

# **Continued Studies for the Knights Ferry Gravel Replenishment Project, Phase 2**

## **Project Information**

**1. Proposal Title:**

Continued Studies for the Knights Ferry Gravel Replenishment Project, Phase 2

**2. Proposal applicants:**

Carl Mesick, Carl Mesick Consultants

**3. Corresponding Contact Person:**

Carl Mesick

Carl Mesick Consultants

7981 Crystal Boulevard El Dorado, California 95623-4817

530 620-3631

cmcfish@innercite.com

**4. Project Keywords:**

**At-risk species, fish**

**Habitat Restoration, Instream**

**Salmon/Steelhead Biology**

**5. Type of project:**

Implementation\_Pilot

**6. Does the project involve land acquisition, either in fee or through a conservation easement?**

No

**7. Topic Area:**

At-Risk Species Assessments

**8. Type of applicant:**

Private for profit

**9. Location - GIS coordinates:**

Latitude: 37.81070

Longitude: -120.76841

Datum: ?

**Describe project location using information such as water bodies, river miles, road intersections, landmarks, and size in acres.**

Stanislaus River between Two-Mile Bar at river mile 56.8 to Oakdale at river mile 40.2.

**10. Location - Ecozone:**

13.1 Stanislaus River

**11. Location - County:**

Stanislaus

**12. Location - City:**

Does your project fall within a city jurisdiction?

Yes

If yes, please list the city: Oakdale

**13. Location - Tribal Lands:**

Does your project fall on or adjacent to tribal lands?

No

**14. Location - Congressional District:**

California 18th

**15. Location:**

**California State Senate District Number: 12**

**California Assembly District Number: 25**

**16. How many years of funding are you requesting?**

3

**17. Requested Funds:**

a) Are your overhead rates different depending on whether funds are state or federal?

No

If no, list single overhead rate and total requested funds:

Single Overhead Rate: 0

Total Requested Funds: \$412,141

b) Do you have cost share partners already identified?

No

c) Do you have potential cost share partners?

No

d) Are you specifically seeking non-federal cost share funds through this solicitation?

No

If the total non-federal cost share funds requested above does not match the total state funds requested in 17a, please explain the difference:

**18. Is this proposal for next-phase funding of an ongoing project funded by CALFED?**

Yes

If yes, identify project number(s), title(s) and CALFED program (e.g., ERP, Watershed, WUE, Drinking Water):

**#97-N21 Knights Ferry Gravel Replenishment Project ERP**

Have you previously received funding from CALFED for other projects not listed above?

No

**19. Is this proposal for next-phase funding of an ongoing project funded by CVPIA?**

No

Have you previously received funding from CVPIA for other projects not listed above?

Yes

If yes, identify project number(s), title(s) and CVPIA program.

**11332-1-J003 Spawning Habitat and Floodplain Restoration in the Stanislaus River at Two-Mile Bar, Phase 1 AFRP**

20. Is this proposal for next-phase funding of an ongoing project funded by an entity other than CALFED or CVPIA?

No

**Please list suggested reviewers for your proposal.** (optional)

<b>Kris Vyverberg</b>	<b>CA Department of Fish and Game</b>	<b>(916) 653-8711</b>	<b>kavberg@dfg.ca.gov</b>
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<b>Tom Cannon</b>	<b>HDR Engineering, Inc.</b>	<b>(916) 351-3823</b>	<b>tcannon@hdrinc.com</b>
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21. **Comments:**

# Environmental Compliance Checklist

## Continued Studies for the Knights Ferry Gravel Replenishment Project, Phase 2

### 1. CEQA or NEPA Compliance

a) Will this project require compliance with CEQA?

No

b) Will this project require compliance with NEPA?

No

c) If neither CEQA or NEPA compliance is required, please explain why compliance is not required for the actions in this proposal.

Phase 2 of this project is to conduct research only.

### 2. If the project will require CEQA and/or NEPA compliance, identify the lead agency(ies). If not applicable, put "None".

CEQA Lead Agency:

NEPA Lead Agency (or co-lead):

NEPA Co-Lead Agency (if applicable):

### 3. Please check which type of CEQA/NEPA documentation is anticipated.

#### **CEQA**

-Categorical Exemption

-Negative Declaration or Mitigated Negative Declaration

-EIR

**X**none

#### **NEPA**

-Categorical Exclusion

-Environmental Assessment/FONSI

-EIS

**X**none

If you anticipate relying on either the Categorical Exemption or Categorical Exclusion for this project, please specifically identify the exemption and/or exclusion that you believe covers this project.

### 4. CEQA/NEPA Process

a) Is the CEQA/NEPA process complete?

None

b) If the CEQA/NEPA document has been completed, please list document name(s):

### 5. Environmental Permitting and Approvals (If a permit is not required, leave both Required? and Obtained? check boxes blank.)

## **LOCAL PERMITS AND APPROVALS**

Conditional use permit

Variance

Subdivision Map Act

Grading Permit

General Plan Amendment

Specific Plan Approval

Rezone

Williamson Act Contract Cancellation

Other

## **STATE PERMITS AND APPROVALS**

Scientific Collecting Permit

CESA Compliance: 2081

CESA Compliance: NCCP

1601/03

CWA 401 certification

Coastal Development Permit

Reclamation Board Approval

Notification of DPC or BCDC

Other

## **FEDERAL PERMITS AND APPROVALS**

ESA Compliance Section 7 Consultation

ESA Compliance Section 10 Permit                      Required

Rivers and Harbors Act

CWA 404

Other

## **PERMISSION TO ACCESS PROPERTY**

Permission to access city, county or other local agency land.

Agency Name:

Permission to access state land.

Agency Name:

Permission to access federal land.

Agency Name: US Army Corps of Engineers

Required, Obtained

Permission to access private land.

Landowner Name: Frymire, Hunter, Crawford

Required, Obtained

## **6. Comments.**

5. The application for the ESA Section 10 permit was applied for in June 2000.

# **Land Use Checklist**

## **Continued Studies for the Knights Ferry Gravel Replenishment Project, Phase 2**

1. **Does the project involve land acquisition, either in fee or through a conservation easement?**

No

2. **Will the applicant require access across public or private property that the applicant does not own to accomplish the activities in the proposal?**

Yes

3. **Do the actions in the proposal involve physical changes in the land use?**

No

If you answered no to #3, explain what type of actions are involved in the proposal (i.e., research only, planning only).

Phase 2 of this project involves research only.

4. **Comments.**



# **Conflict of Interest Checklist**

## **Continued Studies for the Knights Ferry Gravel Replenishment Project, Phase 2**

Please list below the full names and organizations of all individuals in the following categories:

- Applicants listed in the proposal who wrote the proposal, will be performing the tasks listed in the proposal or who will benefit financially if the proposal is funded.
- Subcontractors listed in the proposal who will perform some tasks listed in the proposal and will benefit financially if the proposal is funded.
- Individuals not listed in the proposal who helped with proposal development, for example by reviewing drafts, or by providing critical suggestions or ideas contained within the proposal.

The information provided on this form will be used to select appropriate and unbiased reviewers for your proposal.

### **Applicant(s):**

Carl Mesick, Carl Mesick Consultants

### **Subcontractor(s):**

Are specific subcontractors identified in this proposal? No

### **Helped with proposal development:**

Are there persons who helped with proposal development?

No

### **Comments:**

None

# Budget Summary

## Continued Studies for the Knights Ferry Gravel Replenishment Project, Phase 2

Please provide a detailed budget for each year of requested funds, indicating on the form whether the indirect costs are based on the Federal overhead rate, State overhead rate, or are independent of fund source.

### Independent of Fund Source

Year 1												
Task No.	Task Description	Direct Labor Hours	Salary (per year)	Benefits (per year)	Travel	Supplies & Expendables	Services or Consultants	Equipment	Other Direct Costs	Total Direct Costs	Indirect Costs	Total Cost
1	Project Management	80	5200	0	0	30	0	0	0	5230.0	0	5230.00
2	Fall 2002 Studies	2711	109783	0	13491	11240	0	0	0	134514.0		134514.00
		2791	114983.00	0.00	13491.00	11270.00	0.00	0.00	0.00	139744.00	0.00	139744.00

Year 2												
Task No.	Task Description	Direct Labor Hours	Salary (per year)	Benefits (per year)	Travel	Supplies & Expendables	Services or Consultants	Equipment	Other Direct Costs	Total Direct Costs	Indirect Costs	Total Cost
1	Project Management	30	1950	0	0	30	0	0	0	1980.0	0	1980.00
3	Fall 2003 Studies	2711	109027	0	13896	6092	0	0	0	129015.0		129015.00
		2741	110977.00	0.00	13896.00	6122.00	0.00	0.00	0.00	130995.00	0.00	130995.00

Year 3												
Task No.	Task Description	Direct Labor Hours	Salary (per year)	Benefits (per year)	Travel	Supplies & Expendables	Services or Consultants	Equipment	Other Direct Costs	Total Direct Costs	Indirect Costs	Total Cost
1	Project Management	61	3965	0	0	40	0	0	0	4005.0	0	4005.00
4	Fall 2004 Studies	2711	109027	0	14300	6270	0	0	0	129597.0	0	129597.00
5	Manuscript Preparation	120	7800	0	0	0	0	0	0	7800.0		7800.00
		2892	120792.00	0.00	14300.00	6310.00	0.00	0.00	0.00	141402.00	0.00	141402.00

**Grand Total=412141.00**

### **Comments.**

None

# Budget Justification

## Continued Studies for the Knights Ferry Gravel Replenishment Project, Phase 2

**Direct Labor Hours.** Provide estimated hours proposed for each individual.

Dr. Mesick, Senior Fisheries Biologist 294 hours/year; Dr. Mesick, Field Supervising Biologist 1,177 hours/year; and Fisheries Technician II/III 1,286 hours/year.

**Salary.** Provide estimated rate of compensation proposed for each individual.

Dr. Mesick, Senior Fisheries Biologist \$65/hour, Dr. Mesick, Field Supervising Biologist \$45/hour, Fisheries Technician III \$30/hour, and Fisheries Technician II \$25/hour.

**Benefits.** Provide the overall benefit rate applicable to each category of employee proposed in the project.

Benefits for Dr. Mesick are included in the billing rate. Benefits are estimated to be 4% of the billing rate. If a Fisheries Technician II or III is hired, benefits will be 4% of the salary.

**Travel.** Provide purpose and estimate costs for all non-local travel.

Purpose is to travel between the El Dorado office and the Stanislaus River field sites and for equipment rental/purchase. Estimated costs for all non-local travel is \$13,491 for the first year of studies, \$13,896 for the second year of studies, and \$14,300 for the third year of studies.

**Supplies & Expendables.** Indicate separately the amounts proposed for office, laboratory, computing, and field supplies.

Estimated field supply costs are \$6,715 for the first year, \$1,567 for the second year, and \$1,745 for the third year. Total station rental/usage is \$4,425 per year. Report production costs are \$100 per year. No office, laboratory, or computing costs will be billed to this project.

**Services or Consultants.** Identify the specific tasks for which these services would be used. Estimate amount of time required and the hourly or daily rate.

No services or consultants will be used.

**Equipment.** Identify non-expendable personal property having a useful life of more than one (1) year and an acquisition cost of more than \$5,000 per unit. If fabrication of equipment is proposed, list parts and materials required for each, and show costs separately from the other items.

None

**Project Management.** Describe the specific costs associated with insuring accomplishment of a specific project, such as inspection of work in progress, validation of costs, report preparation, giving presentations, response to project specific questions and necessary costs directly associated with specific project oversight.

Project management costs are for Dr. Mesick's labor to provide a monitoring plan, invoices, quarterly reports, an oral presentation of results and respond to questions from program managers over the three year life of the project.

**Other Direct Costs.** Provide any other direct costs not already covered.

None

**Indirect Costs.** Explain what is encompassed in the overhead rate (indirect costs). Overhead should include costs associated with general office requirements such as rent, phones, furniture, general office staff, etc., generally distributed by a predetermined percentage (or surcharge) of specific costs.

Approximately 50% of the salary-billing rates are for overhead costs for computer equipment and software, office supplies, reference books, phone and internet service, utilities, furniture, unreimbursed time spent on proposal development, accounting and taxes, attending watershed work groups, employee management, literature searches, and equipment and vehicle maintenance.

# **Executive Summary**

## **Continued Studies for the Knights Ferry Gravel Replenishment Project, Phase 2**

This project would continue the environmental studies for the Knights Ferry Gravel Replenishment Project (KFGRP), which was a 1998 CALFED demonstration project. The objective of the KFGRP was to investigate the benefits and methods of restoring spawning habitat for fall-run chinook salmon at 18 restoration sites in the Stanislaus River between Goodwin Dam and Oakdale. The initial KFGRP studies demonstrated that shortly after construction, salmon redd densities were significantly higher in gravel obtained locally compared to gravel imported from the Tuolumne River. One year after construction, redd densities increased at all project sites relative to the control sites, which suggests that the gravel was rapidly seasoning. This project would continue to investigate hypotheses that the source and size of restoration gravel affect fall-run chinook salmon redd densities. The initial KFGRP studies also demonstrated that intragravel dissolved oxygen levels (D.O.) and bed permeability in artificial and natural chinook salmon redds were significantly greater in restoration sites than in control sites. However, it was not possible to determine whether the KFGRP improved egg survival, because the influence of clay-sized particles, which can adhere to the eggs membrane greatly reducing its ability to absorb D.O., has not been quantified. The effect of suspended fine sediment on egg survival is probably quite important in the Stanislaus River, which becomes very turbid during intense rainstorms. The entombment of alevins also affects egg survival in the Stanislaus River because redd superimposition rates are high and the process of redd superimposition covers the superimposed redd with fine sediment. Preliminary observations suggest that many alevins are entombed in superimposed redds whereas entombment rarely occurs in non-superimposed redds. This project would directly measure egg survival and alevin entombment at artificial and natural redds to investigate hypotheses that adding clean gravel to restore spawning habitat improves both the intragravel habitat conditions and the survival of chinook salmon eggs to emergence. The initial KFGRP studies indicate that moderate flows caused gravel movement at only four of the 18 project riffles where the channel was confined. This project would continue to evaluate the hypothesis that riffles constructed in widened, mined channels will have a longer useful life than those constructed in narrow, unmined channels. This project would continue the KFGRP studies for three years to ensure that a range of escapements, redd superimposition rates, turbid storm runoff, and spring high flow events are evaluated. These studies will help achieve the CALFED ERP, Science Program, and AFRP goals to improve our understanding of at-risk species, such as fall-run chinook salmon, in the San Joaquin region and to conduct adaptive management experiments. The estimated costs for project management is \$11,215, the first year of study is \$134,514, the second year of study is \$129,015, third year of study is \$129,597, and manuscript preparation for a peer-reviewed journal is \$7,800. The total project cost is \$412,141.

# **Proposal**

**Carl Mesick Consultants**

**Continued Studies for the Knights Ferry Gravel Replenishment Project, Phase 2**

Carl Mesick, Carl Mesick Consultants

# CARL MESICK CONSULTANTS

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## **Continued monitoring for the Knights Ferry Gravel Replenishment Project, Phase 2**

### **A. Project Description: Project Goals and Scope of Work**

Carl Mesick Consultants (CMC) is submitting this proposal to continue the environmental studies for the Knights Ferry Gravel Replenishment Project (KFGRP), which was funded by CALFED in 1998. The objective of the KFGRP was to investigate 10 hypotheses regarding the environmental benefits and methods of adding clean gravel to the streambed of the Stanislaus River to improve spawning and incubation habitat for fall-run chinook salmon (*Oncorhynchus tshawytscha*; CMC 2001a). The initial KFGRP studies, which included one year of pre-project studies in fall 1998 and two years of post-project studies in fall 1999 and fall 2000, demonstrated that fall-run chinook salmon will spawn immediately at the tails of pools constructed with newly placed gravel (CMC 2001b). The results also indicated that redd densities were significantly higher in gravel obtained from the Stanislaus River's floodplain compared to similarly-sized gravel imported from the Tuolumne River's floodplain. Redd densities were also higher in Stanislaus River gravel cleaned with a 1/4-inch screen compared to gravel cleaned with a 3/8-inch screen, although the differences were not significant. The results of the second year of post-project studies in fall 2000 indicated that all three types of restoration gravel are rapidly "seasoning" in terms of spawner use (CMC 2001c). Redd densities significantly increased at all three types of restoration gravel relative to the redd densities at control sites in fall 2000 compared to the initial post-project conditions in fall 1999 (Figure 1). CMC hypothesized that chinook salmon probably select spawning sites based on the mineral content or odor of the gravel and the ease of digging a redd (CMC 2001b) and that "seasoning" and fine sediment intrusion affect the suitability of restoration gravel over time. Although the mineral content of the different sources of gravel was not determined during the initial studies, the two sources of gravel differed in color and presumably mineral content and it is likely that the salmon could smell these differences. In addition, salmon frequently construct redds at artificial redd sites, where the construction of the artificial redd in the cemented streambed would have loosened the gravel and facilitated subsequent redd construction. It may also have been easier for salmon to construct redds in the gravel washed with a 1/4-inch screen than in gravel washed with a 3/8-inch screen as it was noticeably easier to dig artificial redds with hoes and shovels in the gravel washed with the smaller screen. Presumably substrate particles between 1/4 and 3/8-inches act as a "lubricant" during redd construction or digging. This project would continue the environmental studies for the KFGRP for a fourth, fifth, and sixth year to evaluate the long-term effects of "seasoning" on chinook salmon spawner use of different sources and sizes of restoration gravel.

The initial KFGRP studies also demonstrated that intragravel dissolved oxygen levels (D.O.) and permeabilities in artificial and natural chinook salmon redds were significantly greater in restoration sites than in control sites (CMC 2001b, 2001c). However, it is not possible to determine whether the survival of chinook salmon eggs to emergence was greater at the KFGRP restoration sites than at the control sites based solely on measurements of D.O. and permeability (CMC 2001b) because the environmental factors that affect egg survival to emergence are poorly

understood (Chapman 1988, Young et al. 1990, CMC 2001b). Interpreting the effects of D.O. and permeability on salmonid egg survival is difficult because suspended clay-sized sediment particles can adhere to the egg's membrane and thereby reduce its ability to absorb D.O. (Stuart 1953). This effect is shown in a comparison of three studies of steelhead trout (*O. mykiss*) egg survival relative to D.O. concentration. A laboratory study by Silver et al. (1963), during which eggs were incubated on clean, porous ceramic plates under highly controlled levels of D.O. and flow, indicates that survival was high (about 80%) at D.O. levels of at least 2.5 mg/l (Figure 2). In contrast, a field study by Coble (1961), during which eggs were placed in plastic mesh sacks with gravel, indicates that egg survival gradually declined as D.O. declined from 9.2 mg/l to 2.6 mg/l (Figure 2). Another field study by Phillips and Campbell (1962), during which eggs were placed in perforated metal boxes with glass beads, indicates that no eggs survived at D.O. levels at or below 7.2 mg/l (Figure 2).

Studies with other salmonid species show similar results. Eggs of chum salmon (*O. keta*; Alderdice et al. 1958), chinook salmon (Silver et al. 1963), and coho salmon (*O. kisutch*; Shumway et al. 1964) incubated under clean laboratory conditions survived to hatching at high rates at D.O. concentrations as low as 2.0 to 2.5 mg/l. Chum salmon eggs that were deposited in natural redds in an experimental stream channel with washed gravels also survived at relatively high rates (50%) at D.O. levels as low as 2.5 mg/l (Koski 1975). Conversely, the survival of coho salmon eggs incubated in natural streams either in natural redds (Koski 1966) or in experimental chambers (Phillips and Campbell 1962) were reduced at D.O. concentrations below 9.0 mg/l and 8.3 mg/l, respectively. Although the adhesion of fines to the egg's membranes was not evaluated in the field studies, it is the most likely explanation for why eggs require greater concentrations of D.O. in natural streams than in a laboratory or in washed gravel.

The survival of salmonid eggs is also dependant on intragravel flow rates, which can be measured as either permeability or apparent velocity. Permeability is the ease with which water passes through gravel and depends on the composition and degree of packing of the gravel and viscosity of the water (Pollard 1955). Apparent velocity is the horizontal vector of interstitial flow and is a function of permeability and hydraulic gradient (Pollard 1955; Freeze and Cherry 1979). It is measured as the rate of flow through a standpipe, which is called apparent yield, divided by the porosity of the surrounding gravel. The actual velocity of flow through interstitial spaces, which is called the true or pore velocity, is faster than the apparent velocity because flow travels around substrate particles whereas apparent velocity assumes that the flow path is linear.

Steelhead trout and coho salmon egg survival to hatching in natural streams has been correlated with apparent velocity, but not as strongly as with D.O. concentration; whereas there have been no correlations with permeability (Coble 1961; Phillips and Campbell 1962). The size of coho salmon and steelhead trout embryos at hatching was reduced at low velocities, regardless of D.O. concentration in the lab (Shumway et al. 1964); whereas steelhead trout and chinook salmon egg survival was not correlated with true velocity under the same laboratory conditions (Silver et al. 1963). The survival of masu salmon (*O. masou*) eggs to the eyed stage in 72 redds was somewhat correlated ( $r^2 = 0.39$ ) with an index of intragravel flow in the Kawabe River, Japan (Kondou et al. 2001). A comparison of five studies, including Gangmark and Bakkala (1960), Coble (1961), Phillips and Campbell (1962), Reiser and White (1988), and Deverall et al. (1993), suggests that the apparent velocity that is critical for egg survival is highly dependant on the intragravel D.O. concentration and possibly the amount of silt adhering to the egg's membrane as well (CMC 2001b).



The effects of suspended fine sediments on the ability of salmon eggs to absorb D.O. is probably quite important in the Stanislaus River, which becomes very turbid during intense rain storms. To study the effects of fines adhering to egg membranes and redd superimposition, this project would directly determine egg survival to emergence rates by planting fall-run chinook salmon eggs in artificial redds while monitoring intragravel D.O. concentrations, apparent velocity, turbidity in the egg pocket, and permeability.

The entombment of alevins is probably another important factor affecting survival to emergence in the Stanislaus River because redd superimposition rates are high (CMC 2001b, 2001c, Mesick 2001a) and the process of redd superimposition frequently covers the superimposed redd with fine sediment. Koski (1966) reported that a majority of mortality in redds was caused by the inability of alevins to emerge. He found numerous dead coho salmon alevins that were completely buttoned-up but extremely emaciated at a depth of 8 inches. Beschta and Jackson (1979) showed that in a flume, fines 0.5 mm in diameter tend to form a barrier in the upper 10 cm of the gravel bed that “seals” against intrusion of fines into the egg pocket but also creates a barrier to emergence. This barrier has been described in salmon redds as a mixture of coarse sand and fines 6 to 12 inches above the egg pocket (Hawke 1978) that has a geometric mean diameter ( $d_g$ ) that was lower than the substrate above and below the middle layer (Platts et al. 1979).

Previous studies that attempted to quantify alevin entombment relative to the amount of fines have not provided conclusive results. Researchers that evaluated emergence rates by capping natural redds with nets, such as Koski (1966, 1975), Tagart (1976), and EA (1992), did not estimate egg viability, fertilization success, the loss of eggs during deposition in the egg pocket (Young et al. 1990), or the escape of fry that migrate under the trap’s netting (Garcia De Leaniz et al. 1993) and so they cannot accurately estimate egg survival to emergence (Chapman 1988, Young et al. 1990). Laboratory studies of the effects of various sand concentrations on emergence rates, such as those by Shelton and Pollock (1966), McCuddin (1977), Tapple and Bjornn (1983), Phillips et al. (1975), tested the ability of large, healthy alevins to emerge under high concentrations of sand, an abnormal condition considering that high concentrations of sand typically result in low D.O. levels and small, weak alevins. These researchers used laboratory troughs with washed gravel and maintained high D.O. levels and either provided high apparent velocities during egg incubation (McCuddin 1977) or planted eyed-eggs (Shelton and Pollock 1966; Tapple and Bjornn 1983) or alevins (Phillips et al. 1975) incubated under optimum conditions. Therefore, their results would predict abnormally high emergence rates if D.O. levels are low when fine sediment intrusion rates are high. These studies indicate that a range of substrate particle sizes, including those  $\leq 0.85$  mm (Shelton and Pollock 1966),  $\leq 3.3$  mm (Koski 1966),  $\leq 4.67$  mm (Tapple and Bjornn 1983), and  $\leq 6.4$  mm (McCuddin 1977), affect entombment rates of alevins.

The quantification of the effect of a sand-silt barrier on entombment of alevins is difficult due to the fragile nature of the barrier. Driving probes to extract freeze cores from egg pockets or driving standpipes into the egg pocket to measure permeability disrupts the sand-silt barrier (Beschta and Jackson 1979). Platts et al. (1979) used a battery of probes to extract a frozen but intact egg pocket that weighed 620 kg; only one was sampled presumably due to the difficulty of working with such a heavy sample.

To compare the survival of chinook salmon eggs to emergence between the restoration sites and the control sites, this project would estimate the rate of egg survival to emergence by planting fall-run chinook salmon eggs in artificial redds and use an index of emergence based on the number of entombed alevins in natural redds that were constructed by similarly sized females.

The fall 1999 and fall 2000 KFGRP studies also indicate that the reconstruction of riffles in mined channels sometimes triggered high rates of fine sediment intrusion during annual pulse flows (CMC 2001b, 2001c). As a result, bed permeabilities declined rapidly at some project sites, thereby potentially affecting spawner use and the survival and emergence of eggs. This project will continue to monitor bed permeability in various reaches of the river.

Sediment transport occurred only at four of the 18 project sites where instream structures, including boulders, mid channel islands and large trees, confined the flow and increased shear stress when flows increased to 3,500 cfs (a moderately high level) approximately seven months after construction. If high flows occur in the next few years, this proposed project will document the effects.

## **1. Problem**

Most Central Valley river ecosystems have been severely degraded over time due to water diversions and land-use practices. The origins of degradation of river ecosystems can be traced back to the 1848 California gold rush, and include the construction of numerous dams, occupation of the floodway, and the mining of gold and gravel from the active channel and floodplain. Gravel and gold mining has been intensive throughout the primary spawning and rearing reaches on the Stanislaus River. A long-time resident of the Stanislaus River corridor reports that inriver mining was particularly intensive during the early 1940s and that draglines were used to excavate both the streambed and part of the floodplain (Frymire, personal communication, see "Notes"). After the peak mining period between 1949 and 1999, Kondolf et al. (2001) estimated that an additional 1,031,800 yd<sup>3</sup> of gravel were extracted from the active channel between Goodwin Dam (RM 58.5) and Oakdale (RM 40). Surveys conducted by the California Department of Fish and Game (DFG 1972) in the 1960s suggest that the riffles were completely excavated from about 55% of the channel between the Knights Ferry County Bridge (RM 54.5) and the Orange Blossom Bridge (RM 47). The few riffles that remain have since become armored and shortened based on a comparison between the DFG surveys conducted in the 1960s and surveys conducted in 1995 and 1996 (Mesick 2001a).

## **2. Justification**

### **Conceptual Model**

Escapement of fall-run chinook salmon to the Stanislaus River has fluctuated between 50 and 35,000 fish since 1946. The fluctuations in escapement are well correlated with streamflow during smolt migration and the number of adult fish that return to spawn (Mesick 2001b). Smolt survival studies with hatchery reared fish suggest that mortality is abnormally high in the deepwater ship channel between Stockton and the confluence with the Mokelumne River and that survival can be improved by either flood flows or a barrier at the head of the Old River which shunts water into the ship channel (Mesick 2001b). One possible explanation for the high mortality rates of hatchery-reared smolts during their 5-10 day migration through the deepwater

ship channel in mid April when water temperatures were generally suitable is that striped bass (*Morone saxatilis*) and other predators congregate in the dredged channels and hatchery reared juvenile salmon are particularly susceptible to predation. Another possible explanation for why escapement increases two years after a flood event is that the survival of fry rearing in the San Joaquin mainstem and Delta may be substantially increased during high flows that presumably reduce the impacts of predation, unscreened diversions, contamination, and other stressors. However, there are insufficient data to assess the survival of juvenile salmonids rearing in the Delta.

A stock-recruitment analysis for the Stanislaus River salmon population from 1946 to 1998 suggests that recruitment is frequently limited by an insufficient number of spawners (a.k.a., stock). The analysis indicates that recruitment initially increases as stock increases but then remains constant after stock exceeds about 2,500 three-year-old fish (Mesick 2001b). The number of spawners returning to the Stanislaus River was fewer than 1,500 fish, which was probably low enough to substantially limit recruitment, during 46% of the years from 1958 to 1998. It is likely that the low abundance of spawners was a result of the combined effects of poor smolt survival when springtime flows were low and high ocean harvest rates of adult salmon.

The stock-recruitment analysis also suggests that the habitat in the Stanislaus River can support the progeny of only about 1,250 adult female salmon. It is likely that instream gravel mining, which peaked during the early 1940s prior to the escapement surveys, degraded the quantity and quality of both spawning and rearing habitat in the Stanislaus River. The upstream dams that blocked the coarse sediment supply worsened the problem as the remaining riffles became armored and smaller as they eroded away. The limited amount of riffle habitat in the Stanislaus River results in high rates of redd superimposition during which the late arriving females either excavate and kill the incubating eggs or deposit the fine sediment from their redd on top of the superimposed redd, thereby entombing the alevins. Dr. Mesick observed numerous dead alevins in superimposed redds but few in non-superimposed redds in the Stanislaus River in February and March 2001 (CMC 2001c). Fine sediment intrusion from redd superimposition also tends to reduce the downwelling of surface flow into the redds which increases the influence of oxygen-poor groundwater in the egg pocket. Low D.O. concentrations either kill the embryos or stunt their growth, which reduces their chances for survival (Chapman 1988). The eggs of late arriving female salmon are susceptible to turbid runoff from winter storms in the Stanislaus River that probably coat the eggs with clay-sized particles that would reduce their ability to absorb oxygen. Stunted fry are frequently observed in the screw traps in the San Joaquin tributaries and they are probably quite vulnerable to water temperatures above 65°F, predation, low food availability, contamination, unscreened diversion and other stressors.

It is also likely that loss of riffle habitat from inriver gravel mining reduced rearing habitat and increased predation of juvenile salmonids. Numerous chinook salmon and steelhead/rainbow trout juveniles were observed using the KFGRP riffles, whereas in mined areas, the juveniles are typically restricted to the densely vegetated river margins to avoid predators (Fisheries Foundation, unpublished data, Tom Cannon, personal communication, see "Notes"). Large schools of Sacramento pikeminnow (*Ptychocheilus grandis*) occur in the mined channels and numerous salmonid fry have been observed in their stomachs (Walser and Smith, personal communication, see "Notes").

The construction of new riffle habitat in the primary spawning reach in the Stanislaus River should increase the abundance and condition of the emerging fry, primarily by reducing redd superimposition. Presumably, healthy fry should be able to tolerate warm temperatures, low food availability, and low levels of contamination and avoid predation, unscreened diversion and other stressors better than stunted fry produced in the highly silted, natural riffles in the Stanislaus River. Restoration of riffle habitat should also decrease the abundance of predators, particular Sacramento pikeminnow which feed extensively on fry (Walser and Smith, personal communication, see “Notes”). Although it will be impossible to eliminate predators throughout the system, particularly in the Delta, an increase in the production in healthy smolts should result in increased recruitment to the adult population.

Although gravel augmentation is a logical solution to the problems caused by inriver gravel mining in Central Valley rivers, early restoration projects in the San Joaquin tributaries were poorly used by spawning salmon (Mesick 2001a) and as a result, only a limited number of new projects were being proposed. The early projects imported gravel from the Merced River, used crushed rock, and removed all rock less than 1/2-inch in diameter. Another concern was that salmon clean the gravel during redd construction and there was no evidence to suggest that adding clean gravel to construct spawning habitat would improve egg survival to emergence. Although the initial KFGRP studies helped to resolve these issues, questions remain as to the long-term benefits of gravel augmentation projects.

## **Hypotheses**

Hypothesis 1. The density of fall-run chinook salmon redds will be higher at the restored project riffles than in the unrestored control riffles.

The density of fall-run chinook salmon redds was studied at 18 project and 7 control riffles in fall 1998 under pre-project conditions and in fall 1999 and fall 2000 under post-project conditions. The results indicate that restoration gravels “season” rapidly such that redd densities substantially increased at the project sites relative to the control sites one year after construction. This project would continue the studies for another three years beginning in fall 2002 at the same KFGRP sites and two new control sites that were evaluated in fall 2000.

Hypothesis 2. Restoration gravel obtained from near the Stanislaus River will be used by more Stanislaus River chinook salmon than will gravel obtained from the Tuolumne River.

The density of fall-run chinook salmon redds was significantly greater ( $P = 0.073$ ) at the sites with Stanislaus River gravel than at sites with similarly-sized Tuolumne River gravel in fall 1999. However, redd densities at the sites with Tuolumne River gravel increased from being lower than those at the control sites in fall 1999 to significantly greater ( $P = 0.009$ ) than those at the control sites in fall 2000. This project will determine whether gravel seasoning has continued since fall 2000.

Hypothesis 3. Restoration gravel between 1/4 and 5 inches will attract more spawners than will gravel between 3/8 and 5 inches.

Although redd densities were consistently greater at the sites with gravel washed with a 1/4-inch screen than at the sites with gravel washed with a 3/8-inch screen in fall 1999 and fall

2000, the differences were not significant ( $P \geq 0.37$ ). This project will collect additional data to test this hypothesis.

Hypothesis 4. Adding gravel without fines to the streambed increases intragravel D.O. concentrations and intragravel flow rates compared to those at the control riffles.

The fall 1999 and fall 2000 studies indicated that D.O. and intragravel flow measured as permeability were significantly greater at artificial and natural chinook salmon redds in restoration riffles than at those in the control riffles. This project will evaluate the effects of four to six years of fine sediment intrusion on intragravel conditions at the restoration riffles in the Stanislaus River.

Hypothesis 5. Restoring riffle habitat with clean gravel will increase egg survival to emergence and the size of emerging fry compared to control riffles.

This hypothesis cannot be evaluated with measurements of intragravel D.O. and flow rates alone due to the influence of clay-sized particles adhering to the eggs. Natural redds will not be capped due to the difficulty in determining both the number of eggs deposited and the number of alevins that escape the net cap (CMC 2001b). Alternatively, chinook salmon eggs from the Merced River Fish Facility will be planted in artificial redds and natural chinook salmon redds will be excavated to estimate alevin entombment rates in project and control riffles.

Hypothesis 6. Riffles constructed in widened, mined channels will have a longer useful life than will riffles constructed in narrow unmined channels.

Following moderately high streamflows of 3,500 cfs in spring 2000, gravel movement occurred at only four of the 18 project riffles where hydraulic controls, such as mid-channel islands, large boulders, or large trees, confined the streamflow and produced high levels of shear stress. This project will continue to monitor bed movement at the 18 project riffles.

### **Selection of Project Type**

The Knights Ferry Gravel Replenishment Project was originally proposed in 1997 as a demonstration project to address two issues regarding restoration. First, no studies had been conducted to determine why salmon spawn at some restoration projects but not others (CMC 2001a). Second, there is uncertainty as to whether adding clean gravel to streambeds would increase the production of healthy juveniles. Although the initial KFGRP environmental studies provide information to help resolve these issues, further studies are needed.

### **3. Approach**

This project includes five tasks, including project management, three years of study, and the preparation of a manuscript for publication in a peer-reviewed journal.

Task 1 Project Management will provide a monitoring plan, invoices, quarterly reports, an oral presentation of results and respond to questions from CALFED or CVPIA managers over the three-year life of the project.

Tasks 2, 3, and 4 will implement the fall 2002, fall 2003, and fall 2004 studies, respectively. The study sites include the 18 KFGRP project riffles, which include TMA, R1, R5, R12A, R12B, R13, R14, R14A, R15, R16, R19, R19A, R28A, R29, R43, R57, R58, and R78, and 9 unrestored control riffles in the Stanislaus River between Goodwin Dam and Oakdale (Figures 3 to 6). Task 5 will prepare a manuscript for publication in a peer-reviewed journal that summarizes all three years of study. Deliverables will include draft and final reports for each year of study and a copy of the manuscript prepared for publication. Draft reports will be sent for review to the Stanislaus Fish Group, all other biologists working in the Stanislaus River basin, and the CALFED or CVPIA program managers. The following describes the approach to be used for each year of study to evaluate six hypotheses regarding the benefits and methods of restoring spawning habitat for fall-run chinook salmon at the KFGRP sites.

Hypotheses 1, 2, and 3. The effects of the source and size of restoration gravel on spawner use will be tested using the following methods:

Redds will be counted and mapped at each study site at 10-day intervals from mid-October through mid-December as was done for the initial KFGRP studies. Contour maps showing bed elevations in 1-foot intervals will be generated showing the precise location of each redd at each study site. If the density of redds continues to be significantly correlated with distance downstream from Goodwin Dam, the barrier to upstream migration, two-tailed *F*-tests will be used to compare the residual variances, slope, and elevations of regressions of redd density versus distance downstream between the project and control sites (Snedecor and Cochran 1989, pages 390-393). The addition of the two new control sites (riffles R2 and R44) should improve the likelihood of detecting actual differences in spawner use.

Hypothesis 4. Adding gravel without fines to the streambed increases intragravel D.O. concentrations and intragravel flow rates compared to those at the control riffles.

This study element will evaluate the effects of four to six years of fine sediment intrusion on intragravel conditions at 18 restoration riffles in the Stanislaus River. Intragravel D.O. and permeability will be measured at a depth of 12 inches in undisturbed gravel and in the vicinity of egg pockets of natural redds with a modified Terhune standpipe. Measurements will be made in undisturbed gravel in early November. Up to five non-superimposed redds will be measured at each riffle in early November and another five will be measured after turbid storm runoff has occurred, presumably in January. If the tailspills of superimposed redds are sufficiently intact to locate the egg pocket, up to 25 superimposed redds will be measured project riffles and another 25 will be measured in control riffles in November and January. The age of each measured redd will be determined from redd mapping for the study of Hypotheses 1, 2 and 3. It will be assumed that an egg pocket is located near the upstream edge of the tailspill in the middle of the redd as reported in the literature (Vronskiy 1972, Hawke 1978).

Hypothesis 5. Restoring riffle habitat with clean gravel will increase egg survival to emergence and the size of emerging fry compared to control riffles.

This hypothesis cannot be evaluated with measurements of intragravel D.O. and flow rates alone and so chinook salmon eggs from the Merced River Fish Facility will be planted in artificial redds to estimate egg survival to emergence and natural chinook salmon redds will be excavated to estimate alevin entombment rates. Three hundred water-hardened eggs will be buried at a depth of 12 inches in fully enclosed egg incubation chambers, approximately the size of 5-gallon buckets, contained within natural looking artificial redds. Six artificial redds will be constructed in each of three types of gravel: (1) restoration gravel washed with a

1/4-inch screen, (2) restoration gravel washed with a 3/8-inch screen, and (3) natural gravel at control sites. These 18 artificial redds will be constructed in early November immediately following a managed pulse flow. It is anticipated that some of these artificial redds will be superimposed by spawning female chinook salmon and it should be possible to detect these effects. Another six artificial redds will be constructed in gravel washed with a 1/4-inch screen in mid-December. It is anticipated that turbid storm runoff will occur prior to the hatching of these eggs, but that redd superimposition rates will be low. It should be possible to detect the influence of fine sediments adhering to the egg's membrane by comparing the survival of eggs planted and intragravel turbidity levels in mid-December to those in early November. Intragravel measurements of D.O. concentration, water temperature, apparent velocity, and turbidity will be monitored at each artificial redd at 10-day intervals during the 100-day incubation and alevin development period. These data will be used to develop a model to estimate egg survival to emergence based on measurements of intragravel conditions alone. Apparent velocity will be measured with a KVA Model 40L Geoflo Groundwater Flowmeter inserted into slotted well pipe buried in each artificial redd (CMC 2001c). The flowmeter produces a heat pulse of about 500 degrees Fahrenheit and uses four pairs of opposed thermistors that surround the heat source to determine the magnitude and direction of flow. Bed permeability will be measured at a depth of 12 inches adjacent to the incubation chamber immediately after planting the eggs and immediately prior to excavating the chamber approximately 110 days later. A chamber to collect emerging fry will not be attached until just prior to emergence to minimize the potential for vandalism, which can be a problem because the Stanislaus River is used by numerous recreational boaters during the incubation period. Alevins that successfully emerge will be sedated, measured to the nearest millimeter, quickly blotted dry and then weighed to the nearest 0.01 grams. Approximately 110-days after planting, the incubation chambers will be retrieved and the number and condition of entombed alevins and dead eggs will be evaluated. Survival rates of the test eggs will also be monitored at the hatchery. The sediment size distribution will be determined for dried substrate samples collected from layers where dead eggs and entombed alevins occur in the incubation baskets. It is recommended that this study should be conducted for three years to ensure that an adequate number of replicates will be collected to determine survival to emergence rates relative to gravel size, redd superimposition, and turbid storm runoff. The number and size of emerging alevins will be compared between sites differing in gravel size, redd superimposition, and turbidity using standard ANOVA methods. Conducting the study over three years will also permit modifications of the incubation chamber and study design if necessary.

A second method will be used to test Hypothesis 5 that focuses on the effect of redd superimposition on the entombment of alevins in natural salmon redds. Restoration gravel is typically cleaned with a 1/4-inch or larger screen such that most of the 3-7 mm diameter sand that affects entombment rates has been eliminated from the restoration gravel (CMC 2001b). Therefore, it is likely that entombment rates should be lower at the restoration sites than in the control sites. Although the incubation chamber studies described above will evaluate the effects of redd superimposition, construction of artificial redds may not create a natural sand barrier within the redd or its effects on entombment. As an index of the number of entombed alevins observed in natural salmon redds, salmon redds constructed by similarly sized females will be excavated to count the number of entombed alevins. The precise location of all redds will be determined with a total station and the size of females constructing the redds will be measured to the nearest millimeter at three riffles with gravel washed with a 1/4-inch screen, three riffles with gravel washed with a 3/8-inch screen and at three control riffles. Approximately 120 days after redd construction, 15 superimposed and 15 non-superimposed redds will be excavated in each gravel type with a hand-held shovel. Redds will be selected that are constructed by similarly-sized females to minimize differences in fecundity and at nearby sites to minimize differences in egg losses due to predators or high velocities that can sweep eggs away during spawning. Alevins and eggs will be collected in large dip nets with

1/8-inch mesh held immediately downstream from the redd. Dead alevins and eggs will be covered in white fungus making them easy to observe and collect. The number of dead alevins and eggs will be compared between the gravel types and between superimposed and non-superimposed redds using two-sample *t*-tests.

Hypothesis 6. Riffles constructed in widened, mined channels will have a longer useful life than will riffles constructed in narrow unmined channels.

Streambed elevations will be measured relative to monuments established in summer 1999 at the 18 project riffles with a total station. Measurements will be made at each site along a single transect established in November 1998 or September 1999, a 15- to 20-foot grid pattern, and at major changes in grade along the streambank and channel bottom. The elevation data will be collected as X, Y, Z coordinates that are stored electronically within the total station and then downloaded to a laptop computer. The data will then be converted into AutoCAD DXF format files. The DXF files will then be imported into a software program called Terrain Version 3.1 developed by Softree Technical Systems to generate the contour maps in one-foot intervals. Changes in bed elevation will be assessed using both the transect data and the contour map.

It is recommended that these studies should be conducted for three years to ensure that an adequate number of replicates has been collected and that a range of escapement, streamflow, and turbid storm runoff have been evaluated.

#### **4. Feasibility**

All study elements, except for planting eggs in incubation chambers, have been successfully implemented by CMC for the initial KFGRP environmental studies. Although egg planting studies can suffer from high failure rates, CMC will follow the techniques used by other researchers who conducted successful studies. To avoid the problems encountered by other studies, CMC will plant eggs within 24 hours of water-hardening and use large incubation chambers to minimize the possibility of eggs contacting the chamber's wire mesh.

CMC has attached signed agreements with the landowners granting access to all study sites.

#### **5. Performance Measures**

The objective of this project is to obtain sufficient field data to evaluate the six hypotheses described above. The following describes the Performance Measures, Metrics, Targets and Baseline for this objective.

Performance Measures: Environmental Indicators will include estimates of spawner use relative to the source and size of gravel, measures of the quality of salmonid egg incubation habitat, chinook salmon egg survival to emergence, and the development of a model suitable for estimating chinook salmon egg survival relative to measurements of intragravel conditions. Specific program actions will be measured according to the production of the deliverables.

Metrics: Environmental Indicators to assess spawner use will include redds/yard<sup>2</sup> at restored and control riffle habitats. The quality of salmonid egg incubation habitat will be measured in terms of intragravel dissolved oxygen concentration and bed permeability in undisturbed gravel and chinook salmon redds, and apparent velocity and turbidity will also be measured in artificial redds. Chinook salmon egg survival will be measured as (1) a percentage of planted eggs that survive to emergence in incubation chambers and (2) an index based on the number of entombed alevins and dead eggs in natural salmon redds. Program actions will be measured in terms of reports and manuscripts produced.



Targets: The metrics for the Environmental Indicators will be that sufficient data are collected to detect true differences with the tests for each of the six hypotheses and that a model can be developed to accurately estimate chinook salmon egg survival to emergence based on habitat measurements.

Baseline: Spawning habitat studies in the Stanislaus River conducted by CMC from fall 1994 to fall 1997 (Mesick 2001a) and for the KFGRP environmental studies from fall 1998 to fall 2000 provide baseline data for this project.

## **6. Data Handling and Storage**

Field data will be entered onto standardized forms that provide specific spaces for the data required for each task. Field supervisors will confirm that all data have been accurately recorded before leaving the study sites by initialing each form. Data collected electronically, such as with a total station, will be stored on hard media, such as a CD. All data analysis will be conducted using standard software programs, such as *Corel Quattro Pro*. Copies of all raw data files, map files, and final analysis files will be submitted to CALFED or CVPIA, if requested.

## **7. Expected Products/Outcomes**

Draft and final reports will be submitted for the Task 2 Fall 2002 Studies, Task 3 Fall 2003 Studies, and Task 4 Fall 2004 Studies. For Task 5, a manuscript describing all three years of study will be submitted to CALFED or the CVPIA and a peer-reviewed journal for publication. If requested by CALFED or CVPIA, oral presentations will be made at annual review meetings.

## **8. Work Schedule**

Assuming that the project is recommended for funding, a contract could be executed by September 2002. Task 1 Project Management would begin immediately and continue throughout the life of this project. Task 2 Fall 2002 Studies would begin as soon as the contract is executed and it would be completed by August 2003, when the final report will be submitted. Task 3 Fall 2003 Studies would begin in October 2003 and it would be completed by August 2004, when the final report will be submitted. Task 4 Fall 2004 Studies would begin in October 2004 and it would be completed by August 2005, when the final report will be submitted. Task 5 Manuscript Preparation would begin in summer 2005 and it would be completed by August 2005.

## **B. Applicability to CALFED ERP and Science Program Goals and Implementation Plan and CVPIA Priorities.**

### **1. ERP, Science Program and CVPIA Priorities**

This project will help achieve the CALFED ERP, Science Program, and Anadromous Fish Restoration Program goals to improve our understanding of at-risk species, such as fall-run chinook salmon, in the San Joaquin region and to conduct adaptive management experiments. The KFGRP had a positive effect on adult reproduction, egg survival, and juvenile rearing for fall-run chinook salmon and possibly steelhead trout as well. This project, which would continue the KFGRP environmental studies, should provide important information needed for the management of these species.

Another priority of the CALFED Science Program is to advance the understanding of ecosystem processes. This project will improve our understanding of the long-term benefits of restoring riffle habitat in mined channels.

This project's targets will contribute to achieving the CVPIA Section 3406(b) goal of doubling the natural production of anadromous fish in the Central Valley over levels that existed between 1967-1991 as well as the goal to restore and replenish, as needed, spawning gravels on the upper Sacramento, American, and Stanislaus rivers [relative to Section 3406(b)(13)]. The US Fish and Wildlife Service has identified the lack of and accessibility to quality stream channel and riparian habitat, as well as spawning gravel availability and suitability as limiting factors for anadromous fish.

## **2. Relationship to Other Ecosystem Restoration Projects.**

CMC, with assistance from McBain and Trush, Smith and Walser Enterprises, and other subcontractors, will begin implementing a large-scale restoration project on the Stanislaus River in fall 2001 that will investigate the importance of restoring functional floodplain habitat adjacent to restored riffle habitat. The Anadromous Fish Restoration Program will fund work at Two-Mile Bar where both the floodplain and riffle habitat will be restored. The Four-Pumps Mitigation Agreement will fund work at Lovers Leap where riffle habitat will be restored but the floodplain will remain heavily encroached with riparian vegetation and constricted by dikes. CMC and Smith and Walser Enterprises will design the riffles to benefit both fall-run chinook salmon and steelhead trout. They will also conduct studies to evaluate the hypothesis that steelhead trout require cover and feeding stations adjacent to their spawning habitat. McBain and Trush will conduct fluvial geomorphic studies to evaluate the effect of a functional floodplain on sediment transport at the restored riffles.

CMC is submitting a proposal titled the Frymire Ranch Project to CALFED in October 2001 that will increase the scope of the above project. By increasing the number of restoration sites, the environmental studies will be strengthened by increasing the number of replicates and it is hoped that it will be possible to detect a population response in terms of increased smolt production and increased escapement.

CMC and Smith and Walser Enterprises are partnering with the Friends of the Tuolumne River to submit a proposal to CALFED in October 2001 to restore spawning habitat for steelhead trout adjacent to Bobcat Flat on the Tuolumne River. McBain and Trush would be restoring the floodplain habitat at Bobcat Flat. If funded, the environmental studies for this project would be integrated with CMC's projects on the Stanislaus River to increase our understanding of the importance of floodplain habitat and flow regimes to salmonid populations.

S.P. Cramer and Associates, California Department of Fish and Game, Fisheries Foundation, CMC, and Smith and Walser Enterprises will submit a proposal to CALFED in October 2001 to study the impact of predation on salmonid production in the Stanislaus River. The restoration of riffle habitat in dredged channels for the KFGRP has reduced the abundance of predators based on reports from professional fishing guides (Walser and Smith, personal communication, see "Notes"). This proposed project would demonstrate the effect of restoring riffle habitat on predation rates and identify the most important predators and their habitat.

The U.S. Fish and Wildlife Service has contracted with the Fisheries Foundation to survey juvenile and adult salmonid habitat use in the Stanislaus River in 2000 and 2001. This study indicated that numerous juvenile chinook salmon and juvenile rainbow/steelhead trout were utilizing the KFGRP riffles constructed in summer 1999 whereas few juveniles were observed in the channels mined for gravel. It is anticipated that this study will continue.

CALFED funded CMC to implement the Knights Ferry Gravel Replenishment Project that added 13,000 tons of gravel at 18 sites between Two-Mile-Bar and the city of Oakdale in summer 1999. This project tested the source, size and placement of gravel for spawning habitat. The results of the KFGRP were used to design this project.

The Commercial Fishermen Salmon Stamp Program funded the Stanislaus Fly Fishermen and the Department of Fish and Game to add 1,000 to 2,000 tons of gravel each year to three sites in the Stanislaus River approximately one mile downstream from Goodwin Dam in 1996 and 1997. The CVPIA Section 3406(b)(13) program provided funds to add more gravel to one site in 2000.

The Four-Pumps Mitigation Agreement funded the construction of three riffles as spawning habitat for chinook salmon in the Stanislaus River at River Miles 47.4, 50.4 and 50.9 in 1994. These riffles were poorly used by spawning salmon and most of the gravel was quickly eroded away partially due to the boulder weirs constructed at the site boundaries. The weirs were intended to stabilize the gravel, but instead increased turbulence and bed shear stress.

### **3. Requests for Next-Phase Funding**

This proposal is requesting next-phase funding for the Knights Ferry Gravel Replenishment Project, #97-N21, to continue the environmental studies. All tasks for the KFGRP should be completed by December 2001. A detailed summary of the KFGRP is provided as an attachment to this proposal.

### **4. Previous Recipients of CALFED Program or CVPIA funding.**

CMC received funding from CALFED for the Knights Ferry Gravel Replenishment Project, #97-N21, which added 13,000 tons of clean gravel to 18 sites on the Stanislaus River from Two-Mile Bar to the city of Oakdale in August 1999.

CMC has contracted with the AFRP, USFWS Agreement Number 11332-J003, for the project titled "Spawning Habitat and Floodplain Restoration in the Stanislaus River, Phase 1, Two-Mile Bar. Work is expected to begin in winter 2001.

CMC's project, "Spawning Habitat and Floodplain Restoration in the Stanislaus River, Phase 1, Lovers Leap, has been recommended for funding from the Four-Pumps Mitigation Agreement. The contract is expected to be executed by March 2002.

### **5. System-Wide Ecosystem Benefits**

The increased awareness of the importance of fluvial geomorphic processes to ecosystem health and sustainability and the damage caused by instream gravel mining, both speak to the need for this project. The primary ecological objective of this project is to restore gravel and rebuild riffles in spawning reaches of the Stanislaus River, where instream gravel mining has reduced the quantity and quality of habitat for fall-run chinook salmon and steelhead/rainbow trout. This project will improve our understanding of how best to restore severely damaged habitat in a river that has highly regulated streamflows. Other projects that employ different designs to restore spawning and rearing habitat for salmon and trout are underway in the Tuolumne, Merced and other Central Valley rivers, and the results of this project should be applicable to all gravel augmentation projects in the Central Valley.

### **C. Qualifications**

**Carl Mesick Consultants**, which was founded in 1992, will implement this project. Dr. Carl Mesick will manage this project and directly supervise all field work. He received his Ph.D. in fisheries science from the University of Arizona in 1984. He has twenty years of experience as a fisheries scientist evaluating the effects of water diversions, hydroelectric operations, stream restoration projects, timber harvest, and mine operations on trout, salmon, non-game species of fish, and invertebrates. Dr. Mesick's expertise includes stream habitat restoration and studies of

instream flow, water temperature, riparian vegetation, sedimentation, entrainment at diversion intakes, food availability, fish passage, fish habitat preference, fish population monitoring, and stream habitat classification. He has studied the spawning habitat of fall-run chinook salmon on the Stanislaus River since 1994. Dr. Mesick manages and supervises all phases of the Knights Ferry Gravel Replenishment Project funded by CALFED, including project design, environmental compliance and permitting, construction supervision, and the monitoring of salmonid spawning habitat. He has managed other large, multi year projects for the City of Los Angeles Department of Water and Power, Southern California Edison, and the Electric Power Research Institute. Dr. Mesick recently worked as a Habitat Restoration Coordinator for the U.S. Fish and Wildlife Service's Anadromous Fish Restoration Program.

## **D. Cost**

### **1. Budget.**

The estimated cost for Task 1 Project Management is \$11,215, Task 2 Fall 2002 Studies is \$134,514, Task 3 Fall 2003 Studies is \$129,015, Task 4 Fall 2004 Studies is \$129,597, and Task 5 Manuscript Preparation is \$7,800. The total project cost is \$412,141. If only a portion of this project were to be funded, Tasks 1 and 2 could be funded separately for \$145,729 or in combination with any of the other tasks.

### **2. Cost-Sharing**

No funds have been allocated to provide cost-share for this project.

## **E. Local Involvement**

A summary of this proposal was distributed to the Stanislaus Fish Group, which consists of agency and consulting biologists active on the Stanislaus River, for their review and comment. Dr. Mesick lead a two-hour discussion of limiting factors for salmonids in the Stanislaus River with the Stanislaus Fish Group on 21 August 2001 that included the impacts of instream mining. CMC will distribute all draft and final task reports to the Stanislaus Fish Group for comment. Public outreach will be achieved by reporting study results to the Oakdale Leader, the local newspaper, and The Record, a newspaper for the City of Stockton. CMC also works closely with the local representatives of California Trout and biology teachers at the local community college.

## **F. Compliance with Standard Terms and Conditions.**

CMC will comply with all state and federal terms.

## **G. Literature Cited**

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## ATTACHMENT 1

### SUMMARY OF THE KNIGHTS FERRY GRAVEL REPLENISHMENT PROJECT

The National Fish and Wildlife Foundation executed a contract with Carl Mesick Consultants to implement the Knights Ferry Gravel Replenishment Project (KFGRP) on 30 September 1998. By 31 March 1999, applications were submitted for all environmental permits and by 15 August 1999, copies of all the permits were submitted to NFWF and CALFED. Construction began on 4 August 1999 and was completed by 24 September 1999. A total of 13,000 tons of gravel was placed at 18 project sites in the Stanislaus River between Goodwin Dam and Oakdale: Six sites received a total of 4,490 tons of Stanislaus River rock 1/4 to 5 inches in diameter; another six sites received a total of 5,570 tons of Stanislaus River rock 3/8 to 5 inches in diameter; and six other sites received a total of 2,940 tons of Tuolumne River rock 3/8 to 5 inches in diameter. The total cost of the project will be approximately \$659,882. CALFED provided \$561,407, the Stockton East Water District provided approximately \$90,000, and Carl Mesick Consultants donated approximately \$8,475 in labor and expenses for project management.

The KFGRP environmental studies were divided into three tasks:

- Task 3, Pre-Project Habitat Evaluations, which documented baseline conditions at the 18 project sites and 7 control sites in fall 1998 and summer 1999;
- Task 5, Initial Post-Project Habitat Evaluations, which documented spawning and incubation conditions in fall 1999; and
- Task 6, Second Year Post-Project Habitat Evaluations, which documented spawning and incubation conditions in fall 2000.

The Task 3 studies produced contour maps of all study sites showing the pre-project streambed elevation in August 1999 and the location of where fall-run chinook salmon spawned in fall 1998. The density of salmon redds was significantly correlated with the distance downstream from Goodwin Dam, the barrier to upstream migration. To compare redd densities between control and project sites, two-tailed *F*-tests were used to compare the residual variances, slope, and elevations of the regressions between redd density and distance downstream. The *F*-tests indicated that there were no significant differences in redd density between the control sites and the unmined portions of the project sites. Although the redd densities at the mined portions of the projects sites were substantially lower than those at the control sites, it was not possible to conduct statistical tests because the densities at the mined sites were not correlated with distance downstream.

The Task 3 studies also indicate that conditions for the survival of salmonid eggs were quite poor. The percentage of particles finer than 1 mm in 50 subsurface substrate samples averaged 11.3% and ranged from 0.23% to 35.8%. The mean permeability of 123 measurements in undisturbed gravel was 3,129 cm/hr. The mean intragravel dissolved oxygen concentration at 77 standpipe sites was 9.5 ppm and 18% of the measurements were below 8 ppm, which may be low enough to result in high rates of egg mortality. Dissolved oxygen concentrations below 11 ppm, which occurred at 70% of the standpipe sites in fall 1998, probably result in the production of small, weak alevins that were unlikely to survive (Chapman 1988). The fall 1998 measurements of intragravel dissolved oxygen were made prior to turbid storm runoff, which is typically correlated with substantial declines in dissolved oxygen (Mesick 2001a). It was not possible to collect samples after the rain storms began due to increased flows for flood control.

The Task 5 initial post-project studies indicated that the source of gravel for restoring riffles significantly affected fall-run chinook salmon spawner use and that intragravel dissolved oxygen concentrations and permeabilities were significantly higher in artificial and natural redds in the restored riffles than in control riffles. The density of salmon redds was significantly greater ( $P =$



0.073) at the sites with Stanislaus River gravel than at sites with similarly-sized Tuolumne River gravel in fall 1999. Although redd densities were about 29% higher where the gravel was cleaned with a 1/4-inch screen than at sites where the gravel was cleaned with a 3/8-inch screen, the difference was not significant ( $P \geq 0.370$ ). The results also suggest that chinook salmon are equally likely to spawn at restoration riffles created by adding gravel to extensively mined channels, naturally flat channels, or the natural tails of pools.

Bed permeabilities at the project riffles declined at most sites following turbid storm runoff in January and February 2000. After a controlled pulse flow for smolt outmigration in spring 2000, permeabilities increased at most sites although very little bed mobilization occurred, but decreased at the upstream half of riffles in a recently mined reach near Lovers Leap. The Lovers Leap reach contains a large volume of fine sediment stored on the streambed and presumably, the addition of gravel triggered the movement of the fines into the riffles. Thermographs buried in artificial redds showed that intragravel water temperatures began to deviate from surface temperatures when the pulse flow and presumably fine sediment intrusion began. Deviations between intragravel and surface water temperatures were correlated with declines in intragravel dissolved oxygen concentrations below 8 ppm, which are probably lethal to incubating eggs.

The Task 6 studies, which were conducted in fall 2000, indicate that the restoration gravel “seasoned” after one year in that chinook salmon redd densities increased in all three types of restoration gravel relative to the redd densities at the control sites when compared to the fall 1999 results. In addition, intragravel dissolved oxygen concentrations and permeabilities remained high in artificial and natural redds in the restored riffles compared to samples collected in control riffles during fall 2000. Apparent velocity was measured with a KVA Model 40L Geoflo Groundwater Flowmeter in slotted wells buried in artificial redds. Apparent velocity declined from an average of 7.2 feet/hour at newly constructed redds to 0.9 feet/hour immediately after a pulse flow that was intended to attract spawners. There were no significant differences in apparent velocity between project riffles and control riffles or at superimposed and non-superimposed redds following the pulse flow. During future studies, the artificial redds will be constructed after the pulse flow to better simulate the conditions at most of the natural redds.

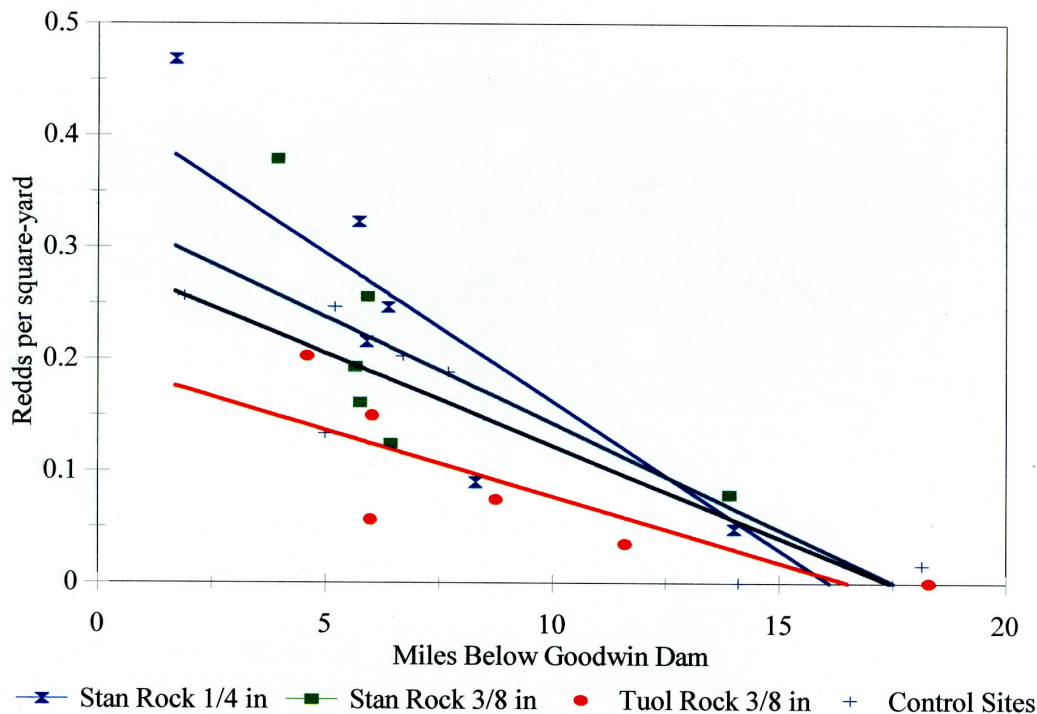
A final report for the Task 3 studies and a draft report for the Task 5 studies are available at the CALFED web site. A draft report for the Task 6 studies is approximately 60% completed and it should be distributed for review by late-November 2001.

Dr. Mesick gave two presentations on the results of the KFGRP environmental studies. One, which was titled “Spawning habitat restoration in the Stanislaus River” was presented at the CALFED Science Conference 2000 in Sacramento on 3 October 2000. The other, which was titled “Egg incubation conditions in restored riffles in the Stanislaus River”, was presented at the American Fisheries Society Annual Meeting in Santa Rosa on 31 March 2001.

Independent observations by professional fishing guides and other fishery biologists indicate that the KFGRP riffles provide excellent habitat for adult steelhead trout and juvenile chinook salmon and rainbow/steelhead trout. Mr. Steve Walser and Mr. Tim Smith, who are professional fishing guides, report that angling for steelhead trout has greatly improved at the KFGRP sites where surface turbulence and deep water provide cover and feeding habitat (Walser and Smith, personal communication). Trevor Kennedy with the Fisheries Foundation, and Tom Cannon, Senior Biologist with HDR Engineering, snorkeled some of the KFGRP sites and report that numerous juvenile salmon and trout utilize the KFGRP riffles, whereas few use the nearby mined channels.

This project should be completed by December 2001.

Fall 1999



Fall 2000

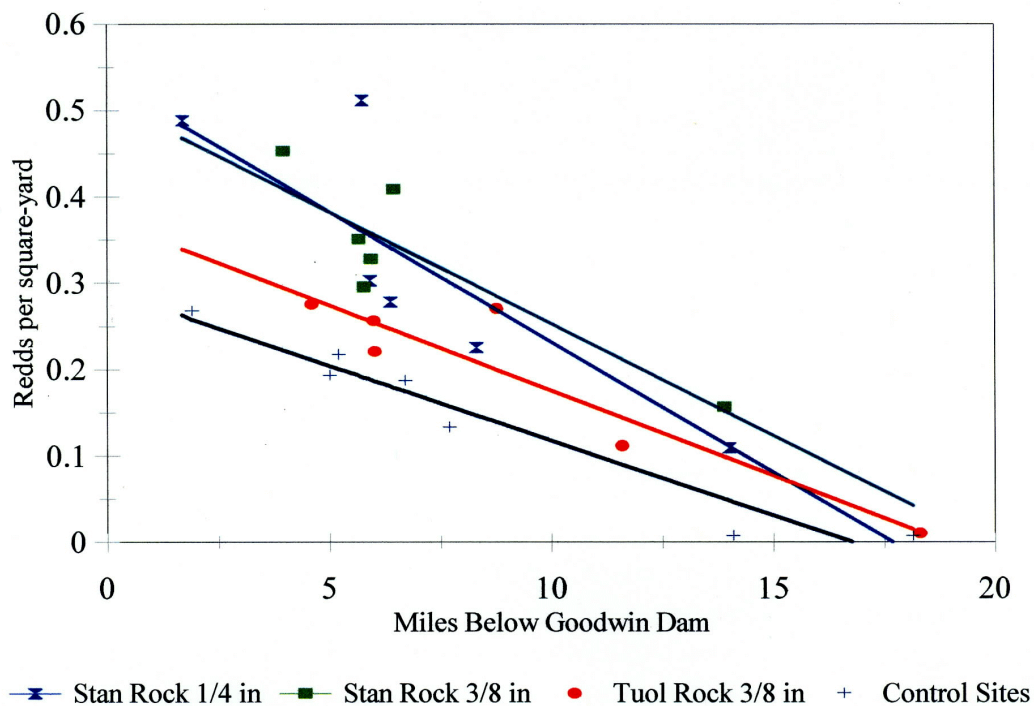


Figure 1. Chinook salmon redd densities at project sites that received three different mixtures of gravel: (1) Stanislaus River rock cleaned with a 1/4-inch screen, (2) Stanislaus River rock cleaned with a 3/8-inch screen, and (3) Tuolumne River rock cleaned with a 3/8-inch screen and the control sites relative to the distance below Goodwin Dam in the Stanislaus River in fall 1999 (upper graph) and fall 2000 (lower graph). Regression models are shown as lines.

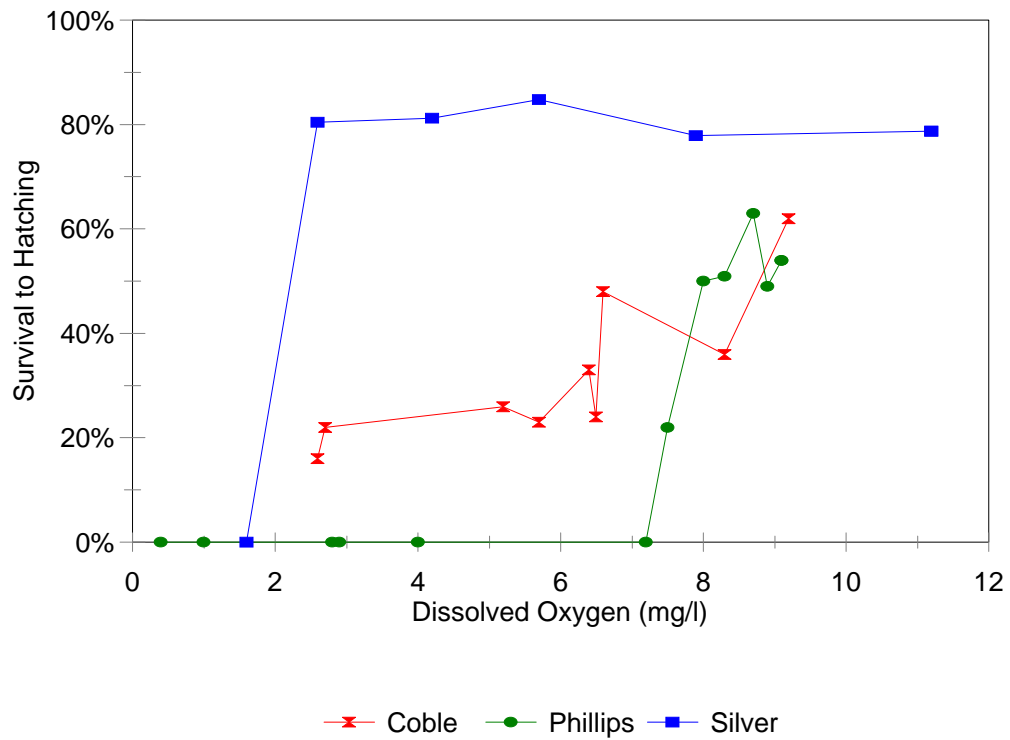
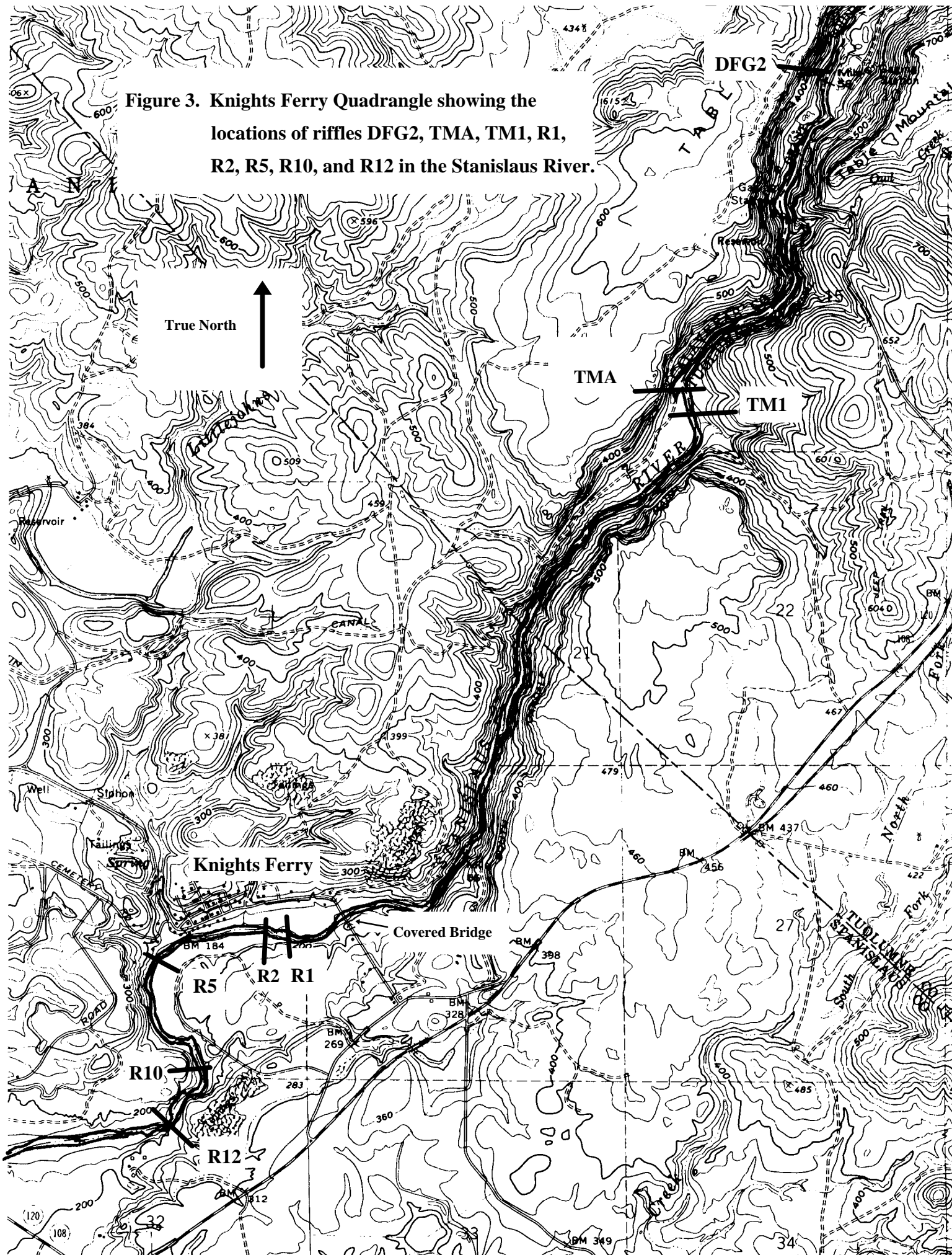


Figure 2. The relationship between dissolved oxygen concentration and the survival to hatching of steelhead trout eggs during a laboratory study by Silver, Warren, and Doudoroff (1963) and two field studies, one by Coble (1961) and the other by Phillips and Campbell (1962).

**Figure 3. Knights Ferry Quadrangle showing the locations of riffles DFG2, TMA, TM1, R1, R2, R5, R10, and R12 in the Stanislaus River.**



**Figure 4. Knights Ferry Quadrangle showing the locations of riffles R11, R12, R12A, R12B, R13, R14, R14A, R15, R16, R19, R19A, R26, and R27 in the Stanislaus River.**

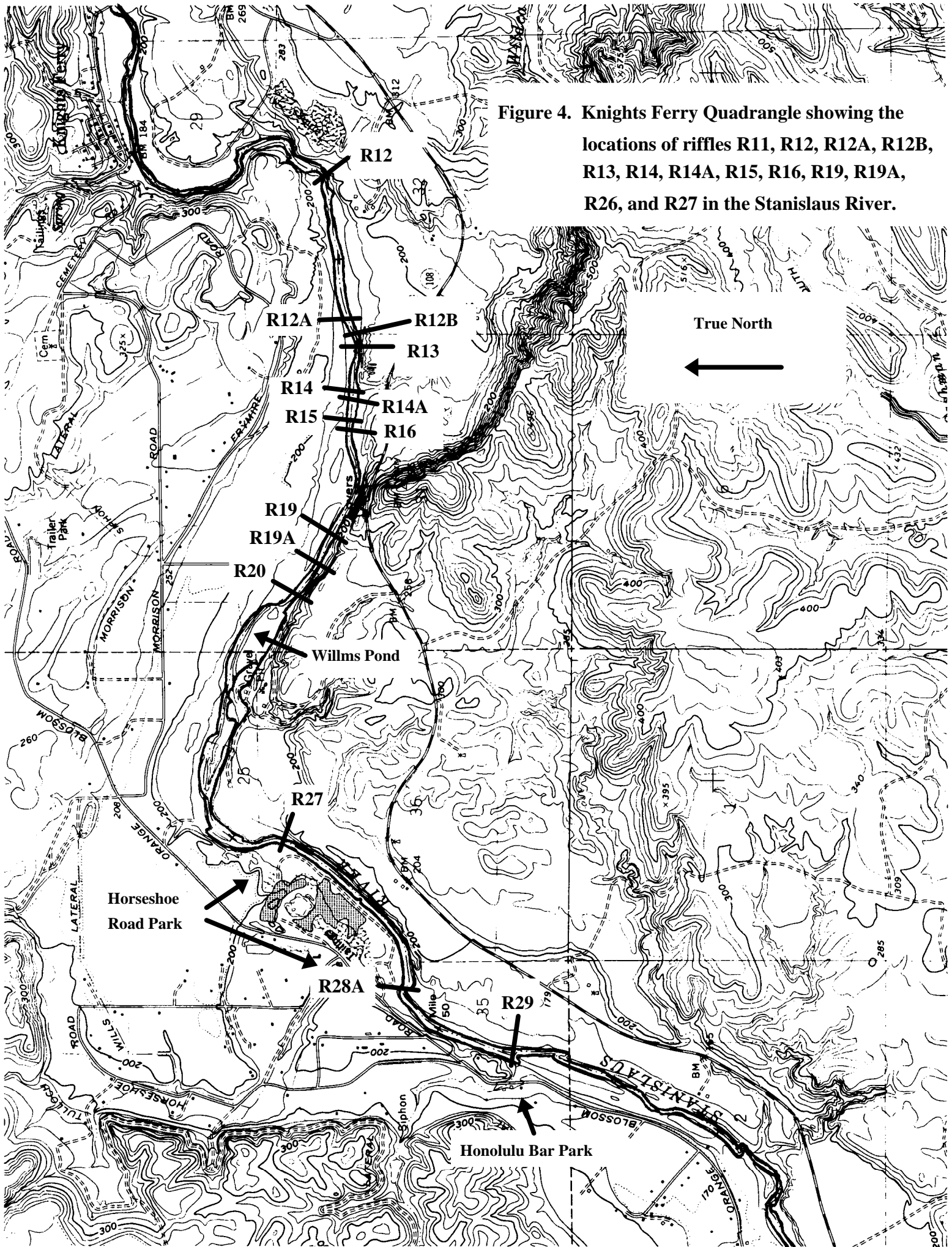


Figure 5. Oakdale Quadrangle showing the locations of riffles R43, R44, R57, R58, and R59 in the Stanislaus River.

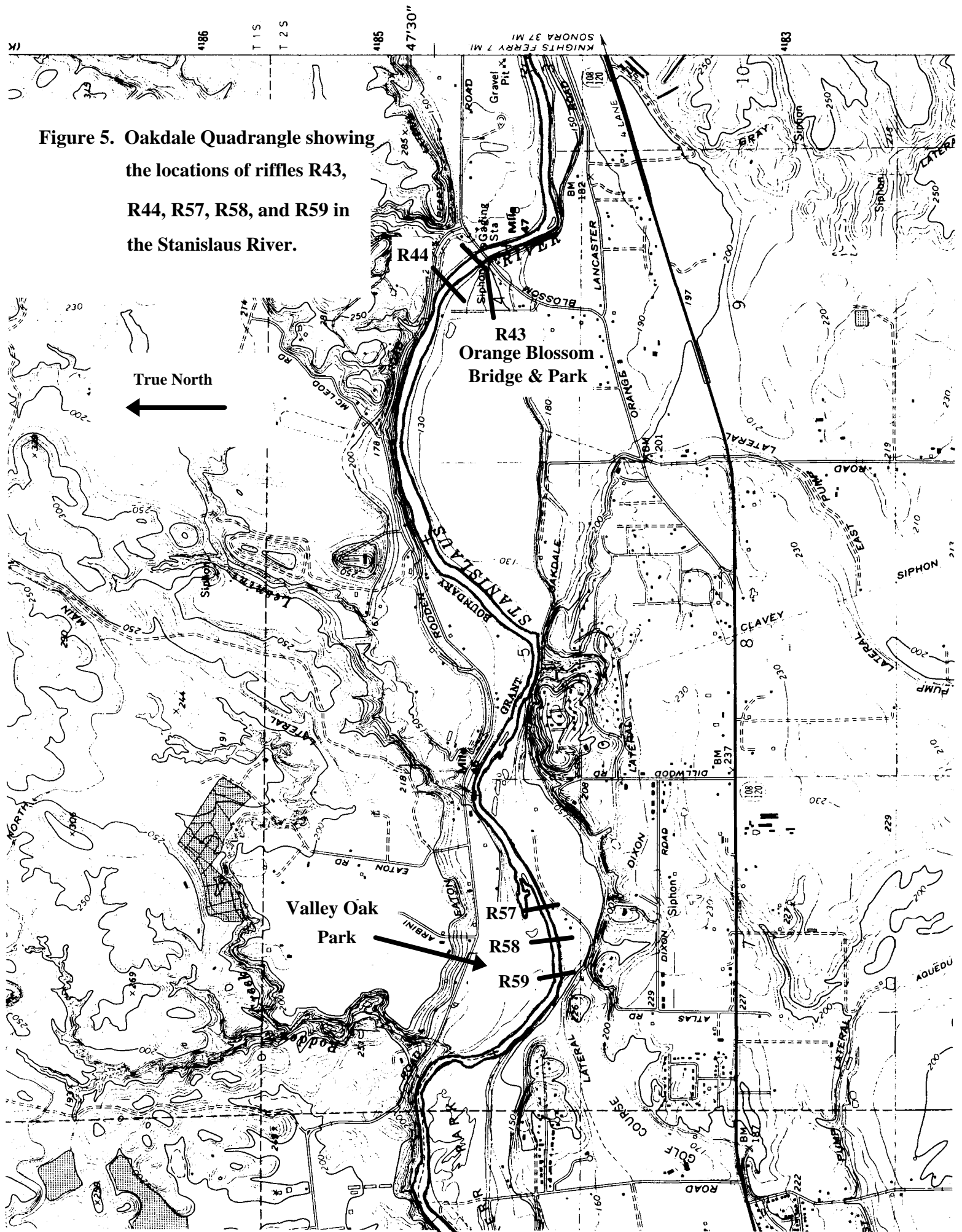
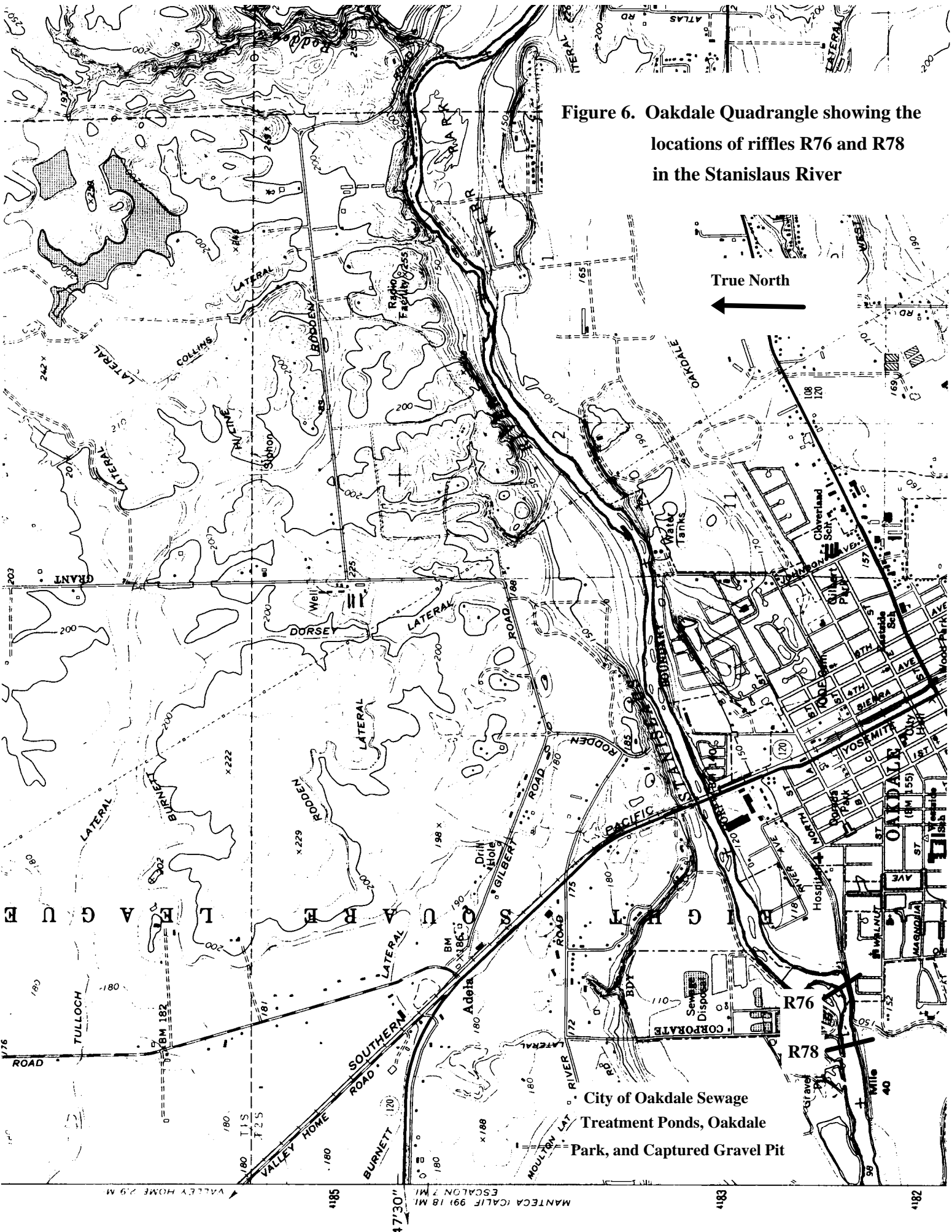




Figure 6. Oakdale Quadrangle showing the locations of riffles R76 and R78 in the Stanislaus River



## Permission Agreements for Access



# CARL MESICK CONSULTANTS

## FISHERY RESOURCE ASSESSMENTS

7981 Crystal Boulevard • El Dorado, CA 95623

Phone/Fax: (530) 620-3631

Email: cmcfish@innercite.com

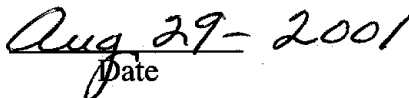
### Access and Gravel Purchase Agreement

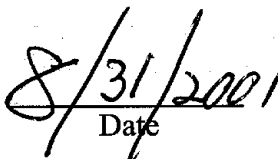
The purpose of this agreement is to notify the CALFED Bay Delta Program that Ms. Nancy Frymire is willing to sell a sufficient quantity of dredger tailings to Carl Mesick Consultants (CMC) or their agents from her property on the south side of Frymire Road to produce clean gravel for a fair market value for the purposes of river restoration. CMC and their agents will improve Ms. Frymire's lower pasture by grading the areas where the tailings were obtained. Ms. Frymire also agrees to provide CMC and their agents with access to her property for the purposes of designing the restoration work, processing the gravel, studying the fish, and monitoring the restoration work. The parties to this agreement agree as follows:

1. Ms. Frymire agrees to sell sufficient raw material from her property to produce about 3,750 cubic yards of clean gravel, sorted to the specifications of CMC, for the fair market value of \$1.56 per cubic yard of clean gravel. An advance payment of \$3,000 has been given to Ms. Frymire by CMC today toward the purchase of 1,875 cubic yards of clean gravel. It is anticipated that the remainder of the gravel will be purchased in 2003.
2. Ms. Frymire agrees to provide access to her property to CMC and their agents during 2003 (or possibly 2004) for the purpose of processing the dredger tailings into clean gravel and then placing it in the riverbed next to her property to help restore fish habitat. No live trees would be removed. Access will be provided by the existing gravel road from Frymire Road. The CMC and their contractor agree to grade and repair the access road. The contractor will include Ms. Frymire in their liability insurance coverage as protection from all claims and losses resulting from work conducted by the contractor. CMC and their agents agree to provide Ms. Frymire with 30 panels of wire stock panels.
3. CMC and their agents agree to grade the areas where dredger tailings are obtained to increase the size of the lower pasture and improve irrigation to it. CMC and their agents agree to plant the newly graded pasture with pasture mix.
4. Ms. Frymire agrees to provide access to her property to CMC and their agents from September 2002 through September 2006 for the purposes of studying the salmon and trout and monitoring the gravel placement in the river.
5. CMC agrees to notify Ms. Frymire in advance of accessing the project site, if requested by Ms. Frymire. Ms. Frymire agrees to notify CMC of any concerns arising under this agreement by contacting Carl Mesick at (530) 620-3631.
6. Any modifications, other than gravel processing and pasture improvement, to Ms. Frymire's property will be restored to the condition in which the property was found before the modifications took place.
7. This agreement may be amended or terminated only by written mutual consent of all parties.

  
Nancy Jane Frymire  
Property Owner

  
Carl Mesick  
Carl Mesick Consultants

  
Date

  
Date

# CARL MESICK CONSULTANTS FISHERY RESOURCE ASSESSMENTS

7981 Crystal Boulevard • El Dorado, CA 95623

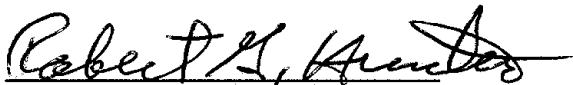
Phone/Fax: (530) 620-3631

Email: cmcfish@innercite.com

## Access and Gravel Purchase Agreement

The purpose of this agreement is to notify the CALFED Bay Delta Program that Mr. Bob Hunter is willing to sell either raw material or sorted, clean gravel to Carl Mesick Consultants or their agents from his property on the west side of Sonora Road for a fair market value for the purposes of river restoration. Mr. Hunter also agrees to provide Carl Mesick Consultants and their agents with access to his property for the purposes of monitoring the restoration work and conducting fisheries studies. The parties to this agreement agree as follows:

1. Mr. Hunter agrees to sell either raw or processed gravel from his property, AP 002-40-21, to produce about 950 cubic yards (1,500 tons) of clean gravel, sorted to the specifications of Carl Mesick Consultants, for a fair market value. The raw gravel will be obtained from exposed gravel tailings on Mr. Hunter's property. It is anticipated that the gravel will be purchased in 2003.
2. If Mr. Hunter sells Carl Mesick Consultants processed gravel, the gravel will be sorted with a 1/4-inch screen and 5-inch grizzly and washed to Carl Mesick Consultants specifications to produce a final product of with a median diameter of 0.8 inches (20 mm). Mr. Hunter will produce the gravel within four months after he has been given written notice from Carl Mesick Consultants.
3. If Mr. Hunter sells Carl Mesick Consultants raw gravel, Mr. Hunter agrees to provide access to his property to Carl Mesick Consultants and their agents for the purpose of processing the raw material into clean gravel. Access will be provided by the existing road from Kennedy Road through parcel AP 002-40-21.
4. Mr. Hunter agrees to provide access to his property to Carl Mesick Consultants and their agents to design the restoration work, place the processed gravel in the riverbed next to his property to restore fish habitat, and to monitor the gravel placement and study the benefits of the restoration work for salmon and trout. The gravel placement will probably occur for two weeks during summer 2003 whereas the design work and fisheries studies will occur between September 2002 and December 2006. Access will be provided by the existing road from Kennedy Road through parcel AP 002-40-21.
5. Carl Mesick Consultants agrees to notify Mr. Hunter in advance of accessing the project site, if requested by Mr. Hunter. Mr. Hunter agrees to notify Carl Mesick Consultants of any concerns arising under this agreement by contacting Carl Mesick at (530) 620-3631.
6. Any modifications, other than gravel processing, to Mr. Hunter's property will be restored to the condition in which the property was found before the modifications took place.
7. This agreement may be amended or terminated only by written mutual consent of all parties.



Bob Hunter

Property Owner

8/26/01  
Date



Carl Mesick

Carl Mesick Consultants

8/24/01  
Date

# CARL MESICK CONSULTANTS

## FISHERY RESOURCE ASSESSMENTS

7981 Crystal Boulevard • El Dorado, CA 95623


Phone/Fax: (530) 620-3631

Email: cmcfish@innercite.com

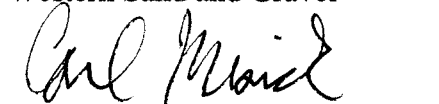
### Access and Gravel Purchase Agreement

The purpose of this agreement is to notify the CALFED Bay Delta Program that Western Sand and Gravel (WS&G) is willing to sell a sufficient quantity of raw material to Carl Mesick Consultants or their agents from their property on the south side of Frymire Road to produce clean gravel for a fair market value for the purposes of river restoration. WS&G also agrees to provide Carl Mesick Consultants and their agents with access to their property for the purposes of processing the gravel and monitoring the restoration work. The parties to this agreement agree as follows:

1. WS&G agrees to sell sufficient raw gravel from their property, AP 002-43-31 and AP 002-43-33, to produce about 6,554 cubic yards of clean gravel, sorted to the specifications of Carl Mesick Consultants, for \$5.00 per cubic yard of clean gravel minus a donation of \$3.44 per cubic yard to this project. WS&G's donation gives a net cost of \$1.56 per cubic yard of clean gravel. The raw gravel will be obtained from exposed gravels in the 8,000 cfs flood easement owned by the U.S. Army Corps of Engineers. The gravel will be purchased as soon as Carl Mesick Consultants is notified that CALFED has awarded Carl Mesick Consultants funding for this project, presumably in October 2000.
2. WS&G agrees to provide access to their property to Carl Mesick Consultants and their agents during 2001 and 2002 for the purpose of processing the raw material into clean gravel and then placing it in the riverbed next to their property to help restore fish habitat. Access will be provided by the existing gravel road from Frymire Road through parcel AP 002-43-33.
3. WS&G agrees to provide access to their property to Carl Mesick Consultants and their agents from January 2001 through January 2005 for the purpose of monitoring the effects of gravel placement in the river.
4. Carl Mesick Consultants agrees to notify WS&G in advance of accessing the project site, if requested by WS&G. WS&G agrees to notify Carl Mesick Consultants of any concerns arising under this agreement by contacting Carl Mesick at (530) 620-3631.
5. Any modifications, other than gravel processing, to WS&G's property will be restored to the condition in which the property was found before the modifications took place.
6. This agreement may be amended or terminated only by written mutual consent of all parties.

  
Gordon Crawford, President  
Western Sand and Gravel

5/10/00.  
Date

  
Carl Mesick  
Carl Mesick Consultants

5/10/00.  
Date



REPLY TO  
ATTENTION OF

**DEPARTMENT OF THE ARMY  
U.S. ARMY ENGINEER DISTRICT, SACRAMENTO  
CORPS OF ENGINEERS  
1325 J STREET  
SACRAMENTO, CALIFORNIA 95814-2922**

June 5, 2000

Management and Disposal Branch

SUBJECT: Stanislaus River Parks, California; License No. DACW05-3-00-579, Knights Ferry Gravel Replenishment Project

Mr. Carl Mesick  
d.b.a. Carl Mesick Consultants  
7981 Crystal Boulevard  
El Dorado, California 95623

Dear Mr. Mesick:

Enclosed for your records is a fully executed copy of License Number DACW05-3-00-579, which allows for your use of Government land at our Stanislaus River Parks in connection with the Knights Ferry Gravel Replenishment Project.

Should you have any questions concerning this agreement or the project, please contact Ms. Elizabeth Youn of my staff whose phone number is (916) 557-7013 or 6815.

Sincerely,

A handwritten signature in black ink, appearing to read "Ken Fox", is written over a circular stamp.

Ken Fox  
Chief, Management and Disposal Branch

Enclosure