities, such as the Water Contractors. Here, those private benefits will equal well over $100 billion during the proposed 50-year license term.

Similarly, these minimal federal payments have nothing to do with compensation due to a community when a tax-paying asset, such as the Big Bend Project, has been permanently removed from the tax rolls of the County in order to create and operate a profitable power generation facility, such as this Project. Finally, in many other cases where the federal government has taken private property and other resources from a community in order to create and operate hydro projects, all or much of the low-cost electricity produced at those hydro projects has been provided to the communities whose lands and resources were taken, and based on the U.S. Government's costs of production (i.e., no return on equity). The 26 dams of the Bonneville Power Administration provide one excellent example of this benefit sharing. The low cost power produced by the Bonneville dams is provided to Pacific Northwest residents and businesses as preference entities, and at Bonneville's cost of production.[39]

2.5 The Availability Of Low Cost Electrical Power Has A Very Positive Effect On Regional Economic Development

At Section 2.3, Role of Electrical Power in Regional Economic Development, the CH_2M Hill critique seeks to use business location statistics to support the contention that the

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38 *See* Socio-Economic Impacts of The Oroville Facilities Project on Butte County, California, January, 2006; prepared by FMY Associates (*Socio-Economic Impacts Report*) filed at the Commission on April 26, 2006.

39 *See*, e.g., Bonneville Project Act of 1937, sections 2,4 and 6, 16 U.S.C. Sec 832, et seq. and the Pacific Northwest Electric Power Planning and Conservation Act, 16 U.S.C. Sec. 839, et seq.

provision of low cost power to Butte County would not provide any economic development benefits. This contradicts reason and other studies that are directly on point.[40]

For example, the New York Power Authority provides low cost power to the host communities and region as part of both the St. Lawrence and Niagara Power Projects. During the renewal of the Niagara Project license (Project No. 2216) the Authority filed a report detailing the financial benefits of low cost power.[41] In detailing specifically the value of low cost power provided to the host communities, the report, prepared by the Center for Development Analysis (CENDA), of Amherst, New York, states, at page 10-123:

> After interviewing and surveying many industrial and municipal customers, CENDA estimated that directly and indirectly, the Project supports 143,000 jobs in Western New York and an additional 110,000 elsewhere in New York State. Overall, the Project supports a considerable share of all business and household incomes in Erie, Niagara, and Chautauqua Counties. It was calculated that in Niagara County about 18% of household income and 38% of business income is directly or indirectly supported via industrial customers.... At the township level, 19% of residential income and 15% of business income in Lewiston depends on the Niagara Power Project. In Niagara Falls the corresponding values are 22% and 28%, and in Buffalo they are 21% and 26% respectively.
>
> In Niagara County, CENDA found, approximately $11.8 million in property taxes is attributable to the economic activity supported by the Power Project. About $5.1 million, or 43% of total property taxes in Niagara Falls; $510,000, or 4% of property taxes in Lewiston; and $4.4 million and $1.8 million, respectively, in property taxes are generated via industrial customers supported by the Power Project.

Additionally, many utilities, including several in California, have programs that provide low-cost power to communities in order to spur economic development and attract and retain jobs. This is based on a clear linkage between adequate supplies of low-cost electricity and business location decisions. As discussed more fully in the *Socio-Economic Impact Report*, the provision of even a modest allocation of low cost power to Butte County would provide large economic development benefits, creating jobs and benefiting all County residents.[42]

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40 *See Comments of FMY Associates, Inc., on Filings Submitted by California Department Of Water Resources and the State Water Contractors Regarding the Socio-Economic Impacts of the Oroville Project Facilities on Butte County, California*, at p. 6-7 (submitted concurrently with this filing) (FMY Response).

41 *First-Stage Consultation Report, Volume 1*, Niagara Power Project (FERC No. 2216), New York Power Authority, December 2002.

42 *See Socio-Economic Impact Study*, at p. 22.

2.6 Benefits Attributable To The Presence Of The Project.

2.6.1 Tax Revenues From The Project.

CH_2M Hill's Report maintains that Butte County's failure to account for direct and indirect benefits of the Project is a significant flaw. Unfortunately, CH_2M Hill's Report fails to accurately account for Project costs and assumes that revenues just mysteriously materialize. To understand the fundamental flaws in CH_2M Hill's assumptions, one must understand local government finance in California.

In its analysis, CH_2M Hill asserts that there are "Project-related intergovernmental transfers" that are not counted in the County's cost assessment. The critique even claims that intergovernmental transfers account for over 50 percent of the General Fund revenues for Butte County.[43] Such an assertion is absurd and totally misrepresents the Butte County budget and the fiscal reality of California counties.

Butte County's 2004-05 Budget accounted for $145,806,508 in "State Revenues", $70,773,110 in "Federal Revenues" and $5,155,486 in "Other Intergovernmental Revenues." What the CH_2M Hill analysis failed to understand or acknowledge is that every dollar received is tied to a specific program and/or mandate from the state and/or federal government and Butte County does not have the discretion to change or ignore these allocations. California counties are a subdivision of the State of California and, as such, act as an agent of the State of California in the administration of state and federal social service programs such as CalWORKS, TANF, In Home Support Services, Foster Care, Child Support Services, and others. The revenues to support those programs, as well as the actual cash transfers made to program recipients, are accounted for in the above described revenue accounts. In fact, the State uses an independent accountant to ensure that the funds have been appropriately expended and audits the County's expenditures annually. **There is not one dime of discretionary funds transferred to Butte County through these accounts that could be used to offset the fiscal impacts of the Project.** In fact, during the 2003/04 budget year, Butte County documented $38 million in negative financial impacts from State budget and administrative decisions. Thus, to assume that there are "magical" intergovernmental revenues that somehow reimburse Butte County for the services expended on the Project is simply false.

2.6.2 Benefits Of Flood Control.

Section 2.4.2 of the CH_2M Hill Report suggests that Butte County benefits significantly from the flood control aspects of the Project, referencing Army Corps of Engineers reports published in 1970.

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[43] *See* the asterisk note at the bottom of the table produced on page 20 of the CH_2M Hill report.

First, neither DWR nor the State Water Contractors paid for the portion of Lake Oroville devoted to flood control; the Federal Government through Congress, the Corps of Engineers, and the taxpayers of Butte County paid these expenses.

Second, the claims made in the report group the entire Feather River Region into one section and fail to distinguish between the various levels of flood protection provided (or not provided) to specific portions of the region. As noted below, most if not all significant flood control benefits from the Project are experienced by communities located downstream from Butte County. Third, in a report prepared by the U. S. Army Corp of engineers ("USACE") in 2002,[44] the discussion of flood control benefits focused primarily on the impacts to Sutter and Yuba Counties downstream from Butte County.[45] Furthermore, the USACE report notes that other entities have contributed to the strengthening and maintenance of flood control facilities in the Feather River Region. The report notes[46]:

> Subsequent Federal projects, including Phase II of the Sacramento River Flood Control Systems Evaluation and the Sacramento River Bank Protection Project, and emergency assistance programs have provided assistance for the reconstruction and strengthening of various reaches of levees within the Feather River Basin.

Fourth, the maps provided by the Department of Water Resources (SP-E4 FP Maps 12-27-04.pdf and SP-E4 12-27-04.pdf) outlines flood plains for the DWR 100-year and 500-year (1% and 0.2%) events, however these maps do not provide flow information for a comparison of these events with historic discharges from the Oroville Facilities.

Fifth, the report ignores the fact that Butte County residents began building levies along the Feather River in 1908 and weathered many floods prior to the construction of the Oroville Dam. In fact, prior analyses by the Department of Water Resources indicate that the benefit of flood control from the Project lie primarily downstream from Butte County, in Yuba and Sutter Counties.[47]

Finally, and most important, the report fails to note that the dams constructed as part of the Project expose large portions of Butte County to a catastrophic flood risk, due to dam failure caused by operator error, terrorism or earthquakes. These threats would not exist

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[44] *See*, for instance, *Sacramento and San Joaquin River Basins Comprehensive Study*, California, Interim Report, US Army Corps of Engineers, December 20, 2002, at p. 95.

[45] *Id.*

[46] *Id.* at p. 95.

[47] For example, a DWR News Special Edition report on the "California State Water Project – Past, Present, Future" stated: "Construction on the Oroville site actually began even before the passage of the Burns-Porter Act. A $25 million emergency appropriation was passed in 1957 after a record late 1955-early 1956 flood, which devastated Northern and Central California. Statewide, 64 deaths were recorded, **mainly in Sutter County and Yuba City**, and more than $200 million of property damage. [emphasis added]"; *see also*, California State Water Project – Past, Present, Future, Department of Water Resources, p. 22.

absent the Project. All of these threats to Butte County, although remote, represent a risk of catastrophic loss that far outweighs any minimal reduction in flood risk. Thus, due to the Project, the County has been forced to trade the risk of minor flooding damage on an occasional basis for the threat of total loss due to a dam failure or similar catastrophic event. Certainly in the face of this remote but devastating potential it is impossible for the Project to claim it provides the County with any financially demonstrable flood benefits. In any cost/benefit analysis, the potential flood related costs to Butte County would far outweigh any claimed benefits.

3.0 BUTTE COUNTY'S ANALYSIS OF THE TCW REPORT

This report was prepared by the same consultant, Mr. Tom Wegge of TCW Economics ("TCW' or "TCW Report"), who prepared DWR Reports R-18 and R-19, both filed as part of the renewal of the license for the Project. The TCW Report is thus an attempt to address shortcomings in the original DWR studies. It also advances new theories on Project benefits in order to offset the findings of Butte County in its *Operational Impacts Report* and *Socio-Economic Impacts Report.*

3.1 The TCW Report Creates Illusory Project Benefits in an Attempt to Offset Unmitigated Project Costs to Butte County

The first section of the TCW report seeks to create new benefits from the Project in order to offset the unmitigated cost impacts of the Project on Butte County. The report offers no factual basis for statements made on value, and fails to supply <u>any</u> empirical evidence for the claims advanced.

3.1.1 Recreation Benefits

The TCW Report at Section 2.1.1 suggests that the Project provides $9,100,000 in monetary value to Butte County residents because they can avoid having to drive to other locales for recreation. This estimate is made from whole cloth. Absolutely no facts are provided in this report to support this supposition.

Furthermore, such a suggestion ignores the many recreational opportunities that existed along the Feather River before the Project was built and which were destroyed by the Project. These recreational opportunities include the Oroville Regatta, boating, skiing, fishing and whitewater rafting. The Project area has always been a source of hiking and horseback riding trails.

There is no basis to the report's contention that this "benefit" should be valued at $9,100,000. If anything, the Project destroyed as many recreational opportunities as it created.

3.1.2 Flood Protection Benefits

The TCW Report at Section 2.1, states that flood protection is a benefit of the Project and places a value on that claimed benefit of $9.4 million per year. Again, this assertion is not supported by any evidence or documentation. In fact the only support for the claim is a reference to Mr. Mark Andersen, a DWR employee who was a principal negotiator for DWR in the settlement negotiations.

As discussed in the County's response to the CH_2M Hill Report above, at Section 2.6.2, the Project provides few if any flood control benefits to Butte County. In fact, the Project creates the risk of catastrophic loss due to dam failure or terrorism events. Additionally, TCW fails to note the Project was located in an area that has experienced earthquakes. Because the Town of Oroville and all County offices and facilities are immediately below the dam and immediately adjacent to the Thermalito Power Canal, the Project has created far more potential for serious flooding than protection. The claims of flood control benefits to Butte County could only come from persons and companies that live elsewhere.

At Section 2.1.3, the TCW Report maintains that there is a Project benefit associated with providing a reliable water supply to local growers, but does not place a value on this benefit. The report fatally fails to mention the fact that the water districts serving the local growers hold California State surface water rights that are senior to DWR's water rights for the Project. In the absence of the water districts' contract with DWR, the water districts would be entitled to take the <u>entire</u> flow of the Feather River in critically dry water years.

Furthermore, the report entirely ignores the studies produced by local growers that document the loss of production due to DWR's failure to meet water temperature standards, as agreed in their water contracts.

Finally, because of the water districts' senior water rights, the report cannot properly place any value on this alleged benefit. Moreover, TCW's Report fails to identify how this "benefit" offsets the documented operational and other costs of the Project to the County.

3.1.3 Impact On Local Economy

The TCW Report, at Section 2.1.5.1, attempts to show positive economic impacts from the Project by including worker salaries and Operation and Maintenance (O&M) expenditures made by DWR for the Project. However, the TCW Report fails to provide any documentation or even specific information to support these claims. The Report also ignores the distribution of tax receipts under California law. Most of the transactions noted in the TCW Report, even if accurate, would occur within the Town of Oroville, and thus the County would gain none of these tax receipts or benefits.

The TCW Report claims that O&M expenditures of the Oroville Facilities by State agencies provides benefits to Butte County. However, TCW fails to mention that its R-19 Report showed that the O&M by State agencies caused the County **a net loss of $114,200 each year**. (DWR Report R-19, Section 5.1.1.2 and Table 5.1-3 at p. 5-3) As stated by TCW in the R-19 Report: "*This annual deficit reflects the inability of sales tax revenues generated by O&M expenditures and other revenues generated by the population supported by these expenditure to offset the costs to the County of providing services to these residents.*" (DWR Report R-19 at p. 5-3)

While there may be employees of DWR or other agencies supporting the Project who live in Butte County, the benefits of these few jobs have to be offset by the employment opportunities lost when the Project was built. Certainly the employees of Pacific Gas & Electric were displaced when the Big Bend Power Plant was purchased and decommissioned (not to mention the loss of tax revenues when this facility was destroyed). Additionally, numerous lumber-related jobs and businesses were lost when 41,000 acres of land was taken into the Project boundaries. For instance, prior to the flooding of the Project area, that part of Butte County had a large reserve of commercially-viable gravel. That sector of Butte County's economy no longer exists.

3.1.4 The TCW Report Improperly Discounts Project Impacts On Social Services Programs Of Butte County

The TCW Report at Section 2.1.5.2 seeks to minimize the adverse impacts the Project has had on the social service programs and costs of the County. As discussed in the County's response the CH_2M Hill Report above, at Section 2.3, the Project has greatly increased the County's Social Service caseloads and costs.

In fact, in just the eight years after the Project was completed, individuals and families in the County receiving subsistence payments more than tripled and the total financial burden on the County from such payments increased from $2.4 million to $6.8 million per year; a 184% increase in subsistence payments. Those impacts continue to this day with the County experiencing some of the highest social service costs in the State, as described in the County's *Operational Impacts Report*. Not only do many of the former Project workers and those acquiring abandoned/low cost construction housing, and their families, remain on the County's social service rolls, but the negative impacts are also felt through the low paying and seasonal jobs created by the Project (*Operational Impacts Report* at Section 4.6, pages 53-57)

3.2 The Report Misrepresents The Loss Of Property Taxes Revenues And How Those Losses Should Be Mitigated

The TCW Report at Section 2.2.2 discusses foregone property taxes and suggests that Butte County has overestimated lost tax revenues because: a) mixed residential and commercial uses, which could have occurred as an alternative to the Project, would have created additional service burdens on Butte County; b) much of the land occupied by the Project is less than ideal from a development potential; c) some of the Project lands were already in public ownership and likely would have remained in public ownership; d) flood control protection allows a higher level of development outside of the Project; and, e) only a portion of the foregone property taxes would be allocated to Butte County due to tax distribution formulae regarding property taxes.

Importantly, this section of the TCW Report fails to provide any substantiation of these claims and each contention is in error.

First, the TCW Report fails to acknowledge that all residential and commercial development on the lands now owned by the Project would pay property taxes to the County. These additional residents and businesses also generate other types of economic activity that benefit the County as a whole, as well as increasing tax receipts to Butte County. Such receipts provide at least some offsets to service impacts.

Second, the TCW report misrepresents the distribution of property tax receipts within Butte County. The distribution of receipts is entirely dependent upon the taxing districts overlaying a particular parcel. The vast majority of the lands within the Project area have few taxing jurisdictions overlying the area, thus the percentage of tax receipts retained by Butte County would be significantly larger than claimed by TCW. In addition, the TCW Report fails to recognize the increase in property tax retention resulting from the passage of Proposition 1A. The 13 percent figure referenced by TCW is reflective of average retention by Butte County on a county-wide basis prior to the passage of Proposition 1A.

Third, the TCW Report lists as a Project benefit the fact that DWR reduced Butte County's cost allocation to the State Water Project (estimated by DWR to be $526,000 annually) for the receipt of an allocation of its own water. What TCW fails to note, however, is that Butte County only uses 1,200 acre feet of a 27,500 acre feet water allocation and that any water not used by Butte County is retained by DWR and used to meet state and federal requirements to maintain the San Francisco Bay Delta. Especially during critical, dry, and below normal water years, the value of this water to other California water customers is several times greater than the cost charged by DWR.

3.3 The TCW Report Is Directly Contradicted By Two Reports Recently Filed By The DWR

On May 12, 2006, DWR filed two reports at the FERC in support of its license application: "*Recreation and Tourism Economy in Oroville*" (the "Tourism Report") and "*Property Value Analysis Using Hedonic Property-Pricing Modes*" (the "Property Report") (collectively, "Reports" or "May 12 Reports").

The overriding findings of these two Reports are that the Project has provided few, if any, economic benefits to Butte County over the first license term. In fact, even when looking at the Project's economic effects on County tourism and property values, without factoring in Project costs, the gross benefits to the community have been negligible. For example, the Study Findings in the Tourism Report indicate that even for the town which is most proximate to the Project's recreation facilities, the Town of Oroville, the total effect of all tourism (both Project-related and other) is "typically less than ten percent of total sales."[48]

[48] Tourism Report at pp. ES-2 and 5.

Additionally, when the Tourism Report compares the tourism benefits experienced by Butte County with those experienced by Shasta County as a result of the Lake Shasta project operated by the U.S. Bureau of Reclamation, it is clear that the Project has provided very negligible benefits (again, even excluding Project costs) to the host community. As the DWR Tourism Report found when it compared these two project areas, "key tourism sectors, including eating and drinking establishments, miscellaneous retail establishments and hotels and lodging places collectively are about twice as large [in Shasta County] when viewed as a percent of overall employment as they are in the Oroville area."[49] Thus, Project-related tourism has provided very few economic benefits to Butte County and, as discussed below, the Project's positive effects on property values are negligible or nonexistent.

These DWR Report findings are consistent with the findings of the County's *Operational Impacts Report* and *Socio-economic Impacts Report*. The results are also not surprising because the Project has made no financial contributions to the roads, police, fire, rescue and other government infrastructure required to make recreation facilities safe and desirable to the public. The Project has not provided Butte County residents with any demonstrable economic benefits. Even when compared with Lake Shasta, where the federal government has made payments and supported the local government infrastructure, one can see that at least 50 percent of the reasonably expected tourism benefits in Butte County have been lost.[50] DWR's failure to reimburse the County for the many government services that it relies on, and its failure to provide any payments or infrastructure improvements (including the many facility improvements promised when the Project was first licensed), led to study findings showing no appreciable economic benefits from the Project to the host community.[51]

These DWR Reports help illustrate some of the net negative effects of the Project on Butte County. When total tourism expenditures in Butte County from all sources has increased by less than 10 percent, and the County has seen property values remain nearly flat, and far below the rate of growth experienced in other California state and local communities, it is clear that the Project is not only failing to provide the host community with economic benefits but is in fact financially damaging the Butte County community. When a Project that has taken over 41,000 acres of County land pays no taxes or PILOT to support the local government, provides no Project benefits in the form of low-cost power to the community, and makes no contributions toward necessary public

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49 Tourism Report at p. ES-5.

50 Although the Tourism Report suggests that the Shasta Lake Project may have provided tourism related-benefits not found with the Oroville Project because it is a somewhat older Project, the County submits that over 35 years of experience is sufficient to determine the Oroville Project's effects on the host community.

51 Although DWR/MWD also claim that the private settlement reached with two small communities in the County, with a combined population of approximately 40,000, should be considered an offset to Project costs, it is noteworthy that these so-called payments are largely at the discretion of DWR, particularly for a license of less than 50 years, and are not indexed to inflation or any other escalator that reflects the time value of money.

infrastructure, it is to be expected that the host community will suffer. This is what the County's studies have documented and these DWR Reports confirm.

Three findings from these DWR Reports are particularly noteworthy in showing the complete lack of Project benefits to Butte County and the local community. First, despite the fact that the Project attracts over 1.7 million visitors per year, few of those visitors spend their tourism dollars in the County. As noted in the Tourism Report, tourism from all sources amounts to no more than 10 percent of all local business sales, even in the Town of Oroville, the town that is closest to the Project's recreation facilities. This is because most tourists are either from surrounding Northern California areas, and thus return home after a visit to the Project facilities, or are campers and therefore also do not rely on local hotels, restaurants and shops for products and services.

Second, even according to these DWR Reports, the Project creates few local jobs. As noted in DWR's Tourism Report, "Total employment in the Oroville area is 18,835 jobs, whereas total employment in Shasta County is 81,970. Even with a much larger employment base, the relative importance of tourism related jobs in Shasta County is greater than in the Oroville area."[52] Further, as noted in this Report, the tourism sector in Shasta County is "about twice as large" as in the Oroville area, yet Shasta County has almost <u>four times</u> as many tourism-related jobs. Thus, the claims of the most recent TCW and CH_2M Hill Reports that the Project has created jobs and brought economic benefits to Butte County, are contradicted by DWR's own studies.

Third, the DWR Tourism Report finds that one of the "other limitations in attracting more tourist business to Oroville include the lack of facilities to host meetings and ceremonies associated with events (such as bass tournaments), and a lack of facilities to adequately accommodate the special needs of boaters."[53] This finding is also completely consistent with the County's findings and comments, which have noted the long waiting list for boat launching and storage facilities on Lake Oroville, the lack of adequate marinas and the lack of adequate overnight facilities for visitors. Just as important, however, when one compares DWR's own findings that the County lacks adequate faculties to attract more tourism business with the promises made by DWR at the time the first license was issued to build such facilities (promises that were never fulfilled), one can see an additional element of harm experienced in the County. At the time of the first license proceeding, DWR was able to attract local support for the Project by promising to build many new facilities. These new facilities included a new lodge at Kelly Ridge, a monorail to transport visitors, a steam train, and a restaurant and snack bar at the Visitor Center.[54] Unfortunately, however, none of DWR's promises have been kept and none of these facilities were ever built.

Finally, the DWR Property Value Report also shows that the Project has done nothing to increase local property values. In fact, for the over twenty years studied (1991 – 2002)

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[52] Tourism Report at ES-5.

[53] Tourism Report at p. 7.

[54] DWR's unmet development promises are discussed further in Section 4.0 below.

there has been only nominal growth in local property values, "the magnitude of this positive trend is roughly $307 per year."[55] This level of increase is far below the property value increases experienced elsewhere in California and in the adjacent communities. For example, according to the U. S. Census for 2000, the median house value in Butte County was $129,800 and for the State of California $211,500. According to 1990 U. S. Census, the median house value in Butte County was $94,000 and for the State as a whole $194,000. Thus, an increase in real estate value of approximately $307 per year represents a property value growth rate of less than one-half of one percent. This is well below State, national and regional values.

Again, contrary to TCW and CH_2M Hill's most recent claims of Project benefits to the host community, DWR's own Report shows that the Project has instead helped depress the value of local real estate. The rate of increase in value for local real estate has significantly lagged behind the rate of property value increase experienced in other areas in the Northern California region, as well as lagging behind property value increases for the State as a whole.

3.4 The Report Underestimates the Number of Visitor Days to Devalue the Impact of the Project On Butte County

As explained in response to the CH_2M Hill Report at Section 2.1.1 above, the County used DWR data to estimate visitor days at the Project. The TCW Report fails to address if, or how, the fiscal impacts on the County would vary between a visitor staying at the Project all day, or traveling between various locations within the Project. Further, the County's *Operational Impact Report* used peak period impacts for those services and cost items that must be based on peak demands. Certainly fire trucks, police cars, road equipment and maintenance must be sufficient to meet peak demands. Additionally, as explained in the *Operational Impacts Report* and above at Section 2.3, highly trained fire, law enforcement and rescue personnel must be hired on an annual basis and to meet peak period demands. Further, because many other State agency law enforcement personnel for the Project are reduced or reassigned for the winter period the Butte County law enforcement responsibilities at the Project are not substantially reduced in the winter period. Although there are fewer Project visitors in the winter period, Butte County law enforcement and fire personnel must respond to a high percentage of the total incidents and calls for assistance at the Project that do arise.

The TCW Report at Section 3.1.1.2 criticizes the County's use of the Area of Highest Use for computing road impacts. As discussed more fully above, however, the County's assessment of Project impacts on its roadways was based on a road-specific and area-specific analysis of the primary roads used by non-resident Project visitors. In addition, of the County's total road maintenance costs for those roads only a small percentage of its costs were allocated to Project demands. In fact, in order to avoid disputes the County used the lower end of the cost allocation range by excluding many Project-related costs.

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[55] Property Values Report at p. 22.

These conservative assumptions included:

- The County's calculated average annual cost per mile of maintenance rate does not take into account the In-County Project visitors who travel the same roads to the Project. Absent the Project, these County residents would not be traveling the roads that lead to the Project and there would be less wear and tear on the roads.

- The rate does not include non-visitor travel on the roads related to the Project including, but not limited to: garbage trucks, sewage/septic service, medical/rescue vehicles, law enforcement vehicles, tow trucks, and State staff that provide direct services to the Project.

- The rate does not take into account the greater burden on the roads from the heavier vehicle used by non-resident visitors, including boat trailers with boats and recreation vehicles.

- The County only included major arterial and connector roads in calculating the costs to the County. There are many minor County-maintained roads used by Project visitors that were not included in the calculation.

At Section 3.1.1.3 the TCW Report criticizes calculations on law enforcement service demands because they are higher than actual service levels. A fatal flaw in the original R-19 report, noted by the County on several occasions, is the Report's reliance on Butte County's current budget as a true indicator of service demand and need. As discussed above at Section 2.4, Butte County suffers from severe economic problems and is unable to afford needed law enforcement staffing, as documented by the State of California. Relying on Butte County's current budget as a measure of service demand, as DWR R-19 Report does, fails to recognize legitimate and documented unmet needs in law enforcement.

4.0 BUTTE COUNTY SUPPORT FOR THE PROJECT AND OTHER CONCERNS

4.1 Butte County's Initial Support For The Project

Throughout this proceeding, MWD has pointed to the strong support the Project enjoyed in Butte County at its inception. What MWD fails to note, however, is that this support was predicated on public statements from the licensee and promised benefits that never materialized. For example, DWR proposed the construction of a lodge at Kelly Ridge,[56] a monorail to transport visitors from Kelly Ridge to a switchyard area where the flow of

[56] For a detailed explanation of the improvements proposed, see Department of Water Resources Economic *Analysis of the Oroville Visitor Facilities*, February 1966. The lodge is described on page 42.

electricity would be regulated,[57] a steam train to transport visitors from the station adjacent to the Oroville Municipal Auditorium (visitor parking),[58] as well as a restaurant and snack bar in the visitor center.[59] DWR also projected annual visitor days to the Project of 2,400,000 by the year 2008.[60] Thus, initial public support for the Project was predicated on DWR commitments to make the Project's recreation areas a true recreation and economic benefit to the County and its citizens. Unfortunately, none of those promises were kept by DWR and the County and its citizens continue to bear the costs of DWR's decision to export all Project benefits while leaving the County to suffer under the Project's economic burdens.

4.2 DWR's Response To Non-Settling Intervenors

DWR filed a response to the intervention of Butte County and other non-settling intervenors on May 26, 2006 ("DWR Response"). In its response DWR claims "[i]t is abundantly clear that the real objection of the non-settling intervenors is not to the process, but to the fact that the process did not give them the particular results they desired." (DWR Response at p. 10) The County disagrees. In reality, DWR through its ALP process failed to meaningfully analyze, discuss, and address the continuing major unresolved issues of Butte County, the Project's host community, all three federally recognized Native American tribes, and the water districts holding water rights senior to DWR on the Feather River.

FERC staff assigned to the ALP process have acknowledged that the Butte County team of staff, consultants, and attorneys constructively and proactively engaged in the ALP and relicensing process. On numerous occasions the County team gave suggestions to DWR on how to improve the process and move it forward more expeditiously.

Unfortunately, from 2004 on, the process became increasingly one-sided and opaque as DWR only focused on completing its license application by January 2005. Implementation and consequent completion of Phase 1 studies were delayed and the PM&E submission and review process had to proceed without necessary study results. DWR publicly acknowledged this problem but said that the process had to move forward because of the January 2005 application deadline. DWR had promised that follow-on Phase 2 studies would be performed to assure the County and other local participants that short-comings in the Phase 1 studies would be remedied by the Phase 2 studies. However, non-environmental Phase 2 studies only occurred on a very limited basis because of significant Phase 1 study delays. DWR also asserted that it spent too much money on Phase 1 studies and had no additional funds for Phase 2 studies.

From 2004 on, it became increasingly clear that unless an ALP participant had negotiating leverage with DWR, such as federal agencies with mandatory conditioning

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57 *Id.* at 15.

58 *Id.* at 16.

59 *Id.* at 14.

60 *Id.* at 19.

authority, the proposed PM&E would not be seriously considered by DWR, regardless of the data and the PM&E's merits, unless it fit within DWR and the State Water Contractors' undisclosed cost parameters. Otherwise, DWR would have the PM&E classified as a settlement item at the Work Group level, which resulted in the effective termination of any further consideration of the PM&E at any level.[61]

4.3 Thermalito Afterbay Water Temperatures

During the ALP process, the County was under the impression that discussions between DWR and the Water Districts were being held and that objective studies were being conducted that would assess the damage being done to the local rice crops by the colder water being delivered to the Water Districts. Such studies were also supposed to look at the potential for further damage that might occur with the proposed lower water temperatures necessary for anadromous fish.

However, so far the local water districts' and DWR's filing show that they are in complete disagreement. DWR has not adequately addressed Butte County's PM&E #3, entitled "Thermalito Afterbay Water Temperature Improvements," and dated August 26, 2003. PM&E #3 contained proposed structural and operational improvements that would provide warmer water for the local rice farmers and colder water for anadromous fish.

Sadly DWR's comments on this and other issues continue to reflect DWR's inability to effectively address the adverse County impacts and concerns.

5.0 CONCLUSION

As demonstrated by the County's Operational Impacts and Socio-Economic Studies, and again in this Response, Butte County has borne the brunt of the adverse impacts of the Project for 50 years. As the saying goes, "justice delayed is justice denied," and the Federal Power Act's re-licensing requirement is designed to give communities, like Butte County, the ability to periodically raise issues relating to the Project's impact on their community. Butte County respectfully requests the Commission find that the permit conditions proposed by the County represent the only just and reasonable outcome in this, and that FERC impose permit conditions on the Project that will mitigate the Project's adverse impacts on the citizens of Butte County.

61 The ability and right to appeal disputes over PM&Es to the Plenary Group, as specified in the May 1, 2001 Process Protocols and unchanged in the January 26, 2004 revision, was terminated when DWR held the last Plenary Group meeting on May 18, 2004.

Exhibit 1

MEMO
6/20/2006

TO: Paul McIntosh
Chief Administrative Officer
County of Butte
25 County Center Drive
Oroville, CA 95965

FROM: Jon Ebeling, Ph.D.
Consultant to Butte County regarding economic impact and survey research

RE: My opinions on the percentages reported by the California Department of Water Resources of Visitors to the Lake Oroville recreation from outside of Butte County.

I have a unique background for this assessment since I was a member of the technical Review Team established by the California Department of Water Resources, (DWR) beginning my participation at the early meetings. I am also a retired professor who specialized in Public Finance, Statistics and Survey Research at California State University, Chico. I taught these subjects for thirty two years at the University and I have a Ph.D. in Economic Development.

Things to note:

1. While trying to estimate from the data DWR has supplied, mainly in R-13, Recreation Surveys, it is clear that DWR's consultants have not done a high quality job.

2. They reported the use of the following methods to get data that might give estimates of various issues related to attendance and use of the Lake Oroville facilities. Only a small portion of their work focuses on estimating the number of persons from outside the County. The primary survey they use for this estimate is an on-site survey consisting of 2,583 completed face to face interviews in the field. They also conducted a Hunter Survey, a similar site survey, and a household survey. The latter is a subset of the face to face survey relying on a very weak method of data collection. The surveys of hunters and similar sites do not lend themselves to estimation for the number of persons who is from outside the County.

3. The face to face survey indicates what is shown here as Table 1. It is from R-13 "Recreation Surveys" Final, dated December 2004. Table F-1 on Page F-1 has the survey data on respondents from inside Butte County and outside Butte County. These Survey methods have been criticized extensively by this author in other filings. In summary the criticisms indicate failures to control for errors, failures to provide important information on responses to the mailers and failures to provide tabulations on question responses.

Further the sampling frames are not high quality in terms of the coverage of data collection at random times and random places. Consequently, the errors in these survey results are potentially high.

4. There are frequent references to "professional judgment" in the R-19 report referenced earlier in this memo. These terms are never made clear. The result is that the reader cannot feel that the data I reliable. Thus one has to question the veracity of the estimates of visitors to the facilities from inside and outside Butte County. Frequently, references are made to adjustments to the data, but there is no effort to show either how the adjustments were made or the effect of the judgments on the data being presented.

5. The sample sizes for the survey were clearly inadequate to obtain precise estimates by resource sites; this is especially true for some of the sites as will be shown in Table 3. The R-13 Report states that there is a response rate of mail back surveys equaling 45%. This is not correct since the division of 1,071 by 2,583 produces a value of 41.5%. Further there is no clear information on non responses within the mailed back questionnaires. Often times, self administered questionnaires yield poor quality data because persons cannot follow the script nor do they wish to answer all questions. Telephone follow ups might have improved that surveying.

6. Table F-2 indicates that the Respondents from Butte County are 53.5% of the sample of on-site persons surveyed; that means that 46.5% of the face to face respondents came from outside of Butte County. The Confidence interval for this is 48.2% at the upper end and 44.9% at the lower end using the confidence levels DWR uses, 90%.

7. A high quality firm will provide a basic set of tables showing the response rates and responses for each of the questions in the surveys being used. This is helpful as it adds to the understanding of the data processing and provides a higher sense of confidence in the survey research firm.

The data in Table 1 comes from "Recreation Surveys" R-13, final dated December 2004. Page F-1 has Table F-1 entitled "On-Site Survey respondents from Butte County".

TABLE 1
EXTRACTED RESULTS FROM DWR REPORT USING THE ON SITE SURVEYS
(IN PERCENTAGES)

	Lake Oroville	Diversion Pool	LFC	Thermolito Forebay	Thermolito Afterbay	OWA
Butte County Residents	50.3	59.7	71.8	78.0	62.2	35.3
Other Counties	49.7	40.3	28.2	22.0	37.8	63.7

The on site survey consisted of a face to face contact and then a mail back survey. The latter is used to estimate spending behaviors after the respondent has completed the recreation activity. OWA stands for Oroville Wildlife Area. LFC refers to the "low flow channel", located below the Diversion Pool and offering viewing opportunities, tours, and educational education events.

There were 2,583 surveys by the on-site method across the six resource areas in Table 1. Table 2 indicates the On-site and Mail back survey samples by resource areas. This is also from the Report R-13, page 4.12.

In general methodologically, this is very poor quality survey research. DWR should have obtained phone numbers, asked for an interview follow up and dates to call and then proceeded with that method to obtain data. As it is, this data provides only 41.5% of the total respondents interviewed face to face and DWR uses this sample for estimating spending behavior in R-18 and R-19. We don't know how the response rate is calculated, and the reports do not show the final response rates by questions inside the survey. This would have ensured a more reliable set of estimates.

Overall reliability can be estimated with the use of confidence limits. Here are the confidence limits for the data on the sample of face to face interviews, 2,583 respondents. The upper limit of a question which has a 50% to 50% response rate, a procedure using the most conservative calculation for limits, has 50.8% as the upper limit and the lower limit is 49.2%. This means there is a 10% chance that the true value lays outside these limits in repeated samples of this group.

If the sample size is decreased then the precision of the estimate is widened as exemplified here with a sample of 1,071 respondents. The upper limit is 51.3% and the lower limit is 48.7%. So as an example the estimation of the spending behavior is less precise in this data because the sample of mailed back questionnaires is smaller.

TABLE 2
SAMPLE SIZE OF THE TWO SURVEYS

	On-site Survey		Mail back Survey		
Resource Area	Sample size	Percent of Total sample	Sample Size	Percent of Total sample	Participation Rate in Percents
Lake Oroville	1,396	54.0	632	59.0	45.3
Diversion Pool	62	2.4	32	3.0	51.6
LFC	169	6.5	58	5.4	34.3
Thermal to Forebay	311	12.0	99	9.2	31.8
Thermal to Afterbay	295	11.4	120	11.2	40.6
OWA	350	13.6	130	12.1	37.1
Total	2,583	100.0	1,071	100.0	41.5

Notice that some of these survey samples are extremely small. This has been a criticism of mine for a long time on this project. Their response has always been there is not enough money to do a larger sample. They have used a technique of data collection, the mail back survey, which I find very poor quality. This is particularly important since it serves as the basis for estimating the dam's impact on the County.

Table 3 shows the confidence limits for those outside Butte County at various locations around the facility. These are based on using the percentages from Table 1. A 90% confidence interval is calculated here, too.

TABLE 3
UPPER AND LOWER LIMITS OF THE OUTSIDE BUTTE COUNTY ESTIMATES PRODUCED BY DWR AT THE SEVERAL RESOURCE SITES AROUND LAKE OROVILLE
(In percentages from R-13)

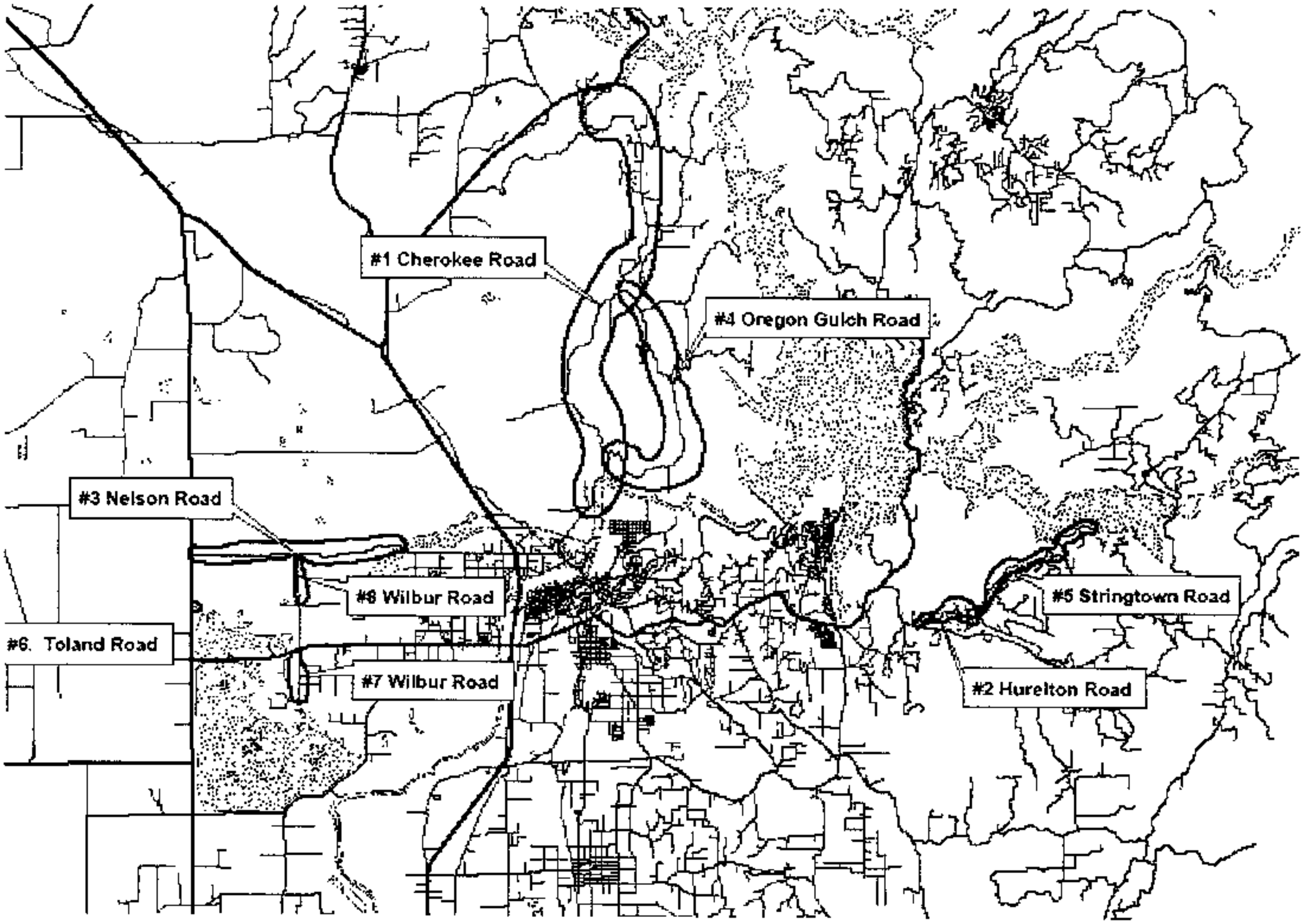
Resource Site	Sample size	Lower limit	Upper limit
Lake Oroville	1396	47.5	51.9
Diversion Pool	62	30.0	50.6
LFC	169	22.5	33.9
Thermalito Forebay	311	19.7	24.3
Thermalito Afterbay	295	33.1	42.6
OWA	350	59.5	67.9

As I've noted there are serious problems in reliability with this data for making estimates of persons participating from inside or from outside of the County. In addition, the data that drives the economic impact models uses this material for estimation. It is unfortunate but this material remains the only data base available to estimate the number of persons who come from outside the County and who spend money here.

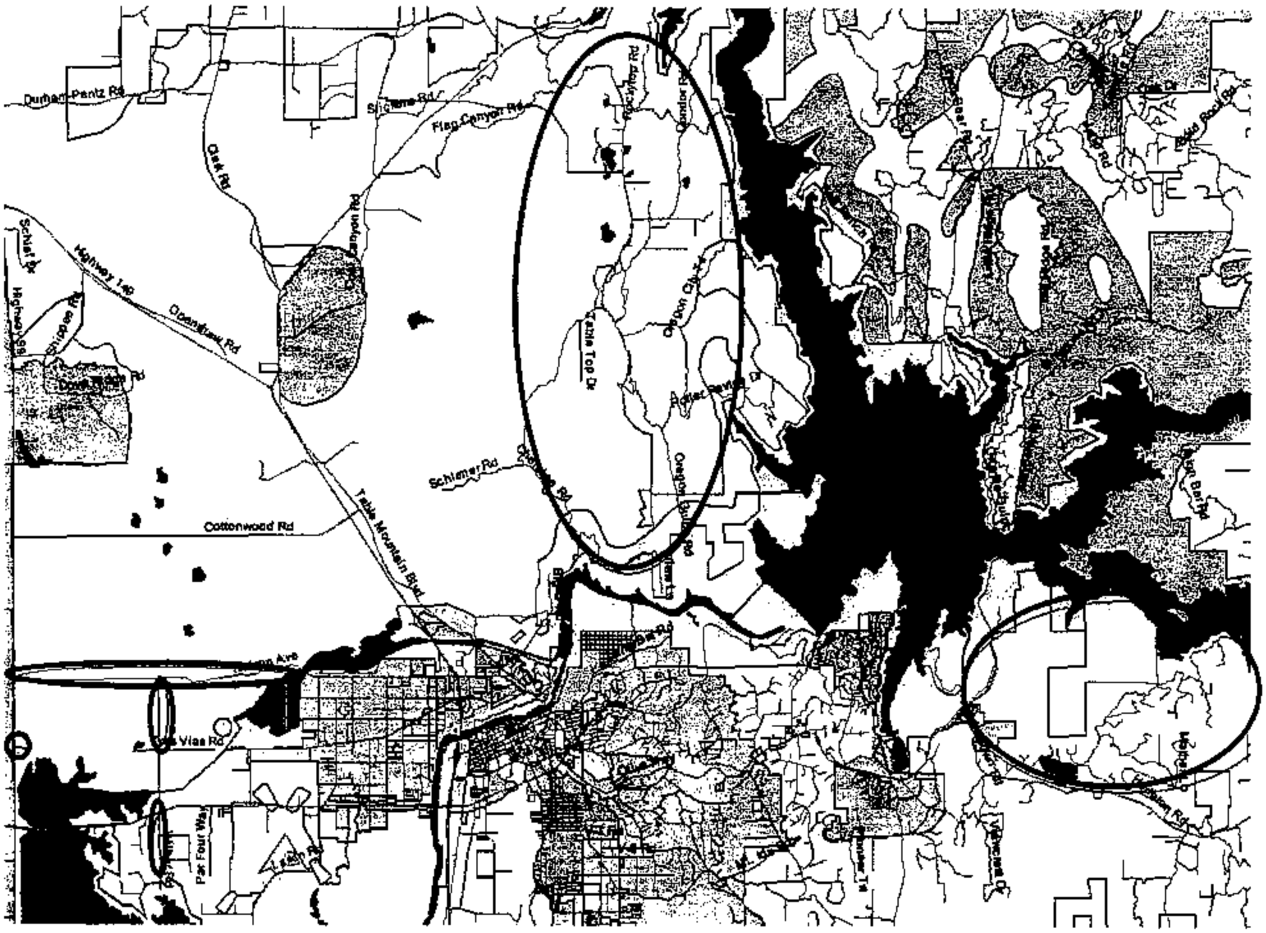
Appendix A

Butte County Roads

Map 1
Eight Stretches of Roads Listed in Exhibit 10



Map 2
General Plan Designations

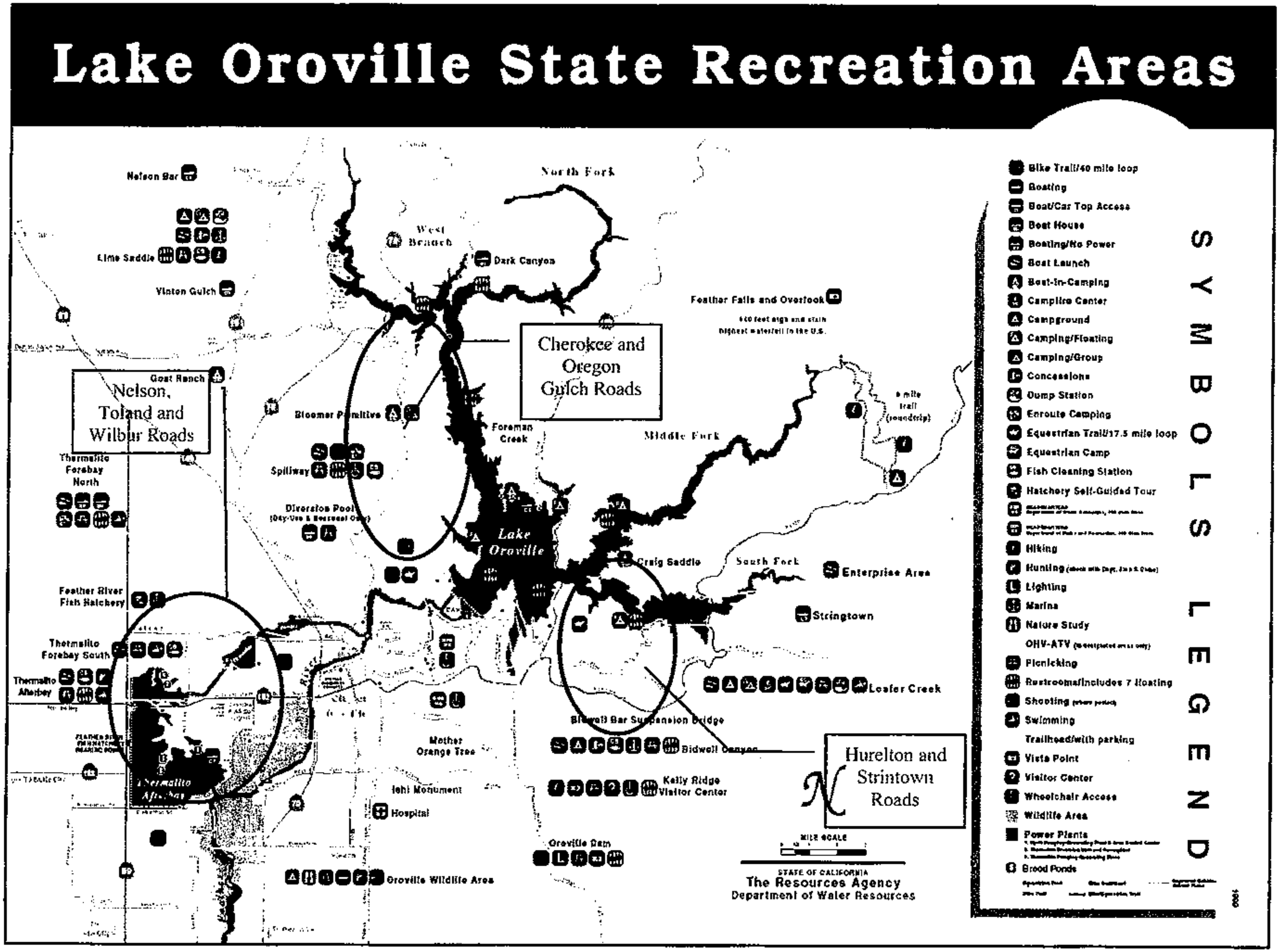


Legend

Grazing and Open Land (GOL) – 40+ acres per parcel – 1 single-family dwelling unit per parcel

Agricultural-Residential (AR) – 1-40 acres per parcel – 1 single-family dwelling unit per parcel

Map of Project
Access on Unpaved/Substandard County Roads



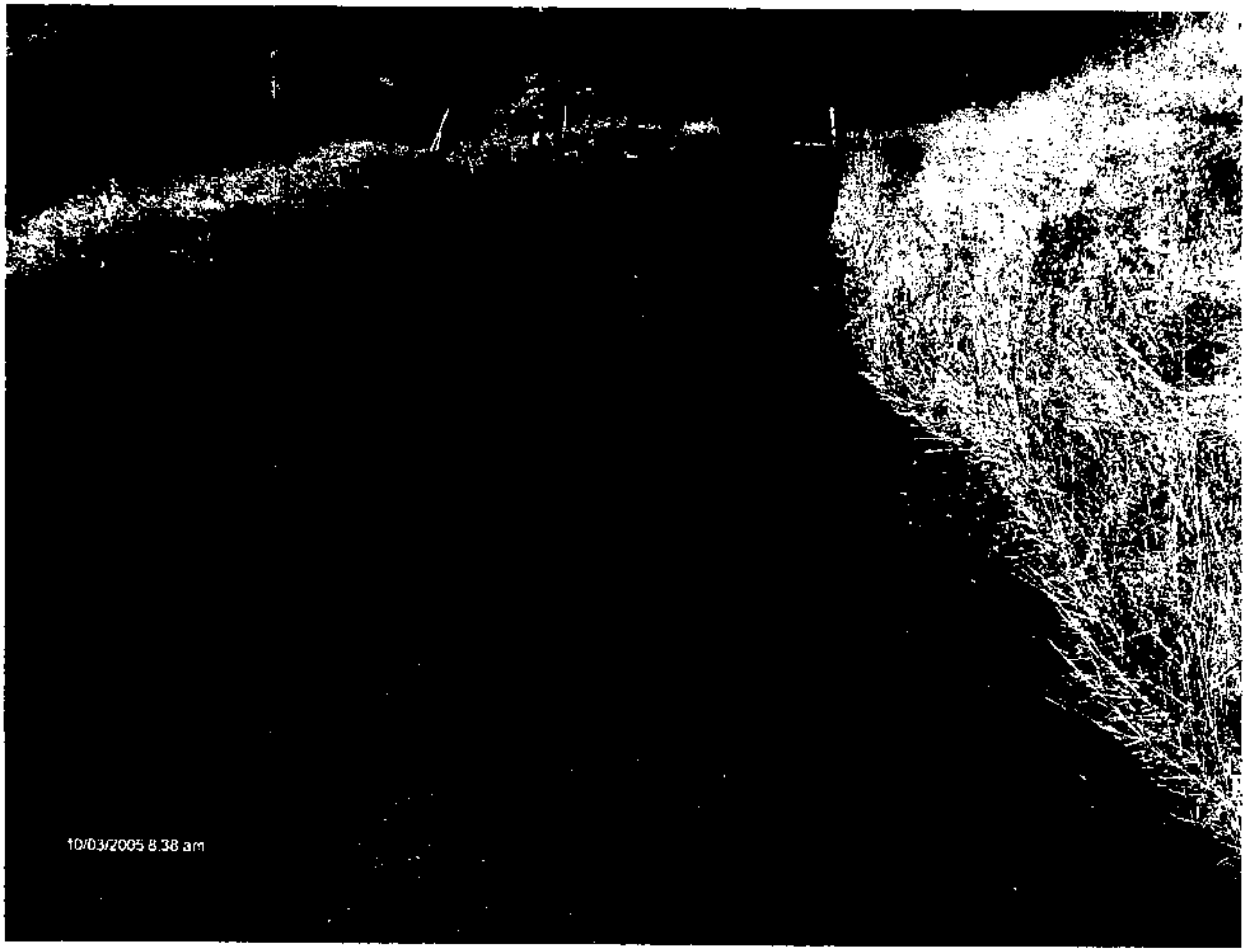


Figure 1
Cherokee Road
Source: Tom Odekirk, Butte County Public Works, October 3, 2005

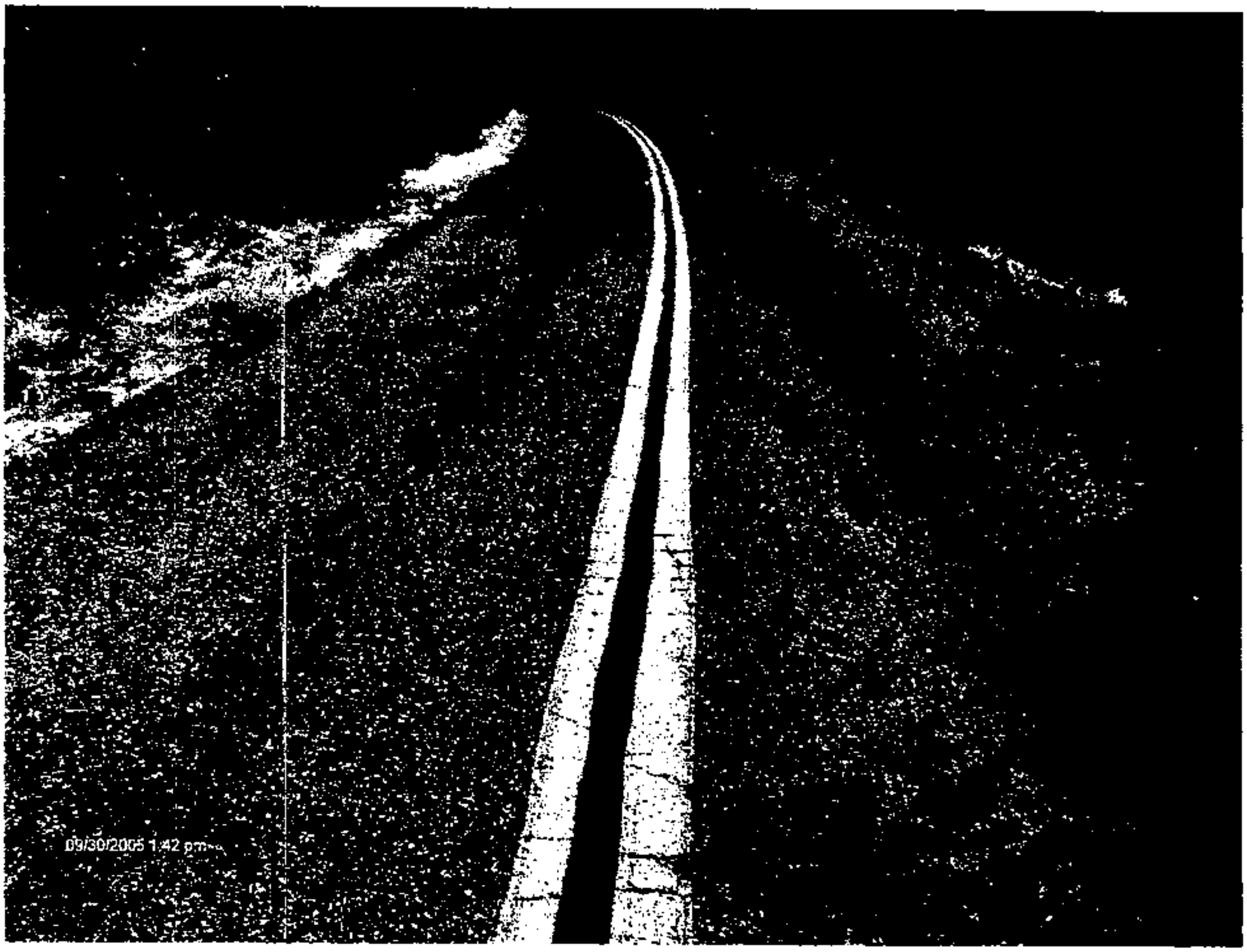


Figure 2
Hurelton Road
Source: Tom Odekirk, Butte County Public Works, October 3, 2005

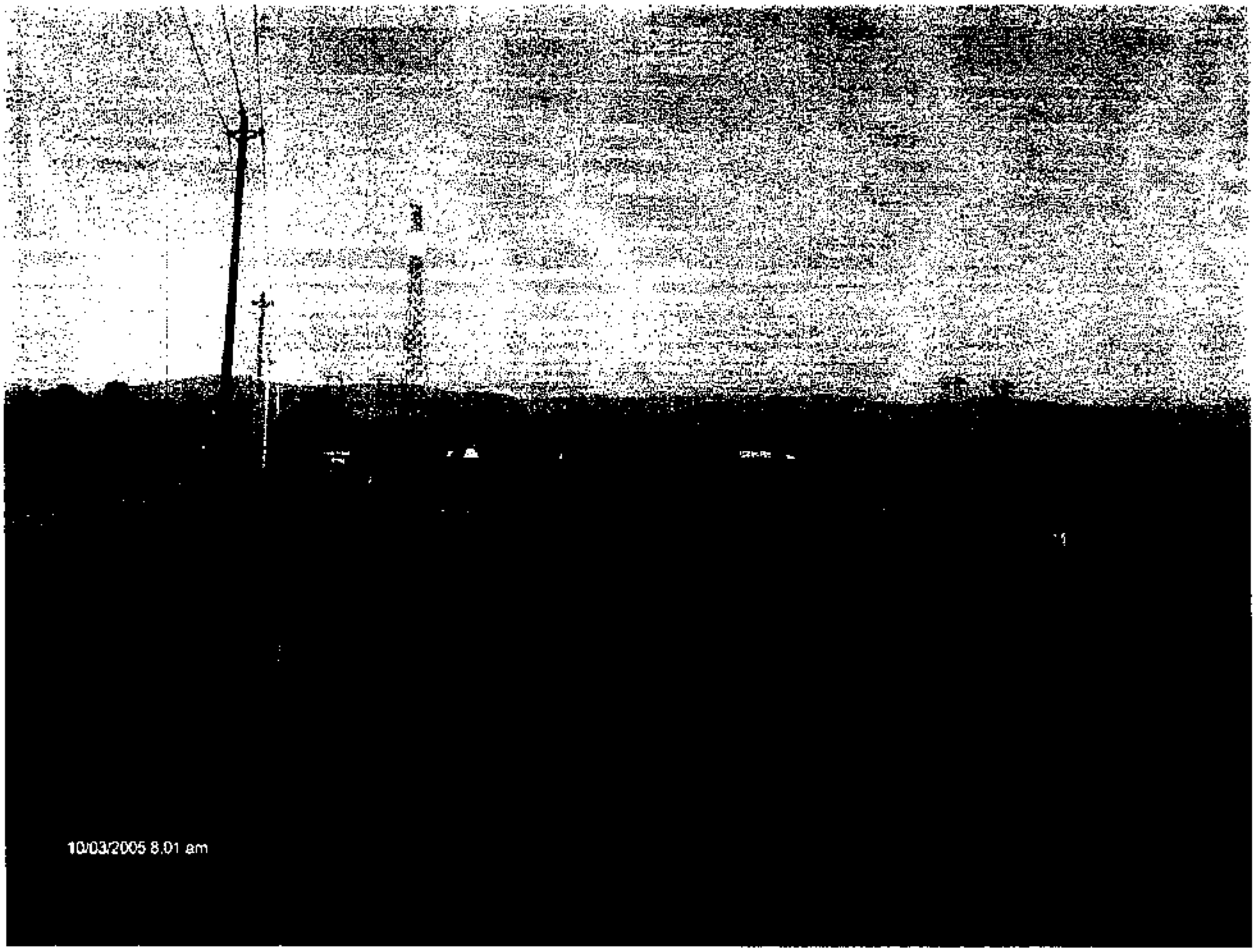


Figure 3
Nelson Road
Source: Tom Odekirk, Butte County Public Works, October 3, 2005

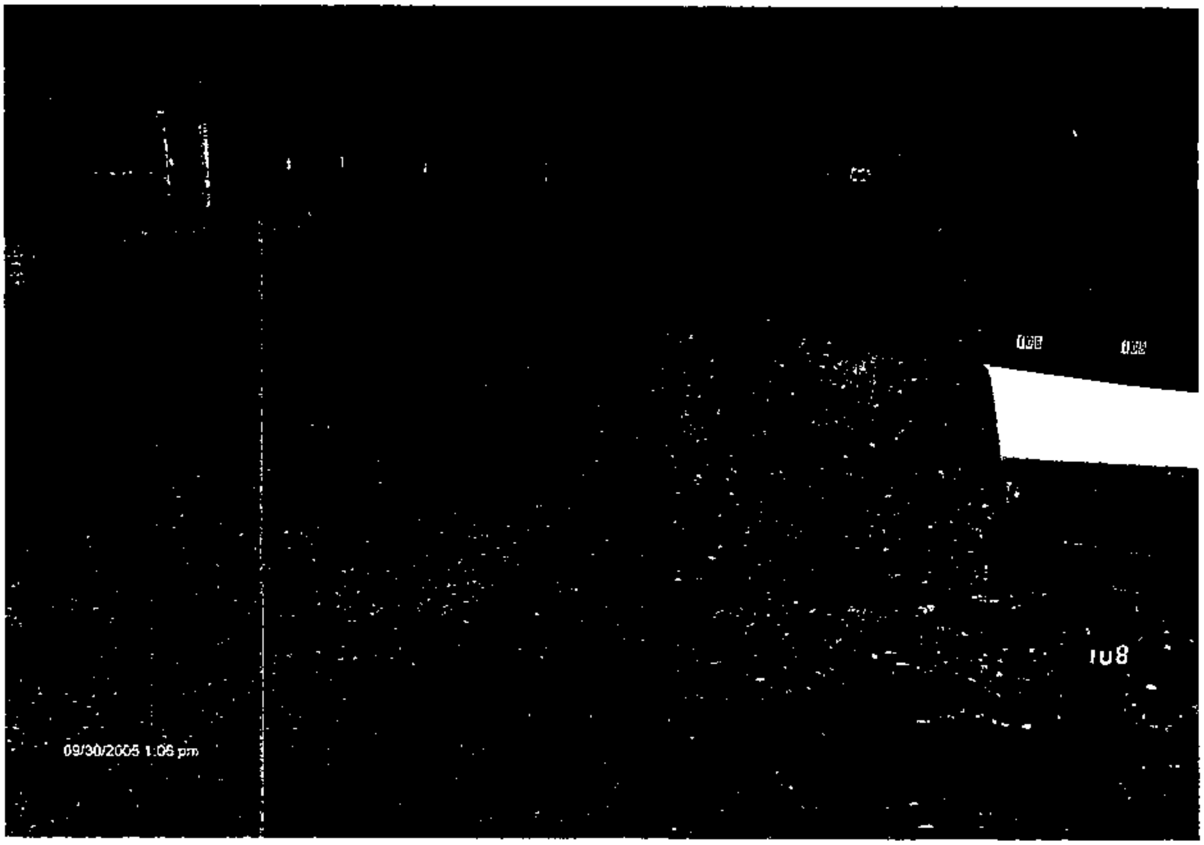


Figure 4
Stringtown Road
Source: Tom Odekirk, Butte County Public Works, October 3, 2005

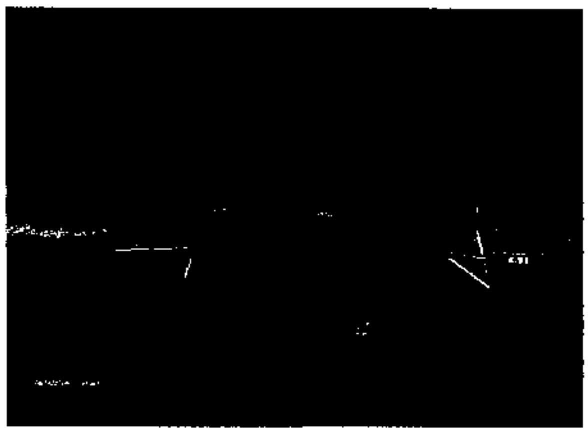
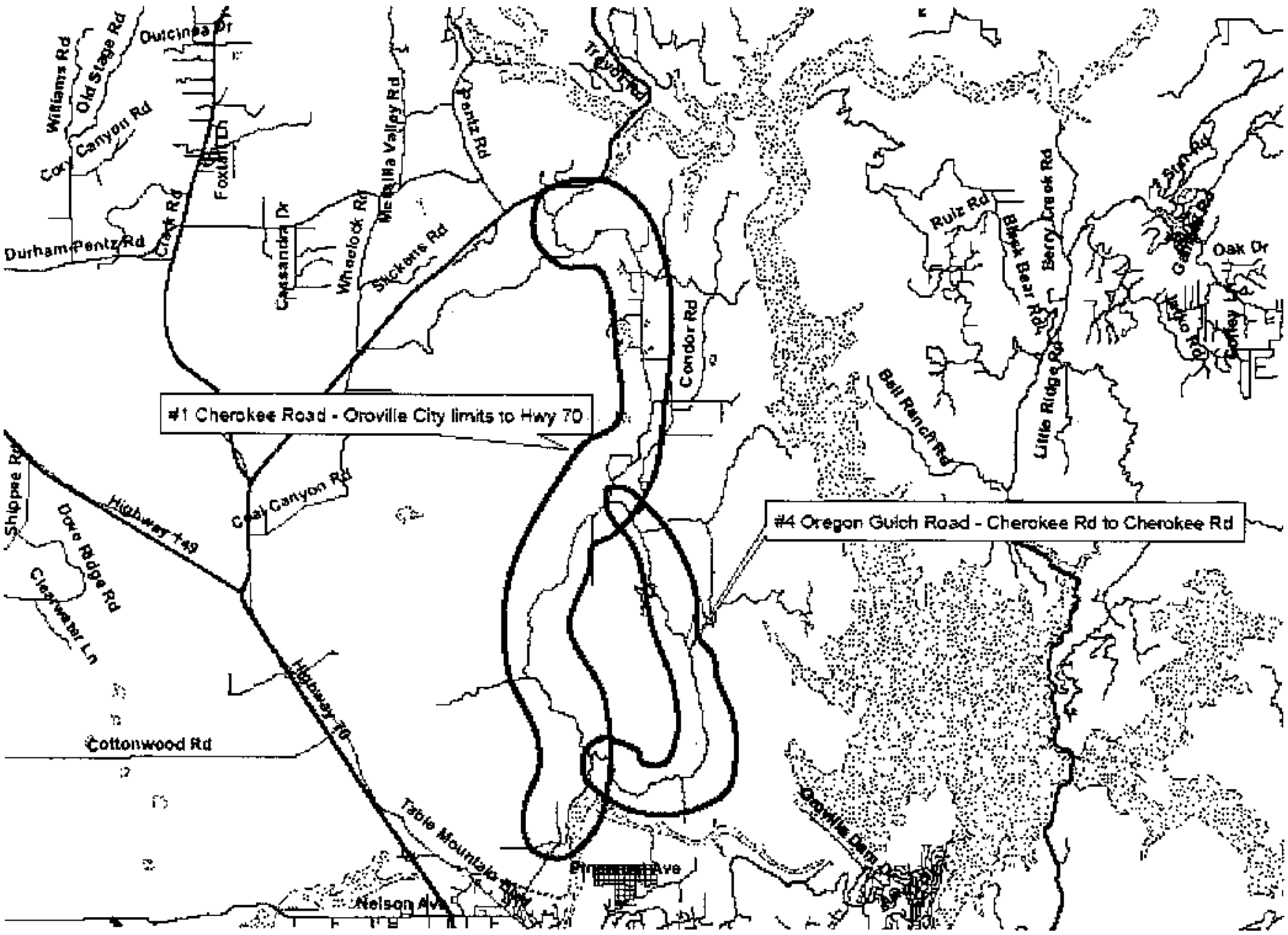
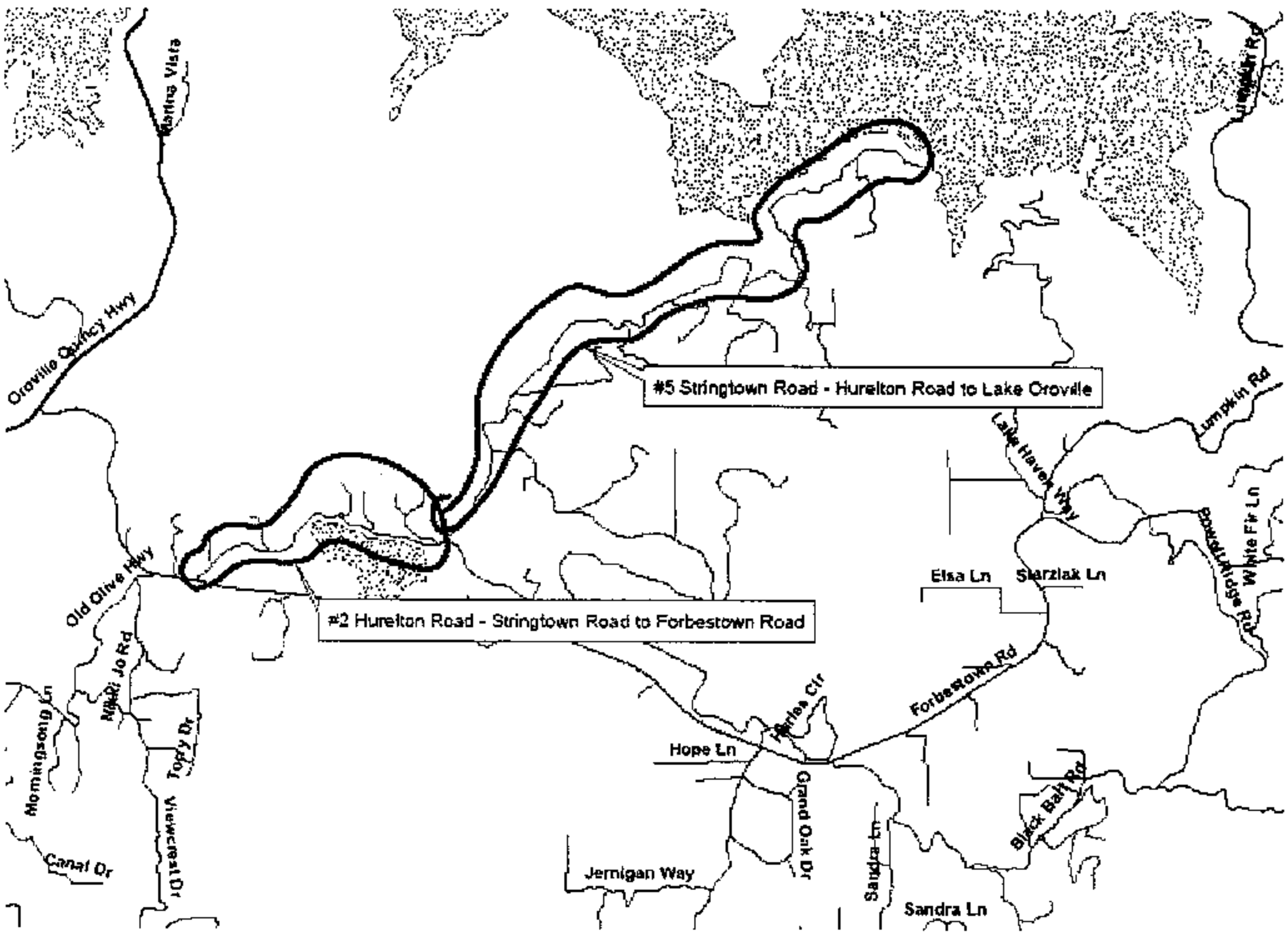


Figure 5
Toland Road
Photos taken by Tom Odekirk, Butte County Public Works, on June 6, 2006

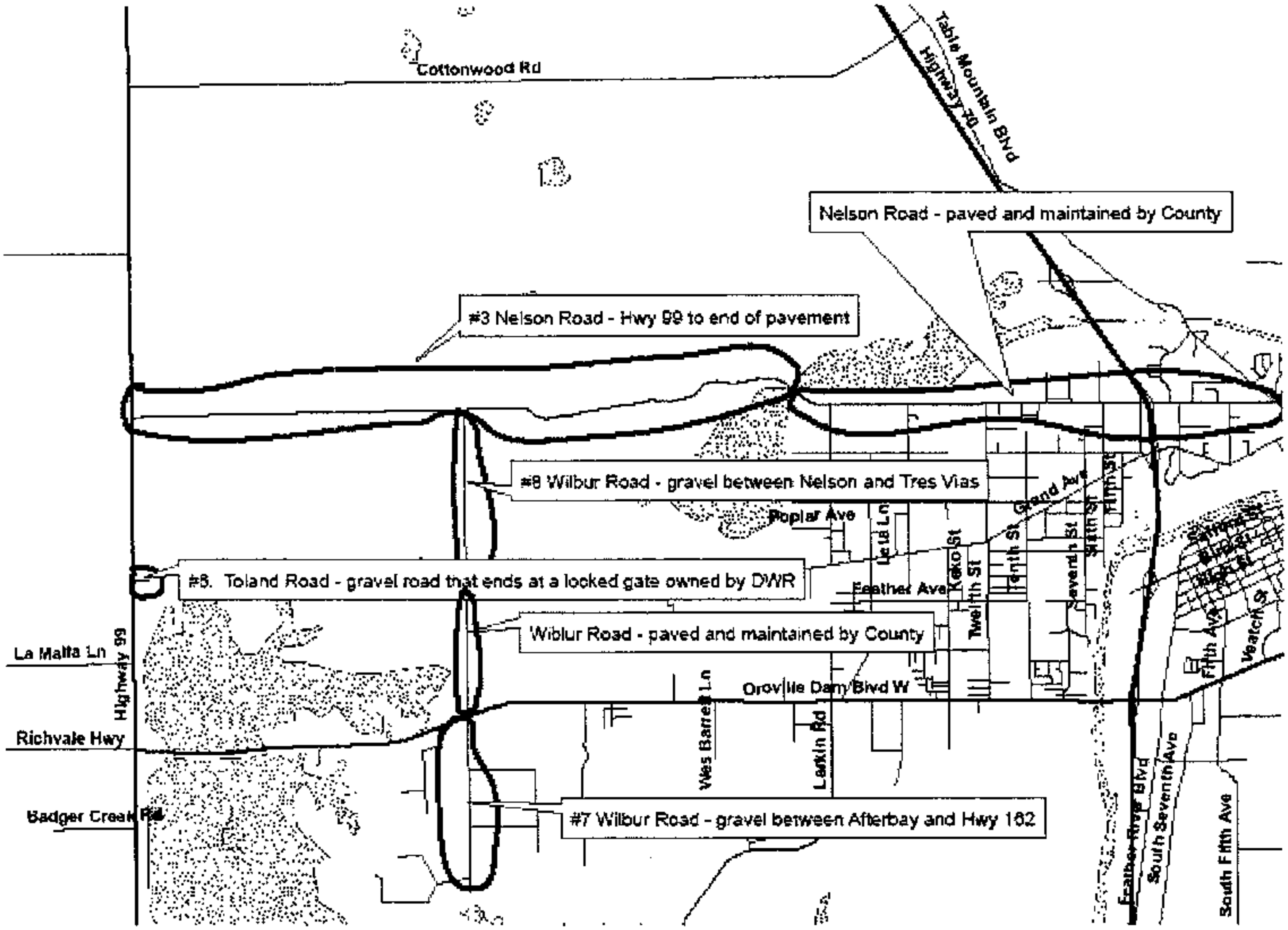
Map 4
Cherokee Road and Oregon Gulch Road
Access to Bloomer and Potter Ravine areas of the Project



Map 5
Hurelton Road and Stringtown Road
Access to Stringtown area of the Project



Map 6
Wilbur Road, Toland Road, and Nelson Road
Access to Afterbay and Forebay



UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

CALIFORNIA DEPARTMENT OF WATER RESOURCES	OROVILLE FACILITIES PROJECT NO. 2100

AFFIDAVIT OF PAUL MCINTOSH

STATE OF CALIFORNIA)
) ss.
COUNTY OF BUTTE)

Paul McIntosh, being first duly sworn upon oath, states as follows:

1. I am over 18 years old, have personal knowledge of the facts stated in this affidavit, and am competent to testify to these facts.

2. I am the Chief Administrative Officer for Butte County, California, a position I have held since 2002. My office is located at 25 County Center Drive in Oroville, California within the zip code 95965.

3. I have over 25 years of local government experience, including 20 years of experience with Northern California counties. I hold a master's degree in public administration with an emphasis on public finance and public management.

4. Under my direction, County personnel with responsibility for specific impact areas assisted in preparing a response to both the "Response of the State Water

Contractors and Metropolitan Water District of Southern California to Interventions Protests and Comments" (filed with the Federal Energy Regulatory Commission ("FERC") on May 25, 2006, and docketed as eLibrary Accession No. 20060525-5069) and the "Response of the California Department of Water Resources to Recommendations, Terms and Conditions, Prescriptions, and Settlement Comments" (filed with FERC on May 26, 2006, and docketed as eLibrary Accession No. 20060526-5039).

7. The report prepared by County Personnel under my direction is entitled "Butte County, California's Response to the May 2006 Reports of CH_2M Hill and TCW Economics."

8. A true and correct copy of "Butte County, California's Response to the May 2006 Reports of CH_2M Hill and TCW Economics" is attached to this filing.

DATED this 23 day of June, 2006.

Paul McIntosh

Paul McIntosh

SUBSCRIBED and SWORN to before me this 23 day of June 2006, by Paul McIntosh.

Print Name:__________
Notary Public in and for the State of California, residing at __________
My commission expires: Oct. 29. 2006

State of California County of Butte

Subscribed and sworn to (or affirmed)
Before me on this 23 day of June, 2006, by

Paul McIntosh

personally known to me or proved to me on the basis of satisfactory evidence to be the person(~~s~~) who appeared before me.

Signature Kelly M. Sloan, Notary Public

KELLY M. SLOAN
Commission # 1382280
Notary Public - California
Butte County
My Comm. Expires Oct 29, 2006

APPENDIX B

Comments of FMY Associates, Inc. on Filings Submitted by California Department of Water Resources and the State Water Contractors Regarding the Socio-Economic Impacts of the Oroville Project Facilities on Butte County, California

(June 2006)

APPENDIX H

APPENDIX H

SPATIAL DISTRIBUTION OF WATER TEMPERATURE AFFECTS ON RICE PRODUCTIVITIY

PREPARED BY RANDALL G. MUTTERS,

UNIVERSITY OF CALIFORNIA

APRIL 20, 2007

Spatial Distribution of Water Temperature Affects on Rice Productivity

Final Report prepared for the California Department of Water Resources

May 1, 2005 to April 30, 2006
With an extension to June 30, 2006

Randall G. Mutters
University of California
2279 B Del Oro Avenue
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April 20, 2007

Executive Summary

Rice production in California is uniquely situated in the heart of the state's largest watershed. The water used for irrigation is often diverted from rivers with dams where water temperatures are controlled to optimize fish habitat and frequently sub-optimal for rice production. Potential problems associated with low water temperature (Tw) and rice production in California associated with dam construction were first reported in the 1950's and 1960's. Subsequent published studies (e.g. Roel et al, 2005) reported rice yield losses as high as 25% in the intake checks due to low Tw originating from the Feather River. To better describe this phenomenon, a controlled study was conducted at 6 sites located throughout the rice production area that uses water diverted from the Thermalito Afterbay. All sites were fitted with a network of Tw and air temperature recording sensors. Temperatures were logged continuously throughout the growing season. Plant growth and health were observed at regular intervals. Experimental plots adjacent to the temperature sensors were harvested with the UCD research combine. Growers reported yields were also recorded. Thermal infrared images (TIR) were captured on three dates and equated to Tw and yield to test if remotely sensed data can predict rice yields. Data were analyzed using a series of regression and ANOVA procedures and graphically illustrated with a geographic information system.

Prolonged exposure to cold water reduced the yield of rice at all locations. The yield loss, averaged across locations was 14% based on experimental data. The total number of hours of Tw below 65 F from planting to panicle initiation (TNPI) predicted yield loss whether the field data were analyzed individually or pooled in various combinations (p-values of 0.05 or lower). Low yields were associated with delayed and reduced plant growth. Remotely captured TIR images predicted Tw, TNPI, and yield at two sites with a significant degree of confidence. This approach was inconsistent at the other research sites and requires further investigation to establish its reliability.

Low temperature water such as that originating from the Feather River adversely impacts rice productivity and results in substantial yield reductions. The water temperature related yield loss was evident throughout in the rice production zone served by the irrigation districts diverting water from the Thermalito Afterbay.

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Richvale Irrigation District site 2	R-2
Biggs West Gridley Irrigation District site 1	B-1
Biggs West Gridley Irrigation District site 2	B-2
Joint Water Districts Board	JWDB
Western Canal Water District	WCWD
Richvale Irrigation District	RID
Department of Water Resources	DWR
Water temperature	Tw
Hours < 65 F planting to tiller	TNTL
Hours < 65 F planting to panicle initiation	TNPI
Panicle initiation	PI
Days from planting to tiller	DTT
Days from planting to PI	DTPI
Heads per area	HA
Seeds per head	SH
Plant height at harvest	PH
Moisture content	MC
Thermal infrared	TIR

Introduction

Rice is the primary crop in the Sacramento Valley of California, typically occupying approximately 550,000 acres. Since the interior valleys of California all have a Mediterranean climate, in which there is virtually no summer rain, the source of nearly all water for Sacramento Valley rice production is a network of reservoirs in the Sierra Nevada, Cascade Mountains, and their foothills that trap the runoff from snow melt.

Rice production in California is uniquely situated in the heart of the state's largest watershed. The production area is flanked to the south by a rapidly expanding urban area. It co-occupies an area with some of the remaining native salmon fisheries in the state. Consequently, water resource management decisions must attend to the needs of urban users, wildlife habitat, and agricultural production. The water used for irrigation is often diverted from rivers where water temperatures (Tw) are controlled to optimize fish habitat by releasing water at selected depths from reservoirs.

Following the construction of Shasta Dam in 1945, the Tw in the Sacramento River below the dam decreased by as much as 16 F (Raney et al, 1957). In the rice growing corridor adjacent to the river, growers found that often as much as five percent of their planted acreage did not mature in time for harvest. Raney (1963) postulated that the proposed construction of the Oroville Dam could have a similar affect on the Feather River Tw and the rice fields served by the river.

Feather River water is frequently colder than the optimum for rice production. Growers continue to observe reduced rice yields in large areas adjacent to the field water inlets. The extent of the yield losses attributable to low Tw in rice fields irrigated with Feather River water were documented by Mutters et al. (2003) and Roel et al. (2005). Plants exhibited delayed heading, heads that did not fill or mature by the end of the growing season. This same phenomenon, a reduction of irrigation water temperature delivered to rice fields after the construction of dams and the associated loss in rice productivity was also observed in Japan (Inoue et al, 1965).

Japan, like California, only grows japonica varieties of rice. Takamura et al. (1961) found that rice growth and yield are limited more by Tw than by air temperature (Ta) before the mid-reproductive period. Enomoto (1937) demonstrated that the rice plant growing in water with a temperature below 66 F, averaged over the period from transplanting to heading, did not produce grain even though the Ta was sufficiently high. Matsuo (1957) observed that rice required a minimum water temperature of 55 F to sustain growth. In a review article, Ogiwara and Terashima (2001) cite several studies carried out by Japanese scientists indicating that the physiologically critical Tw for the germination and early seedling growth is around 63 F.

Working in California, Chapman and Peterson (1962) studied the effects under laboratory conditions of Tw on early seedling growth and establishment. They found that at Tw less than 68 F there was a significant reduction in shoot elongation. Water temperatures between 77 and 86 F were concluded to be the most favorable for rice seedling establishment. Hearth and Ormrod (1965) studied the effects of Tw on growth and development of flooded rice seedling for different California rice varieties and found that shoot growth was retarded at a Tw below 61 F.

Shimono et al (2002) established fields trail for three years to determine the response of biomass and grain yield to Tw (61 to 65 F) at different crop stages. They found that grain yield was most severely reduced by low Tw during the vegetative period reducing grain yield by as much as 20%. Water temperature stress during the reproductive period also reduced yield. Ogiwara and Terashima (2001) found that under field conditions low Tw impeded root coleoptile growth, a critical factor in the establishment of rice seedlings under flooded soil conditions.

Mutters et al (2003) reported that the number of accumulated hours of exposure to Tw below 65 F accurately described the observed loss in productivity within a field, and that the period between planting and panicle initiation was the most sensitive. In a subsequent study, Roel et al (2005) compared two measures of water temperature affects. These authors reported that the total number of hours below the threshold proved equal to, or better than, the inverse degree-days model in describing the relationship between yield loss and low water temperature. A non-linear regression model relating yield loss to the total number of hours below a threshold adequately fit the data from two fields in two years in the Sacramento Valley.

Another important factor in the study of the effect of low water temperature on rice is the spatial distribution of the phenomenon. An understanding of the spatial distribution of water temperature may aid in the estimation of the extent of the affects, both within a field and regionally. Although the spatial distribution of water temperature may in principle be determined through a dense grid of temperature sensors placed in the field, a potentially less expensive method that also conveys the data with a higher spatial resolution is thermal infrared (TIR) remote sensing. This method has been extensively used to remotely measure both terrestrial and water temperatures at the surface of the earth (Lillesand and Kiefer, 2000). Torgerson et al. (1999, 2001) describe the use of TIR remote sensing to measure stream temperatures. There does not appear, however, to be any reported extensive discussions of the use of TIR images to estimate water temperature in rice fields.

The extent to which Tw management in the Feather River, and consequently the Thermalito Afterbay, adversely impacts regional rice production is a point of discussion in the relicensing of the Lake Oroville dam. To augment this discussion, more information was needed to better understand the severity and regional extent of the phenomena. Thus, a controlled study with two main objectives was launched. The first objective of the study was to ascertain the extent of and the degree to which low temperature water affects the productivity of rice within selected fields. The second objective was to evaluate the potential of remotely sensed TIR images to adequately predict rice yield loss on a regional level.

Contractual Objectives and Specific Tasks

1. Plan in-field study in coordination with DWR, WCWD and JWDB. Select six appropriate fields for experimentation and secure approval from owners and operators.
2. Install loggers in Check 1 and Check 3 of each experimental field at appropriate locations to provide adequate and representative data. The installed loggers will continuously record the temperature of water and ambient air temperature for the growing and maturing period of rice.
3. Record and document all stages of rice growth especially of any problems during the rice germination, growing and maturing season such as infestations, weed problems, application of herbicides and pesticides, any unusual weather events or any other

condition which occurs which would effect the fields experiment results and interpretation

4. Download collected data as frequently as weekly of sooner.
5. Obtain thermal infrared images of the area that includes the five experimental fields and the service areas of WCWD and JWDB or more and appropriate software for the interpretation of images. The timing of each image to be selected by mutual agreement of UC ANR and DWR. Calibrate the satellite images with yield monitor data to provide information in the distribution of yield effects on regional basis.
6. Arrange, coordinate, oversee, and record harvest yields of Check 1 and 3 from each experimental field and additional fields with irrigation turnouts as available. Harvest to be conducted with experimental and commercial harvesters.
7. Develop a relationship between experimental and commercial harvest yields to enable interpretation of additional commercial field monitor results at other fields (other than the experimental) with water delivery turnouts.
8. Prepare and submit a draft report.
9. Prepare final report.
10. Present results to Technical Work Group

Materials and Methods

Experimental design and objectives were formulated by the Technical Advisory Committee. Committee members were from the University of California Division of Agriculture and Natural Resources, California Department of Water Resources (DWR), Metropolitan Water District, State Water Contractors, Western Canal Water District, Richvale Irrigation District, Biggs West Gridley Irrigation District and consultants contracted by the DWR. The studies were conducted in six different fields in 2005. One located near the beginning and a second one near the end of each of the service districts of the Western Canal Water District (WCWD), Richvale Irrigation District (RID), and the Biggs West Gridley Irrigation District (BWGD) in Butte County California. The field sites were designated W-1 and W-2, R-1 and R-2, and B-1 and B-2 for the WCWD, RID, and BWGD sites 1 and 2, respectively. All fields are located near Richvale, CA (Latitude/Longitude coordinates: W-1 = 39.5224806/-121.6940058; W-2 = 39.5947334/-121.8766688; R-1 = 39.493708/-121.719008; R-2 = 39.5073038/-121.8104406; B-1 = 39.4351882/-121.745064; and B-2 = 39.3785238/-121.7822568) and were irrigated from water inlets from adjacent district irrigation canals.

At each location checks 1 and 3 were fitted with a grid or transect pattern of 25 recording dual channel temperature sensors (Hobo H8 Pro, Onset Computer Corporation, Bourne, MA). The data loggers were attached to stakes placed vertically in the field. Data logger locations were geo-referenced using a backpack differential global positioning systems (DGPS) receiver (Trimble AG 132, Trimble Navigation, Sunnyvale, CA). There were 18 sensors in check 1 and 7 sensors in check 3 at all locations, except R-1 where 17 sensors were located in check 1 and 8 in check 3. The installation pattern at R-1 was in a fan pattern radiating from the water inlet. By design and as approved by the Technical Advisory Committee, the intent was to describe the spatial extent of the 'cold water plume' originating the from the water inlet. Sensors were installed immediately before the fields were flooded for seeding. As the rice grew, the canopy air temperature sensors were moved upward so that they were always near the top of the canopy. Water temperature sensors remained immediately above the soil-water interface for the duration of the experiment. At all sensor locations, water and canopy temperatures were measured every 15 minutes over the growing season (May 1 to August 31) and downloaded weekly. The sizes of checks 1 and 3 at each experimental site are presented in Table 1. Field sizes were supplied by the USDA Farm Services Agency. These values are also used by numerous Federal, State, and Local agencies including the USDA, CA Department of Pesticide Regulation, and the County Agricultural Commissioner.

Table 1. The sizes in acres of checks 1 and 3 at all experimental sites in 2005. Source: USDA Farm Services Agency.

Location	Check 1	Check 3
W-1	12.10	12.10
W-2	22.50	23.00
R-1	17.65	22.30
R-2	12.10	12.10
B-1	19.95	13.20
B-2	14.25	19.59

With a degree of variation to accommodate the demands of each location, the collaborating growers managed the studies sites using standard production practices for the area (Hill et al., 1992). The specific cultivation practices, planting date, seeding rate, and pest management for each location are presented in Table 2. A description of the variety of rice grown at each location is provided in Table 3. The soils at all locations are generally classed as thermic soils in the flood basins of the Sacramento Valley. Specifically the soils at W-1, W-2, R-1, and B-1 are in the Esquon-Neerdobe complex: Fine, smectitic, thermic Xeric Epiaquerts. R-2 and B-2 soils were in the Lofgren-Blavo complex: Very-fine, smectitic, thermic Xeric Duraquerts (USDA-NRCS, 2006).

Days to first tiller, panicle initiation, and 50% heading were noted at all sensor locations. At harvest yield, yield components and percent blanking were recorded in the vicinity of each sensor. Sensors were removed before harvest. A sample plot (7.5 X 20 ft) was harvested with a research plot combine at each sensor location. Harvest moisture and plot yield were recorded. Cooperating growers harvested the entire area of checks 1 and 3 with production scale combines. Check 1 and 3 yields adjusted to 14% MC were provided by the growers. No experimental plot data was available from the R-2, check 3 location. The un-harvested area adjacent to the temperature sensors left by the grower following the commercial harvest operations was too small to recover an adequate yield sample. Interpolated ($1/d^2$) yield maps of the field were created using a geographic information system (Arcview, ESRI, Redlands, CA).

Yield reduction was computed as the percent of yield loss with respect to the most productive yield location in the field using the equation:

$$Y_r = 100\ (1 - Y_i/Y_{max}).$$

Where Yr is the percent yield reduction, Yi is the yield in lb/a (corrected to 14% moisture content) at location i, and Ymax is the maximum yield measured in check 1. The Statgraphics software package (Statpoint Inc., Herdon, VA) was used for correlation, regression analysis, and ANOVA. The low Tw exposure model was based on the total hours below a threshold temperature of 65 F from planting to panicle initiation accumulated over the period from planting to panicle initiation, approximately 80 days for each field (Mutters et al, 2003; Roel et al, 2005). The results of analysis relating yield loss to Tw are limited to check 1 at all sites. By design it was assumed that check 3 was not affected by water temperature. Unbiased regression models were chosen using Mallow's Cp statistic based on a comparison of total mean squared error to the true error variance. Durbin-Watson statistic was used detect the presence of autocorrelation in the residuals from a regression analysis (Neter et al, 1996). Multivariate regression analysis with yield as the dependent variable considered the following independent variables as predictors: DTT, DTPI, TNTL, TNPI, plant height at harvest, HA, SH, lodging, stem severity, and aggregate sheath spot severity. Milling yield appraisals were done by the USDA Federal Grain Inspection Service in West Sacramento. Milling yield is the of percent of unbroken, milled white rice remaining out of 100 pounds of paddy rice run through the milling process.

One approach to test whether a single universal model could be employed to describe plant response to low Tw was to combine data from multiple sites across and within irrigation districts into a master data set. Analysis revealed a striking difference in response of the early planted fields as compared to the late planted fields to low Tw. It was apparent that the single response function was unsatisfactory. Among the possibilities explored for combining data, the following were the most promising and are presented below: late planted sites, early planted sites, and the sites closest to the Afterbay (i.e the coldest sites).

Predawn thermal infrared (TIR) images in the 8-12 μm waveband were captured at each field (except R-2) three times during the seasons (June 22, July 7, and July 22) with an airplane mounted thermal infrared sensor. The scanning array thermal imager used built–in blackbody temperature references to continuously calibrate the HgCdTe multi-element detectors. These images were georeferenced to field coordinates using the ImageWarp extension of ArcView. Data loggers locations were overlaid on the georeferenced images and at each location the digital number from the TIR images were extracted using the GIS. Extracted DN values were from 4 pixels representing 380 sq ft (36 m^2) with the location of the recording temperature sensors approximately at the point of intersection of the 4 pixels. The actual area harvested for yield at each sensor location was about 39% of and lies within the 4 pixel area. The satellite image of the study area captured in mid August was too late in the growing season to be of any benefit. Thus, the analysis of satellite imaging is not presented herein.

Results are presented in English units given the applied nature of the subject matter.

Table 2. Production time table, procedures, applications, and harvest for the water temperature study sites in 2005.

Western 1

Land Preparation: Chisel (2X), Disc (1X), Land plane (1X), Roll (1X)
Variety: M-205
Seeding rate: 150 lb/a, water seeded with pre-soaked seed
Planting date: May 10, 2005
Drain date: September 15, 2005
Harvest date: October 2, 2005
Fertilizer application: 130 lb N incorporated as aqua ammonia, 200 lb/a of 16-16-16 blend (N, P, K)
Herbicide application: cyhalofop (12 oz/acre); propanil (6 qt/acre)
Insecticide application: lambda cyhalothrin (0.03 lb/a)

Western 2

Land Preparation: Field cultivator (1X), Disc (1X), Cultivator (1X), Land plane (1X), Roll (1X)
Variety: L-205
Seeding rate: 170 lb/a, drill seeded
Planting date: May 7, 2005
Drain date: September 23, 2005
Harvest date: October 7, 2005
Fertilizer application: 170 lb/a N as ammonium sulfate, 60 lb/a each of P and K.
Herbicide application: propanil (6 qt/acre), cyhalofop (12 oz/acres), triclopyr (8 oz/acre)
Insecticide application: copper sulfate (10 lb/a)

Richvale 1

Land Preparation: Chisel (2X), Disc (2X), Land plane (1X)
Variety: S-102
Seeding rate: 160 lb/a, water seeded with presoaked seed
Planting date: May 4, 2005
Drain date: August 29, 2005
Harvest date: September 13, 2005
Fertilizer application: 100 lb/a N as aqua ammonia, 250 lb/a of 8-21-21 (N, P, K) blend, 10 lb/a of Zn.
Herbicide application: clomazone (0.58 lb/a), propanil (6 qt/acre)
Insecticide application: diflubenzuron (0.12 lb/a)

Richvale 2

Land Preparation: Chisel (1X), disc (2X), roll (1X)
Variety: M-202

Seeding rate: 150 lb/a, water seeded with presoaked seed
Planting date: June 4, 2005
Drain date: October 16, 2005
Harvest date: November 11, 2005
Fertilizer application: 130 lb/a N as aqua ammonia, 200 lb/a of 13-13-13 (N, P, K) blend
Herbicide application: thiobencarb (3.83 lb/a), propanil (6 qt/acre)
Insecticide application: copper sulfate (10 lb/a)

Biggs 1

Land Preparation: chisel (2X), disc (2X), land plane (1X)
Variety: M-104
Seeding rate: 150 lb/a, water seeded with presoaked seed
Planting date: May 24, 2005
Drain date: September 14, 2005
Harvest date: October 7. 2005
Fertilizer application: 100 lb/a N as aqua ammonia, 300 lb/a 13-13-32 (N, P, K) blend, 10 lb/a of Zn
Herbicide application: clomazone (0.25 of 0.58 lb/a), molinate (35 lb/a), propanil (6 qt/acre)
Insecticide application: 15 lb/a copper sulfate

Biggs 2

Land Preparation: chisel (2X), disc (2X), landplane (1X)
Variety: S-102
Seeding rate: 170 lb/a, water seeded with presoaked seed
Planting date: May 7, 2005
Drain date: September 13, 2005
Harvest date: August 23, 2005
Fertilizer application: 110 lb/a N as aqua ammonia, 261 lb/a of 16-19-23 (N, P, K) blend, 10 lb/a Zn
Herbicide application: thiobencarb (3.83 lb/a), triclopyr (8 oz/acre)
Insecticide application: None

Table 3. Description of varieties grown at the six experimental research sites in 2005.

Western 1

M-205

Grain Type: Medium grain

Maturity: Early

Vigor (poor=1, excellent=5): 4.2

Lodging (none=1 complete=99): 16

Blanking Tolerance (worst=1 A-301, best=5 M-103): 4.5

Stem Rot Score (worst=10, best=1): 5.4

Height (in): 36.6 (93 cm)

Rel. Yield Potential (lb/a, last 5-yr. avg.): 105% of M-202

Days to 50% Heading: 92

Comments: Very high yield potential. Matures three to five days later than M-202. Low lodging. Threshes easily but does not shatter. Harvest moisture should not be below 18% or above 22%.

Western 2

L-205

Grain Type: Semidwarf long grain

Maturity: Early

Seedling Vigor (poor=1, excellent=5): 3.9

Lodging (%): 10

Greenhouse Blanking (%): 15

Stem Rot Score (worst=10, best=1): 5.8

Aggregate Sheath Spot Score (worst=10, best=1): 2.2

Plant Height (in): 35.8 (91 cm)

Yield (1994-98): 8608

Days to 50% Heading: 88

Harvest Moisture (%): 15.6

Comments: L-205 is an early maturing, smooth, semidwarf long grain, with improved milling yield and dry cooking characteristics. Photoperiod insensitive, it heads 2 days later than L-204. Seedling vigor is slightly weaker and it is about 2 inches taller than L-

203 and L-204. It is slightly more susceptible than L-203 and L-204 to stemrot and aggregate sheathspot. Harvest at relatively low moisture content, 16-18%, for maximum head rice. L-205 is suitable for traditional US long-grain markets and for processing.

Richvale 1

S-102

Grain Type: Short

Maturity: Very Early

Vigor (poor=1, excellent=5): 4.3

Lodging (none=1 all=99): 19

Blanking Tolerance (worst=1 A-301, best=5 M-103): 4

Stem Rot Score (worst=10, best=1): 7.1

Height: 92 cm (36.2 in)

Rel. Yield Potential (lb/a),1996: 96% of M-202

Days to 50% Heading: 81

Comments: Very high yield potential and two weeks earlier than S-201. Good resistance to low temperature blanking. Grain is 8% larger than S-201 with less chalkiness. Rough leaves and hulls; grain dries down rapidly during ripening. Susceptible to stem rot.

Richvale 2

M-202

Grain Type: Medium grain

Maturity: Early

Vigor (poor=1, excellent=5): 4.4

Lodging (none=1 complete=99): 22

Blanking Tolerance (worst=1 A-301, best=5 M-103): 4

Stem Rot Score (worst=10, best=1): 6.4

Height (in): 36.5

Rel. Yield Potential (lb/a, last 5-yr. avg.): 100% of M-202

Days to 50% Heading: 90

Comments: Very high yield potential. Matures three days earlier, ripens more uniformly, and more resistant to blanking than M-201. Moderate lodging. Threshes easily but does not shatter. Harvest moisture should not be below 18% or above 22%.

Biggs -1

M-104

Grain Type: Medium

Maturity: Very Early

Vigor (poor=1, excellent=5): 4.5

Lodging (none=0 all=99): 38

Blanking Tolerance (worst=1 A-301, best=5 M-103): 5

Stem Rot Score (worst=10, best=1): 5

Height (in): 35.9 (91 cm)

Rel. Yield Potential (lb/a, last 5-yr. avg.): 98% of M-202

Days to 50% Heading: 92

Comments: Traits similar to M-103 except it has a higher yield potential and better early season vigor particularly in the cool production zones. This variety is an alternative variety in coldest rice producing areas and for late (or delayed) planting in warmer areas.

Biggs – 2

M-206

Grain Type: Medium grain

Maturity: Early

Vigor (poor=1, excellent=5): 4.5

Lodging (none=1 complete=99): 18

Blanking Tolerance (worst=1 A-301, best=5 M-103): 4.5

Stem Rot Score (worst=10, best=1): 5.4

Height (in): 37.4 (95 cm)

Comments: Very high yield potential. Better adapted to cooler areas than M-205; when compared to M-202, heads about 5 days earlier, shows improved resistance to blanking, and potentially better head yield (3%). During ripening the kernel moisture may "hang" for a few days at around 26%.

Results and Discussion

The 2005 rice season was not strikingly different from the previous 3 years (Table 4). The average daily maximum temperature during the first three months of the 4 growing seasons ranged from 85 F to 87 F and the minimum ranged from 58 F to 59 F. June 2005 average maximum and minimum temperature was the lowest compared to the other three years. In contrast July 2005 average temperature was the highest of the four year period and similar to 2003. Total accumulated solar radiation in 2005 was 54521 langleys during May, June, and July, the lowest of the four year period. The lower total was attributable to the reduced incident radiation in May; a month marked by several rain fall events. Solar radiation during June and July of 2005 were comparable to 2004, which was an excellent year for rice production.

Table 4. The average daily maximum temperature (Tmax, F), minimum temperature (Tmin, F) and solar radiation (langleys) for 2002 through 2005. Data from CIMIS station 12 Durham, CA.

	Tmax	Tmin	Solar Rad*		Tmax	Tmin	Solar Rad*
2005				**2004**			
May	79	53	15864	May	80	53	18893
June	81	56	18138	June	86	59	19586
July	94	64	20519	July	90	61	20865
Ave/Total	85	58	54521	Ave/Total	85	58	59344
2003				**2002**			
May	79	52	17594	May	80	52	19658
June	89	60	21060	June	89	60	21140
July	95	64	20764	July	91	61	20872
Ave/Total	87	59	59418	Ave/Total	86	58	61670

* solar radiation

The cooler temperatures in June 2005 when compared to the previous four years accounted for the fewer number of degree days (DD) accumulated overall and more specifically in June (Table 5). Based on lower and upper temperature thresholds of 55 F and 100F, respectively, there were 1514 accumulated in 2005 from May through July. 2005. DD accrual in 2001 was the highest at 1782.

Table 5. Accumulated degree days over a 5 year period based on temperature data from the CIMIS station 12 in Durham, CA.

Month	2005	2004	2003	2002	2001
May	357	379	353	370	589
June	413	527	577	575	558
July	745	628	757	653	634
Total	1514	1534	1687	1598	1782

The relatively fewer DD in 2005, however, does not appear to be an inadequate number for potentially high rice productivity. Comparing 2005 and 2004 there was only a 20 DD difference. Nonetheless within the last 5 years, county wide average yields were the greatest in 2004 (Table 6) when the DD were comparable to 2005. The lower average yields in 2005 were attributable to the wet conditions in May during land preparation and the relatively cooler temperatures in June. Warm temperatures in July and August (data not shown) accelerated growth resulting in the total number of days to rice maturity being similar to previous years. These weather conditions describe the macroclimate experienced by all experimental sites. There is virtually no local variation in climatic conditions within Butte County during the rice growing season (JF Thompson, Dept. of Ag. Eng., UCD, personal communication). Consequently, variation in productivity within and between experimental sites can not be ascribed to local difference in general weather patterns.

Table 6. Average rice yields in Butte County for 2001, 2002, 2003, 2004, and 2005 pooled across varieties. Source: Agricultural Commissioner, Butte County.

Year	Average yield (cwt*/acre)
2001	8600
2002	8660
2003	8100
2004	9140
2005	7600

* Cwt = 100 pounds of paddy rice (unshelled) at 14% moisture content.

The Butte County Rice Growers Association reported that yields were down for all varieties in 2005 as compared to 2004 (Table 7). In 2004 average yield averaged across the four most widely planted varieties was 9650 lb/a while the comparative average in 2005 was 7800 lb/a, a 19% decrease. M-205 exhibited the smallest reduction between years and M-104 the largest at 15% and 22%, respectively. On average, milling yields were better in 2005, 62.6% as compared to 61.2% in 2004. Individually all varieties except M-104 exhibited higher milling scores in 2005, of which the largest increase was for M-206 (+2.5%). Average check 1 milling yields at the cooler locations were 48, 49, and 55% for W-1, R-1, and B-1, respectively. Millings yields at the other locations were similar to the BUCRA pool averages.

Table 7. The pool average rice grain and milling yields by variety in 2004 and 2005 as reported by the Butte County Rice Growers Association (BUCRA).

Year	Variety	Yield (cwt/acre)	Milling yield (%)
2004	M-104	94.9	62.8
	M-202	96.1	59.9
	M-205	95.4	62.4
	M-206	99.4	60.8
	Average	96.5	61.2
2005	M-104	73.8	61.4
	M-202	78.0	61.5
	M-205	80.7	64.1
	M-206	79.5	63.3
	Average	78.0	62.6

Grower reported yields and those yields corrected by the area harvested by the research combine at the sensor locations are presented in Table 8. For example, at W-1 the total harvested weight of rice in check 1 was 80114 lb. The combined weight for the experimental plots was 435 lb. Thus tag weight plus plot weights equal 80549 lb; divided by 12.1 acres results in an overall yield for check 1 of 6657 lb/a for W-1. Comparing the check 3 yields from the experimental sites to the county averages, W-1, W-2, R-1, and R-2 were all at or above the BUCRA pool average (Tables 7 and 8). B-1 and B-2 yields were 5 % and 10 % lower than the pool average, respectively. In contrast the check 1 yields at all sites, except W-2, were lower than the BUCRA pool, as well as the county average yields based on grower reported values.

Table 8. Grower reported yields in checks 1 and 3 (lb/a @ 14% MC) for all locations and corrected for by the grain harvested from the experimental plots.

Location	Yield (lb/a)	Total Wt Tags	Total Wt Tags + Plots
W1-CK1	6657	80114	80549
W1-CK3	9176	110814	111033
W2-CK1	8354	187480	187980
W2-CK3	9039	207690	207900
R1-CK1	7162	123840	125770
R1-CK3	10413	231108	233038
R2-CK1	5948	71547	71976
R2-CK3	6810	82401	NA
B1-CK1	5897	117306	117652
B1-CK3	7173	94512	94678
B2-CK1	6281	89063	89499
B2-CK3	6569	128510	128684

The grower reported yields in check 1 were lower than the corresponding yields in check 3 at all sites (Table 8). Compared to the grower reported yields for checks 1, yield estimates using the average experimental plots weights ranged from 979 lb/a higher at R-2 to 310 lb/a lower at B-2. On average the experimental estimates were 214 lb/a higher than the grower yields, about 3 %. In checks 3, the experimental plots yield estimates were lower than the grower reported yields at 4 of the 5 locations were data was available (Table 10). The largest discrepancy was at R-1 where the experimental plots under estimated the yield by 2006 lb/a. There were 8 experimental plots located in R-1, check 3 with a total area of 1200 sq ft. This represents less than 1% of the total area of R-1, check 3 (22.3 acres). At this location, the diagonal transect of experimental plots was an inadequate sub-sample of the population to capture a fair representation of the actual yield. Given that the grower reported yield is based on harvesting the entire population in check 3, this value (10413 lb/a) is the actual yield. At all other locations the experimental plot provided a reasonable estimation of the actual yield.

Table 9. Yields (lb/a @ 14% MC) of check 1 at all experimental sites based on averaged experimental plots yields (EP) and grower reported yields (G).

	W-1	W-2	R-1	R-2	B-1	B-2
EP	7037	8068	6920	6927	5587	7045
G	6657	8354	7162	5948	5897	6281
Ave	6847	8211	7032	6438	5742	6663

Table 10. Yields (lb/a @ 14% MC) of check 3 at all experimental sites based on averaged experimental plots (EP) and grower reported yields (G).

	W-1	W-2	R-1	R-2	B-1	B-2
EP	9085	8716	8407	NA	6906	7210
G	9176	9039	10413	6810	7173	6569
Ave	9131	8878	9410	NA	7040	6890

Consistently at the experimental locations representing a broad geographic expanse of the rice production zone in Butte County, fields adjacent to water delivery canals produced less rice in check 1 than in check 3 (Table 8). Based on experimental plot values the yield reductions ranged from 2.3% at B-2 to 22.5% at W-1 (Table 11). Grower yields documented the lowest reduction at B-2 and the highest at R-1, 4.4% and 31.2%, respectively. Average yield loss based on experimental plots was 13.8%, somewhat lower that the 16.9% loss reported by growers. The discrepancy at R-1, check 3 is apparently the principal reason for this difference. Based on both methods of calculation, across sites there was a 15.3% comparative yield loss in check1 in relation to check 3.

Table 11. Yield reductions (%) in check 1 as compared to check 3 at all experimental sites based on experimental plot yields averaged across all sensor locations (EP) and grower reported yields (G).

	W-1	W-2	R-1	R-2	B-1	B-2	Ave
EP	22.5	7.4	17.9	NA	19.1	2.3	13.8
G	27.5	7.6	31.2	12.7	17.8	4.4	16.9
Ave	25.0	7.5	24.6	12.7	18.5	3.3	15.3

Pronounced differences in plant growth and development were observed at several temperature sensor locations in check 1, particularly at sites W-1, R-1, and B-1 near the water inlets. For example, plant nears in the water inlet at W-1 required 43 days to reach the tiller stage and 80 days to reach panicle initiation. This was as much as 20 and 25 days, respectively, longer than areas further removed from the water inlet (Table 12). Interestingly plants near sensor 25 in the third check were also somewhat delayed. Research conducted at the same field site in 2001 and 2002 (Mutters et al, 2003) documented a cold water seep between checks that moved along the northern edge of the field, thereby creating a low temperature zone in checks 2 and 3 in an area adjacent to the main water canal.

Plant growth observations were taken in close proximity to the temperature sensors. The sensors located near water inlets were readily identifiable by plant growth. For example at W-2 (located approximately 15 miles from the water diversion point at the Thermalito Afterbay) there were four water inlets into check 1, one at sensors 1, 3, 5, and 6. Sensor 6 was collocated with the fourth and most westerly inlet. Panicle initiation was delayed by as much as one week near the water inlets. Such a delay in plant development negatively impacts yield potential. The onset of tillering marks the beginning of the exponential growth phase of the rice plant when the vegetative biomass and leaf area are accumulated to support the carbon fixation capacity needed to produce high yields. Inadequate and delayed growth at this stage negatively impacts yield potential (Luh, 1980). Panicle initiation marks the transition from the vegetative phase to the reproductive phase of the plant's life. A delay in panicle initiation can shorten the duration of grain fill and consequently reduce yield potential. Additionally, such a delay in development further impacts yield potential by pushing the grain fill period into a seasonal time frame with cooler temperatures and shorter days (Luh, 1980).

Table 12. Days after planting required to reach tillering (TL) and panicle initiation (PI) at each temperature sensor location (1 through 25) located at all experiment sites in 2005. Sensors 1-18 were located in Check 1; 19 – 25 in Check 3. Except for R-1 where sensors 1-17 were located in Check 1.

Temp	W-1		W-2		R-1		R-2		B-1		B-2	
Sensor	TL	PI	TL	PI	TL	PI	TL	PI	TL	PI	TL	PI
1	43	80	37	68	51	92	32	32	43	64	33	70
2	43	59	34	68	46	85	32	32	43	60	33	58
3	23	59	37	68	46	64	35	35	43	57	33	55
4	23	59	34	61	41	58	32	32	43	50	33	55
5	23	59	47	68	41	58	32	32	30	50	33	55
6	23	55	39	68	41	58	32	32	30	50	33	55
7	23	55	37	62	41	58	32	32	30	50	33	55
8	23	55	34	61	41	58	32	32	30	50	33	55
9	23	55	34	61	41	64	32	32	43	50	33	55
10	23	59	37	61	41	71	32	32	43	50	33	55
11	23	55	37	61	41	64	32	32	43	50	33	55
12	38	55	32	62	41	58	32	32	43	57	33	58
13	38	55	37	61	41	58	28	28	30	60	33	55
14	23	59	42	61	41	58	28	28	30	50	33	55
15	23	55	42	61	41	58	32	32	30	50	33	55
16	23	55	44	61	31	58	28	28	30	50	33	55
17	23	55	44	61	41	58	28	28	30	50	33	55
18	23	55	46	61	41	58	28	28	30	50	33	55
19	30	59	34	61	41	58	28	28	24	50	33	55
20	30	55	34	61	41	58	28	28	24	50	33	55
21	28	55	34	61	41	58	28	28	24	50	33	55
22	28	55	34	61	41	58	28	28	24	50	33	55
23	28	55	32	61	41	58	28	28	24	50	33	55
24	28	55	32	61	41	58	28	28	24	50	33	55
25	28	59	34	61	41	58	28	28	24	50	33	55

The extent of the delayed growth associated with water inlet is illustrated in Figure 1. At R-1, 40 days after planting plants at sensor location 1 in the water inlet were one-half the height with one-half the biomass of plants located near sensor 4. Moreover, the incremental increase in plant height with distance away from the water inlet suggested an accumulated dose response function as was previously reported by Roel et al (2005) and Shimono et al (2002). Similar growth delays were noted at all sites but they were most pronounced at the locations nearest the Afterbay in all districts, i.e. W-1, R-1, and B-1.

Figure 1. Plants taken from sensor locations 1 (water inlet) through 4 at the R-1 site 40 days after planting. Note the difference in plant size and growth stage. Refer to Figure 9 for sensor placement.

Areas exhibiting delayed growth soon after planting remained apparent throughout the growing season and harvest. For example at W-1 when panicle emergence occurred in areas of the field farthest removed from the water inlet, plants near the inlet had not yet produced any heads (Figure 2 and Table 12). The affect of water temperature on plant height observed earlier in the season remained apparent at heading. Plant heights ranged from 21 inches near the water inlet to 34 inches at the most remote locations at the southern extent of the check far removed from the water inlet.

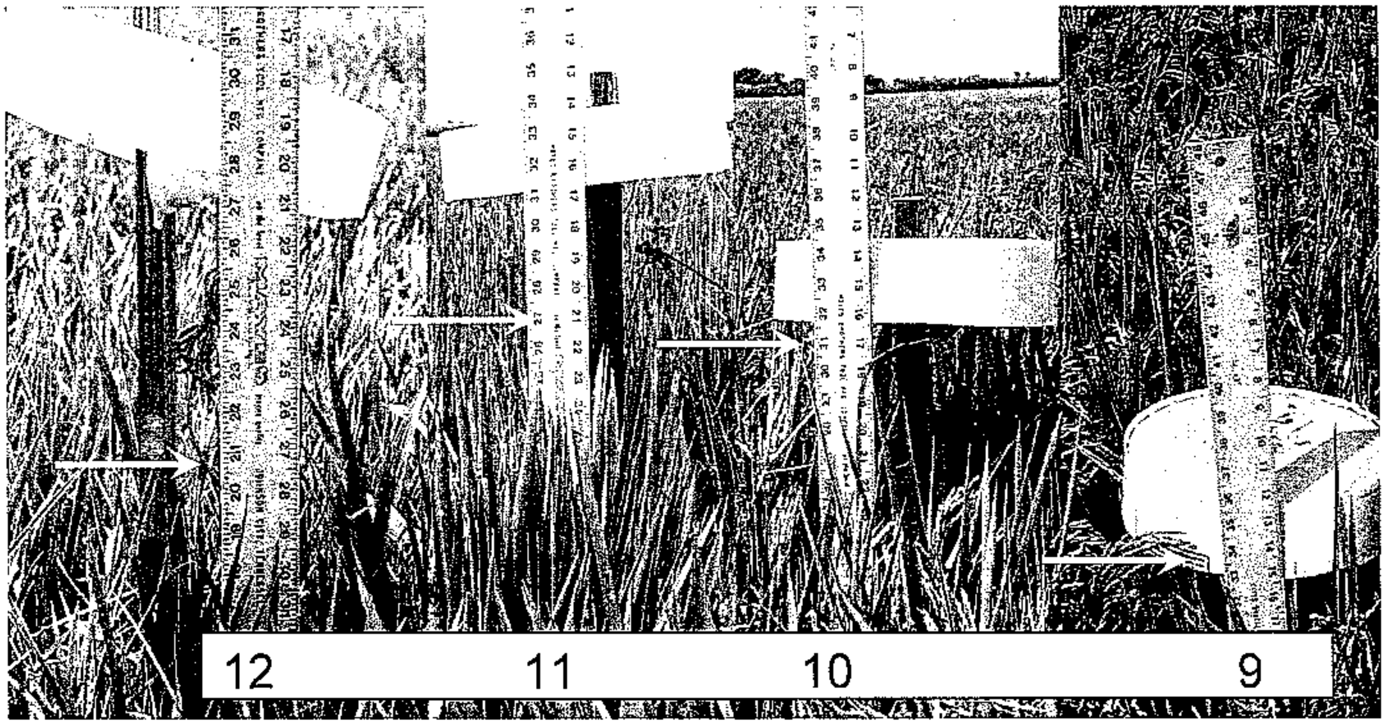


Figure 2. Plant height at heading at W-1 at sensor locations 12, 11, 10, and 9, the middle row of sensors going from the north (12) to the south (9). Refer to Figure 34.

The delayed growth and reduced plant stature was reflected in the yield (Table 13). The shortest plants at heading produced the lowest yields. Yields ranged from a low of 0 lb/a to a high of 9160 lb/a at sensor locations 12 and 9, respectively. The yield loss was related to the total number of hours below 65 F to which the plant was exposed from planting to panicle initiation. Plants near sensor 12 experienced 935 TNPI while the plants near sensor 9 were exposed to only 284 TNPI. A closer inspection of the spatial yield variability at all sites indicated that yield was closely related to TNPI.

Table 13. Plant height at heading, total number of hours below 65 F from planting to panicle initiation (TNPI) and the corresponding yields (lb/a) at sensor locations 9, 10, 11, and 12 at the W-1 site.

Sensor	Plant at Heading (in)	TNPI	Yield
9	34	284	9160
10	31	348	8055
11	27	607	5750
12	21	935	0

Western 1

TNPI ranged from 1374 near the water inlet to 255 at the southwestern corner of check 1 at W-1 (Figure 3-A). A plume of low temperature water radiated out from the water inlet (designated with an arrow). There was a gradation in TNPI from the north to the south of check 1 where the TNPI decreased with distance from the inlet. Interestingly, spatial yield loss patterns exhibited a distribution similar to the TNPI, wherein the highest TNPI corresponded to the highest yield loss (Figure 3-B). The color contours do not exactly match in Figures 2-A and 2-B because the range intervals were chosen for illustrative purposes rather than growth characteristics. To test this apparent relationship, regression analysis demonstrated that the measured yield loss was strongly related to TNPI (Figure 4). A polynomial model fitting TNPI produced a coefficient of determination (R^2) value of 0.95 and a probability of $p < 0.0000$. The red lines delineate the confidence intervals. There was no indication of autocorrelation based on the Durbin-Watson statistic. This is a powerful indication that exposure to low temperature water was responsible for the observed yield loss at W-1, a loss not limited to area near the inlet but one that extends a considerable distance across the field. Other researchers working in California to identifying sources of in-field variability in yield have rarely observed such a strong and consistent predictor.

For example, Roel and Plant (2004) in a 3-year study on rice, where water temperature was not considered, found that none of the 11 field descriptive independent variables were consistently associated with yield. Soil organic matter was identified twice, soil penetration resistance once, and percentage of silt content over a 3 year period. The authors pointed out that the inconsistency may be due to intercorrelation of the variables. In contrast, 3 years of research at the W-1 site demonstrated the TNPI was consistently highly correlated with yield loss. Analysis of pooled data over the years of 2001, 2002 (Roel et al, 2005), and 2005 produced an R^2 value of 0.74 and $p < 0.001$ (data not shown).

In 2005, a multivariate analysis testing a suite of independent variables against the dependent variable, yield (lb/a), showed a multiple linear regression model described the relationship between yield and 3 independent variables, DTT, TNPI, and TNTL (Figure 5). The equation of the fitted model is:

$$\text{Yield} = 19099.3 - 451.474 * \text{DTT} - 13.3436 * \text{TNPI} + 25.4634 * \text{TNTL}$$

Since the P-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between the variables at the 99.0% confidence level.

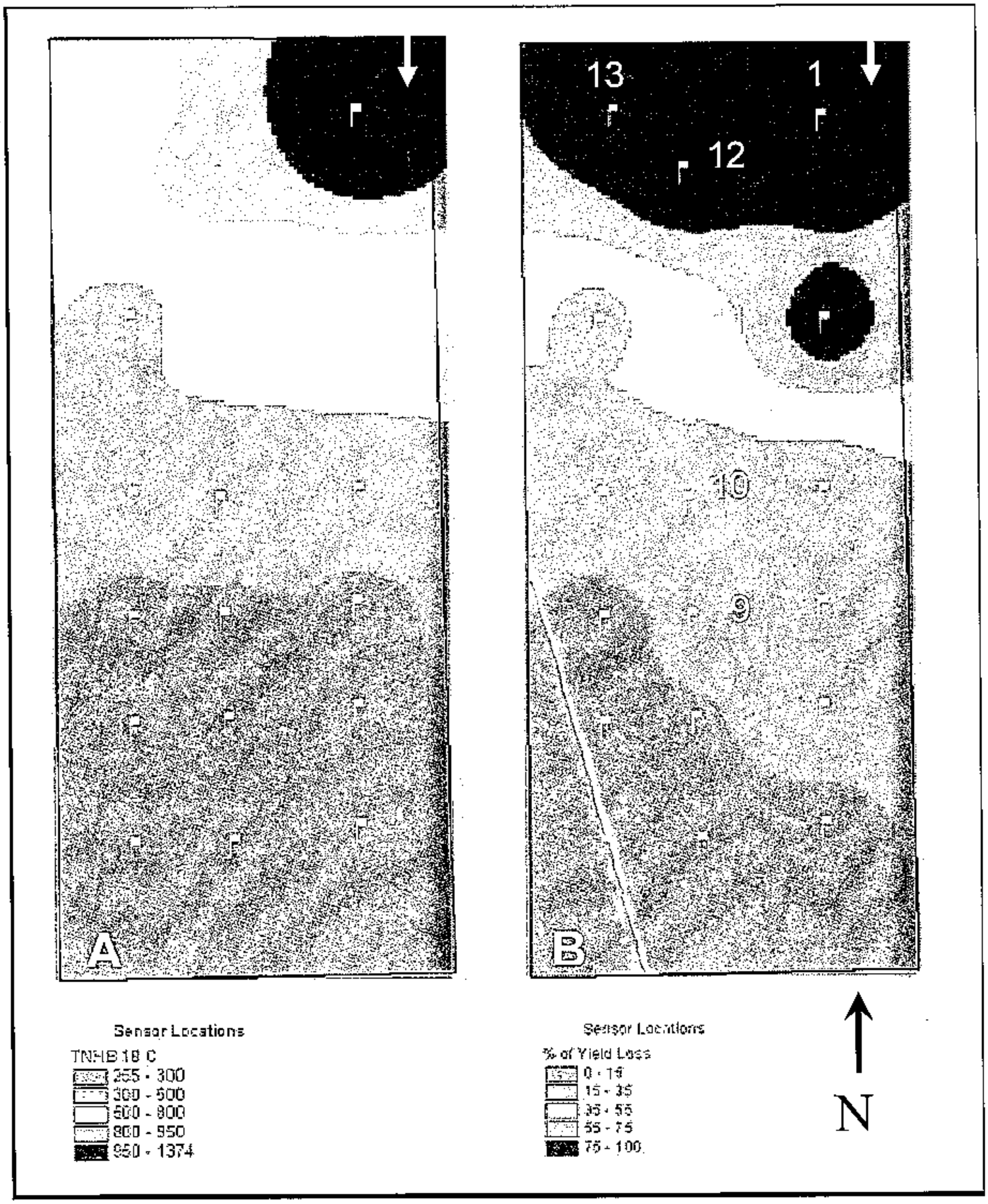
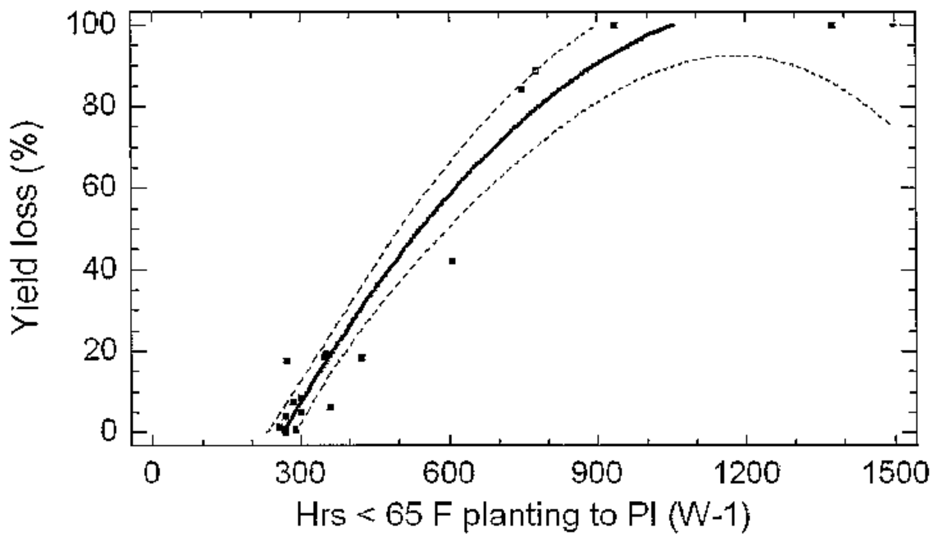


Figure 3. Interpolation of geo-referenced THPI (65F = 18.3 C) and yield loss (%) data for Western 1 (W-1) check 1. The arrow designates the water inlet. Sensor 1 is located at the inlet. Sensors 1, 12, and 13 are in the northern most row.

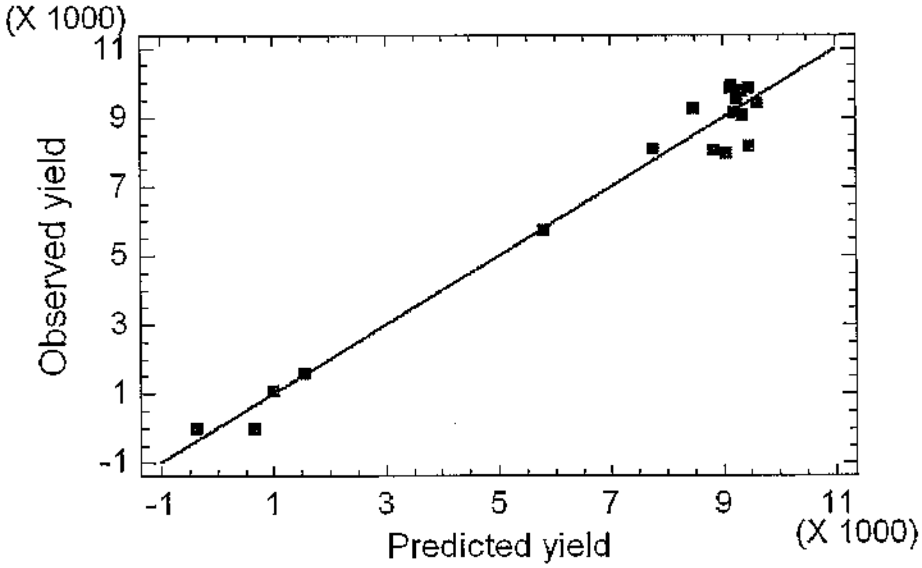


Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	21977.0	2	10988.5	144.35	0.0000
Residual	1141.86	15	76.124		
Total (Corr.)	23118.9	17			

R-squared = 95.0609 percent
Standard Error of Est. = 8.72491
Mean absolute error = 6.05939
Durbin-Watson statistic = 1.98626 (P=0.3691)

Figure 4. Yield loss (YL %) as a function of the total number of hours below 65 F from planting to panicle initiation (TNPI) at the Western 1 (W-1) site. YL % = $-0.0001X^2 + 0.2614X - 61.687$, where X = TNPI.



Model

Parameter	Estimate	Standard Error	T Statistic	P-Value
CONSTANT	19099.3	1012.09	18.8711	0.0000
W-1.Days to tiller	-451.474	63.4852	-7.11148	0.0000
W-1.Hrs 65 PI	-13.3436	2.08718	-6.39314	0.0000
W-1.Hrs 65 tiller	25.4634	5.51843	4.61424	0.0004

Analysis of Variance

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Model	2.21243E8	3	7.37477E7	162.37	0.0000
Residual	6.35875E6	14	454196.		
Total (Corr.)	2.27602E8	17			

R-squared = 97.2062 percent
Standard Error of Est. = 673.941
Mean absolute error = 475.12
Durbin-Watson statistic = 0.969249 (P=0.0534)

Figure 5. Predicted yield versus observed yield as calculated by multiple regression analysis predicting yield (lb/a) as a function of the independent variables: DTT, TNTL,

and TNPI at the W-1 sight.

Western 2

TNPI ranged from 58 to 394 at W-2 (Figure 6-A). The greatest exposure to low water temperature occurred near the inlets of which there were four. The grower intentionally diverted water through four weirs in an effort to minimize the cold water impact. Such infrastructure options are not available to all growers given field layout and economic restrictions. The TNPI was less at W-2 as compared to W-1 due to the distance from the diversion, approximately 15 miles as opposed to about 1 mile at W-1.

Yield loss ranged from 1 to 36% and the location of the lower yields followed a pattern similar to the TNPI (Figure 6-B). Regression analysis demonstrated that TNPI was highly correlated with the measured yield loss (Figure 7). Similar to W-1, the injury due to cold water exposure begins at under 300 hours. The one-variable regression yielded an R^2 value of 0.70 and a p-value of 0.0011. Thus at both sites in the Western Irrigation Water District TNPI was a reliable predictor of yield loss even at a location relatively distant from the point of diversion at the Afterbay.

Multivariate regression linear modeling (Figure 8) to describe the relationship between yield (lb/a) and 3 independent variables, DTT, DNPI, and DNTL resulted in the following equation:

Yield = 12366.0 - 21.7424*DTT - 23.3587*TNPI + 14.3472*TNTL.

Since the p-value in the ANOVA table is less than 0.01, there is a statistically significant relationship between the variables at the 99.0% confidence level.

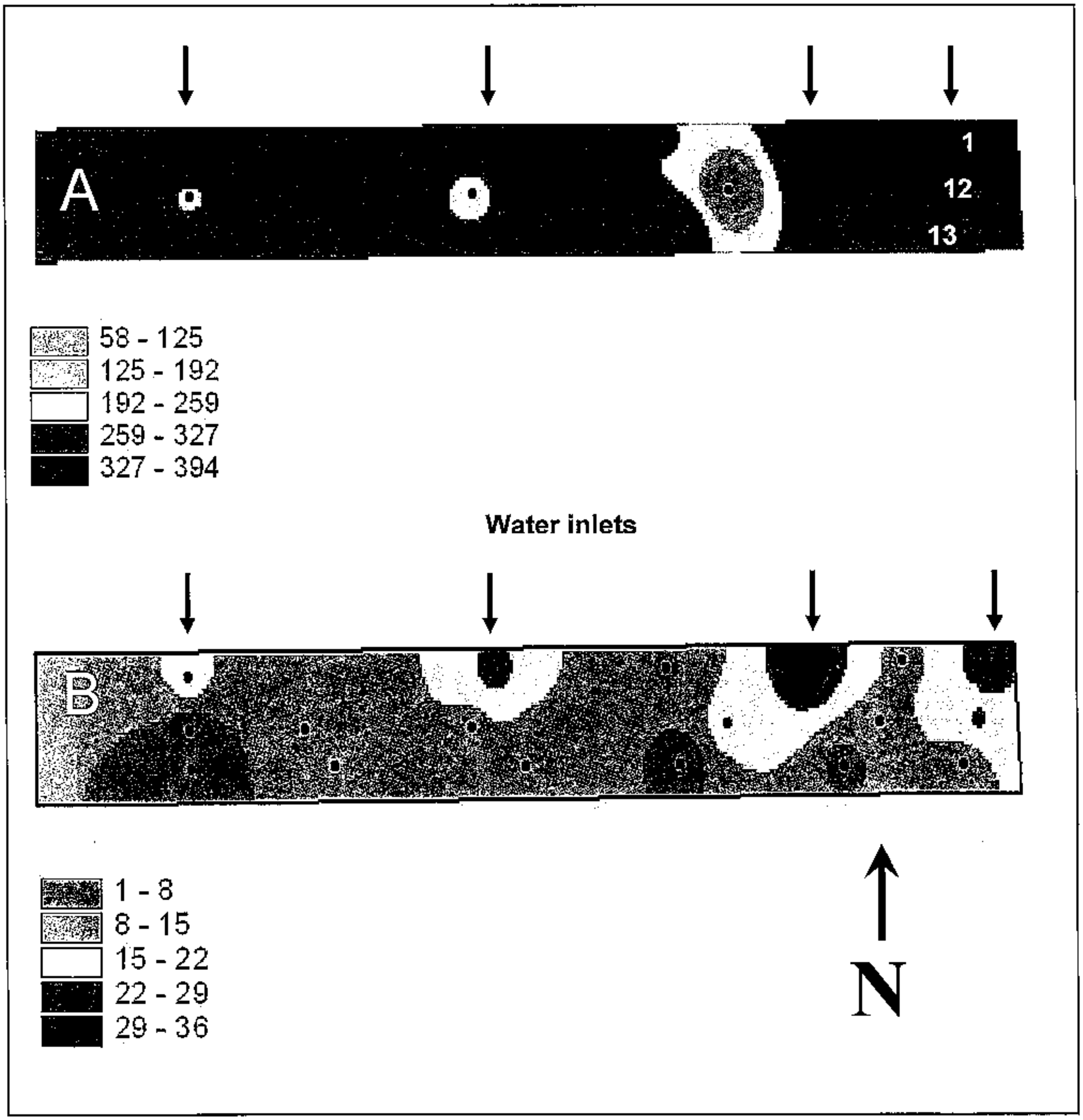
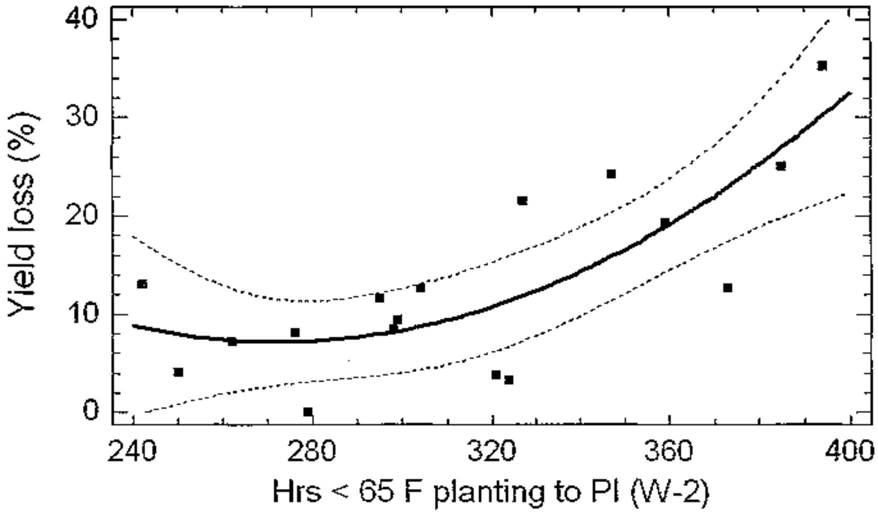


Figure 6. Interpolation of geo-referenced THPI (65 F = 18.3 C) and yield loss (%) data for W-2 check 1. Sensors were placed in a serpentine fashion. Sensors 1, 12, and 13 are labeled (A).

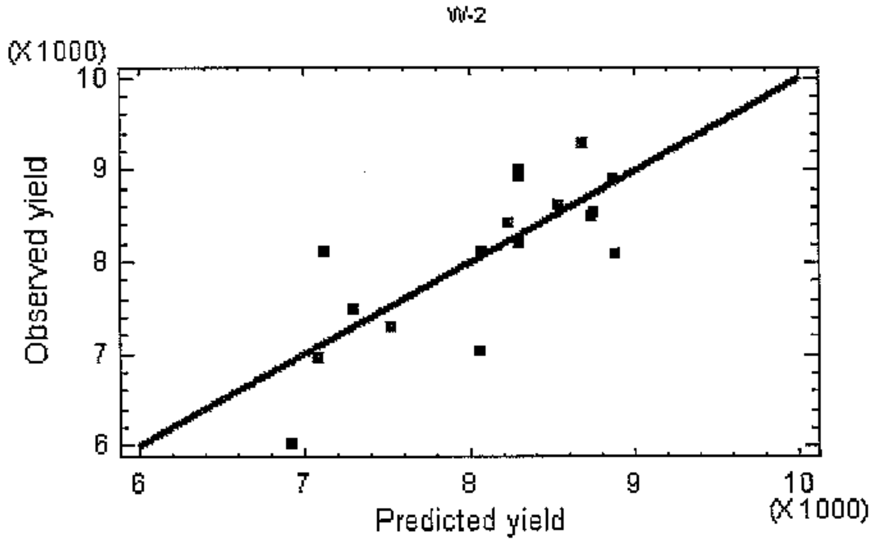


Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	870.689	2	435.344	11.44	0.0011
Residual	532.773	14	38.0552		
Total (Corr.)	1403.46	16			

R-squared = 70.161 percent
Standard Error of Est. = 6.16889
Mean absolute error = 4.50223
Durbin-Watson statistic = 1.60684 (P=0.1491)

Figure 7. Yield loss (%) as a function of TNPI at the Western 2 (W-2) site.



Model

		Standard	T	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
CONSTANT	12366.0	2889.17	4.2801	0.0009
W-2.Days to tiller	-21.7424	93.0472	-0.23367	0.8189
W-2.Hrs 65 PI	-23.3587	13.2043	-1.76903	0.1003
W-2.Hrs 65 tiller	14.3472	18.4371	0.778171	0.4504

Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	7.08114E6	3	2.36038E6	6.07	0.0082
Residual	5.05141E6	13	388570.		
Total (Corr.)	1.21325E7	16			

R-squared = 58.3648 percent
Standard Error of Est. = 623.354
Mean absolute error = 420.751
Durbin-Watson statistic = 2.34618 (P=0.6436)

Figure 8. Predicted yield versus observed yield as calculated by multiple regression analysis predicting yield (lb/a) as a function of the independent variables: DTT, TNPI, and TNTL at the W-2 site.

Richvale 1

TNPI ranged from 311 to 1449 hours at R-1 (Figure 8-A). The interpolated distribution of TNPI is highest at the water inlet decreasing with distance with lowest values (i.e. warmest water) near the southwestern and southeastern corners of the check. Yield loss followed a similar pattern with the high loss (100%) occurring near the inlet and lessening with distance (Figure 8-B). The extent of the cold water temperature affect is apparent in an aerial photograph taken at heading (Figure 9). The study site is located in the bottom field with the arrow at the water inlet. The dark green color indicative of plants where the heads have not yet emerged shows the area where plant growth is delayed. The impacted area extends nearly the entire width of check 1, which is 250 feet wide. The lighter colored green area is where the heads have emerged in the corners of check 1 and in the adjacent check 2.

TNPI as the sole independent variable in a regression analysis resulted in an R^2 value of 0.92 with a p-value of 0.0000 (Figure 10). No autocorrelation was detected (Durbin-Watson statistic = 2.58999 (P=0.8385). Regressing the host of independent variables recorded against the dependent variable, yield (lb/a), resulted in following multiple linear regression model:

Yield (lb/a) = 5555.52 + 136.511*DTPI - 13.1829*TNPI.

The associated R^2 value was 0.93 with a p-value of 0.0000 that indicates a statistically significant relationship between yield and the two independent variables.

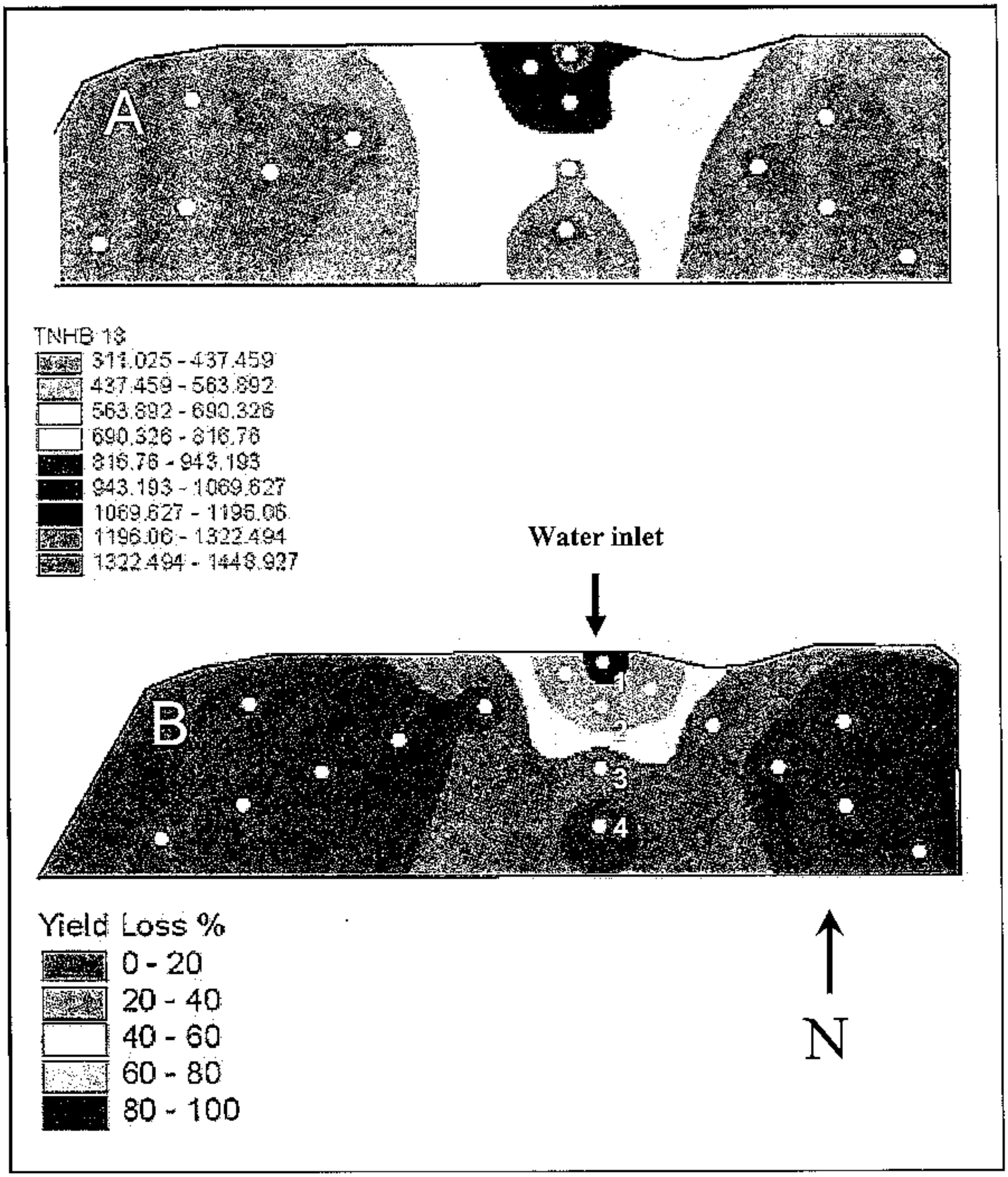


Figure 9. Interpolation of geo-referenced THPI (65 F = 18.3 C) and yield loss (%) data for R-1 check 1.

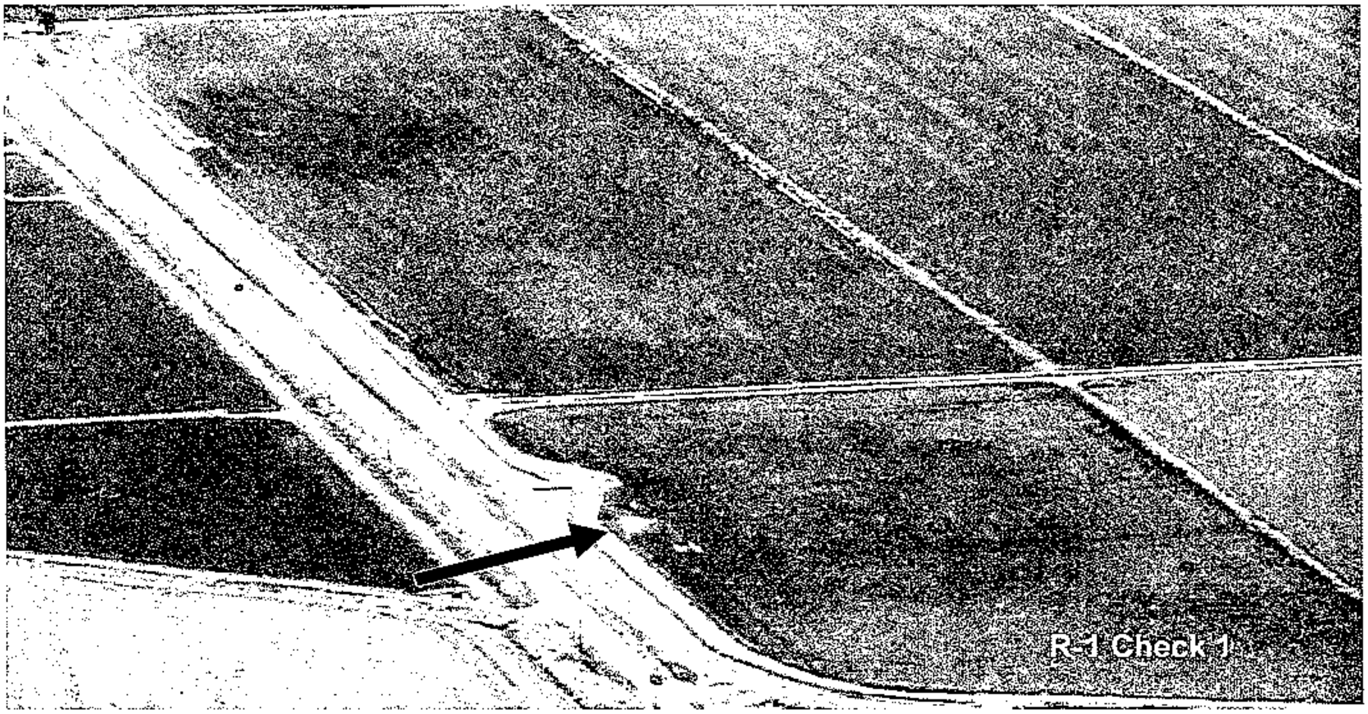
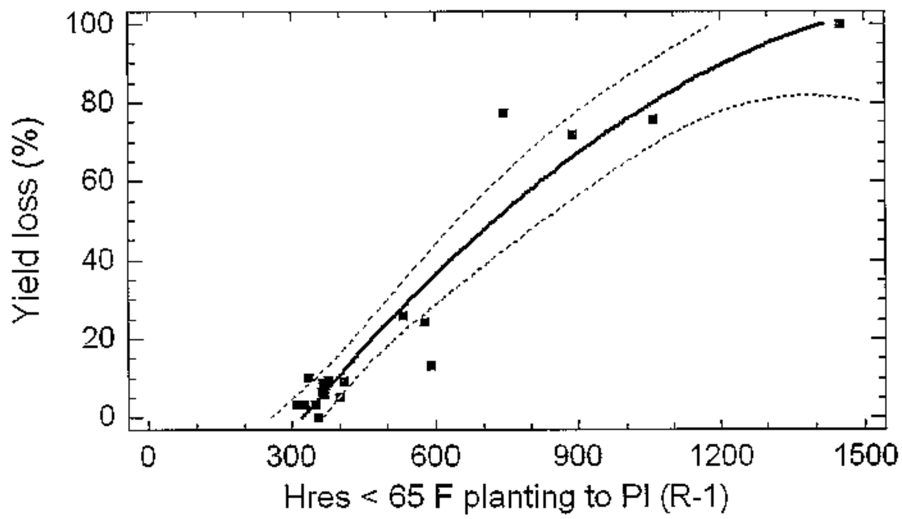


Figure 10. Aerial view of the R-1 site at heading illustrating the cold water "foot print" radiating out from the water inlet indicated by the arrow. Best viewed in color.

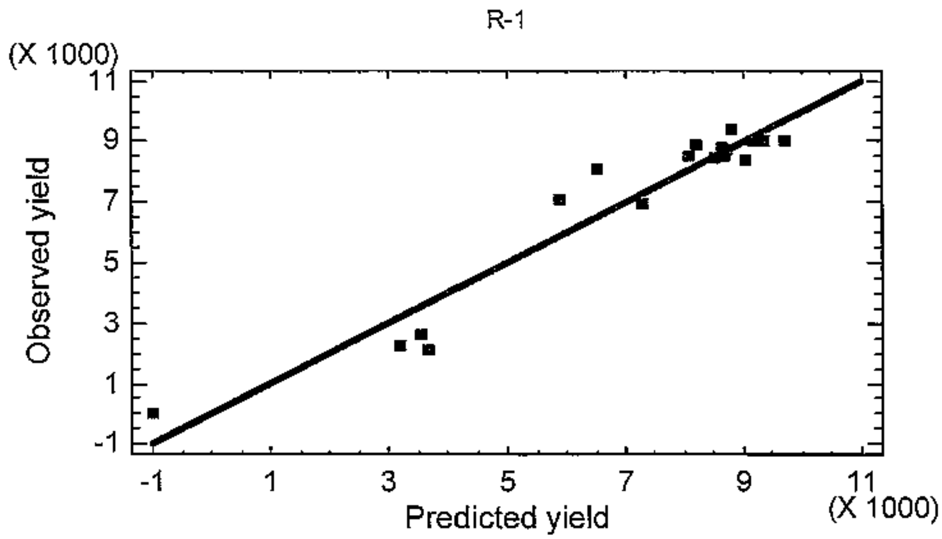


Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	15932.3	2	7966.14	83.39	0.0000
Residual	1432.87	15	95.5245		
Total (Corr.)	17365.1	17			

R-squared = 92.0231 percent
Standard Error of Est. = 9.77366
Mean absolute error = 5.86078
Durbin-Watson statistic = 2.58999 (P=0.8385)

Figure 11. Yield loss (%) as a function TNPI at the Richvale 1 (R-1) sight.



Model

		Standard	T	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
CONSTANT	5555.52	2529.55	2.19625	0.0442
R-1.Days to PI	136.511	53.0447	2.57351	0.0212
R-1.Hrs 65 PI	-13.1829	1.71004	-7.70911	0.0000

Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	1.41042E8	2	7.05212E7	94.16	0.0000
Residual	1.1234E7	15	748931.		
Total (Corr.)	1.52276E8	17			

R-squared = 92.6226 percent
Standard Error of Est. = 865.408
Mean absolute error = 627.621
Durbin-Watson statistic = 2.62564 (P=0.8578)

Figure 12. Predicted yield versus observed yield as calculated by multiple regression analysis predicting yield (lb/a) as a function of the independent variables: DPI and TNPI at the R-1 site.

Richvale 2

At R-2, the TNPI ranged from 106 to 192 (Figure 13-A). The longer exposure times occurred near the water inlets. The grower uses two inlets for about one-half of the season or until the plants reached their full vegetative growth. As was the case at W-2, this was to minimize the cold water impact. The two are readily apparent in Figure 13-A. The yield losses generally followed the TNPI contours with highest loss zones (23 to 29%) occurring at the colder locations (Figure 13-B). The best fitting single variable model regressing TNPI against yield loss was a linear function with an R^2 value of 0.41 and a significant p-value of 0.0042 (Figure 14).

Multivariate analysis output showed that fitting a multiple linear model describing the relationship between yield (lb/a) and the suite of independent variables listed in Materials and Methods was statistically significant at the 95% confidence level (data not shown). Although the equation was statistically significant none of the individual variables produced p-values of 0.05 or less.

Unlike the previous three sites, measurable yield loss occurred at TNPI under 200 hours. R-2 was a late planted field (June 4). In 2005, the late planted fields (R-2 and B-1, discussed below) exhibited a more acute response to cold water exposure than the early planted fields.

The cold water "foot print" can be seen in the aerial photograph shortly before harvest (Figure 15). Yield and milling quality are commonly lower in these areas. In the event of early rains and a cool autumn such areas may sometimes go unharvested because of inadequate heat units to mature the crop and wet conditions inhibiting the dry down of the grain to a harvestable moisture content. Noteworthy is the fact that the low temperature water affects extended beyond the zone visible in the photograph. A simple visible inspection at the time of harvest is an insufficient means of ascertaining the actual zone of reduced yield as is illustrated in Figure 12-B where the yield loss extends across the width of the first check.

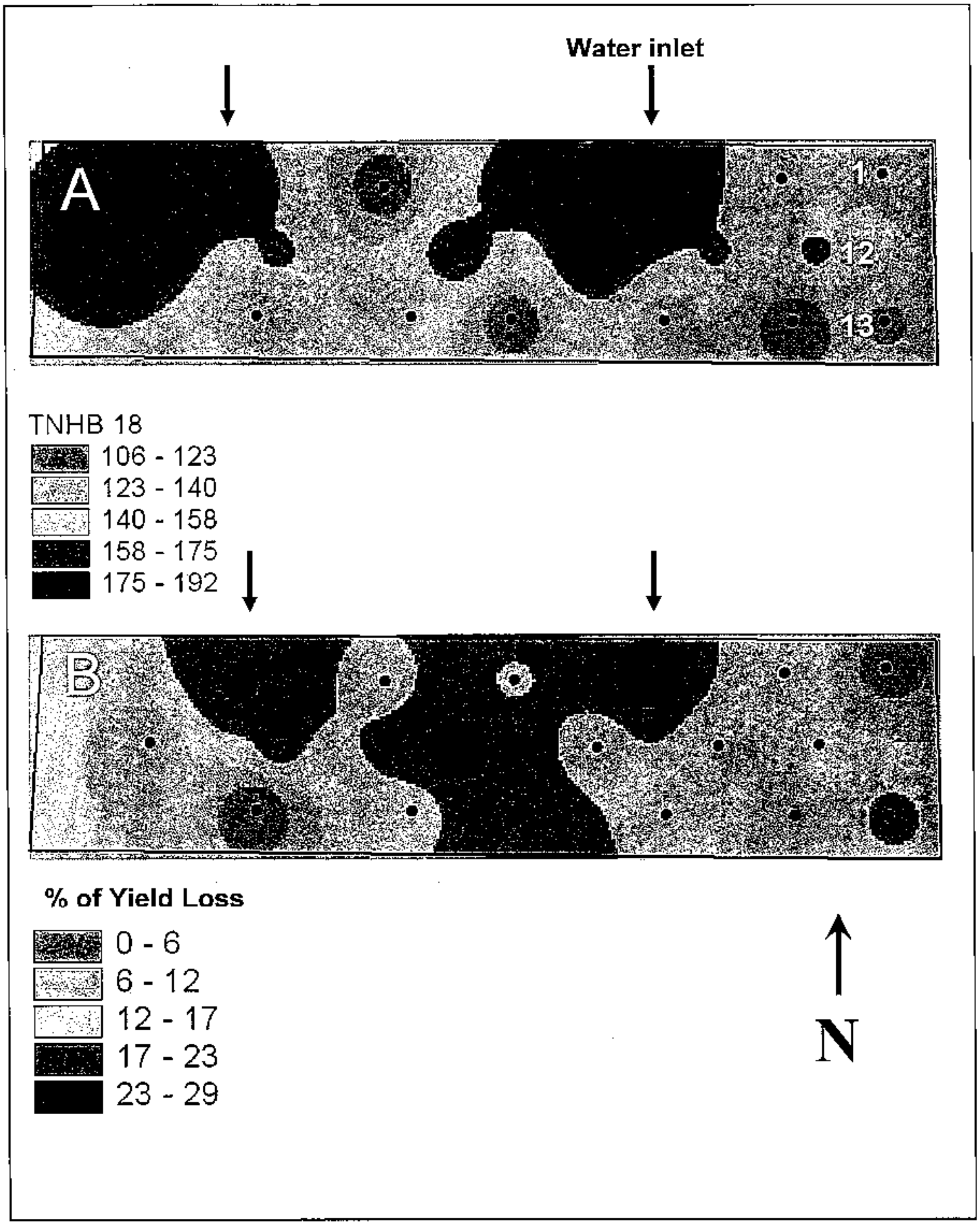
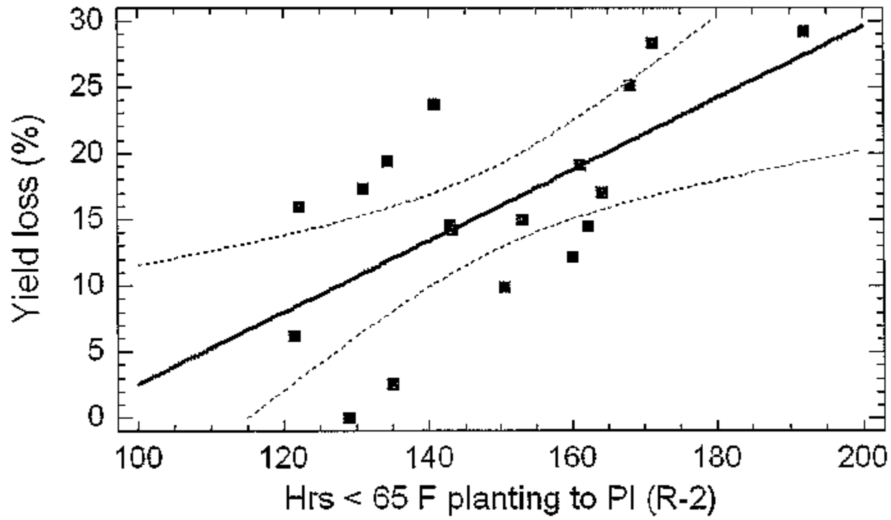


Figure 13. Interpolation of geo-referenced THPI (65 F = 18.3 C) and yield loss (%) data for R-2 check 1. Sensors placed in a serpentine fashion. Sensors 1, 12, and 13 are labeled (A).



Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	3.00788E6	1	3.00788E6	11.13	0.0042
Residual	4.32318E6	16	270199.		
Total (Corr.)	7.33105E6	17			

R-squared = 41.0293 percent
Standard Error of Est. = 519.806
Mean absolute error = 406.529
Durbin-Watson statistic = 1.61964 (P=0.1861)

Figure 14. Yield loss (%) as a function TNPI at the Richvale 2 (R-2) site.

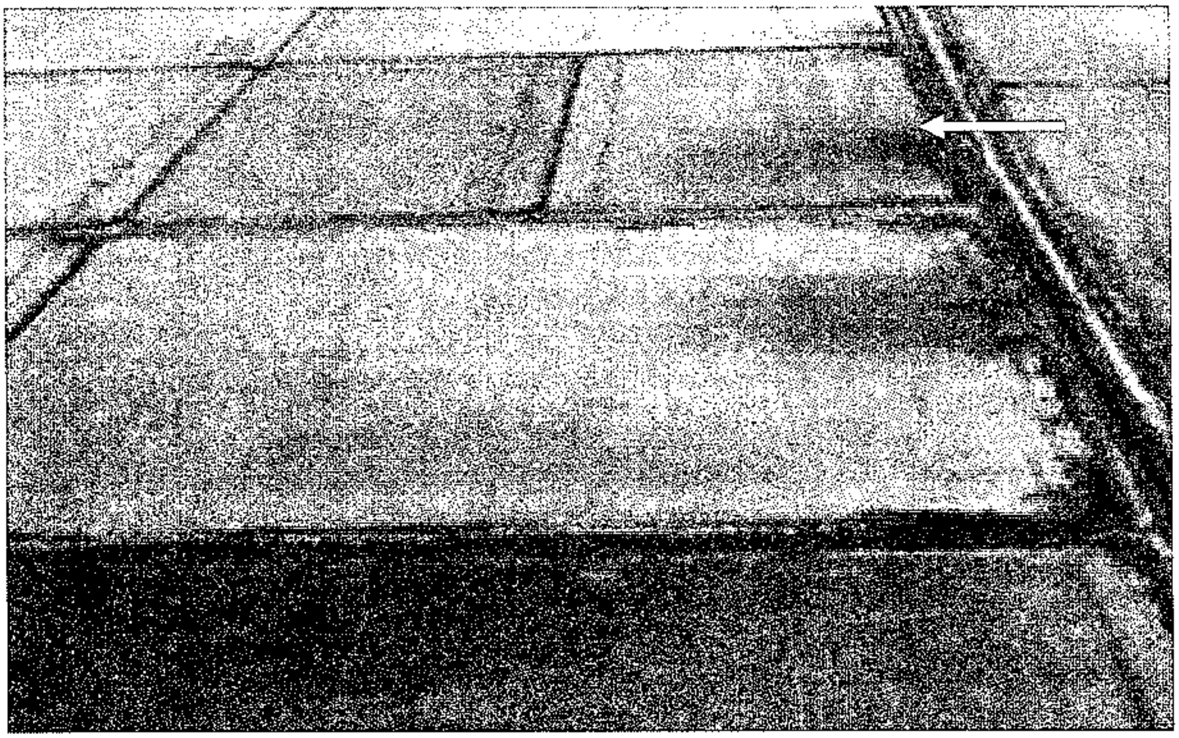


Figure 15. Aerial view of the R-2 site at harvest time illustrating the cold water "foot print" radiating out from the water inlet as designated by the arrow. A similarly affected area is apparent in the adjacent field. Best viewed in color.

Biggs West Gridley 1

TNPI ranged from 159 to 302 hours in check 1 at B-2 (Figure 16 A). The coldest water was near the water inlet, designated by an arrow. The weir between checks 1 and 2 was located in the southeastern corner. The water flow toward check 2 appears to influence the distribution of the low water temperature zone, in that it stretches toward water exit from check 1. Anecdotal evidence provided by the grower and substantiated by visual inspection of the research team suggested that the low water temperature affects continue into check 2 along the water flow path along the eastern edge of the field. Interpolated yield loss contours are comparable to the interpolated temperature gradient (Figure 16 B). Yield losses ranged from 90% near the water inlet to virtually zero at the western end of the check. A zone of delayed maturity (similar to Figure 15) roughly corresponded to the 55 to 90% yield loss region at B-1. The cold water affects extended over half way across the check at this location.

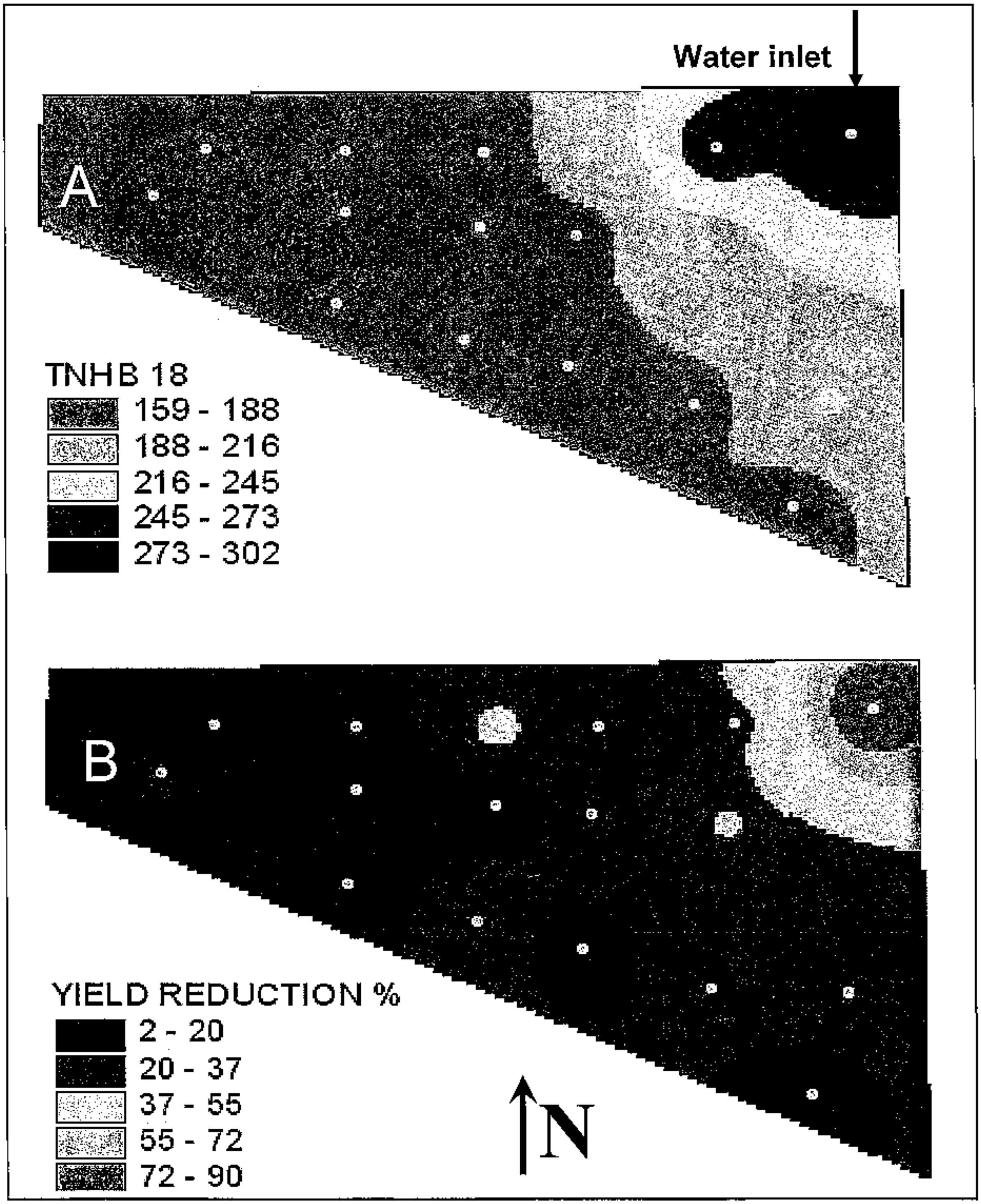
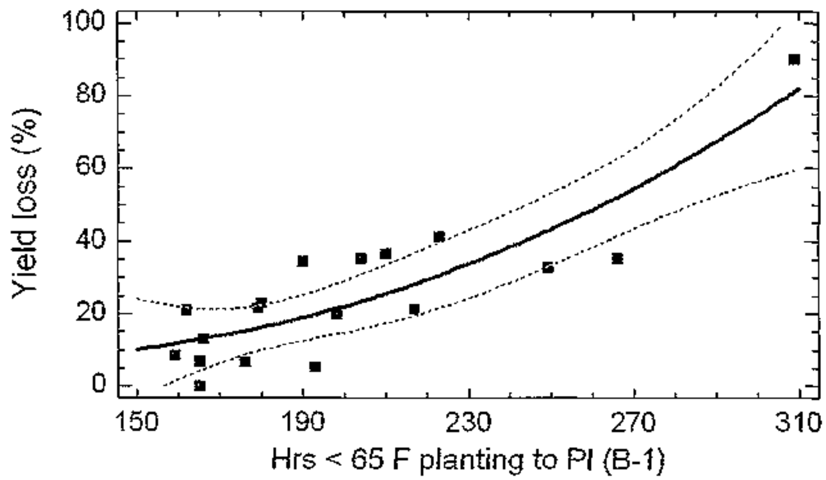


Figure 16. Interpolation of geo-referenced THPI (65 F = 18.3 C) and yield loss (%) data for B-1 check 1.

One variable regression analysis relating TNPI to yield loss resulted in an R^2 of 0.74 and a p-value of 0.0000 (Figure 17) with measurable yield beginning to accrue around 150 hours similar to the other late planted site, R-2.



Analysis of Variance

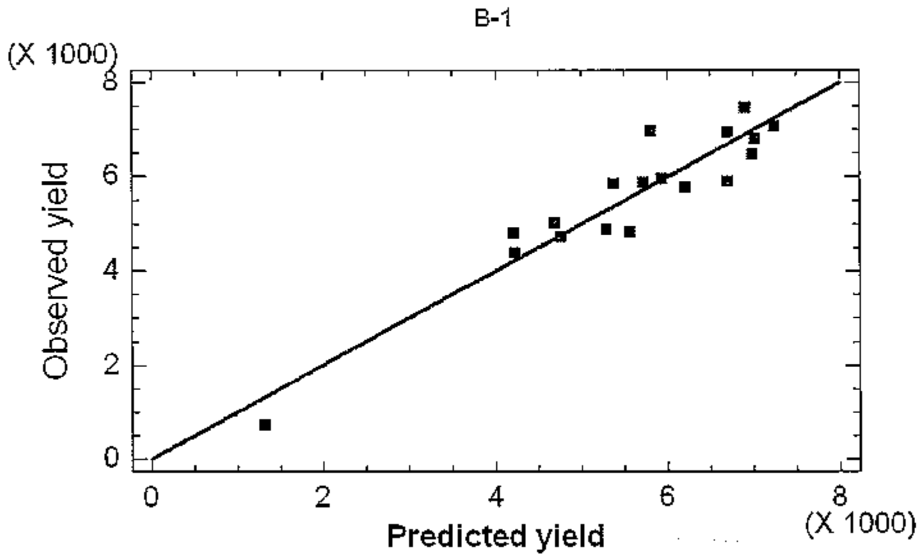
Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	5366.21	2	2683.11	22.64	0.0000
Residual	1777.65	15	118.51		
Total (Corr.)	7143.86	17			

R-squared = 73.6214 percent
Standard Error of Est. = 10.8862
Mean absolute error = 8.84308
Durbin-Watson statistic = 2.14089 (P=0.4868)

Figure 17. Yield loss (%) as a function TNPI at the Biggs West Gridley - 1 (B-1) site.

Multivariate output showed that a linear regression model to describe the relationship between B-1 yield (lb/a) and 3 independent variables, DPI, TNPI, and HA, resulted in an R^2 of 0.88 and a p-value of 0.0000. The equation of the fitted model is:

$$\text{Yield (lb/a)} = 131.813 + 213.862*\text{DPI} - 40.4742*\text{DNPI} + 29.8642*\text{HA}.$$



Model

		Standard	T	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
CONSTANT	131.813	2788.82	0.0472649	0.9630
B-1.Days to PI	213.862	54.2593	3.94149	0.0015
B-1.Hrs 65 PI	-40.4742	5.935	-6.81957	0.0000
B-1.Heads per area	29.8642	8.97674	3.32684	0.0050

Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	3.51714E7	3	1.17238E7	35.03	0.0000
Residual	4.68512E6	14	334651.		
Total (Corr.)	3.98565E7	17			

R-squared = 88.245 percent
Standard Error of Est. = 578.491
Mean absolute error = 420.975
Durbin-Watson statistic = 2.11098 (P=0.4944)

Figure 18. Predicted yield versus observed yield as calculated by multiple regression analysis predicting yield (lb/a) as a function of the independent variables: DTPI, TNPI, and heads per area (HA) at the Biggs West Gridley -1 (B-1) site.

Biggs West Gridley 2

TNPI ranged from 168 to 442 hours at B-2 (Figure 19-A). The coldest area was at the water inlet. The low temperature water appeared to remain sequestered in the southern part of the check. The weir conducting the water flow between checks (water outlet on map) was in the southwest corner of the field in close proximity to the water inlet. Based on this map and field observations, the low temperature water moved into check 2 more readily than moving north within check 1. Delayed growth was observed at the water inlet into check 2. Yield loss was greatest near the water inlet into check 1 (32%, Figure 19-B). The yield loss showed a distribution similar to TNPI and the severity diminished with distance away from the inlet. Unexplained by TNPI was the area of moderate loss (20-24%) at the north end of check 1. Neither did number of heads per area, seeds per head, plant height, lodging, and incidence of disease account for reduced yields in northern part of the check.

A linear regression relating TNPI and yield loss was significant at the 99% confidence level and accounted for 36% of the observed yield variation (Figure 20). Multivariate analysis showed that TNPI and PH were the best predictors of yield at B-2 (Figure 21). The predictive equation with an R^2 of 0.41 and a p-value of 0.0198 is:

$$\text{Yield (lb/a)} = 6134.9 - 4.01705 * \text{DNPI} + 48.4617 * \text{HA}.$$

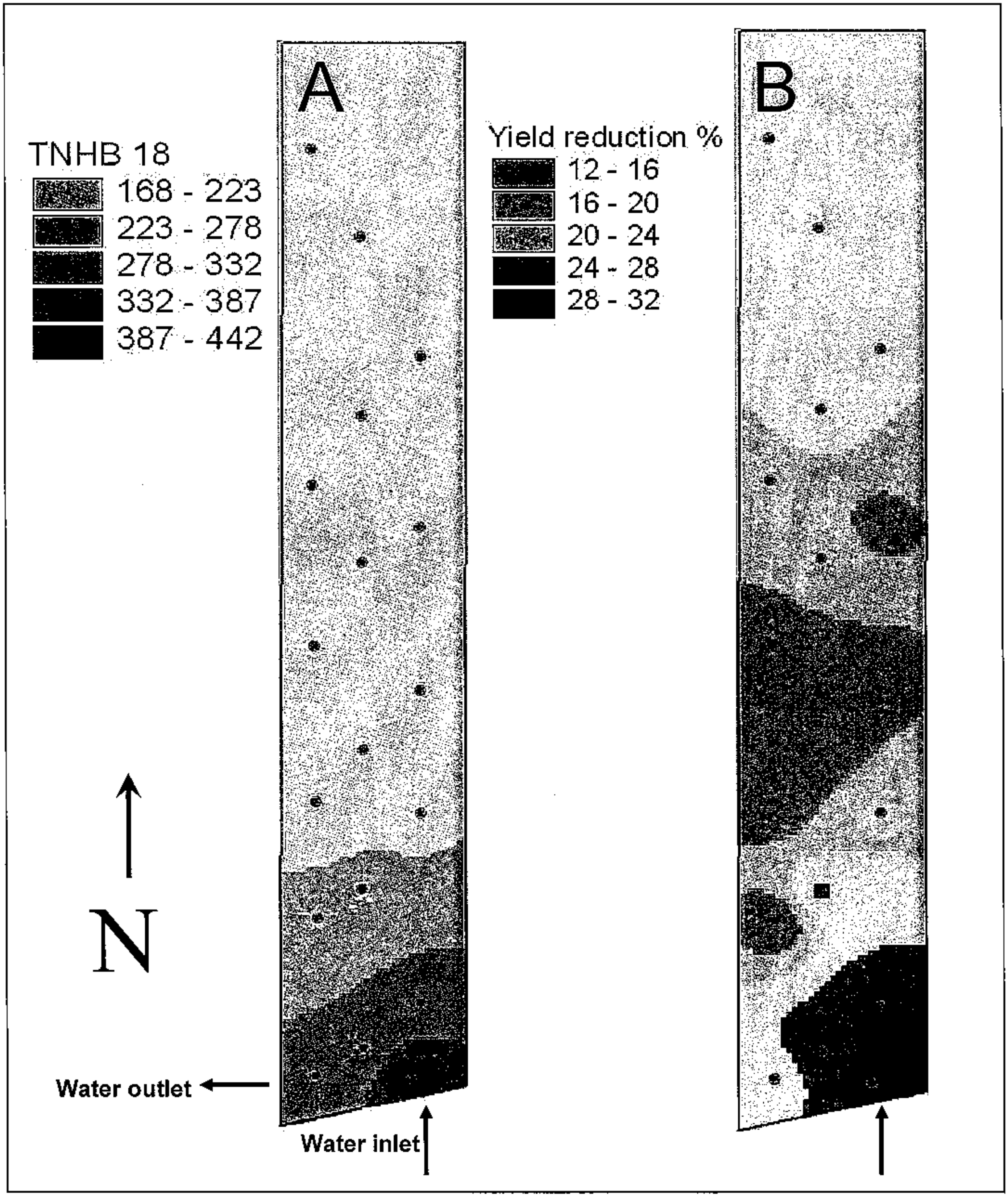
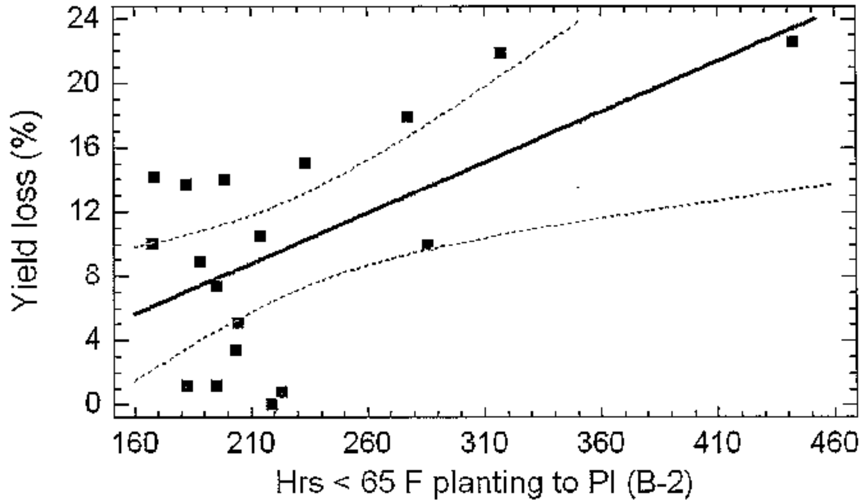


Figure 19. Interpolation of geo-referenced THPI (65 F = 18.3 C) and yield loss (%) data for B-2 check 1.

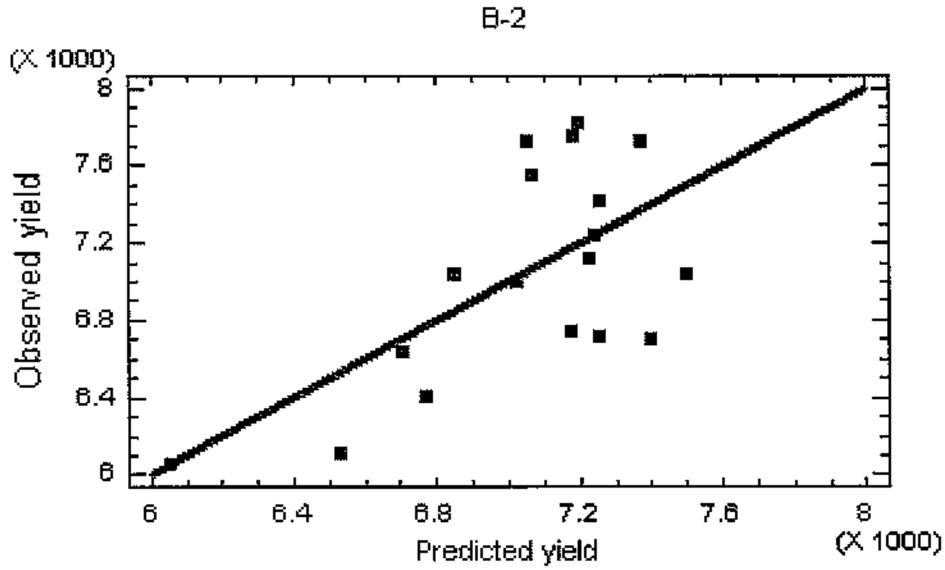


Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	305.323	1	305.323	8.98	0.0085
Residual	543.801	16	33.9876		
Total (Corr.)	849.124	17			

R-squared = 35.9544 percent
Standard Error of Est. = 5.82989
Mean absolute error = 4.85639
Durbin-Watson statistic = 1.22942 (P=0.0671)
Lag 1 residual autocorrelation = 0.343074

Figure 20. Yield loss (%) as a function TNPI at the Biggs West Gridley - 2 (B-2) site.



Model

		Standard	T	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
CONSTANT	6134.9	1883.02	3.258	0.0053
B-2.Hrs 65 PI	-4.01705	1.82817	-2.1973	0.0441
B-2.Plant Ht inches	48.4617	43.9867	1.10173	0.2879

Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	2.11427E6	2	1.05714E6	5.16	0.0198
Residual	3.07509E6	15	205006.		
Total (Corr.)	5.18937E6	17			

R-squared = 40.7424 percent
Standard Error of Est. = 452.776
Mean absolute error = 341.595
Durbin-Watson statistic = 1.30366 (P=0.0513)

Figure 21. Predicted yield versus observed yield as calculated by multiple regression analysis predicting yield (lb/a) as a function of the independent variables: TNPI and plant height (PH) at the Biggs West Gridley - 2 (B-2) site.

Combined Sites

Western Canal Water District

Among the water districts, only the WCWD sites could be combined presumably because both were planted at about the same time. However, this experiment was not designed to test planting time affects. When data from W-1 and W-2 were combined a single model relating TNPI to yield loss was significant at the P < 0.001 level and accounted for 93% of the yield variability (Figure 22). W-1 and W-2 represented the extremes of potential exposure to cold water within the WCWD. Based on 2005 data, it is conceivable that a single model could be used to estimate yield loss for intake checks along the main canals throughout the WCWD.

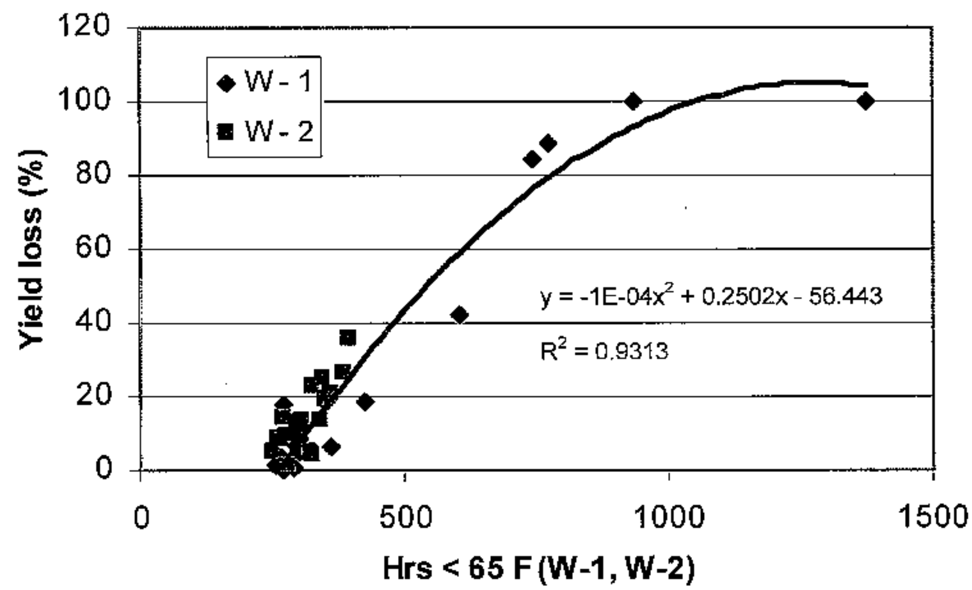


Figure 22. One predictive model relating TNPI to yield loss (%) for W-1 and W-2.

Richvale Irrigation District

Unlike WCWD, plant response to cold water exposure was strikingly different between sites (Figure 23). The slope of the linear response function relating TNPI to yield loss for R-2 was more acute than that of R-1. In other words, per hour of exposure to water temperature less than 65 F a greater yield loss would be expected at R-2. Additionally the effects began accumulating at 150 hours at R-2 as compared to about 300 hours at R-1. One possible but untested explanation is that late planting dates predispose rice plants to have a greater degree sensitivity to cold water.

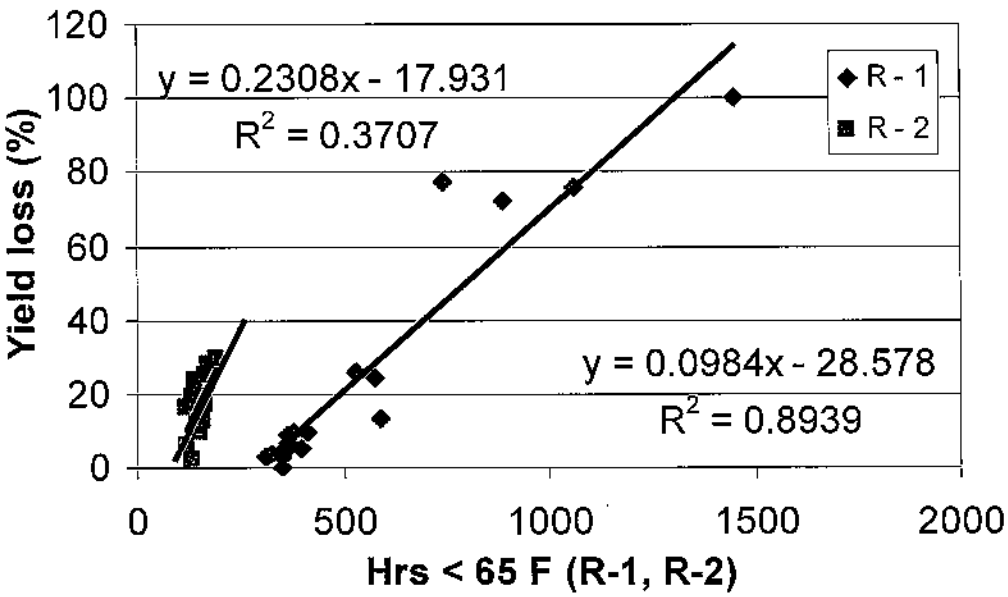


Figure 23. Comparison of the linear models relating TNPI to yield loss (%) for R-1 and R-2.

Biggs West Gridley Irrigation District

In a fashion similar to the Richvale sites, B-1 and B-2 exhibited dissimilar responses to cold water exposure (Figure 24). The later planted field (B-1) proved to be more sensitive to incremental increases in TNPI than was observed for B-2. In contrast to the Richvale sites comparison, however, both of the Biggs West Gridley locations showed a linear increase in yield loss starting at about 150 hours. R-2, B-1, and B-2 all displayed a similar threshold of injury..

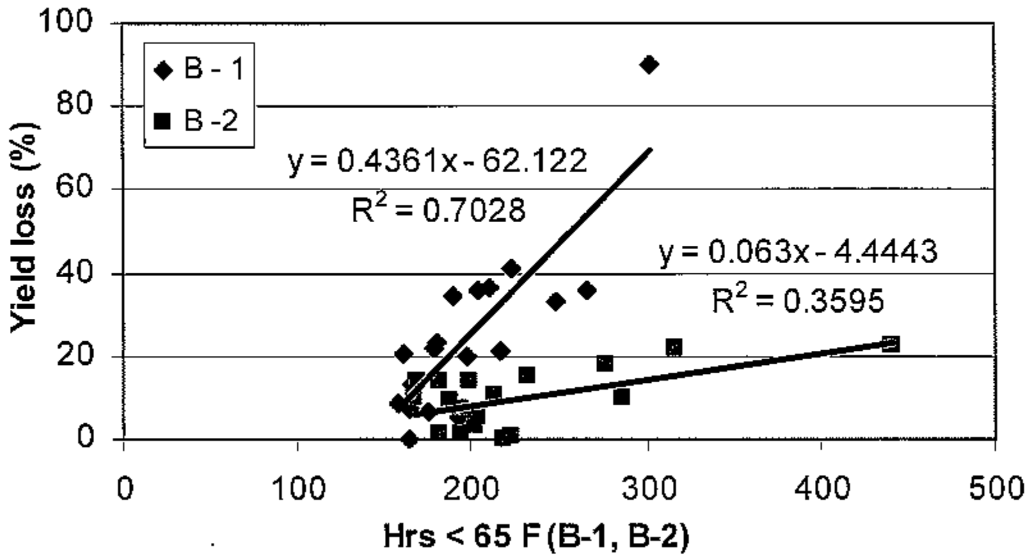
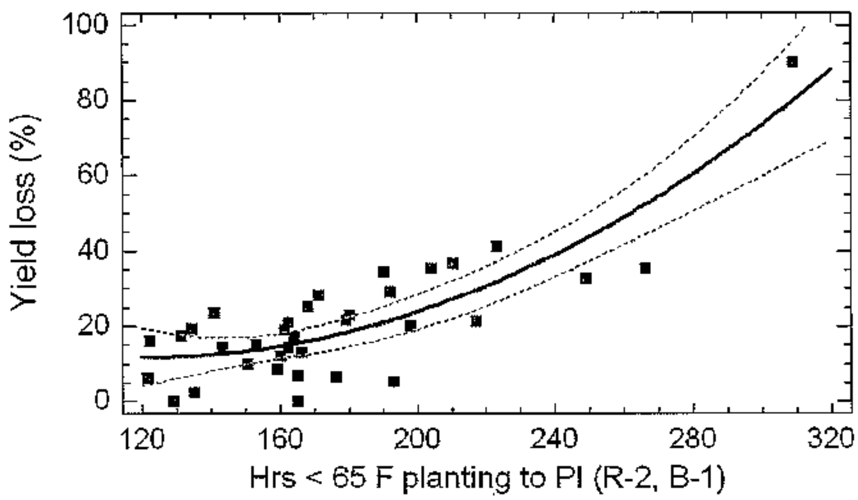


Figure 24. Comparison of the linear models relating TNPI to yield loss (%) for Biggs West Gridley sites 1 and 2.

Late Planted: R-2 and B-1

Data from the late planted fields were combined to determine if a single model would describe the relationship between TNPI and yield loss. Single variable regression produced an R^2 value of 0.69 and a model that was statistically significant ($p = 0.0000$, Figure 25). Testing a linear multivariate approach to depicting the late site response demonstrated that TNPI was the only significant factor (Figure 26). The equation of the fitted model for yield is:

Late planted.yield (lb/a) = 10276.1 - 22.5875*TNPI

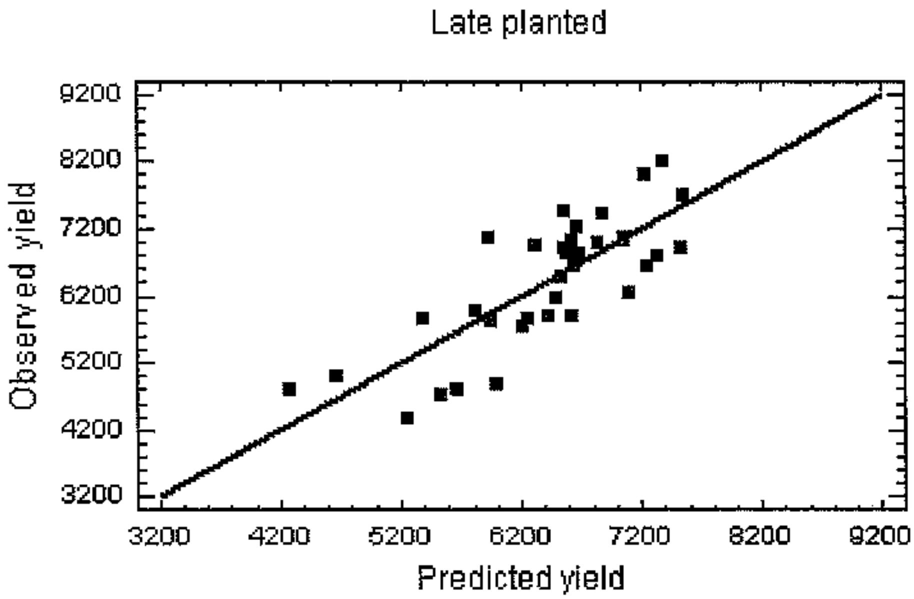


Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	6355.77	2	3177.88	39.30	0.0000
Residual	2668.29	33	80.8572		
Total (Corr.)	9024.06	35			

R-squared = 69.1470 percent
Standard Error of Est. = 8.99207
Mean absolute error = 7.37652
Durbin-Watson statistic = 1.95353 (P=0.3507)

Figure 25. Yield loss (%) as a function TNPI at the late planted R-2 and B-1 sites.



Model

		Standard	T	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
CONSTANT	10276.1	528.174	19.4559	0.0000
Late Planted.Hrs 65 PI	-22.5875	3.03163	-7.45062	0.0000

Analysis of Variance

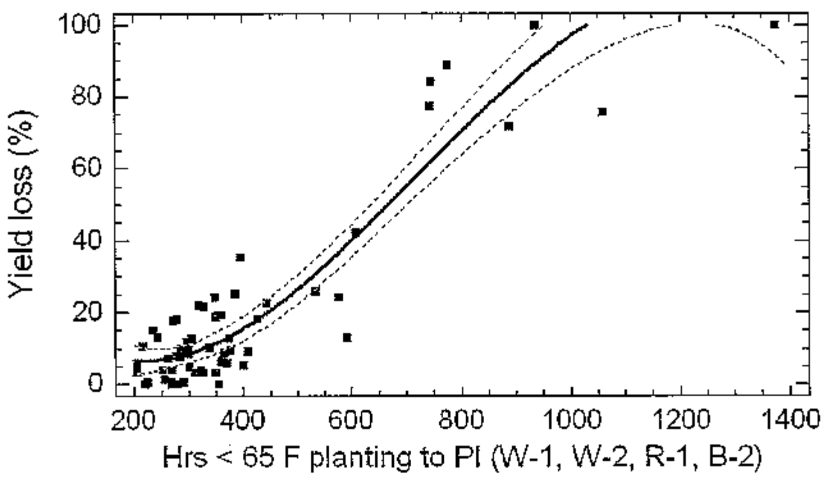
Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	2.01362E7	1	2.01362E7	55.51	0.0000
Residual	1.19703E7	33	362738.		
Total (Corr.)	3.21066E7	34			

R-squared = 62.7168 percent
Standard Error of Est. = 602.277
Mean absolute error = 495.854
Durbin-Watson statistic = 1.94132 (P=0.3811)

Figure 26. Predicted yield versus observed yield as calculated by multiple regression analysis predicting yield (lb/a) as a function of the independent variable: TNPI at late planted sites (R-2, B-1).

Early Planted:W-1, W-2, R-1, and B-2

Using aggregated data from the early planted fields, a single equation described plant response to cold water exposure (Figure 27). TNPI as the sole predictor of yield loss resulted in a regression analysis with an R^2 value of 0.88 and a p-value of 0.0000. These sites encompassed the extremes of the three irrigation districts' service areas, ranging from the coldest (W-1) to the warmest (B-2) sites. Based on 2005 data, a single model describing the region wide impact of cold water on rice productivity was possible for fields planted at about the same time. A linear multivariate model found that TNPI and DTPI were the best predictors of yield at the early planted sites (Figure 28).

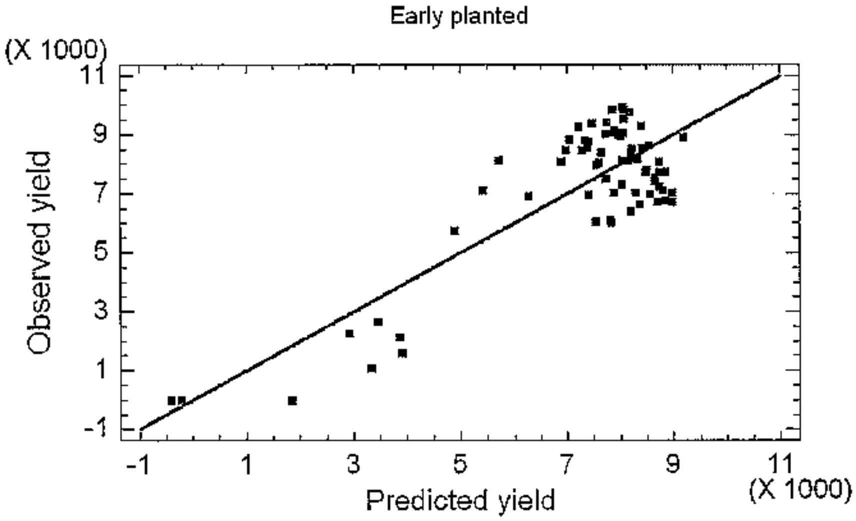


Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	41535.8	3	13845.3	159.12	0.0000
Residual	5829.79	67	87.0118		
Total (Corr.)	47365.6	70			

R-squared = 87.6919 percent
Standard Error of Est. = 9.32801
Mean absolute error = 6.97043
Durbin-Watson statistic = 1.48335 (P=0.0988)

Figure 27. Yield loss (%) as a function TNPI at the early planted sites. W-1, W-2, R-1, and B-2 sites.



Model

		Standard	T	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
CONSTANT	6488.3	1812.02	3.5807	0.0006
Early Planted.Days to PI	73.7958	34.168	2.15979	0.0343
Early Planted.Hrs 65 PI	-9.31285	0.931459	-9.99812	0.0000

Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	2.84239E8	2	1.4212E8	75.71	0.0000
Residual	1.27646E8	68	1.87715E6		
Total (Corr.)	4.11886E8	70			

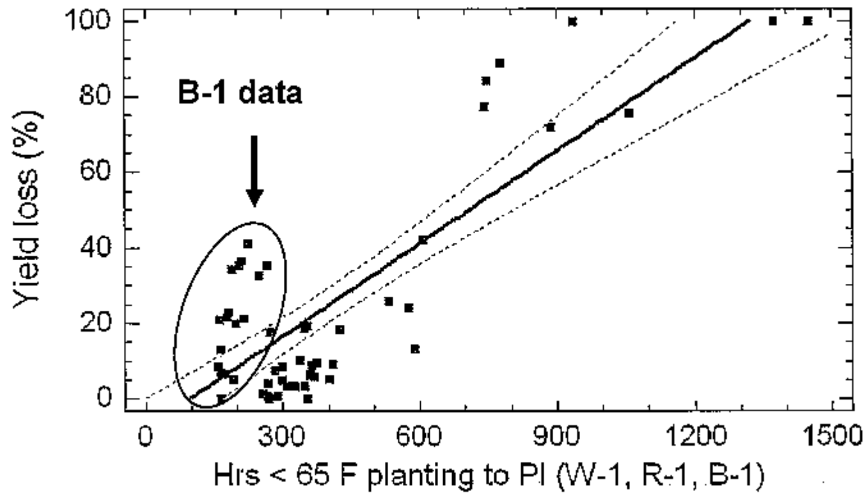
R-squared = 69.0093 percent
Standard Error of Est. = 1370.09
Mean absolute error = 1171.71
Durbin-Watson statistic = 0.874083 (P=0.0612)

Figure 28. Predicted yield versus observed yield as calculated by multiple regression analysis predicting yield (lb/a) as a function of the independent variables DTPI and TNPI for W-1, W-2, R-1 and B-2.

First Site in Each District: W-1, R-1, and B-1

Yield loss and water temperature combined for the coldest locations in each irrigation district was best fitted with a linear model (Figure 29). Although the results indicated a significant relationship between TNPI and yield loss ($R^2 = 0.68$; $p = 0.0000$), the B-1 data reduced the quality of the fit as compared to a model minus the B-1 results (data not shown). The B-1 data is apparent in that it is somewhat spurious when compared to data from the other sites (Figure 26). Multivariate regression fitting the dependent variable, yield (lb/a), to 3 independent variables, TNPI, DTPI, and SH resulted in the following predictive equation with an R^2 value of 0.69 (Figure 30):

First Sites Yield (lb/a) = -146.563 + 117.525*DTPI - 8.1235*TNPI + 53.5533*SH

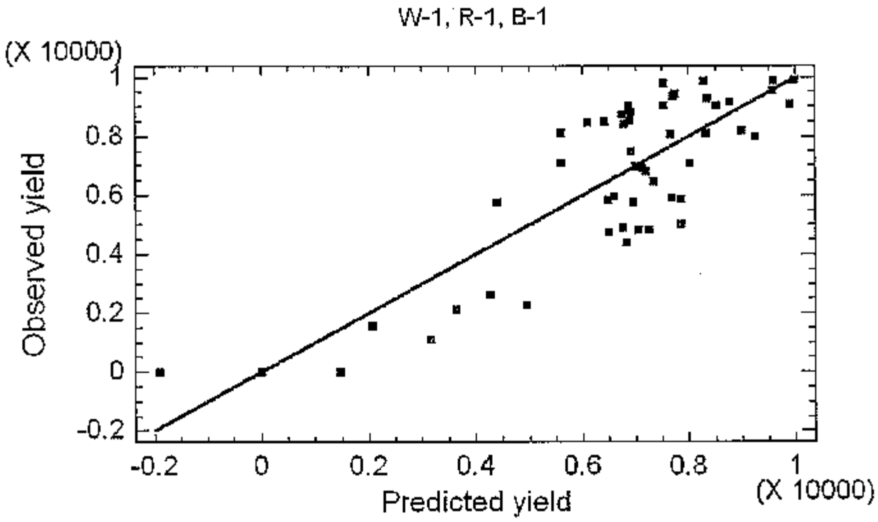


Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	29519.0	1	29519.0	106.18	0.0000
Residual	14178.7	51	278.013		
Total (Corr.)	43697.7	52			

R-squared = 67.5528 percent
Standard Error of Est. = 16.6737
Mean absolute error = 13.8486
Durbin-Watson statistic = 1.16083 (P=0.70105)

Figure 29. Yield loss (%) as a function TNPI at the sites closest to the points of diversion, W-1, R-1, and B-1.



Model

		Standard	*T*	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
CONSTANT	-146.563	2359.74	-0.0621097	0.9507
W-1 R-1 B-1.Days to PI	117.525	51.1763	2.29648	0.0260
W-1 R-1 B-1.Hrs 65 PI	-8.1235	1.53155	-5.3041	0.0000
W-1 R-1 B-1.Seeds per head	53.5533	11.9807	4.46996	0.0000

Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	2.82488E8	3	9.41627E7	36.14	0.0000
Residual	1.27661E8	49	2.60533E6		
Total (Corr.)	4.10149E8	52			

R-squared = 68.8745 percent
Standard Error of Est. = 1614.1
Mean absolute error = 1324.98
Durbin-Watson statistic = 1.13975 (P=0.08002)

Figure 30. Predicted yield versus observed yield as calculated by multiple regression analysis predicting yield (lb/a) as a function of the independent variables: DTPI, TNPI, and seeds per head (SH) at the combined W-1, R-1, and B-1 sites.

Thermal Infrared Images (TIR)

The use of remotely sensed TIR to measure the temperature of the earth's surface and bodies of water is well established (Torgerson et al, 1999, 2001). In these applications of TIR, the temperature is static pertaining to only one moment in time; one image equates to one temperature measurement. This study, however, confirmed what was previously reported (Mutters, 2003; Roel 2005) that the cold water temperature effect is a dose response function. The negative effects, in terms of yield loss, are accumulated over time. Therefore the challenge to using this technology is how best to use a single point measure (TIR) to predict a plant stress response integrated over time (yield loss ∫ TNPI). Simply put, this is a four-step process. Tw refers to a water temperature at a given time.

1. Relate TIR to Tw. Well documented in the literature.
2. Relate Tw to TNPI. A static measure describing an accumulative measure.
3. Relate TIR to TNPI. Possible if 1 and 2 are successful.
4. Relate TIR to Yield loss (YL). Since TNPI is a good predictor of YL and if TIR adequately describes TNPI, it follows that YL may be predicted by TIR.

Although it is possible to jump directly to the comparison of TIR to YL, the intervening steps are needed to ensure that a significant relationship between TIR and yield is defensible and not a merely serendipitous association. It is reasonable to expect a loss in resolution at each iteration (i.e. decreasing R^2 values) should this technique be employed on a regional scale by incrementally scaling from the field level. There are no serious discussions in the literature pertaining to such an application of TIR. The results reported herein should be considered as exploratory.

The approach taken was to capture TIR images at two key points in the rice plant's life cycle, tiller and panicle initiation; the first representing an important moment in the vegetative cycle and the second a critical time of reproduction. The choice of these points was also based on preliminary work on the same subject conducted by R Plant, UC Davis (personal communication). The exact of time that the aerial image was captured and the absolute calibration of the TIR image are required. The calibration changes with every flight. Of the three flights date (June 22, July 7 and July 22), July 7 proved to be the strongest data set for predicting plant response to water temperature. The June 22 data was dispersed with no discernible patterns. The TIR data from July 22 would lend itself to regression analysis but the resulting model(s) would be asymptotic-like in nature and of little predictive value (Figure 31).

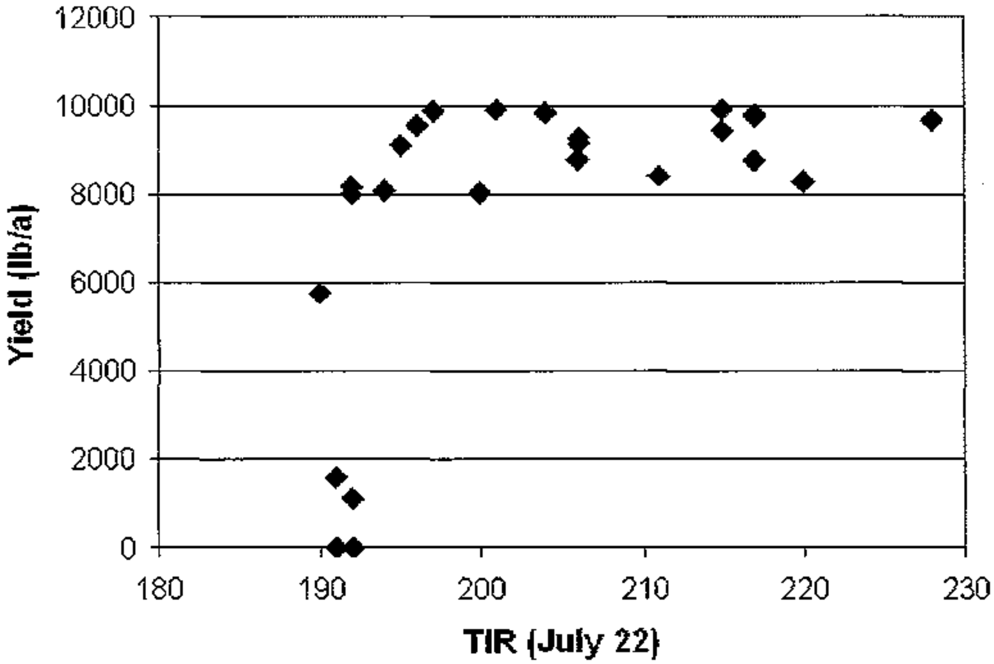
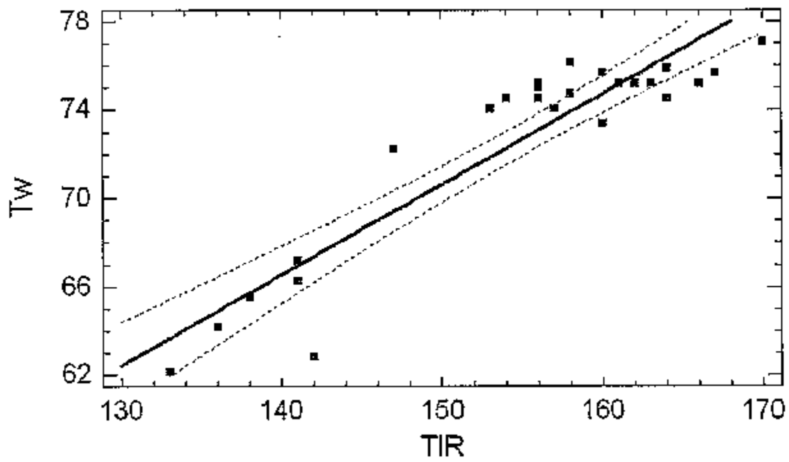


Figure 31. Relationship between the thermal infrared image (TIR) and yields on July 22, 2005 for all sensor locations at the Western 1 experimental sight.

TIR as a predictor of Tw is typically a linear function, as was the case for W-1 (Figure 32). Water temperatures at the time of the over flight from each geo-referenced sensor were used. Regression analysis fitted a single variable model relating the independent variable TIR to the dependent variable Tw with an R^2 of 0.85 and a p-value of 0.0000. The critical temperature of 65 F corresponds to 136 on the TIR scale. The equation is:

Water Temp F = 9.29353 + 0.408926*TIR July 7.

W-1



Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	440.499	1	440.499	134.55	0.0000
Residual	75.301	23	3.27396		
Total (Corr.)	515.8	24			

R-squared = 85.4011 percent
Standard Error of Est. = 1.80941
Mean absolute error = 1.42014
Durbin-Watson statistic = 1.57889 (P=0.1064)

Figure 32. Relationship between the thermal infrared image (TIR) and water temperature (Tw) on July 7, 2005 for all sensors in check 1 at the Western 1 experimental sight.

At W-1, a second degree polynomial with TIR as the sole independent variable proved to be a good predictor of TNPI (R^2 = 0.83, Figure 33). The statistically significant equation is:

TNPI = 26882.2-328.006*TIR July 7 + 1.00886*TIR July 7^2.

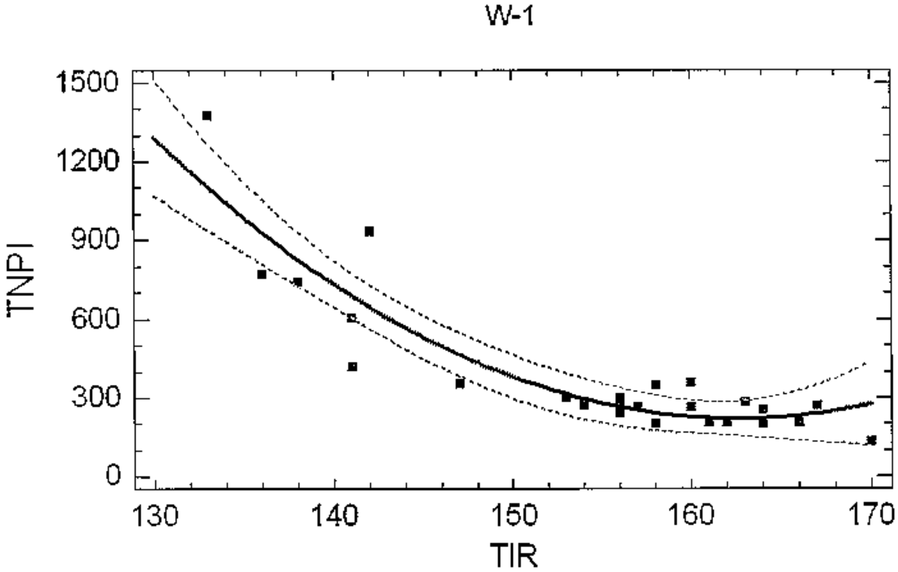
Similar analysis using the June 22 and the July 22 TIR data produced insignificant relationships with R^2 values of 0.06 and 0.31, respectively (data not shown). At TIR values above about 160, the equation becomes less sensitive. Interestingly, the TNPI threshold for yield loss for the aggregated early planted sites is around 300 and related to a TIR value of about 160.

TIR as a single independent predictor of yield resulted in a statistically significant equation with an R^2 of 0.81 (Figure 34). TIR was more sensitive to yields below about 8000 lb/a. For example there were four locations with yield near 8000 lb/a, highlighted in Figure 33. The associated TIR values ranged from 140 to 158. Nonetheless with over 80% of the yield variability was accounted for by TIR, the technique is a promising tool for evaluating wide area yields.

The relationship between yield loss and TIR (Figure 35) showed a similar relationship as was observed in Figure 34, albeit inverted, resulting in nearly identical R^2 values. This is not surprising given that the yield loss calculation is a transformation process of the yield data. The predictive equation

$$\text{Yield loss} = 3317.79 - 41.1465 * \text{TIR July 7} + 0.127746 * \text{TIR July 7}^{\wedge}2$$

discerned yield losses greater than about 10% (Figure 35).



Model

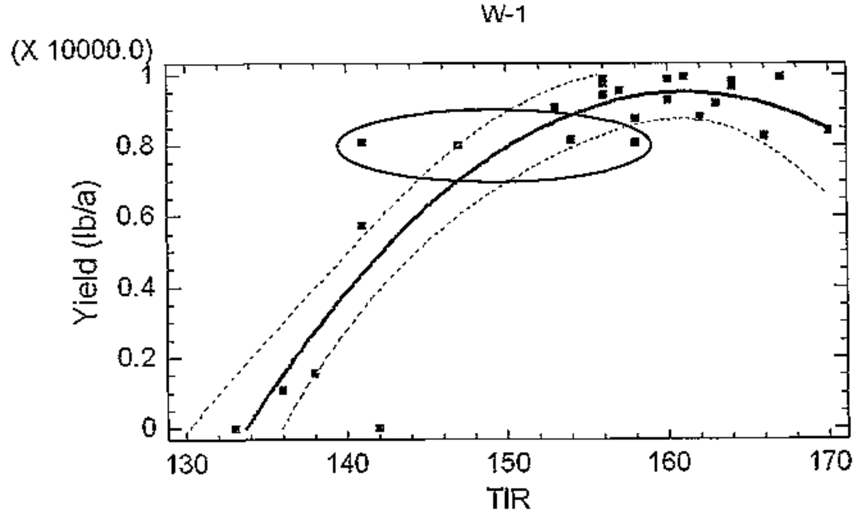
		Standard	T	
Parameter	*Estimate*	*Error*	*Statistic*	*P-Value*
CONSTANT	26882.2	5861.72	4.58606	0.0001
TIR July 7 DN	-328.006	77.8167	-4.21512	0.0004
TIR July 7 DN^2	1.00886	0.257225	3.92209	0.0007

Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	1.62577E6	2	812886.	52.48	0.0000
Residual	340750.	22	15488.6		
Total (Corr.)	1.96652E6	24			

R-squared = 82.6725 percent

Figure 33. Relationship between the thermal infrared image (TIR) and TNPI on July 7, 2005 for all sensors in check 1 at the Western 1 experimental sight.



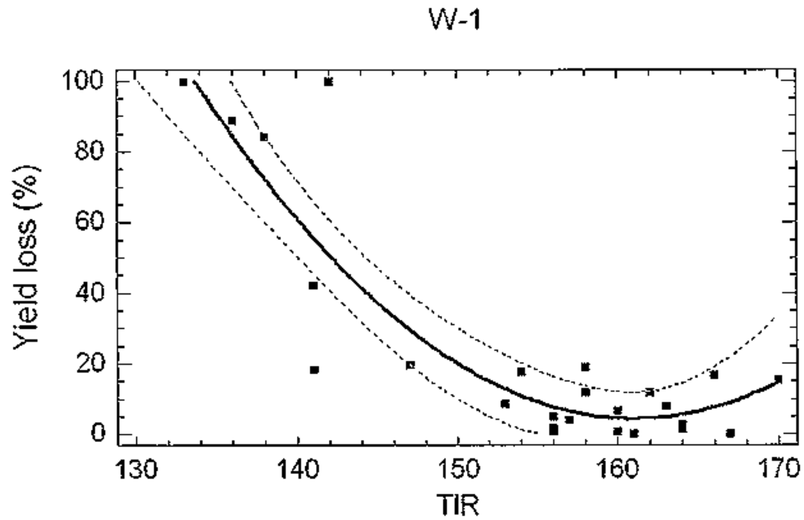
Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	2.02746E8	2	1.01373E8	45.65	0.0000
Residual	4.88547E7	22	2.22067E6		
Total (Corr.)	2.51601E8	24			

R-squared = 80.5824 percent

TIR Yield = -319695. + 4087.98*TIR July 7 DN-12.6917*TIR July 7 DN^2

Figure 34. Relationship between the thermal infrared image (TIR) and yield (lb/a) on July 7, 2005 for all sensors in check 1 at the Western 1 experimental sight.



Analysis of Variance

Source	*Sum of Squares*	*Df*	*Mean Square*	*F-Ratio*	*P-Value*
Model	20538.0	2	10269.0	45.65	0.0000
Residual	4948.47	22	224.93		
Total (Corr.)	25486.5	24			

R-squared = 80.584 percent

Figure 35. Relationship between the thermal infrared image (TIR) and yield loss (%) on July 7, 2005 for all sensors in check 1 at the Western 1 experimental sight.

Combining data from all sensors (checks 1 and 3) from 5 sites demonstrated that TIR predicted Tw at four of the six sites (Table 14). No aerial image was available for R-2 on this date. TIR accounted for between 44 and 92% of the variation in Tw. TIR was significantly correlated with TNPI and yield at only 2 sites, W-1 and R-1; the two coldest locations. Considering only checks 1 moderately improved the worth of TIR as a predictor (Table 15). The relationship between TIR and Tw was significant at four of the five sites where aerial images were available. The relationships between TIR and TNPI across location showed a similar trend. TIR satisfactorily predicted yields at W-1, W-2, and R-1. In general the utility of

TIR was the strongest at the early planted sites, W-1, W-2, R-1, and B-2. At B-1, there was no significant relationship of TIR to any of the dependent variables tested at any date.

Table 14. Correlation between thermal infrared digital values (TIR) and water temperature (Tw) in degrees F, hours < 65 F (TNPI), and yield (YLD) on July 7, 2005 for all sensors at all experimental sites. All coefficient of determination values presented are significant at P < 0.05 level or greater; ns = non-significant. NA = no aerial image available.

Correlation	W-1	W-2	R-1	R-2	B-1	B-2
TIR vs Tw	0.92	0.44	0.90	NA	ns	0.64
TIR vs. TNPI	0.83	ns	0.66	NA	ns	ns
TIR vs. YLD	0.81	ns	0.62	NA	ns	ns

Table 15. Correlation between thermal infrared digital values (TIR) and water temperature (Tw) in degrees F, hours < 65 F (TNPI), and yield (YLD) on July 7, 2005 for sensors located in checks 1 at all experimental sites. All coefficient of determination values presented are significant at P < 0.05 level or greater; ns = non-significant; NA = no aerial image available.

Correlation	W-1	W-2	R-1	R-2	B-1	B-2
TIR vs Tw	0.85	0.69	0.69	NA	ns	0.72
TIR vs. TNPI	0.83	0.82	0.68	NA	ns	0.34
TIR vs. YLD	0.81	0.80	0.64	NA	ns	ns

Summary and Conclusions

Prolonged exposure to cold water reduced the yields of rice at all locations. Check 1 (cold water intake) yields were consistently lower that check 3 yields whether calculated using data from experimental plots or grower reported yields. The yield reduction averaged across locations was 14% and 17% based on experimental plots and grower yields, respectively. TNPI was the best and consistently statistically significant single predictor of yield loss under all circumstances whether the field data were analyzed individually or pooled in various combinations (p-values of 0.05 or lower). Furthermore TNPI was consistently significant (p-values of 0.05 or lower) in multivariate analysis relating yield to a suite of variables. Of the nine multivariate analyses conducted, other than TNPI, only TDPI proved significant more than twice.

Previous work investigating factors (11, excluding water temperature) underlying yield variability in two California rice fields found no consistent relationships across location and years (Roel and Plant, 2004). Yet in the current study and in two previous years (2000 & 2001; Roel et al 2005), the duration of exposure to low water temperature proved to be a consistent predictor of yield loss. Mutters et al (2003) demonstrated that the critical period of exposure was from seeding to panicle initiation. Similarly, Shimono et al (2002) observed that low temperature water during the vegetative period (planting to panicle initiation) reduced yield by 20% and was accompanied by delayed growth and reduced plant biomass. Delayed growth and reduced biomass associated with low water temperature was observed in the present study, as well.

Remotely captured TIR images predicted Tw, TNPI, and yield at the W-1 and R-1 sites with a significant degree of confidence. This approach was inconsistent at the other research sites. Additional work is needed to identify the optimal growth stage for relating yield loss to TIR accompanied by extensive ground truthing to establish its reliability.

Unquestionably based on this experiment and substantiated by the scientific literature it may be concluded that low temperature water, such as that originating from the Feather River, adversely impacts rice growth and development and results in substantial yield reductions. The water temperature related yield loss was evident throughout in the rice production zone served by the irrigation districts diverting water from the Thermalito Afterbay.

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APPENDIX I

APPENDIX I

MEASURING THE EFFECTS OF LOW WATER TEMPERATURE ON BLANKING AND GRAIN YIELD IN CALIFORNIA RICE PRODUCTION

PREPARED BY R.G. MUTTERS, J.W. ECKERT, A. ROEL AND R.E. PLANT

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MEASURING THE EFFECT OF LOW WATER TEMPERATURE ON BLANKING AND GRAIN YIELD IN CALIFORNIA RICE PRODUCTION

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Abstract

Cold air temperatures adversely affect the productivity of many crops. There have been few systematic efforts to measure at the field level the effect of low water temperatures on blanking and yield in rice. Neither have there been systematic efforts to measure the temperature distribution of water in a check (paddy), in order to determine the actual percent loss due to low inlet water temperatures. Water temperature has increasingly become a matter of concern for California rice growers due to need for public water agencies to improve habitat for fish. Prudent management of water resources to meet the needs of environmental and agricultural interests requires the quantification of water temperature effects on rice productivity. Thus, the objectives of the study were to determine the spatial and seasonal variability in water temperature in a rice field, quantify the temperature effects on plant productivity; and determine whether water temperature can be based on thermal infrared images. In this study, a rice field was fitted with a grid pattern of recording temperature sensors. At each grid point location, hourly water and canopy temperatures, yield, yield components, and phenological development were measured. Plant development and yield were negatively impacted when exposed to water temperatures below 19° C. Plants were sensitive to cold water from planting through panicle initiation. The intensity of the effects increased proportional to the time of exposure. The cold-water effects were present over a wide geographic area and detectable using remotely sensed thermal images.

Keywords: low temperature, cold water, blanking

Introduction

Rice production in California is uniquely situated in the heart of the state's largest watershed. The production area is flanked to the south by a rapidly expanding urban area and co-occupies an area with the few remaining native salmon fisheries in the state. Consequently, water resource management decisions must attend to the needs of urban users, wildlife habitat, and agricultural production. Yet it is not quantity of available water alone that drives the debate, but one of quality in terms of temperature. Species of fish protected under the U.S. Endangered Species Act require cold water temperatures to in a time frame that coincides with the majority of the rice-growing season.

In California, the standard practice is to sow soaked seeds by airplane into fields flooded to a depth of 8 to 13 cm. A permanent flood is maintained except for brief periods when the water is lowered for herbicide applications. The water used for irrigation is often diverted from rivers where water temperatures are controlled to optimize fish habitat by releasing water at selected depths from reservoirs. The water temperatures are frequently sub-optimal for rice production.

Rice plants have ideal temperature ranges for growth and development. Water temperatures markedly influenced the successful establishment of a rice stand when water seeded (Ormrod and Bunter, 1961). Chapman and Peterson (1962) observed that water temperatures between 25° C and 30° C were most favorable for seedling establishment in a water-seeded system. Conversely, Saito (1964a) reported that days required for seedling emergence increased linearly when temperatures decreased from 17° C to 12° C. The authors postulated that weak coleoptile vigor and root growth contributed to the poor seedling establishment under cold water conditions. Top growth of rice plants after transplanting decreased below approximately 18° C (Chamura and Honma, 1973). Water temperature was more significant than air temperature in contributing to reduced seedling growth because the growing point is submerged (Matsushima et. al., 1964a). Similarly, tillering reportedly increased with rising air temperatures in the range of 15° C to 33° C (Oka, 1955; Chamura and Honma, 1973) and that low temperatures also decreased tiller elongation. Ormrod and Bunter (1961) reported a linear decline in respiration of rice seedlings with increasing exposure time to cold temperatures. Low air temperature induced male sterility was first documented by Terao et al. (1940a). More recent studies by Kashibuchi (1968) indicated that in addition to the temperature itself, the duration of the exposure was an essential factor in understanding plant response.

In the rice fields of California, reduced yields near the water intake points due to cold water were documented as early as 1957 (Ramey et al.). The heightened awareness of cold water effects resulted from dam construction on rivers and the consequential decline in the temperatures of the water supplied to rice fields. Plants exhibited, according to Ramey, delayed heading, poor grain fill, and lack of maturity. Shimono et al. (2001) found the delay in vegetative and reproductive development in rice was linearly correlated to time of exposure to water temperatures below 20° C. Grower's casual observation and experimental quantification of the phenomenon are limited to the small areas of the field visually affected. There have been few systematic efforts to measure the impact of low water temperatures on blanking and yield and elucidate the spatial variability of water temperature within a field. New technologies for capturing thermal images provide a cost effective means for assessing spatial patterns in water temperature (Torgersen et al., 2001) and the relationship between water temperature and fish habitat (Torgersen et al., 1999).

Quantifying these factors is important for two reasons. Firstly, a precise quantification of the yield loss will allow growers to determine whether the economic gains from modifying water delivery and routing systems justify the associated investment. Secondly, it will provide growers with the information needed to illustrate to state agencies the consequences of water management decisions resulting from cold water deliveries to agriculture. Furthermore, establishing the utility of thermal infrared imaging to describe water temperature variability would provide a cost effective means of identifying the impacted fields on a regional scale. Thus, the objectives of the study were to: 1. Quantify the effect of low water temperature on the within field variability in rice yield loss and associated yield component response, and 2. Determine whether water temperature distribution and absolute water temperature can be estimated based on thermal infrared remote sensing.

Material and Methods

In 2001 and 2002, a rice field near Richvale, CA with cold inlets from adjacent district irrigation canals was fitted with a grid or transect pattern of recording temperature sensors (Hobo, Onset Corp, Bourne, MA; Figure 1). At all sensor locations, water and canopy temperatures were measured hourly over the growing season (May 1 to August 31). Soaked seeds were sown by airplane into the flooded field at a rate of 150 kg/ha on May 10, 2001 and May 12, 2002. One hundred fifty kg/ha of N, 40 kg/ha P, and 50 kg/ha of K were applied preplant. The host grower managed the study site using standard production practices. As the rice grew, the canopy sensors were moved upward so that they were always near the top of the canopy. Days to first tiller, panicle initiation, boot, and 50% heading were noted at all sample locations. At harvest, yield, yield components, and percent blanking were recorded in the vicinity of each sensor. Sensors were removed before harvest. A sample plot (2.5 X 3.5 m) was harvested with an experimental plot combine at each sample location. Yield standardized to 14% moisture content and harvest moisture were recorded. Interpolated yield maps of the field were created using a geographic information system (Arcview, ESRI, Redlands, CA). Predawn thermal images were captured three times during the season (June 10, July 31, and August 28) with an airplane mounted thermal infrared sensor. Data were processed using regression analysis and mean separation procedures.

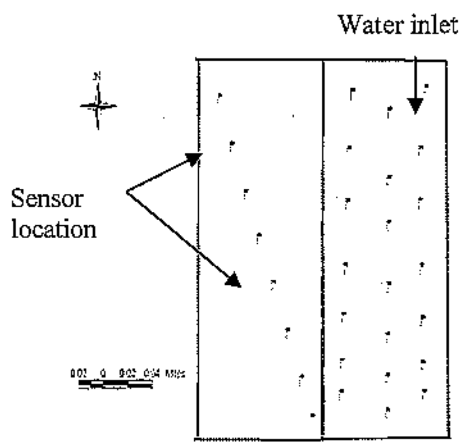
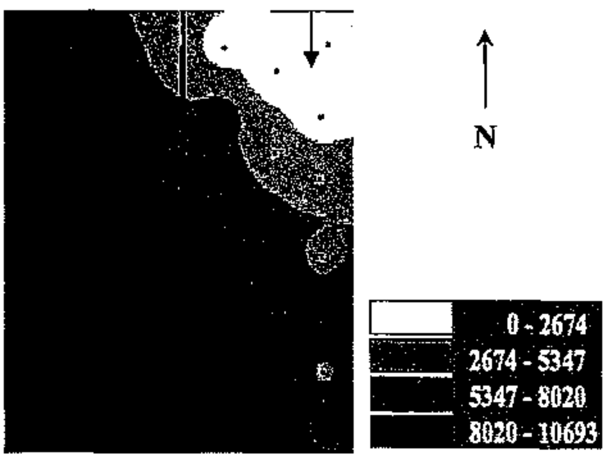


Figure 1. Sensor deployment and water inlet at the Richvale, CA study sight.

Results and Discussion

Grain yields ranged from 400 kg/ha where the cold water first enters the field to over 10,000 kg/ha at the southern reach of the first check (Figure 2). Interestingly, there was a gradient in the yield loss across the study site from north to south. Based on anecdotal observations by growers, the cold water effects are restricted to a small area around the water inlet. These results, however, demonstrated that measurable yield losses occur in a broader area than previously recognized. The yield reductions observed in the northeastern corner of the second check were attributed to seepage of water through the levy; there was no direct flow of water between the checks in this area.



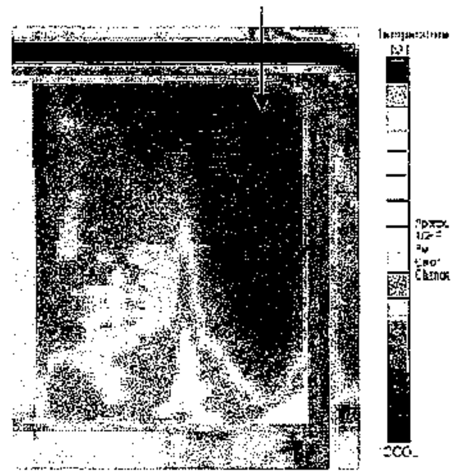


Figure 2. Interpolated yield map of the study site expressed as kg/ha (left).

Figure 3. Remotely sensed thermal infrared image of the study site taken June 10, 30 days after planting (right).

Figure 3 shows a remotely sensed thermal image of the study site represented in Figure 2. The cooler areas of the field (dark blue) correspond to same areas where ground based temperature measurements identified cold areas and associated reduced yields. The pattern of remotely sensed canopy temperature matches that of the water temperature (Figure 4), but is somewhat lower due to the thermal inertia of the water. Although the spatial patterns of water and canopy temperatures are similar, the absolute difference between water and canopy is much less in the colder part of the field.

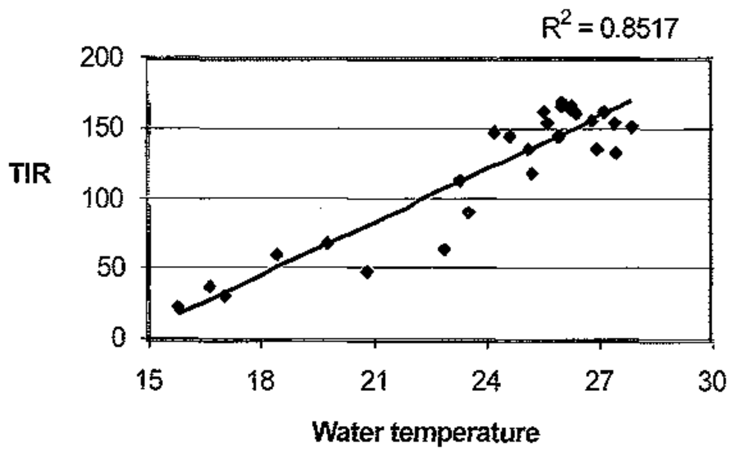


Figure 4. Relationship between thermal infrared value and water temperature.

Figure 4 indicates that thermal infrared imagery can provide a useful and relatively inexpensive way to measure the spatial distribution of water temperatures. Good agreement between air-based and ground-based temperature measurements of flowing water (R^2=0.99) was also noted by Torgersen et al. (2001). The authors caution that interpretation of water temperature data from thermal imagery requires a thorough understanding of environmental and physical characteristics of the water surface (e.g. delineating between rice canopy and water temperatures).

Delays in plant development coincided with the thermal gradient across the study site and the associated yield reductions (Table 1). Onset of tillering ranged from 43 days after planting (DAP) near the cold water inlet to 32 DAP in the warmer areas. The chronic exposure to cold water further delayed plant development resulting in a 20 day spread in the time required to reach panicle initiation (PI) across the sight, as compared to a 10 day difference in phenology at tillering. The increasing delay in growth continued through boot and 50% heading. The data suggest that the cold water effects resemble a dose-response function, in that, the severity is influenced by temperature and duration of exposure.

Table 1. Days after planting (DAP) to reach different growth stages, 2002. PI = panicle initiation.

	1st tiller	PI	Boot	50% heading
	DAP			
North	43	85	120	----
(inlet)	34	69	104	114
	31	64	90	104
South	32	64	88	96

Head sizes ranged from 13 to 17 cm in length when sampled along the middle transect of the study site (Table 2). The number of seeds per head declined from 53 to 0 as a result of cold water. Similarly, percent blanking ranged from 98% to 12% at the cold and warm extremes of the check, respectively. Noteworthy, air temperatures during pollen meiosis were comparable at the north and south ends of the check (data not shown). The data suggests that cold water caused the high rate of blanking, not cold air temperatures. Along the mid section of the field, yields ranged from 400 to 9100 kg/ha. Importantly, there was an associated reduction in grain quality (data not shown). Rice grower's returns are based on milling yields, as well as yield weight. Because the cold water delayed maturity, the number of physiologically mature seeds was reduced. Thus, the structural integrity of the immature endosperm was compromised and fractured during the milling process, resulting in lower mill out-turns.

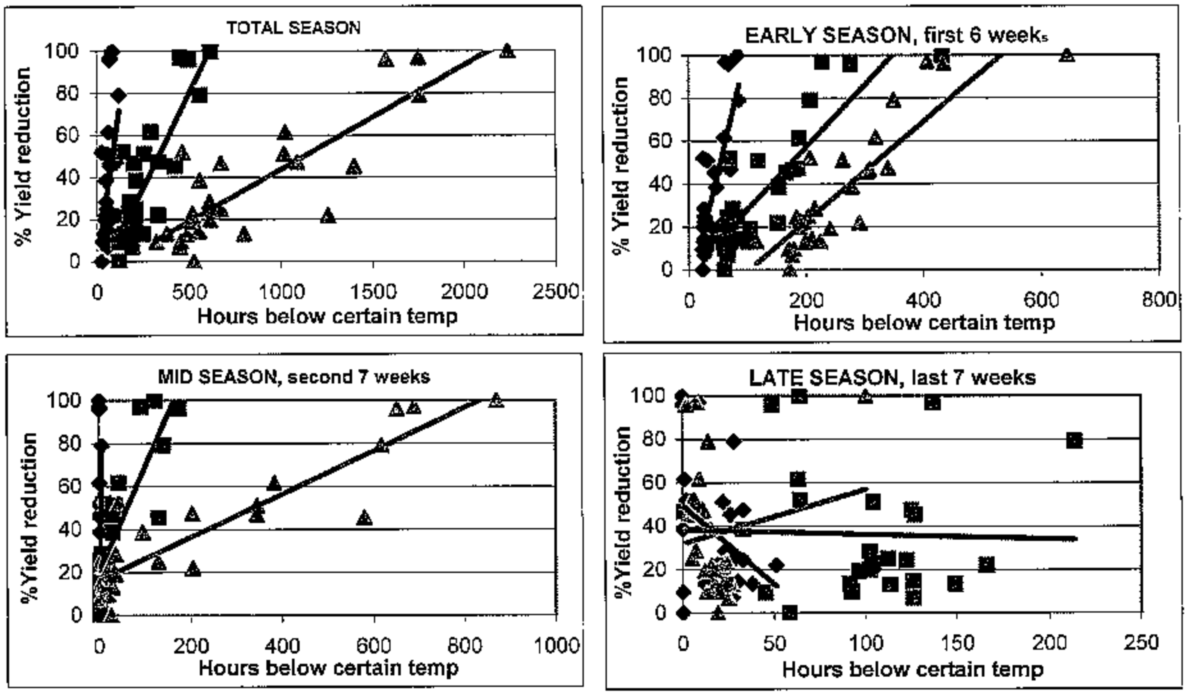
Table 2. Yield components at the center row of probe locations, 2002. MC = moisture content.

	Head length (cm)	Seeds per panicle	% blanks	Yield (kg) @ 14% MC
North	14	0	98	402
(inlet)	13	10	53	2288
	16	48	29	5924
South	17	53	12	9138

To further investigate the suggested dose-response concept, the relationship between exposure time to cold water and the corresponding yield reduction was considered (Figures 5 to 8). The yield loss response to accumulated hours below 13° C, 16° C, and 19° C during the early and mid season was linear. Late season effects were non-significant at any temperature. The statistical analysis of the regression lines revealed that the early season effects were more pronounced (Table 3). This is indirect evidence that the main impact of low temperature water on yield is in delaying early crop growth and to a lesser, albeit significant, extent on reproductive processes (e.g. blanking).

Conclusions

The deleterious effects of cold water on rice productivity occur well beyond the visually impacted area immediately adjacent to the water inlet. The spatial variability in water temperature is discernible using remotely sensed thermal infrared images, which is well correlated to ground based measurements. The magnitude of the delayed plant development and grain yield is related to the time of exposure, as well the actual temperature. Cold water temperatures were the most injurious during the first six weeks of the growing season, but reproductive processes are also effected as evidenced by blanking.



Figures 5 – 8. Yield reduction in rice as affected by temperature at different stages of growth. Fig.5 = total season; Fig. 6 = early season; Fig. 7 = mid season; Fig. 8 = late season. ◆ = 13° C; ■ = 16° C; ▲ = 19° C.

Table 3. Slope analysis for early season, mid season, late season, and total season effect of exposure to of water temperature less than 13°, 16°, and 19° C.

Period/temperature	Slope	Std. Error	R2	F	p-level
Early season					
< 13°	1.12	0.170	0.64	43.8	0.000**
< 16°	0.29	0.033	0.75	76.4	0.000**
< 19°	0.23	0.025	0.77	83.3	0.000**
Mid season					
< 13°	8.70	4.850	0.11	3.26	0.083 ns
< 16°	0.48	0.060	0.72 6	5.8	0.000**
< 19°	0.09	0.010	0.83	125.8	0.000**
Late season					
< 13°	-0.73	0.38	0.12	3.66	0.070 ns
< 16°	-0.02	0.13	0.00	0.03	0.860ns
< 19°	0.08	0.02	0.26	8.77	0.006*
Total season					
< 13°	0.60	0.213	0.24	8.07	0.009*
< 16°	0.17	0.022	0.72	65.6	0.000**
< 19°	0.05	0.006	0.74	70.7	0.000**

n=27; ** = significant at alpha 0.001; * = significant at alpha 0.05; ns = nonsignificant.

Acknowledgement
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APPENDIX J

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EFFECT OF LOW WATER TEMPERATURE ON RICE YIELD IN CALIFORNIA

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Effect of Low Water Temperature on Rice Yield in California

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ABSTRACT

Water temperature has increasingly become a matter of concern for California rice (*Oryza sativa* L.) growers due to a need for public water agencies to improve habitat for fish. Prudent management of water resources to balance the needs of environmental and agricultural interests requires the quantification of water temperature effects on rice productivity. Our objective was to evaluate two alternative thermal unit models for the effect of low water temperature on yield. One model was based on the total number of hours below a given threshold water temperature T_b (abbreviated TNHB T_b) and the other was based on the concept of inverse degree days (i.e., degree days below a given threshold water temperature) (abbreviated IDD). We tested these models at a range of values of T_b between 10 and 25°C on data from two commercial fields during 2 yr. Results showed that the effect of low water temperature may be much greater than would be apparent from the visual appearance of the rice plants. Values of IDD and TNHB T_b were very highly correlated for 4 of the 4-yr field combinations. A logistic curve model based on TNHB 20°C provided the best fit to the aggregated data.

Water temperature has increasingly become a matter of concern for California rice growers due to a need for public water agencies to improve habitat for fish. Prudent management of water resources to balance the needs of environmental and agricultural interests requires the quantification of the effect of low water temperature on rice productivity. Rice production in California is almost entirely situated in the Sacramento Valley, the state's largest watershed. The production area co-occupies a region with the few remaining native salmon (*Oncorhynchus* spp.) fisheries in the state (Mutters et al., 2002, 2003). The standard seeding practice in California is to sow soaked seeds by airplane into fields flooded to a depth of 8 to 13 cm. A permanent flood is maintained except for brief periods when water is lowered for herbicide applications. The water used for irrigation is often diverted from rivers where water temperatures are controlled by releasing water at selected depths from reservoirs. Water temperatures may be suboptimal for rice production (Mutters et al., 2002, 2003).

Rice grown under flooding in cool climates may be subjected to suboptimal water temperature (T_w) at any stage of the crop cycle. It is commonly observed in northern California that cold water damage reduces rice yields near field intake boxes (Raney et al., 1957). Plants in this vicinity are delayed in heading, heads do not fill, or maturity is not reached by the end of the normal growing season. When the Shasta Dam was completed in 1945, the temperature of the Sacramento River just below the dam changed suddenly from 16.1 to 7.2°C, and T_w fell almost 3°C at Sacramento, CA, 418 km below the dam (Raney et al., 1957; Raney, 1963). Immediately after this, rice growers found that as much as 5% of their planted hectareage did not mature in time to harvest at the end of the cropping season. The temperature of irrigation water taken from the river more than 160 km below the Shasta Dam was sufficiently low to impact rice growth (Raney, 1963). Before construction of the Oroville Dam, Raney et al. (1957, Raney, 1963) pointed out that this dam could cause the Feather River, from which much rice is irrigated, to become colder during the growing season.

This same phenomenon, a reduction of irrigation water temperature delivered to rice field after the construction of dams, has also been observed in Japan (Inoue et al., 1965). Most Japanese rice fields are transplanted under flooded conditions, and lower T_w is considered an important limiting factor in rice production in many locations of the country (Inoue et al., 1965). The rapid development of hydroelectric power plants after World War II accelerated cold water problems. Japanese scientists have tested several different basin warming designs (Mihara and Onuma, 1955; Mihara et al., 1959a, 1959b) in an attempt to solve this problem.

Although there is a vast literature regarding the effect of air temperature (T_a) at different growing stages of the rice crop (IRRI, 1976) there has been much less work performed at the field level concerning the effects of T_w on currently available rice varieties. Shimono et al. (2002, 2004) found that photosynthesis, growth, and yield are limited more by T_w than by T_a before the mid-reproductive period. Chapman and Peterson (1962) found that at temperatures below 20°C there was a significant reduction in shoot elongation. Hearth and Ormrod (1965) studied the effects of T_w on growth and development of flooded rice seedlings for different California and Texas rice varieties. They found that growth was retarded at 16°C, and that 32°C was the most favorable temperature.

Although there have been several laboratory studies of the effect of water temperature on rice growth, there have been few systematic efforts to measure at the field level the effect of low water temperatures on yield in rice. In addition, those studies that have been done have been performed under fixed T_w conditions, while temperature in a commercial rice field varies during the day. The objective of this study was to evaluate two al-

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Abbreviations: DGPS, differential global positioning systems; IDD, inverse degree days; TNHB, total number of hours below; YR, yield reduction.

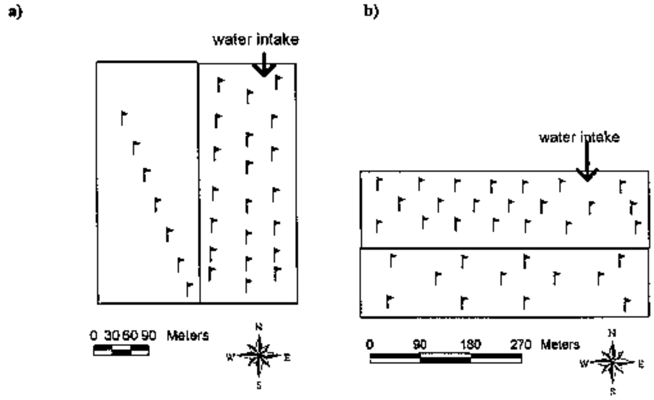

Fig. 1. Sensor deployment in both (a) Field 1 and (b) Field 2. Arrows indicate water intake and flows.

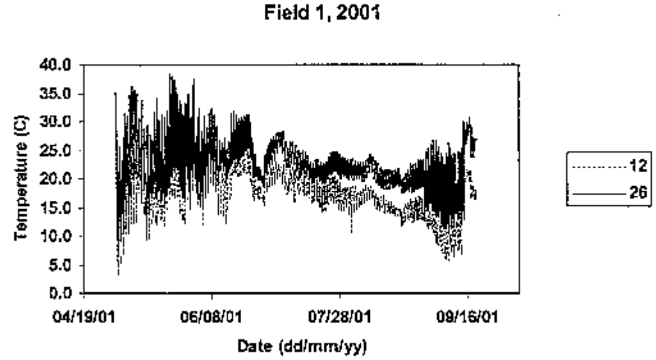

Fig. 2. Temperature record from sensors located in the coldest (Sensor 12) and warmest (Sensor 26) parts of Field 1 in 2001. The pattern from Field 2 was similar except that all temperatures were warmer and oscillations at the end of the season tended to be much smaller.

ternative thermal unit models for the effect of low water temperature on yield. One model was based on the total number of hours below a given threshold water temperature and the other was based on the concept of inverse degree days, that is, degree days below a given threshold water temperature threshold. We tested these models over a range of values of T_b from 10 to 25°C to quantify water temperature effects on plant productivity.

MATERIALS AND METHODS

Data Collection

The studies were performed during 2000 and 2001 in two different fields, which will be denoted Field 1 and Field 2. In Field 1, the work was conducted in two adjacent 4.7-ha checks. In Field 2, the work was in two adjacent 5-ha checks. Both fields are located near Richvale, CA (UTM Zone 10, coordinates: E: 613 328 N: 4264 313 and E: 602 316 N: 4372 940; for Field 1 and 2, respectively). Field 1 is located approximately 1 km from the Lake Oroville–Thermalito Afterbay reservoir complex and receives very cold water from this source. Field 2 is located approximately 6 km from the same source and receives water that has been warmed considerably during its passage through the canal system.

The soil survey (Lytle, 1998) of Butte County indicates that soils of the study fields are a mixture of Kimball loam (fine, mixed, active, thermic Mollic Palexerafls), San Joaquin loam (fine, mixed, active, thermic, Abruptic Durixeralfs), and Bruella loam (fine-loamy, mixed, Ultic Palexeralfs). Medium grain rice cultivar M-202 was sown via air in both fields. The fields were managed by the grower using standard practices for the area (Hill et al., 1992).

Data loggers (Hobo H8 Pro, Onset Computer Corp., Bourne, MA) were installed immediately after seeding in a grid or transect pattern in each field (Fig. 1). The data loggers were attached to stakes placed vertically in the field, with the external (water temperature) sensors placed approximately 5 cm below field water level. Water temperatures were measured hourly throughout the growing season. Data logger locations were georeferenced using a backpack differential global positioning systems (DGPS) receiver (Trimble AG 132, Trimble Navigation, Sunnyvale, CA). Data from one sensor in Field 1 in 2001 and two sensors in Field 2 in 2002 were incomplete, so no data from these sensors were used.

Planting dates were 8 May 2001 and 1 May 2002 for Field 1, and 14 May 2001 and 9 May 2002 for Field 2. The periods in which data were recorded were approximately from planting date to date at which the field was drained. These dates were from 1 May to 21 Sept. 2001 and from 27 Apr. to 9 Sept. 2002 in Field 1, and from 25 May to 21 Sept. 2001 and 11 May to 15 Sept. 2002 in Field 2. Data from 29 data loggers were used in both years in both fields. Sensors were removed before harvest. At harvest, yield, yield components, and percent blanking were recorded in the vicinity of each sensor. A sample plot (2.5 by 3.5 m) was harvested with an experimental plot combine at each sensor location. Yield standardized to 14% moisture content and harvest moisture were recorded.

Data Analysis

We tested two models for the effects of water temperature on yield. The first model, which is based on the number of hours that the water temperature is below a given water temperature threshold T_b, is denoted TNHB T_b. The second model

Table 1. Values of IDD and TNHB T_b for even values of T_b for every fifth sensor for Field 1, 2001, along with the correlation coefficient across all sensors between the two measures.

		Threshold T_b, °C							
Method	Sensor	10	12	14	16	18	20	22	24
IDD	1	0	−1	−10	−46	−159	−350	−568	−792
IDD	6	−1	−2	−4	−9	−22	−61	−158	−315
IDD	11	−3	−6	−12	−27	−64	−156	−308	−504
IDD	16	−1	−3	−8	−21	−42	−89	−201	−383
IDD	21	−1	−2	−4	−8	−18	−52	−137	−281
IDD	26	−1	−2	−4	−9	−19	−49	−132	−274
Correlation coeff.		−0.94	−0.75	−0.92	−0.96	−0.98	−0.97	−0.95	−0.89
TNHB	1	11	22	40	100	240	774	1563	2151
TNHB	6	25	49	124	245	729	1489	2144	2491
TNHB	11	16	32	107	201	350	867	1809	2457
TNHB	16	9	21	35	74	191	652	1414	1999
TNHB	26	11	24	37	76	192	597	1375	1990

Table 2. Values of IDD and TNHB T_b for even values of T_b for every fifth sensor for Field 1, 2002, along with the correlation coefficient across all sensors between the two measures.

		Threshold T_b, °C							
Method	Sensor	10	12	14	16	18	20	22	24
IDD	1	0	−1	−13	−51	−159	−331	−544	−767
IDD	6	−1	−4	−13	−30	−60	−118	−252	−437
IDD	11	0	−1	−5	−17	−45	−133	−297	−497
IDD	16	−1	−3	−12	−31	−85	−221	−407	−610
IDD	21	−2	−5	−13	−30	−58	−114	−225	−384
IDD	26	−1	−3	−10	−25	−52	−108	−219	−383
Correlation coeff.		−0.77	−0.85	−0.91	−0.93	−0.97	−0.95	−0.92	−0.87
TNHB	1	0	46	248	819	1738	2391	2635	2720
TNHB	6	21	62	160	267	463	1108	2017	2372
TNHB	11	0	25	86	212	563	1597	2250	2536
TNHB	16	18	52	177	308	1138	2061	2335	2514
TNHB	21	21	63	148	257	444	965	1659	2182
TNHB	26	18	44	131	230	442	971	1681	2267

is based on the heat unit concept used in pest management (Zalom, 1983). This measure of accumulated heat is known as physiological time and is measured in degree-days. In pest management 1 degree-day is equal to 1° above a specified temperature threshold during a 24-h period. For this study, instead of using degree-days directly an inverse degree-day concept was used. Inverse degree-days were computed as follows. The inverse degree days on day j, IDD(j), is given by the following:

$$\mathrm{IDD}(j) = \sum_{i=1}^{24}(T_{w,i} - T_b)^-$$

where $T_{w,i}$ is the water temperature at hour i, and the operation $()^-$ is defined as taking the value only if it is negative, that is, for any x,

$$(x)^- = \begin{cases} x : x \leq 0 \\ 0 : x > 0 \end{cases}$$

The total IDD are then obtained by summing the daily IDD. Note that by this definition IDD is negative when water temperature is below T_b. The difference between the IDD and the TNHB T_b models is that the former takes into account the magnitude of the difference between T_w and T_b as well as the duration, while the latter is based only on the duration.

We tested a range values for the threshold T_b from 10 to 25°C. This range of temperatures was selected to span the range of values identified in the literature as affecting rice growth during some phenological stage. Yield reduction was computed as the percent of yield loss with respect to the most productive yield location in the field that year using the equation

$$Y_r = 100\left(1 - \frac{Y_i}{Y_{\max}}\right)$$

where Y_r is the percent yield reduction, Y_i is the yield in kg ha^{-1} (corrected to 14% moisture content) at location i, and Y_{max} is the maximum yield measured in the field. The Statistica software package (Statsoft, Tulsa, OK) was used for correlation and linear regression analysis. Following the initial study to determine the best measure, we examined the relationship of yield reduction to this quantity over a range of threshold values. To standardize the model, we evaluated the sums generating IDD and TNHB T_b over a period of 2900 h (i.e., approximately 121 d) for each season and field.

RESULTS AND DISCUSSION

Visual examination of the records showed a pattern that was consistent across three of the field-year combinations and all of the sensors. This pattern was that water temperatures early in the season exhibited a daily oscillation through a wide range of values, ranging from as low as 5°C to values as high as 30°C and in some cases 35°C. This diurnal pattern persisted for about the first 40 d of the season, after which the water temperature settled to a consistent value of approximately 20°C until the end of the season, when somewhat smaller oscillations in temperature resumed (Fig. 2). The damping at midseason was presumably due to the increased thermal mass of the green vegetation. The exception to this pattern was Field 2 in 2001, in which several sensors recorded very large oscillations for about the last 30 d of

Table 3. Values of IDD and TNHB T_b for even values of T_b for every fifth sensor for Field 2, 2001, along with the correlation coefficient across all sensors between the two measures.

		Threshold T_b, °C							
Method	Sensor	10	12	14	16	18	20	22	24
IDD	1	0	−1	−9	−26	−51	−93	−187	−330
IDD	6	0	0	−1	−8	−29	−76	−192	−362
IDD	11	0	−2	−11	−29	−58	−105	−212	−373
IDD	16	0	0	0	−5	−23	−76	−193	−359
IDD	21	0	−2	−11	−28	−53	−99	−201	−353
IDD	26	0	0	0	−3	−20	−82	−208	−377
Correlation coeff.		−0.94	−0.99	−0.99	−0.96	−0.13	0.09	−0.16	−0.63
TNHB	1	3	42	140	251	357	762	1444	1941
TNHB	6	0	7	24	165	348	949	1779	2217
TNHB	11	5	56	164	282	401	863	1670	2110
TNHB	16	0	1	11	124	347	1024	1769	2160
TNHB	21	6	56	156	254	346	880	1556	2010
TNHB	26	0	1	12	99	350	1176	1829	2182

Table 4. Values of IDD and TNHB T_b for even values of T_b for every fifth sensor for Field 2, 2002, along with the correlation coefficient across all sensors between the two measures.

		Threshold T_b, °C							
Method	Sensor	10	12	14	16	18	20	22	24
IDD	1	0	−1	−4	−15	−35	−95	−238	−419
IDD	6	0	0	−2	−10	−29	−85	−195	−352
IDD	11	0	0	−3	−13	−34	−88	−195	−357
IDD	16	0	0	−2	−10	−29	−81	−183	−331
IDD	21	0	0	−2	−8	−25	−72	−160	−297
IDD	26	0	0	−2	−10	−27	−72	−157	−285
Correlation coeff.		−0.20	−0.39	−0.92	−0.96	−0.92	−0.88	−0.89	−0.94
TNHB	1	0	26	72	178	343	1260	2008	2314
TNHB	6	0	7	45	148	344	979	1692	2070
TNHB	11	0	11	67	168	380	961	1664	2151
TNHB	16	0	8	47	146	324	934	1571	1922
TNHB	21	0	5	41	131	297	831	1335	1890
TNHB	26	0	7	48	133	298	810	1248	1843

the record. We do not know the reason for this anomaly, and it may have been an artifact since the affected sensors did not follow any spatial pattern. The data were included in the analysis and had a negligible influence on the results.

Values of IDD and TNHB T_b were highly correlated for all values of T_b except in the field with anomalous behavior, and for the lowest values of T_b in Field 2 in 2002 (Tables 1–4). Examination of the data from this field indicated a different relationship (still linear) in those parts of the field showing late season temperature oscillations from those that did not. The relation between TNHB T_b and yield reduction (YR) was much less affected by the sensors' anomalous behavior than was that between IDD and YR.

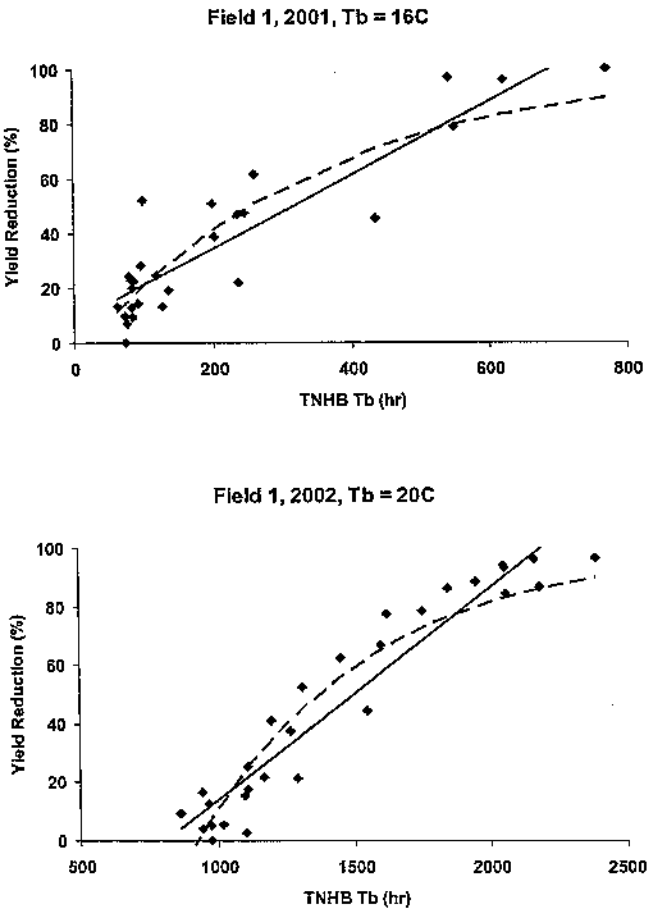

Fig. 3. Plots of the data for Field 1 for the value of T_b that provided the best fit. In each curve the solid line is the simple linear regression and the dashed line is the best fitting exponential model.

Because the values of IDD and TNHB T_b were so highly correlated except in the one anomalous case, we initially examined the relationship between both measures and YR for this data set. The IDD was not significantly related to YR ($p > 0.05$), whereas the relationship between TNHB 19°C and YR, although poor, was significant. Preliminary examination of other cases revealed that, as expected, there was little difference between TNHB T_b and IDD, but that the former was consistently a slightly better predictor of YR. Based on these preliminary results and the apparently greater robustness of TNHB T_b we dropped IDD from further analysis and focused on TNHB T_b.

Simple linear regression models for the relation between TNHB T_b and YR were separately fit to each field-year combination. Over the range of values of T_b from 10 to 25°C the values of r^2 for the models ranged from 0.01 to 0.83 for Field 1, 2001; from 0.05 to 0.91 for Field 2, 2002; from 0.00 to 0.28 for Field 2, 2001; and from 0.05 to 0.88 for Field 2, 2002 (Fig. 3 and 4). Because the data for Field 1 in both years had an obviously asymptotic behavior (Fig. 3), a model of the form $YR = \exp[-a(b - \text{TNHB} \times T_b)]$ was also fit to these data. The exponential model did not improve the fit for the 2001 data ($R^2 = 0.82$) but did for the 2002 data ($R^2 = 0.92$).

Data were then aggregated across all four field–year combinations. A logistic model of the form is as follows:

$$y = y_0 + \frac{ae^{b(t-c)}}{1 + e^{b(t-c)}} \qquad [1]$$

where y represents YR and t represents TNHB T_b, was fit to the data for each value of T_b. The value $T_b = 20$°C provided the best fit ($R^2 = 0.84$) (Fig. 5). The values of the parameters are $y_0 = 7.65$, $a = 88.34$, $b = 0.0046$, $c = 1506.64$. The nonzero value of y_0 indicates that a three-phase relationship exists between TNHB T_b and Y_r. Below approximately 400 h of exposure there is a baseline yield reduction independent of exposure duration. This may have been primarily related to factors other than T_w. Between approximately 400 and 2000 h increasing exposure to cold water was associated

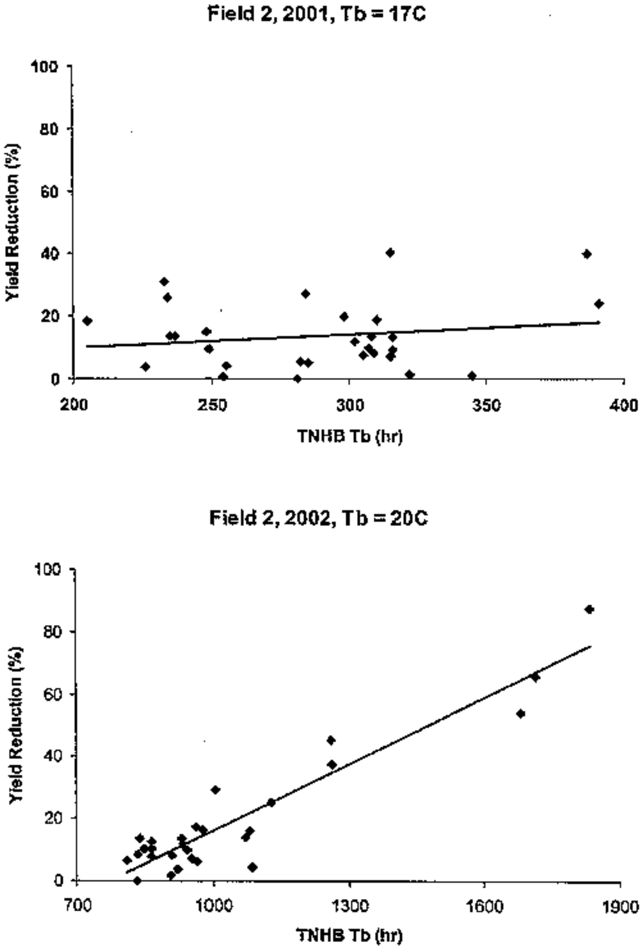

Fig. 4. Plots of the data for Field 2 for the value of T_b that provided the best fit. In each curve the solid line is the simple linear regression.

with increasing yield loss, and at exposures greater than 2000 h yield loss was virtually total.

SUMMARY AND CONCLUSIONS

This study shows that irrigation water in some areas of California rice production is below optimal temperature, as was forecast by Raney et al. (1957) and Raney (1963). The effect of cold water is not uniform across the field but may extend beyond the immediate area of the water inlet. Indeed, visual inspection of the fields indicated that loss of yield due to low water temperature occurred in regions where no visible effect could be seen. There is little difference in predictive capacity between the measures inverse degree-days and total number of hours below a threshold temperature, and indeed the latter is somewhat better. This somewhat unexpected result may be in part due to the fact that the amplitude of the temperature oscillations is relatively constant, as may be seen from Fig. 2. It also indicates that duration of low water temperature is more important than its magnitude.

Our results indicate that under field conditions in California the temperature value 20°C serves as a threshold for yield loss due to cold water effects. At low exposure levels, however, the effect of low water temperature is

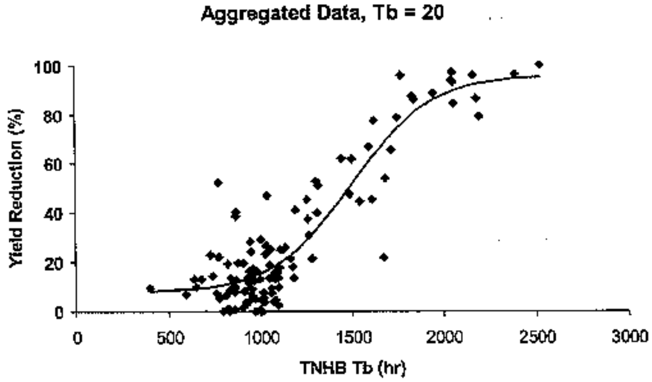

Fig. 5. Plot of the aggregated data for T_b = 20°C of all field–year combinations. The solid curve is the best fit of the modified logistic equation of the form of Eq. [1] in the text.

not linear. Below about 400 h of exposure low water temperature has little or no effect on yield. The relationship between yield loss and low water temperature in a single field and year could generally be modeled with reasonable accuracy by simple linear regression. Above about 2000 h of exposure crop yield is almost 100% reduced. A modified logistic model provided a good representation for data aggregated across years and fields. This model indicates that a considerable proportion of yield variation (84%) in these two fields can be associated to water temperature effects.

This study indicates that substantial rice yield loss may occur at water temperatures within the range already existing in California irrigation systems. The adjustment of water temperatures to meet environmental needs may therefore affect rice productivity. The present analysis does not explicitly concern itself with time during the growing season at which the crop was exposed to low water temperature. There was, however, an indication (data not shown) that the effect of low water temperature varies depending on when the exposure occurs. This variation should be the subject of future study, particularly to determine strategies of temperature control that provide a balance between rice productivity and environmental benefit.

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APPENDIX K

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SITE-SPECIFIC ANALYSIS, FACTORS UNDERLYING YIELD VARIABILITY IN TWO CALIFORNIA RICE FIELDS

PREPARED BY ALVARO ROEL AND RICHARD E. PLANT

FEBRUARY 2004

SITE-SPECIFIC ANALYSIS

Factors Underlying Yield Variability in Two California Rice Fields

Alvaro Roel and Richard E. Plant*

ABSTRACT

Modern technologies associated with precision agriculture provide the opportunity to more precisely measure yield variability and the ecological processes underlying this variability. Effective analysis of data from these measurements requires statistical methods different from those traditionally employed on data from controlled agronomic experiments. Our objective was to develop and test multivariate statistical methods appropriate for use in analyzing precision agriculture data. We analyzed a data set taken from two commercial California rice fields and consisting of yield spatial trends together with soil core data from a grid of sample points. We used cluster analysis to discern spatiotemporal patterns in grain yield. We applied a Monte Carlo randomization process to the generation of clusters to analyze cluster stability. We then used classification and regression trees (CART) to determine the factors underlying cluster distribution. The clustering procedure successfully identified stable, physically meaningful clusters with recognizable spatial and temporal structure. Thus, the randomization procedure may present an attractive alternative to fuzzy clustering. The CART analysis identified some but not all of the factors underlying the cluster patterns. The number of available data values may have been too small to take advantage of the CART partitioning capabilities.

RICE (*Oryza sativa* L.) is one of the world's most important staple crops. Development of effective site-specific management (SSM) techniques for rice production could have a significant impact on world food production (Cassman, 1999). Successful implementation of SSM requires an understanding of the spatial variability of biotic and abiotic factors that influence crop performance, knowledge that currently is often unavailable. This knowledge gap is one of the key limiting factors to the adoption of SSM in agricultural systems. The modern technologies associated with precision agriculture provide an opportunity to more precisely measure yield variability and the ecological processes underlying it and to begin to close this knowledge gap.

There have been a few recent studies exploring in a spatial context the factors underlying yield variability in rice. Dobermann (1994) used multivariate statistics to analyze within-field variability in Russian rice fields. Casanova et al. (1999) used multiple regression and the boundary-line method to study limits on the ability of rice to reach its yield potential. There have been many more studies on the factors underlying yield variability in terrestrial crops. Blackmore et al. (1999) presented a detailed analysis of data from cereal fields in Great Britain in which they made use of yield map data, aerial images, and soil and tissue analysis. Huggins and Alderfer (1995) used multiple regression to study the effects of various factors on yield variability in a 34-yr small-plot–based corn (*Zea mays* L.) fertility trial. They reported that 67% of the variation was explained by climatic and other factors while only 8% was explained by site variability. Sadler et al. (1995, 1998) analyzed yield sequences in corn, wheat (*Triticum aestivum* L.), and soybean [*Glycine max* (L.) Merr.] plots. Interannual yield correlations were statistically significant although the coefficients of determination were fairly low. Lamb et al. (1996, 1997) observed similar results in a 6-yr sequence of corn and corn–soybean systems. Bakhsh et al. (2000) analyzed the factors underlying observed yield variability in a 4-yr sequence of data from a corn–soybean field. After separating the short- and long-range components of variability using median polish, they used variography to describe the short-range variability and visual inspection of the median polish surfaces to describe the long-range effects. Visual inspection of map overlays of the data provided more useful information than correlation analysis of yield and yield-influencing factors. Jaynes et al. (2003) analyzed data from six corn years of a corn–soybean rotation in an Iowa field. Their work is further described below.

The fundamental difficulty in studying yield-influencing factors in commercial fields is the complexity of the phenomena. Environmental factors that influence crop growth and development may be relatively permanent, such as soil properties, or they may be transient, such as pest populations. Interaction with climatic factors may cause an environmental factor to increase yield in one year and decrease it in the next. For example, Porter et al. (1998) found that the relative yields of different plots in a corn–soybean experiment varied depending on seasonal climatic conditions. One way to reduce this complexity is to attempt to organize the field into subregions with similar spatiotemporal behavior. Several researchers have used cluster analysis in an effort to accomplish this. Lark and Stafford (1997) used fuzzy clustering to organize yield map data of combinable crops. Perez-Quezada et al. (2003) used *k*-means clustering (Jain

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Abbreviations: CART, classification and regression trees; DGPS, differential global positioning system; GIS, geographic information system; LAD, least absolute deviation; NDVI, normalized difference vegetation index; OM, organic matter; SP, soil penetration resistance; SSM, site-specific management; TSR, tree-structured regression.

and Dubes, 1984) to identify clusters of similar spatio-temporal behavior in a study of two four-crop rotation fields in California. Jaynes et al. (2003) employed the *k*-means technique to identify yield clusters. They then used multivariate statistical methods to characterize the factors underlying differences in yield between these clusters. They found that cluster analysis identified zones of different topographical environments, and multiple discriminant analysis identified relationships between yield-influencing factors. Dobermann et al. (2003) compared several different classification methods for analysis of yield data from irrigated cornfields.

Plant et al. (1999) used tree-structured regression (TSR) to divide a wheat field into segments and then applied linear regression to these segments. Tree-structured regression is a component of a class of algorithms called classification and regression trees (CART) (Breiman et al., 1984). CART is a nonparametric statistical method that recursively partitions the multidimensional space defined by the explanatory variables into subsets that are as homogeneous as possible in terms of the values of the response variable. Unlike parametric models, which are intended to uncover a single dominant structure in data, CART is designed to work with data that might have multiple structures. Buchleiter and Brodahl (2001) used CART to identify the factors underlying grain yield spatial variability. De'ath and Fabricius (2000) present several examples of the application of CART analysis to ecological data. CART is now an established method in medical diagnosis (e.g., Goldman et al., 1998) and has found applications in meteorology (Burrows, 1991), plant pathology (Baker, 1993), wildlife management (Grubb and King, 1991), species distributions (Vayssieres et al., 2000), soil regionalization (Mertens et al., 2002), and other fields with complex, multivariate data.

Vayssieres et al. (2000) point out several advantages of using CART. First, it is a nonparametric procedure and does not require the specification of a functional form. This eliminates the need to make simplifying assumptions about the data and to test for model goodness-of-fit. CART does automatic stepwise variable selection. As in the case of stepwise regression, this does not ensure finding the absolutely best tree. However, unlike parametric stepwise procedures, CART may select a variable several times because at each stage CART selects the variable holding the most information for the part of the multivariate space on which it is currently working. CART is also extremely robust with respect to outliers, which are generally separated into their own nodes where they no longer affect the rest of the tree. Cook and Goldman (1984) point out two disadvantages of using recursive partitioning methods such as CART. One is that since CART only represents a continuous factor by a series of distinct subranges, parametric methods are better at capturing an algebraic relationship between the response variable and a continuous factor. As a result, the decision tree may obscure linear and simple curvilinear structures of the data. A second disadvantage is that, because of the dichotomous nature of trees, later splits are based on fewer cases than the initial one. Thus, as the tree grows, the identification of additional predictive factors becomes increasingly difficult. Walters et al. (1999), studying models to predict medical outcomes, found that when the relationship between the predictor and response variables was a linear one, linear regression analysis was adequate. However, when nonlinear relationship existed, CART or artificial neural networks yielded better models.

In an earlier paper (Roel and Plant, 2004), we examined sequences of yield map data collected in two California rice fields between 1998 and 2001. These data sets were collected as a part of the commercial harvesting process, and one of the objectives of the first paper was to determine whether they were of sufficient quality for scientific use. Data from the 2001 harvest in one field were discarded as a result of this analysis, leaving one 4-yr sequence and one 3-yr sequence. Median polish (Emerson and Hoaglin, 1983) was used to extract yield trends from each year's data set, and *k*-means clustering was used to organize each sequence of median polish data into clusters. During the 4 yr in which yield data were collected from these fields, other data that might help in identifying the factors underlying yield variability were collected as well. In the present paper, we further develop the clustering methodology and to use CART to analyze these data. Our primary objectives are methodological. Specifically, our goal is the development of effective methods for exploratory analysis of data sets consisting of georeferenced, high-spatial-precision yield data together with spatially extensive edaphic data, with the objective of gaining insight into the factors underlying yield spatial variability. We develop and test a randomization method based on *k*-means clustering for organizing yield data into clusters. We then test CART for effectiveness in providing information on the factors underlying observed yield variability and develop methods for using CART to analyze temporal sequences of yield map data.

MATERIALS AND METHODS

The study was performed from 1998 through 2001 in two rice fields approximately 2 km apart, one of 38 ha (denoted Field 1) and one of 52 ha (denoted Field 2), located near Marysville, CA (UTM Zone 10, coordinates: E: 627 102, N: 4 340 769; and E: 624 970, N: 4 341 076 for Field 1 and 2, respectively). The soils of the study fields consist of approximately 45% Kimball loam (fine, mixed, active, thermic Mollic Palexerafls), 30% San Joaquin loam (fine, mixed, active, thermic, Abruptic Durixeralfs), and 25% Bruella loam (fine-loamy, mixed, Ultic Palexeralfs). Medium-grain rice cultivar M-202 and short-grain cultivar Koshihikari were grown and managed by the cooperator in Fields 1 and 2, respectively, using standard practices for the area (Hill et al., 1992).

Yield Data

Rice was harvested during the years 1998 through 2001 in both fields using a combine equipped with a John Deere Green Star yield-mapping system with real-time differential global positioning system (DGPS). Yield map data files (yield, grain moisture, longitude, and latitude) were collected and imported into the ArcGIS (ESRI, Redlands, CA) geographic information system (GIS) for analysis. A detailed description of the

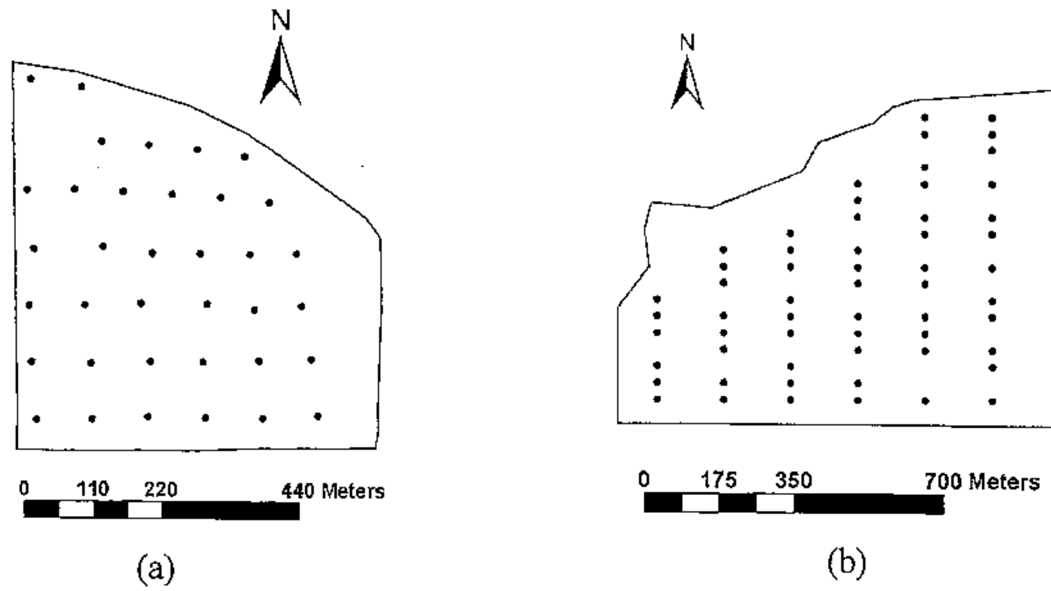

Fig. 1. Soil sampling locations in (a) Field 1 and (b) Field 2.

yield map data analysis is provided by Roel and Plant (2004). As a part of that analysis, yield data were separated into two components, large-scale trend and small-scale variation, using median polish on a 30-m grid. The present study used the large-scale trend values from that analysis.

Soil Data

Thirty-six and 58 soil samples were collected from Fields 1 and 2, respectively, representing approximately one sample per hectare. Figure 1 shows the locations in both fields where soil samples were collected. Soil penetrometer data for both fields were collected in June 2000. Other data were collected in May 1999 in Field 1 and March 2000 in Field 2. Locations of sample points were determined using a Trimble Ag 132 backpack DGPS receiver (Trimble Navigation, Sunnyvale, CA). At each sample point, eight soil cores (0–30 cm depth) were extracted before planting from a circular region of about 3-m radius (approx. 25-m^2 area) such that two cores lay in each of the four quadrants. Sand, silt, and clay content (%) were measured. Soil pH, organic matter (OM, %), P (Bray) (mg kg^{-1}), K (mg kg^{-1}), and Zn (mg kg^{-1}) were determined using standard methods of the University of California Division of Agriculture and Natural Resources Analytical Laboratory (Div. of Agric. and Nat. Resour., 2004). Topsoil depth (cm) and soil penetration resistance (SP, MPa) were measured using a Spectrum SC-900 instantaneous core penetrometer (Spectrum Technologies, Plainfield, IL) at the same locations where soil samples were extracted. This sensor provides soil depth readings in 2.5-cm increments as a load cell measures the penetration resistance. Field 1 was re-leveled by a commercial laser-leveling firm during the winter between the 1998 and 1999 seasons. The cut and fill map developed in the laser-leveling process was used to determine elevation in the field before leveling (m). Soil sampling in Field 1 took place after the laser-leveling operation.

Aerial Image Data

A major infestation of herbicide-resistant early watergrass [*Echinochloa crus-galli* (L.) Beauv.] occurred in Field 1 in 2001. Because the weed population senesced before the rice, the spatial distribution of the infestation was well captured by infrared aerial images. Therefore, late-season aerial image data from each field were included in the analysis. False-color infrared digital aerial images of each field were acquired on 18 Aug. 1998, 5 July 1999, 31 July 2000, and 22 July 2001. Pixel sizes varied between 1 and 3 m on the ground. Images were imported into ArcGIS version 8.3 (ESRI, Redlands, CA), georegistered, band-separated, and transformed into normalized difference vegetation index (NDVI) values. These were obtained using the formula NDVI = (IR – R)/(IR + R) (Lillesand and Kiefer, 1994). The NDVI value at each soil sample location was estimated as the mean of the nine pixel values including and immediately adjacent to the pixel containing that location.

Data Analysis

Correlation analysis was performed using SAS version 8.3 (SAS Inst., Cary, NC). CART analyses were performed using CART for Windows version 5.0 (Salford Systems Inc., San Diego, CA). Cluster analysis was performed using PROC FASTCLUS of SAS version 8.3 (SAS Systems, Cary, NC). This procedure implements k-means cluster analysis (Jain and Dubes, 1984), an iterative procedure. In this algorithm, k points in the data space are initially selected as cluster seeds. Clusters are formed by assigning all other points in the data space to the nearest seed. The means of each cluster are then selected as the new set of k seeds, and the iterative process is repeated. In theory, the process may be iterated to convergence. However, the implementation in PROC FASTCLUS avoids the need for a large number of iterations through its algorithm for selecting the initial seeds. In this algorithm, the first point in the data set with all components specified is selected as the first seed, and other seeds are selected based on their distance from this point.

Our goal in using cluster analysis was to develop clusters that could be used to identify factors underlying observed yield variability. A necessary condition to achieve this goal is that the clusters distinguish values of the yield-determining factors as well as the values of yield themselves. That is, the clusters must be "physically meaningful." One criterion that has been used previously to test for this property is that the clusters be spatially structured, under the assumption that physical properties of the field are spatially structured (Plant et al., 1999; Roel and Plant, 2004). Another possibly more powerful indicator of physical meaning is that the cluster pattern be attained starting from different sets of initial cluster seeds. Since PROC FASTCLUS bases its choice of initial seeds on the order in which the data are entered, we tested for this property by running the procedure from randomly reordered data sets without iterating to convergence. For values of k from 2 through 5, data from Field 1 were processed in this manner 10 times. The procedure was repeated five times for values of k from 5 through 9 with data from Field 1 and for values of k from 2 through 6 with data from Field 2 since initial experience with 10 values of k from Field 1 indicated that five tests were sufficient to observe consistency. We did not iterate to convergence to provide the most severe possible test of cluster stability.

We observed that the result of this re-randomization procedure was that some of the cluster patterns could be aggregated by visual examination of the spatial distribution and cluster means into sets of similar arrangements and that some of the cluster patterns were unique. To clarify the discussion, we will define the terms we use to describe the cluster analysis, making reference to Fig. 2. The individual location elements of the field are called *cells*. For example, Field 1 has 292 cells. The k collections of cells identified by the k-means process are the *clusters*. A *cluster set* is an arrangement of similar cluster patterns that is attained from more than one initial reordering of the data. For example, Field 1 has two sets with k = 2,

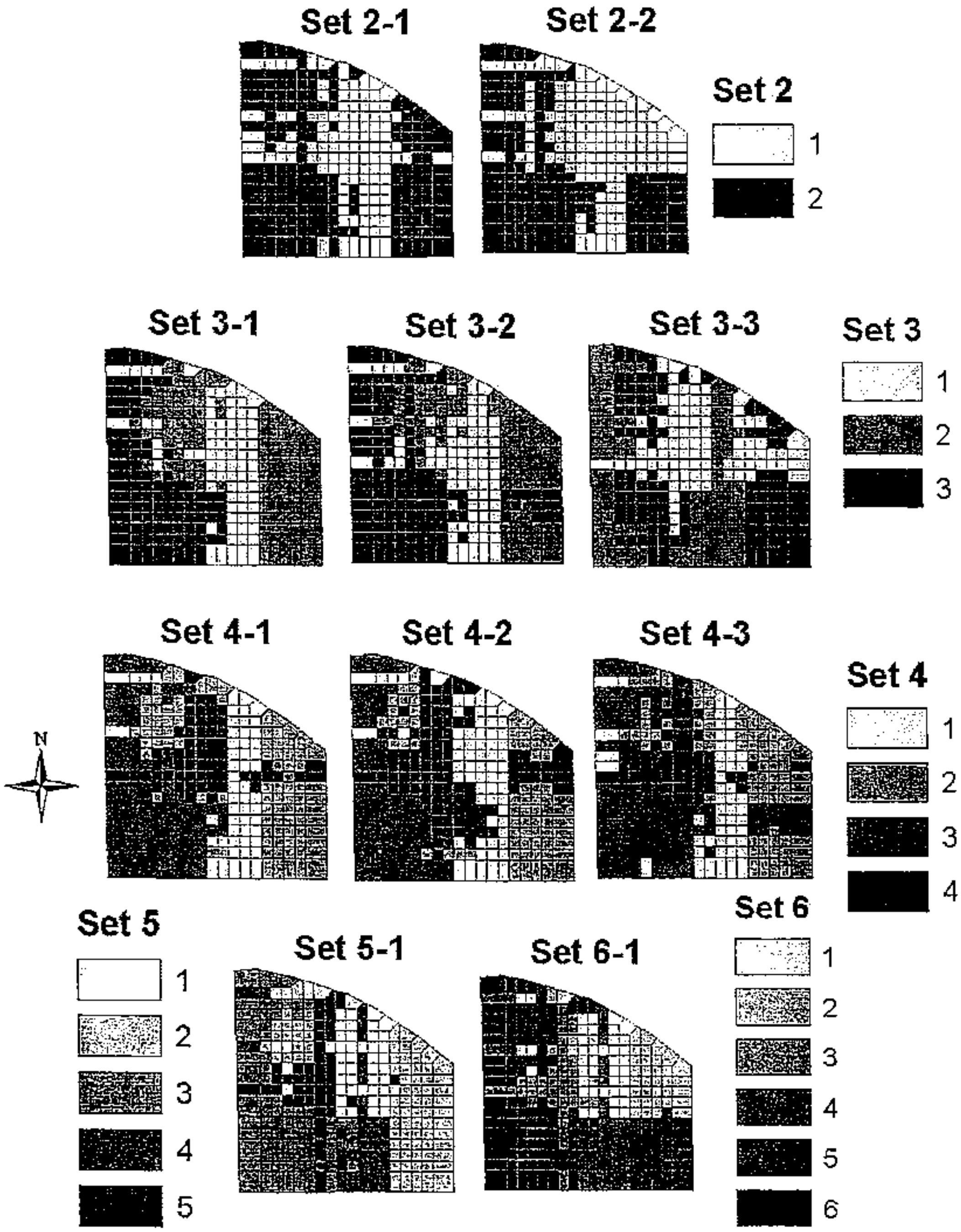

Fig. 2. Cluster sets of Field 1. The number code identifies the value of k, which is the number of clusters, followed by the identification number of the set. For example, Set 2-1 is the first set of two clusters (k = 2). The numbers in the legend identify the gray-scale key of the elements belonging to each cluster.

three sets with $k = 3$, and so forth. The cluster sets are denoted numerically as k-i, where i indexes the sets. For example, the two sets in Field 1 with $k = 2$ are denoted Sets 2-1 and 2-2.

The members of a cluster set may be similar but not identical. To test the cluster sets for internal consistency, we defined an appropriate statistic as follows. Suppose that there are a total of p cells and that the set has n members (i.e., n of the random reorderings of initial seeds result in a member of this set). For example, there are a total of 292 cells in Field 1, and for $k = 6$, the unique set (Fig. 2) with more than one member has two members. Therefore, in this case $k = 6$, $p = 292$, and $n = 2$. Let an indicator β_i, $i = 1, \ldots, p$, be defined for each cell i by

$$\beta_i = \begin{cases} 1 \text{ if in all members cell } i \text{ belongs to the same cluster} \\ 0 \text{ if at least one member cell } i \text{ belongs to a different cluster.} \end{cases}$$

Then the measure of consistency γ of the cluster set is defined by

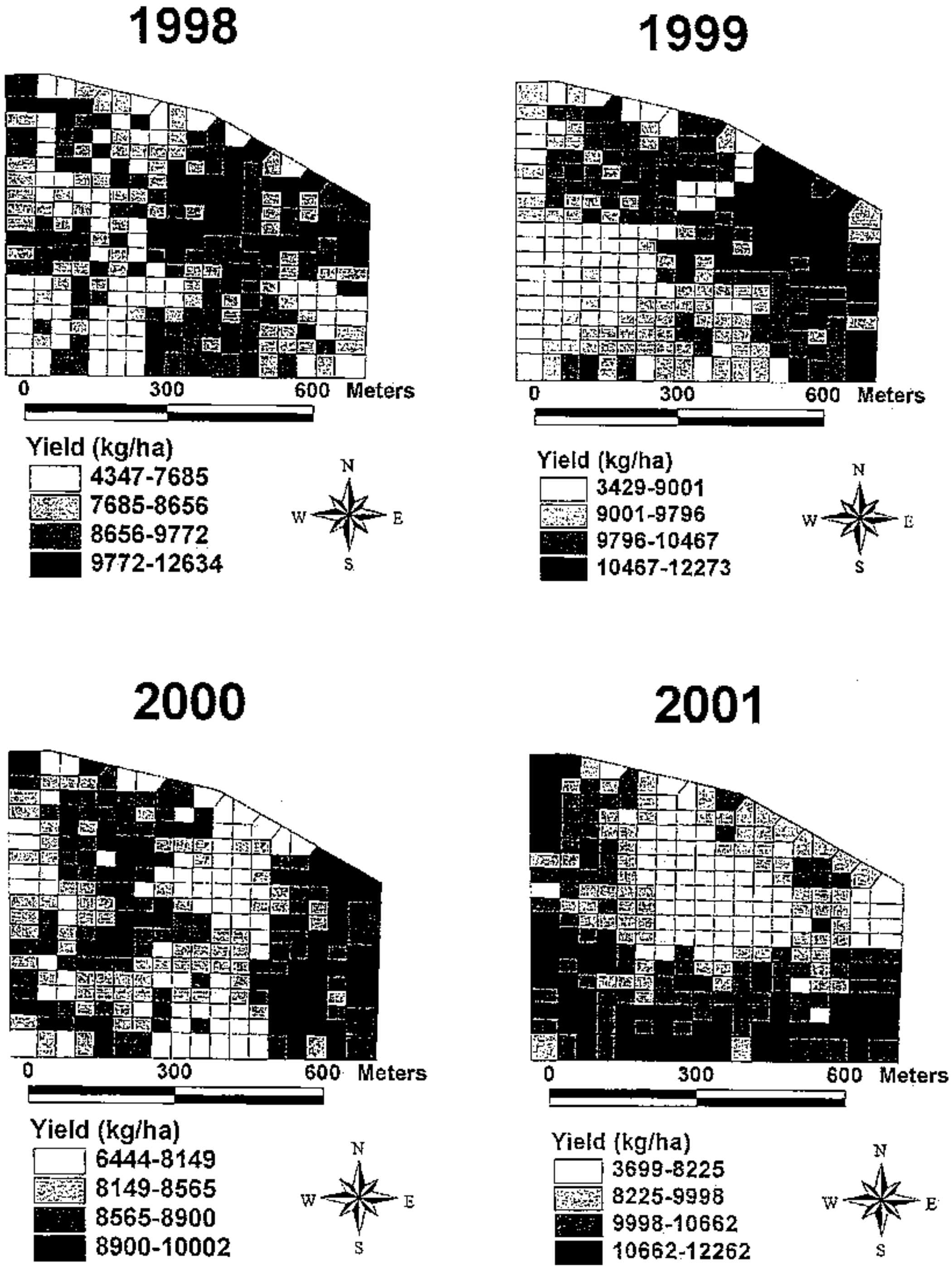

Fig. 3. Large-scale yield trends obtained by Roel and Plant (2004) for Field 1 using median polish. Redrawn from Roel and Plant (2004).

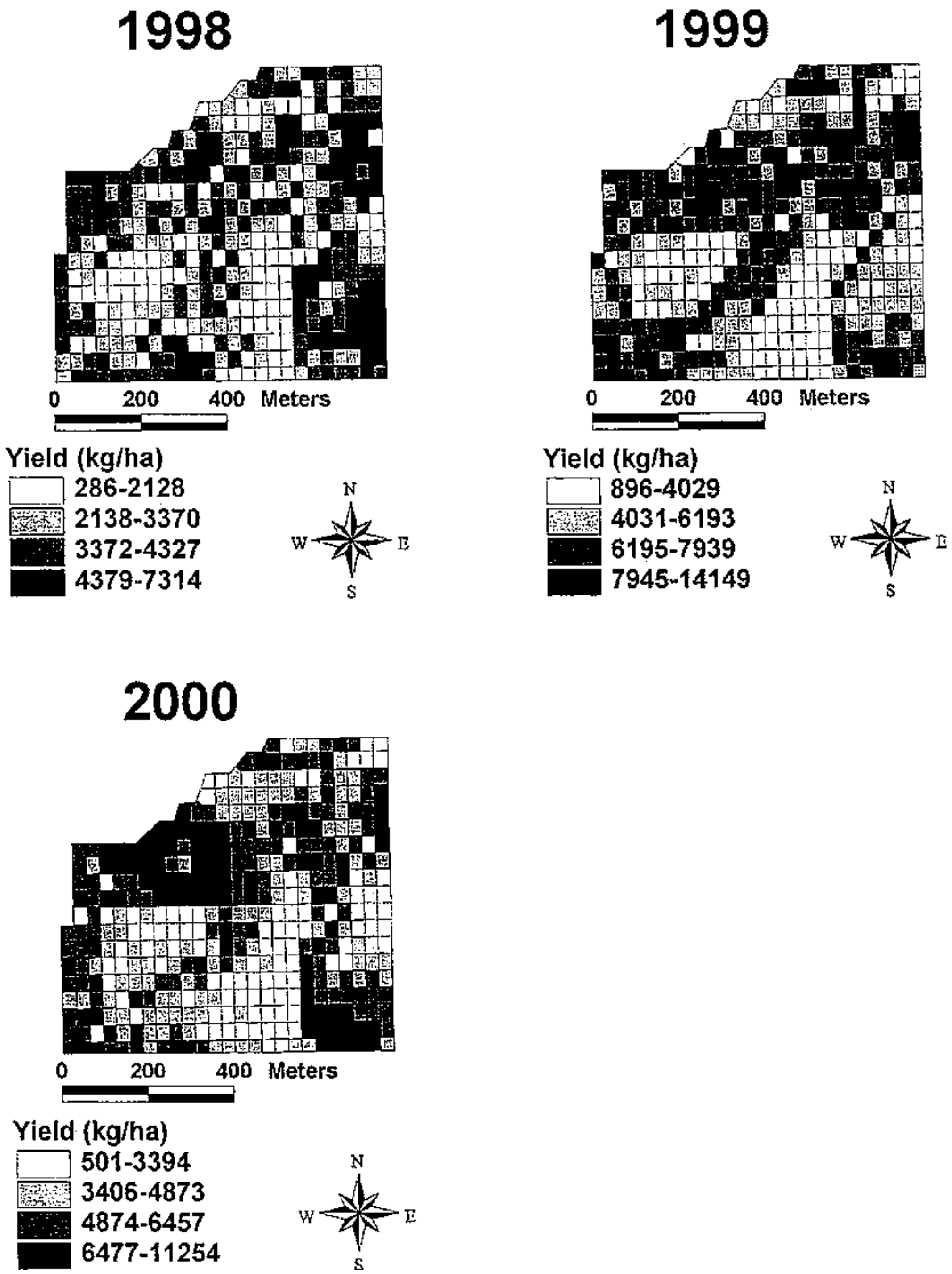

Fig. 4. Large-scale yield trends obtained by Roel and Plant (2004) for Field 2 using median polish. Redrawn form Roel and Plant (2004).

$$\gamma = \frac{\sum_{i=1}^{p} \beta_i - \frac{p}{n^k}}{p - \frac{p}{n^k}} \quad [1]$$

The motivation for this definition of γ is similar to that for Cohen's κ (Cohen, 1960). The quantity p/n^k is the expected number of cells that all belong to the same cluster by chance. If all of the members of the set are identical, then γ has the value 1, and if each cell of each member of the set is randomly assigned one of the k possible values, then $\gamma = 0$. Values of γ were computed for each cluster set. We tested the cluster sets for spatial autocorrelation as an indication of spatial pattern by computing the Moran's I statistic (Cliff and Ord, 1981) for each set. Strictly speaking, since the cluster numbers are nominal-scale data, a multicolor join-count statistic would be more appropriate (Cliff and Ord, 1981). However, Moran's I is much easier to compute and also provides a good indication of the level of spatial autocorrelation in this situation. Computations were performed using macros written in Microsoft Excel (these are available from the corresponding author upon request).

Besides consistency from several initial cluster seeds and

Table 1. Univariate statistics for field soil attributes for Field 1 based on 36 samples.

Statistic	Field soil attribute† PH	P	K	OM	Zn	SP	DP	CL	SI	SA	EL
		mg kg^{-1}	mg kg^{-1}	%	mg kg^{-1}	MPa	cm	%	%	%	m
Mean	4.72	10.06	63.83	1.71	3.87	0.38	18.6	19.1	34.81	46.09	9.97
SD‡	0.28	2.17	12.61	0.23	0.83	0.06	2.4	2.76	1.97	2.13	0.08
Max.	5.3	17.0	115	2.24	2.6	0.56	20.3	25.47	38.40	49.15	10.13
Min.	4.0	6.7	42	1.37	0.48	0.28	15.2	14.72	30.37	41.73	9.83
Skewness	−0.34	1.11	1.89	0.55	5.5	1.02	−0.74	0.59	−0.15	−0.67	−0.03
Median	4.7	9.65	61.5	1.70	3.6	0.39	20.3	18.73	34.62	46.82	9.97
IQR§	0.40	2.95	12.5	0.36	1.45	0.07	5.0	3.30	2.88	2.88	0.14

† PH, pH; P, soil test P; K, soil test K; OM, percentage organic matter; Zn, soil test Zn; SP, soil penetration resistance; DP, soil depth; CL, percentage clay; SI, percentage silt; SA, percentage sand; EL, elevation before 1999 leveling.
‡ Standard deviation.
§ IQR, interquartile range.

Table 2. Univariate statistics for field soil attributes for Field 2 based on 58 samples.

Statistic	Field attribute† PH	P	K	OM	Zn	SP	DP	CL	SI	SA
		mg kg^{-1}	mg kg^{-1}	%	mg kg^{-1}	MPa	cm	%	%	%
Mean	5.93	2.45	100.43	0.91	1.45	0.45	13.8	22.3	45.53	31.97
SD‡	0.47	2.09	28.39	0.33	0.79	0.12	2.4	5.3	6.36	6.01
Max.	7.1	13.4	167.0	1.49	3.4	0.70	16.5	38.0	61.0	43.0
Min.	5.0	0.9	56.0	0.35	0.2	0.24	9.9	15.0	32.0	14.0
Skewness	0.26	3.72	0.88	−0.04	0.55	0.26	−0.59	1.25	0.01	−0.46
Median	5.9	1.9	92.0	0.93	1.3	0.47	15.2	22.0	46.0	32.0
IQR§	0.60	1.3	37.0	0.54	1.2	0.21	4.8	7.0	9.0	7.0

† PH, pH; P, soil test P; K, soil test K; OM, percentage organic matter; Zn, soil test Zn; SP, soil penetration resistance; DP, soil depth; CL, percentage clay; SI, percentage silt; SA, percentage sand.
‡ Standard deviation.
§ IQR, interquartile range.

Table 3. Spearman rank correlation coefficients, r, for Field 1 between rice yield by year, late-season normalized difference vegetation index (NDVI) by year, and field soil attributes. If measurements were spatially independent, $|r| > 0.32$ would imply significance at $P = 0.05$.

	Yield Y98	Y99	Y00	Y01	NDVI N98	N99	N00	N01	Soil attribute† PH	P	K	OM	ZN	SP	DP	CL	SI	SA	EL
Y98		0.50	−0.48	−0.25	0.37	0.45	−0.31	−0.35	−0.27	−0.03	−0.28	0.04	−0.01	0.20	−0.11	0.09	−0.16	0.07	0.29
Y99			0.13	−0.21	0.49	0.22	−0.61	−0.34	−0.52	−0.05	−0.44	0.15	0.03	0.41	−0.11	−0.12	0.14	0.03	0.28
Y00				0.01	−0.13	0.05	0.06	0.01	0.22	−0.22	−0.18	−0.04	−0.07	−0.02	0.02	0.03	0.08	−0.16	−0.02
Y01					0.11	0.31	0.11	0.56	0.10	−0.14	0.24	0.19	0.04	−0.07	0.22	−0.11	0.35	−0.14	−0.50
N98						0.63	−0.53	−0.03	−0.24	−0.18	−0.32	0.25	0.02	0.34	0.19	−0.07	0.11	−0.04	−0.36
N99							0.29	0.29	0.29	−0.48	0.13	−0.04	−0.33	0.46	0.09	0.17	0.04	−0.30	−0.35
N00								0.36	0.32	−0.03	0.29	−0.15	−0.01	−0.22	−0.07	0.16	−0.08	−0.12	−0.21
N01									0.15	−0.05	0.41	−0.05	0.00	−0.01	0.08	0.13	0.04	−0.15	−0.43
PH										−0.31	0.16	−0.53	−0.53	−0.35	0.27	0.60	−0.47	−0.29	−0.13
P											0.00	0.35	0.73	−0.38	0.03	−0.46	0.24	0.38	0.16
K												0.00	−0.24	0.16	−0.22	0.19	−0.17	−0.12	−0.15
OM													0.65	0.14	−0.24	−0.76	0.59	0.38	−0.32
ZN														−0.12	−0.04	−0.69	0.53	0.40	−0.13
SP															−0.49	−0.01	0.14	−0.16	0.02
DP																0.13	−0.62	−0.14	−0.26
CL																	−0.64	−0.67	0.15
SI																		−0.08	−0.15
SA																			−0.02

† PH, pH; P, soil test P; K, soil test K; OM, percentage organic matter; Zn, soil test Zn; SP, soil penetration resistance; DP, soil depth; CL, percentage clay; SI, percentage silt; SA, percentage sand; EL, elevation before 1999 leveling.

spatial pattern, a third indication of whether the clusters are physically meaningful is whether they are hierarchically arranged. In this case, the situation is a bit more subtle, however. Consider the case of an increase in the number of clusters from k to $k + 1$, and without loss of generality, suppose $k = 2$ so that we go from two to three possible values. Suppose that there is a single factor, say, soil clay content, underlying the separation of yield values into the two clusters. When the elements are partitioned into three possible values, the physical property underlying yield variability may continue to be the single factor clay content, it may switch to one or two completely new factors, or it may be comprised of clay content from the original two-cluster partition and some other factor, say, OM, within one of the two original clusters. It is only in the latter case that one would expect the clusters to be hierarchically arranged. Therefore, we did not test statistically for the presence or absence of a hierarchical arrangement. Rather, we visually inspected for such arrangements and used the results of this arrangement in the second phase of the data analysis, which was the use of CART to attempt to determine the factors underlying the clusters.

The explanatory variables for the CART analysis were the soil, elevation, and aerial image data. The analysis was performed as a two-stage process for each field. The first stage

Table 4. Spearman rank correlation coefficients, r, for Field 2 between rice yield by year, late-season normalized difference vegetation index (NDVI) by year, and field soil attributes. If measurements were spatially independent, $|r| > 0.25$ would imply significance at $P = 0.05$.

	Yield			NDVI			Soil attributes†									
	Y98	Y99	Y00	N98	N99	N00	PH	P	K	OM	ZN	SP	DP	CL	SI	SA
Y98		0.64	0.67	0.39	0.32	0.23	−0.24	0.36	−0.32	0.23	0.15	−0.48	0.30	−0.43	0.15	0.20
Y99			0.80	0.51	0.24	0.25	−0.33	0.17	−0.25	0.43	0.36	−0.30	0.15	−0.50	0.41	−0.01
Y00				0.42	0.34	0.20	−0.24	0.33	−0.21	0.35	0.21	−0.32	0.22	−0.35	0.23	0.12
N98					0.70	0.72	−0.34	0.09	−0.45	0.48	0.36	−0.22	0.13	−0.40	0.35	−0.01
N99						0.68	−0.25	0.24	−0.26	0.35	0.18	−0.32	0.28	−0.21	0.17	0.02
N00							−0.43	0.24	−0.28	0.38	0.33	−0.20	0.13	−0.25	0.07	0.12
PH								−0.51	0.49	−0.60	−0.75	0.35	−0.38	0.59	−0.14	−0.32
P									−0.38	0.39	0.35	−0.28	0.37	−0.41	−0.24	0.61
K										−0.70	−0.52	0.27	−0.21	0.78	−0.42	−0.22
OM											0.82	−0.29	0.32	−0.66	0.51	0.05
ZN												−0.29	0.30	−0.57	0.44	0.03
SP													−0.66	0.27	−0.12	−0.12
DP														−0.25	0.05	0.12
CL															−0.45	−0.31
SI																−0.64

† PH, pH; P, soil test P; K, soil test K; OM, percentage organic matter; Zn, soil test Zn; SP, soil penetration resistance; DP, soil depth; CL, percentage clay; SI, percentage silt; SA, percentage sand.

was based on the yield clusters. A member of each cluster set judged to be physically meaningful by the criteria of consistency (as indicated by the γ statistic) and spatial structure (as indicated by Moran's I) was selected for CART analysis. A classification tree was constructed in which the response variable was the cluster number, which ranged from 1 to k. The second stage used TSR to construct a separate regression tree for each year with that year's yield as the response variable. Regression tree analysis can be performed using least squares or least absolute deviation (LAD) regression. Studies comparing the two methods have not found one to be consistently superior (Khoshgoftaar and Seliya, 2002). Consistent with the findings of Plant et al. (1999), we found LAD to produce more easily interpretable results, and we report the results of this method exclusively.

RESULTS AND DISCUSSION

Correlation Analysis

Figures 3 and 4 show the sequence of Thiessen polygons developed by Roel and Plant (2004) for yield trend values of the 4 yr for Field 1 and 3 yr for Field 2, respectively. Yield in Field 1 has no visually apparent persistent pattern over years while in Field 2, there are persistent low- and high-yielding areas. Field 2 had been recently leveled and brought into production, and the low-yielding areas were considered by the cooperating grower to correspond to cut areas of the laser-leveling process. Walker et al. (2003) observed a similar effect of precision leveling on rice yield. A cut-and-fill map for this field was not available. Univariate statistics of soil physical and chemical variables are summarized for Field 1 in Table 1 and for Field 2 in Table 2. The fact that Field 2 had recently been brought into production may explain the disparity in mineral nutrients between fields. The mean measured soil P value in Field 1 was nearly five times that of Field 2, and the Zn level was slightly higher. On the other hand, Field 2 had a higher mean measured soil K level.

Table 5. Cluster sets of Field 1. Each set contains more than one cluster resulting from different randomly selected rearrangements of the data. The table shows set identification; then number k of means (i.e., of clusters); the number of instances n of this set out of total number N of data rearrangements tested; the set consistency statistic γ, given by Eq. [1]; and the Moran's I and corresponding z value under the assumption of normality. For all cluster sets, the number of cells $p = 292$.

Set ID	k	n/N	γ	Moran's I (z)
2-1	2	2/10	1.00	0.58 (13.77)
2-2	2	6/10	0.98	0.67 (15.88)
3-1	3	4/10	0.94	0.72 (16.98)
3-2	3	3/10	0.86	0.65 (15.34)
3-3	3	2/10	0.89	0.58 (13.74)
4-1	4	4/10	0.61	0.65 (15.36)
4-2	4	2/10	0.61	0.62 (14.74)
4-3	4	2/10	0.90	0.60 (14.14)
5-1	5	5/10	0.80	0.51 (12.15)
6-1	6	2/5	0.11	−0.03 (−0.54)

Spearman rank correlation coefficients for Field 1 indicate a weak or even negative interannual correlation between and among yield and late-season NDVI (Table 3), the only exception being a strong correlation between 2001 yield and 2001 NDVI. Significance of coefficients may be overestimated due to spatial autocorrelation between sample values (Cliff and Ord, 1981). There is no consistently high correlation between rice yield and any soil attribute value in this field. High negative values exist between 1999 yield and soil pH ($r = -0.52$) and between 2001 yield and elevation before leveling ($r = -0.50$). Soil pH in this field has a highly negative correlation with OM and a strong positive correlation with clay content.

Spearman rank correlation coefficients in Field 2 present a much more consistent pattern (Table 4). There is a strong interannual correlation among yield values and between yield and late-season NDVI. The soil attribute values displaying consistently highest correlation between themselves and yield are pH, penetration resistance, and clay content, all negatively correlated; and soil test P level in 1998 and soil OM level in 1999 and 2000, both positively correlated. There is a paradoxical negative correlation between soil test K level and yield in 1998 and 1999 in Fields 1 and 2. In general the correlation coefficients among soil attribute values have much higher magnitudes in Field 2 than the corresponding coefficients in Field 1. In particular, soil test K in Field 2

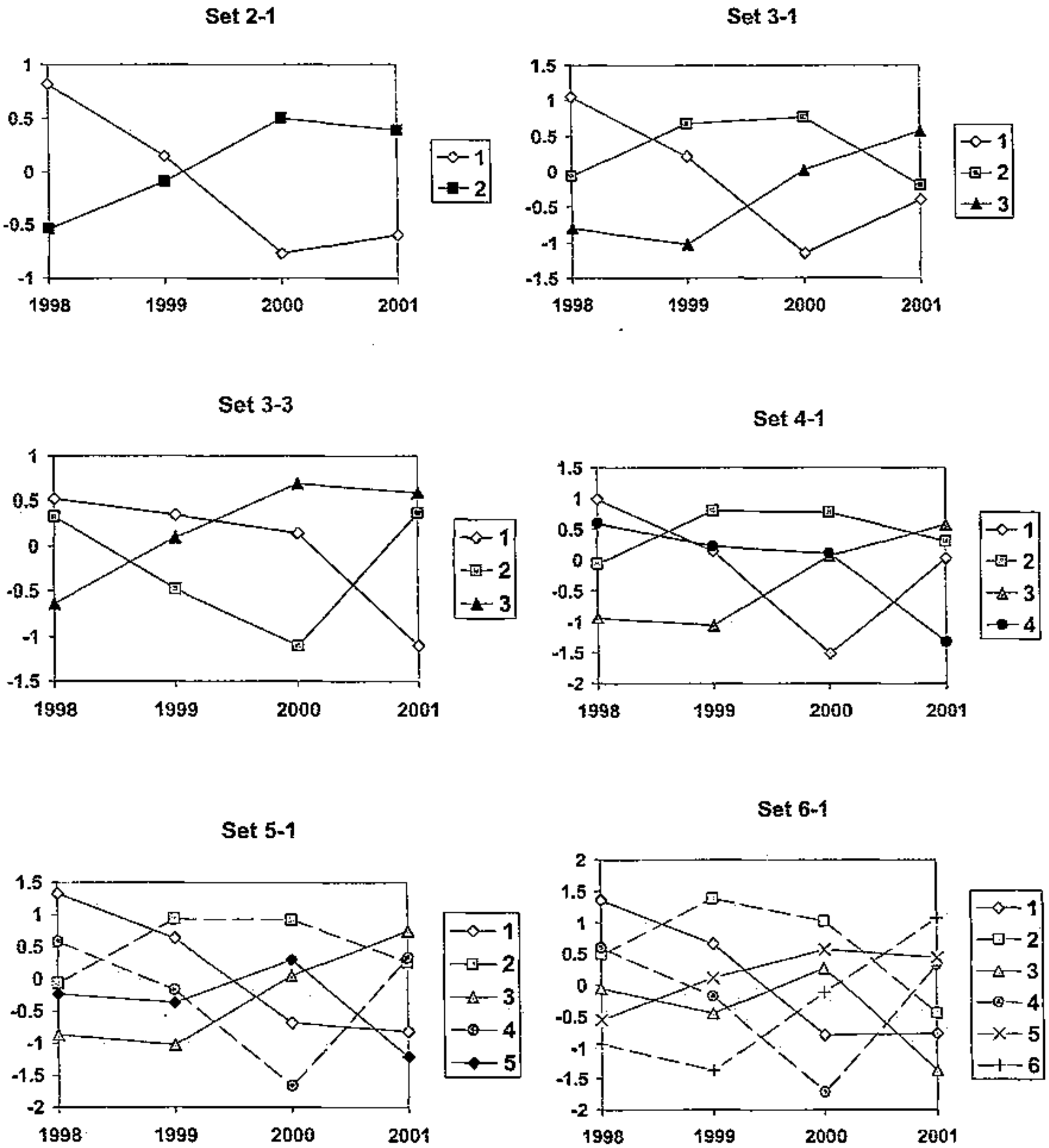

Fig. 5. Cluster means for the clusters of Fig. 2. Each plot shows the sequence of means of standardized yield values, obtained by subtracting the mean and dividing by the standard deviation, of the corresponding cluster for each of the 4 yr of data. To conserve space, the axes are not labeled. The abscissa is the year, and the ordinate is the standardized cluster mean.

has a strong negative correlation with OM and a positive correlation with clay content. This may reflect high clay content in the subsoil exposed by the laser-leveling process.

Cluster Analysis

Table 5 shows the breakdown of cluster sets for Field 1. Not all of the permutations of the data produced clusters that could be identified as belonging to a group. For example, of the 10 permutations tested at $k = 4$, only 8 produced clusters that had a pattern resembling other clusters. Those clusters that could not be identified as a member of a cluster set were ignored. Cluster sets in Field 1 could be identified for values of k less than or equal 6 (Fig. 2). The spatial autocorrelation statistic of the cluster set identified visually for $k = 6$ was not statistically significant, but all other sets were highly significant both in consistency and spatial structure (Table 5). Some of the cluster sets are themselves quite similar (Fig. 2). The γ statistic is 0.65 between Sets 2-1 and 2-2, 0.79 between Sets 3-1 and 3-2, and 0.59 considering all the members of Sets 4-1, 4-2, and 4-3 aggregated together. By examining the spatial arrangements of Fig. 2 and the plots of cluster means of the normalized yields (Fig. 5), hierarchical relationships can be determined. The cluster means of Set 2-2 are very similar to those of Set 2-1, those of Set 3-2 to Set 3-1, and those of Sets 4-2 and 4-3 to Set 4-1. Therefore, these are not displayed in Fig. 5. Cluster 2 of Set 2-1, which has a low value in 1998 and gradually rises, splits into Clusters 2

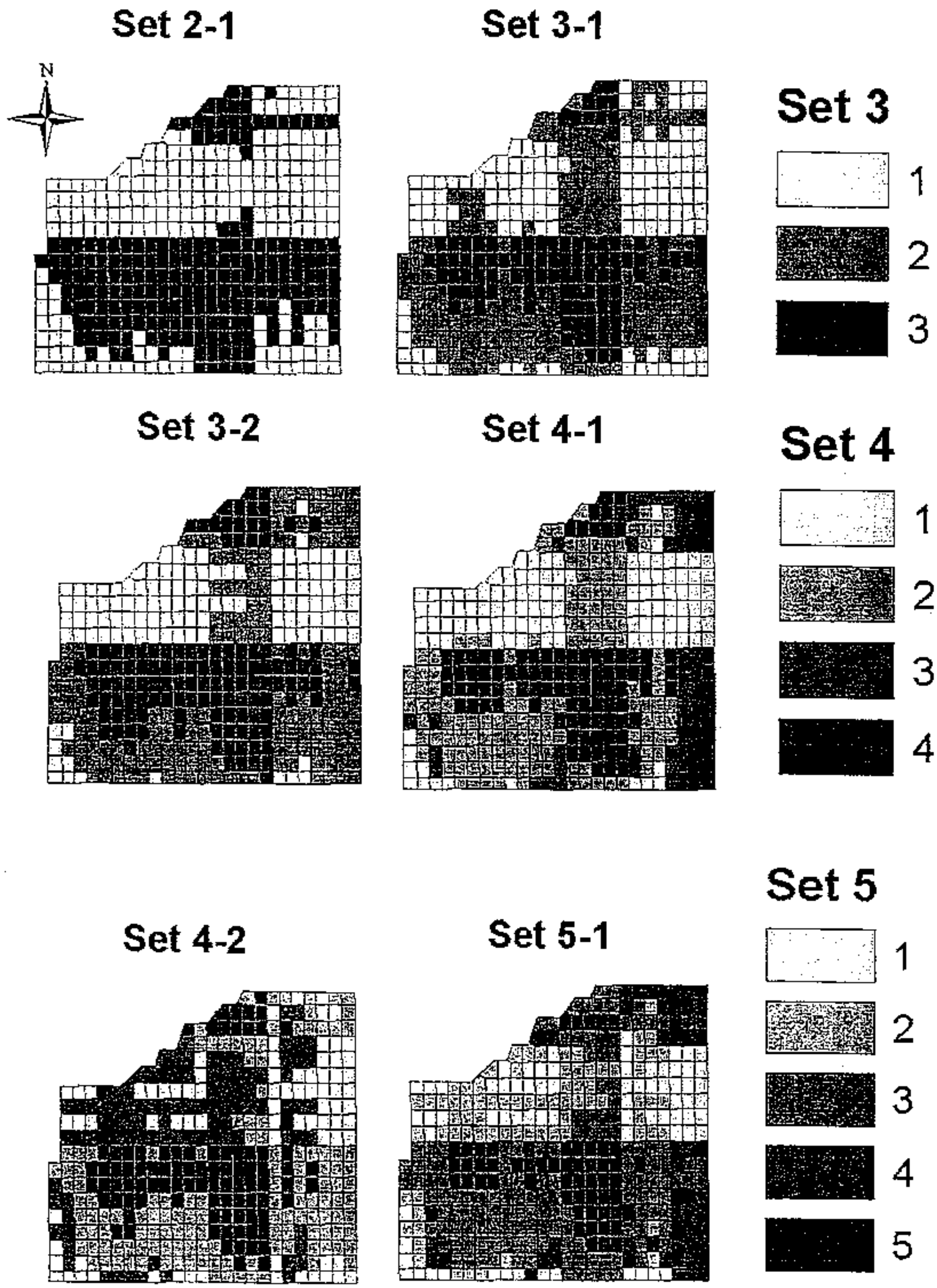

Fig. 6. Cluster sets of Field 2. Coding and legend keys are the same as those of Fig. 2.

and 3 of Set 3-1. Clusters 2 and 3 of Set 3-3 appear to be formed from parts of Clusters 1 and 2 of Set 2-2. The relationship between clusters for $k = 3$ and $k = 4$ is somewhat ambiguous. Clusters 1 and 3 of Set 5-1 are formed from Cluster 1 of Set 4-1. Clusters 2 and 5 of Set 6-1 are formed from Cluster 2 of Set 5-1.

The patterns of clustering associated with Field 2 are considerably simpler than those of Field 1 (Fig. 6 and 7). Set 2-1 consists of a consistently low and a consistently high yield area. The clusters in Sets 3-1 and 3-2 consist of consistently high, medium, and low yield areas that draw their members from both the high and low areas of Set 2-1. The medium yield area of Sets 3-1 and 3-2 splits into two to form Sets 4-1 and 4-2. One of these two again splits to form Set 5-1. All of the cluster sets show a very highly significant level of spatial autocorrelation (Table 6).

Classification and Regression Tree Analysis

The objective of the CART analysis was to relate explanatory field–level factors to the cluster response

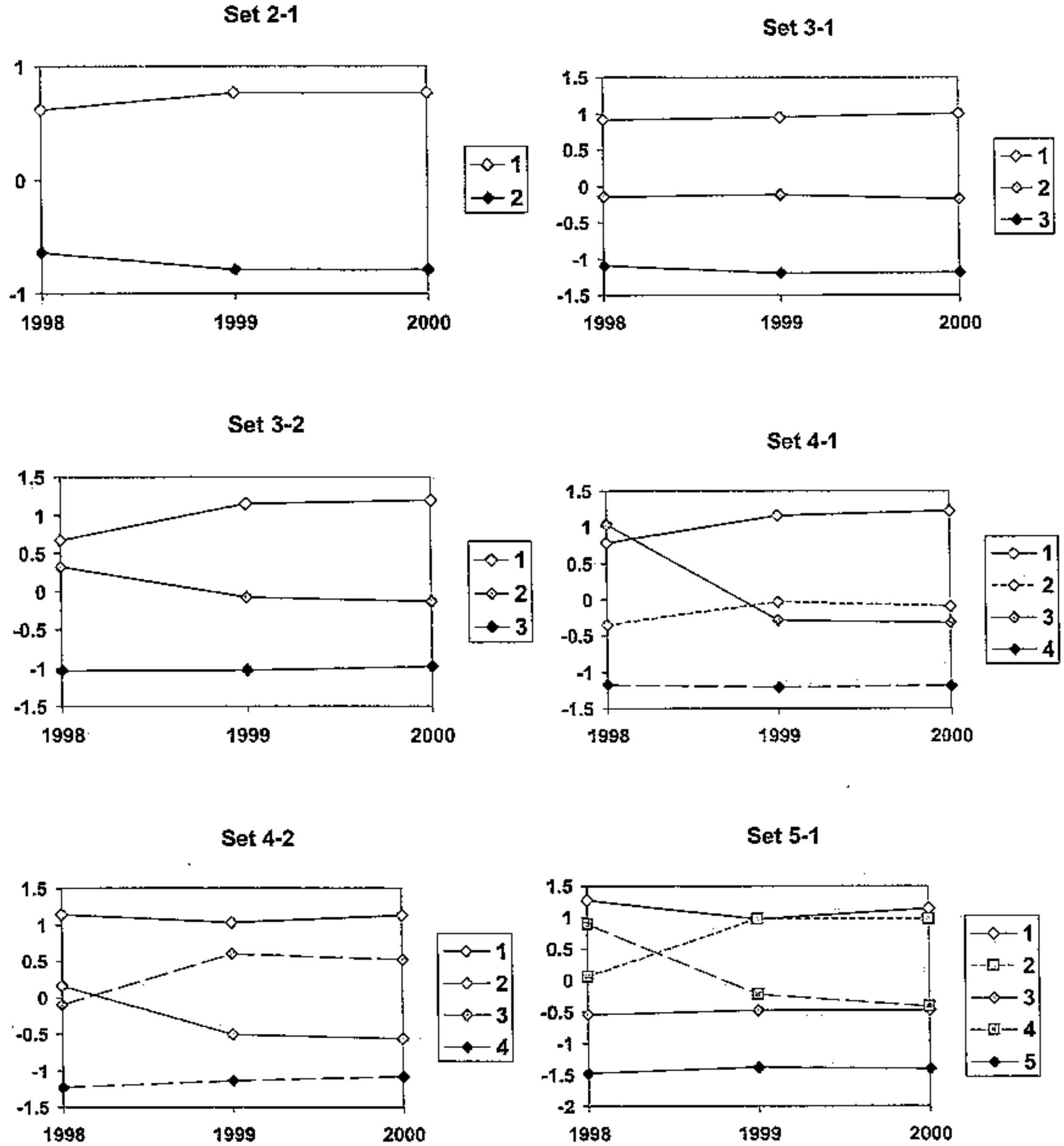

Fig. 7. Cluster means for the clusters of Fig. 6. Each plot shows the sequence of means of standardized yield values, obtained by subtracting the mean and dividing by the standard deviation, of the corresponding cluster for each of the 3 yr of data for this field. To conserve space, the axes are not labeled. The abscissa is the year, and the ordinate is the standardized cluster mean.

values developed in the last section. We followed the philosophy of Henderson and Velleman (1981) in this effort. That is, rather than attempt an objective, straightforward analysis, we explicitly took into account knowledge gained during our observation of the experiment and the preliminary analysis of the data. It is agronomically unlikely that a higher level of K would be associated with decreased yield in this production system. Therefore, we excluded K from the analysis based on the negative correlation with yield indicated in Tables 1 and 2, which we took to indicate multicollinearity with another variable. Similarly, based on our observation that the low-yielding area in the north-central portion of Field 1 in 2001 was due to a large stand of herbicide-resistant watergrass, we included the value of 2001 NDVI to represent this weed density. Similarly to the observation of Plant et al. (1999), we found that NDVI provided an accurate and highly precise representation of the location of the weed population because of the difference in dates of senescence between the weed and the crop.

Best results for the first stage of the CART analysis, the computation of classification trees for the clusters of Fig. 2, were obtained using $k = 4$ (i.e., four clusters). Smaller values of k did not provide sufficient levels of the response variable while at $k = 5$, there were too few values of the explanatory vector in each level of the response variable to obtain splits. Based on the similar temporal patterns of cluster means, we combined Cluster Sets 4-1, 4-2, and 4-3 into one set for the analysis. Of the eight clusters of the combined set (Table 5), six produced legitimate classification trees. The most extensive was produced by two members (Fig. 8) and consisted of two splits, one on NDVI-2001 and one on

Table 6. Cluster sets of Field 2. Each set contains more than one cluster resulting from different randomly selected rearrangements of the data. The table shows set identification; then number k of means (i.e., of clusters); the number of instances n of this set out of total number N of data rearrangements tested; the set consistency statistic γ, given by Eq. [1]; and the Moran's I and corresponding z value under the assumption of normality. For all cluster sets, the number of cells $p = 402$.

Set ID	k	n/N	γ	Moran's I (z)
2-1	2	4/5	1.00	0.71 (19.84)
3-1	3	2/5	0.93	0.76 (21.01)
3-2	3	2/5	0.89	0.79 (21.98)
4-1	4	2/5	0.97	0.75 (20.76)
4-2	4	3/5	0.61	0.59 (16.38)
5-1	5	5/5	0.86	0.69 (19.28)

SP. The other four members yielded trees with only the first split of Fig. 8, on NDVI-2001. Values of NDVI-2001 less than 0.425 distinguished Cluster 4, which was relatively high yielding in 1998 and declined thereafter (Fig. 5 and 6) while values of NDVI-2001 greater than 0.425 and SP less than 0.38 MPa distinguished Cluster 3, which was low yielding in the first 2 yr and then rose to become the highest yielding in the fourth year.

Regression tree analysis of the yield data (Table 7) indicated that low-yielding areas in 1998 included three points of low OM and seven points of low elevation. All but two of these 10 points lie inside Cluster 3 of the aggregated sets, and these make up a majority of the points in this cluster. The same condition on elevation

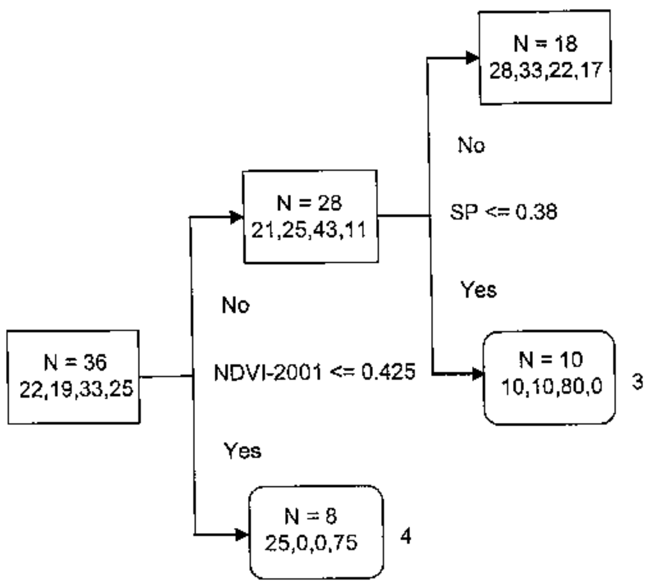

Fig. 8. Classification tree obtained for clusters of Field 1 at $k = 4$. The value of N in each box indicates the number of elements comprising that node of the classification tree. For example, the value $N = 18$ in the uppermost box indicates that there are 18 elements in which normalized difference vegetation index (NDVI)-2001 > 0.425 and soil penetration resistance (SP) > 0.38. The numbers on the second line in each box indicate the percentages of each cluster contained in that classification and regression trees (CART) node. For example, the node corresponding to the uppermost box is comprised of 28% Cluster 1, 33% Cluster 2, etc. Boxes with rounded corners indicate terminal nodes with a majority of members from one cluster, in which case the node is identified with that cluster. For example, the node corresponding to NDVI-2001 > 0.425 and SP ≤ 0.38 MPa is identified as corresponding to Cluster 3. This is indicated by the numeral to the right of the box.

Table 7. Results of the regression tree analysis carried out on the data of Field 1. "Y" indicates yes, and "N" indicates no. No tree had more than two splits, and each tree had at least one terminal node on the first split. Terminal nodes are indicated in parentheses and include the median yield and number of data values. Nonterminal nodes include only the number of data values. The second split is from the nonterminal node of the first split.

Year	First split	Second split
1998	OM ≤ 1.455	ELEV ≤ 9.89
	Y: (7 174, 3) N: 33	Y: (8 114, 7) N: (9 269, 26)
1999	pH ≤ 4.65	None
	Y: (10 351, 12) N: (9 521, 24)	
2000	No tree	
2001	NDVI-2001 ≤ 0.435	ELEV ≤ 9.89
	Y: (8 126, 14) N: 22	Y: (11 346, 7) N: (9 772, 15)

subdivides the highest-yielding seven points in 2001 (Table 7). The sample points lie in the southwest corner of the field, which received the most fill during the laser-leveling operation in 1999. The region with low pH, which had the highest yield in 1999, is located in the northeast portion of the field and does not correspond to any of the clusters. Neither the regression tree nor the classification tree analysis distinguished any factors associated with Clusters 1 or 2.

Classification tree analysis of the cluster data in Field 2 was not as consistent as it was for Field 1. The trees with the greatest number of nodes were obtained with $k = 3$. Trees were consistently able to associate an explanatory variable (which was not the same in each case) with Cluster 3 (Fig. 6 and 7), the lowest-yielding cluster. Figure 9 shows the classification tree for Cluster Set 3-2, in which SP is the distinguishing variable. Of the five runs, OM ≤ 0.05 was identified twice, CL ≤ 23.5 twice, and SP > 0.56 once as the most distinguishing parameter value. This inconsistency may be due to the high level of intercorrelation among these variables, particularly in the area of the field corresponding to Cluster 3. Only six sample points, all located at the geographical boundary of the cluster, satisfied one of these conditions and not all of them. There was no

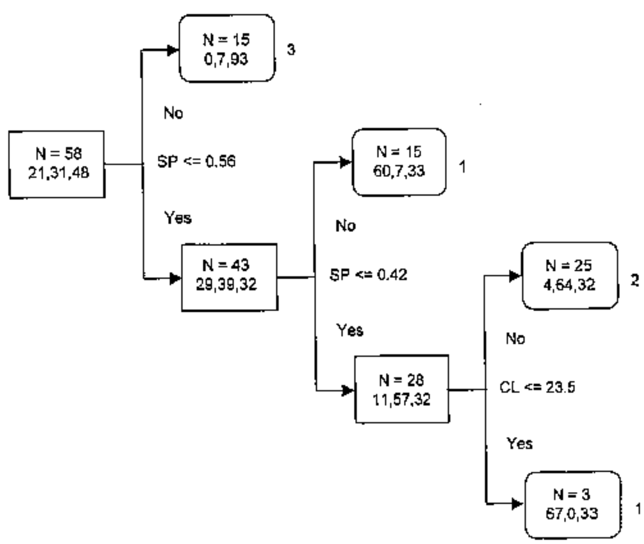

Fig. 9. Classification tree obtained for Field 2 at $k = 3$. The interpretation is the same as that of Fig. 8.

consistent factor distinguishing Clusters 1 and 2. Similarly, LAD regression tree analysis of yield by year was only able to distinguish the lowest-yielding portion of the field, with a single split in each year (not shown). The splits were CL $\leq$ 22.5 in 1998, CL $\leq$ 23.5 in 1999, and SP $>$ 0.56 in 2000.

CONCLUSIONS

Beginning with studies such as that of Lark and Stafford (1997), a number of investigations have been conducted on the use of clustering methods to organize precision agriculture data (Jaynes et al., 2003; Dobermann et al., 2003; Perez-Quezada et al., 2003). The stated objective of these studies has generally been to develop management zones for crop production, but there is a second important application for this sort of analysis: the development of statistical methodologies capable of using precision agriculture data for scientific research. As the application of these multivariate statistical methods becomes perfected and more widely used, it will make possible more precise experiments, both observational and replicated, in commercial fields. This will serve as a useful complement to the more traditional small-plot experiments performed under controlled conditions.

Many of the studies in which cluster analysis has been applied to yield data have used fuzzy clustering. We have adopted an alternative approach more akin to the probabilistic methods of Monte Carlo simulation and to randomization methods (Manly, 1997). Our method uses crisp clusters but carries out a randomization process to identify those cluster sets with the highest probability of occurrence. These are postulated to be most likely to correspond to a real physical process. A debate has been carried out in the decision support literature for two decades concerning the merits of probability theory vs. fuzzy set theory (which is called "possibility theory" in that literature) in dealing with uncertainty (Cheeseman, 1986). Probably the best that can be said is that both methods have something to offer, and in the case of clustering yield monitor data, both should be investigated further.

Our method of analysis consists of two steps: determining the cluster structure based on median polish yield data and using a multivariate technique (in the case of this paper, CART) to associate explanatory variables with the response variables generated by the cluster analysis. This is not the only possible approach; Jaynes et al. (2003) advocate a three-step process. One of the most important issues that must be addressed in the first step of our approach is the assessment of the clusters. We argue that the most important assessment measure is one that provides an indication of how "physically meaningful" the clusters are. This is because a k-means cluster algorithm will generate k clusters, whether or not these correspond to any real physical processes. In a similar way, a hierarchical cluster process will generate hierarchical clusters, even in the absence of any real hierarchy (Jain and Dubes, 1984). Our most important measure of "physical meaning" is stability under random permutations of the initial cluster seeds. The second most important measure is a high level of spatial structure. The third most important measure is evidence of a spatially consistent relation as k is increased.

In this initial test of the method, we did not iterate the k-means clustering algorithm to convergence. Our reason for this was to try to use the method to explore the variability and sensitivity of the cluster patterns. The practice of nonlinear optimization, to which the k-means algorithm is related, often employs a geographical terminology in which the optima are considered as "peaks" and the process of finding them is considered as "hill climbing" (Press et al., 1986). Employing this same topographical analogy, we wished to explore the terrain around the peak as well as find the peak itself. Further investigation will be necessary to determine whether this is the best approach.

Classification and regression trees have been widely used in many areas to associate explanatory variables with response variables. One of their chief drawbacks is that small changes in the distinguishing parameter of a node relatively low in the tree may have a profound effect on the structure of the tree above that node. Our method of random rearrangement partially compensates for this problem by allowing us to view the effects of small changes in the response variable (the cluster pattern) on the tree structure. This is evident in the stability of the trees associated with Field 1 under small perturbations compared with a corresponding instability of the trees associated with Field 2. This does not mean, however, that CART was not useful in identifying the important underlying factors in Field 2. Indeed, in both fields, the method seemed to produce meaningful results but not to be able to identify factors underlying all of the clusters. Possible reasons for this are that the clusters are themselves an artifact, the clusters are real but the factor underlying them was not measured, or there were not sufficient sample data to enable the CART process to construct a full tree. Indeed, the number of sample points, 36 and 58, is at the lower limit of effectiveness of CART (Breiman et al., 1984), which is a disadvantage of the CART method.

These two fields were purposefully selected at the start of the experiment to represent two ends of a spectrum of field behavior (Roel and Plant, 2004). Preliminary data, together with the cooperating grower's experience, indicated that Field 1 appeared to have no particular consistent spatial structure while Field 2 gave a strong preliminary indication of spatial structure due to its recent transition into production as a rice field. In their discussion of the "null hypothesis of precision agriculture," Whelan and McBratney (2000) point out that use of SSM in a field should be contingent on a clear indication that this will bring a substantial economic return. In the case of Field 1, there does not after 4 yr appear to be a consistent pattern of variability that would make this field a good candidate for SSM. In the case of Field 2, it is possible that application of ameliorative inputs to a relatively small part of the field, corresponding to Cluster 3, may provide an economic return where the application of these same inputs on a whole-field basis would not be economically justified.

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