Physical, geochemical and biological influence on spawning site selection and egg and alevin development by Fall run Chinook Salmon.

Project Information

1. **Proposal Title:**

   Physical, geochemical and biological influence on spawning site selection and egg and alevin development by Fall run Chinook Salmon.

2. **Proposal applicants:**

   Timothy Horner, California State University, Sacramento, Department of Geology
   John Williams, Consultant
   Kris Vyverberg, CA Dept. of Fish and Game
   Joseph Merz, EBMUD
   Dixon Roy, CSU Sacramento Chemistry Department

3. **Corresponding Contact Person:**

   Timothy Horner
   California State University, Sacramento
   Geology Department
   916 278-5635
   hornertc@csus.edu

4. **Project Keywords:**

   Anadromous salmonids
   Habitat Evaluation
   Water and Sediment Quality

5. **Type of project:**

   Research

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:**

   University

9. **Location - GIS coordinates:**

Latitude:	38.333
Longitude:	-121.167
Datum:	NAD27

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

This project will examine salmon spawning gravels on the lower reaches of the American, Cosumnes and Mokelumne rivers. The study area for the American River extends from Nimbus Dam (mile marker 23) downstream to Ancil Hoffman Park (mile marker 17). This six mile reach of the river receives approximately 90% of the spawning use on the American River (Vyverberg et al, 1997). In the Cosumnes Basin, the study area extends from the spillway 1.5 miles upstream from the highway 16 bridge (mile marker 34.2) downstream to mile marker 30. This 4.2 mile reach of the river has received high spawning use in historic time, and is the focus of scientific attention as downstream barriers are removed. On the Mokelumne River, the study area extends from Camanche Dam (mile marker) downstream eight miles to the intersection with highway 88. This area includes the majority of the prime spawning habitat on the Mokelumne River (Joe Merz, personal communication).

10. **Location - Ecozone:**

    9.2 Lower American River, 11.1 Cosumnes River, 11.2 Mokelumne River

11. **Location - County:**

    Calaveras, Sacramento

12. **Location - City:**

    Does your project fall within a city jurisdiction?

    Yes

    If yes, please list the city: Sacramento

13. **Location - Tribal Lands:**

    Does your project fall on or adjacent to tribal lands?

    No

14. **Location - Congressional District:**

    5

15. **Location:**

    California State Senate District Number: 5

California Assembly District Number: 10

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: 32%

       Total Requested Funds: $1,090,534

    b) Do you have cost share partners <u>already identified</u>?

       Yes

       If yes, list partners and amount contributed by each:

       California State University Sacramento $198,756

       California Department of Fish and Game $74,861

       EBMUD $34,518

    c) Do you have <u>potential</u> 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?**

    No

    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?

No

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)

Mark Bowen	**US Bureau of Reclamation**	**303-445-2222**	**mbowen@do.usbr.gov**
Erwin Van Nieuwenhuyse	**U.S. Bureau of Reclamation**	**916-978-5213**	**evannieuwenhuyse@mp.usbr.gov**
Leo Winternitz	**City of Sacramento-Metropolitan Water Planning**	**916-264-1998**	**lwinternitz@sacto.org**
Keith Whitener	**Nature Conservancy, Cosumnes River Preserve**	**916-683-1767**	**kwhitener@cosumnes.org**

21. **Comments:**

Environmental Compliance Checklist

<u>Physical, geochemical and biological influence on spawning site selection and egg and alevin development by Fall run Chinook Salmon.</u>

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.

      The majority of our work is "monitoring", and does not alter or affect the streambed in any permanent way. Our initial conversations with regulatory agencies indicate that we will not need permits or consultation for the work described on the American or Cosumnes rivers. If the project is funded we will communicate with U.S. Fish and Wildlife Service, National Marine Fisheries Service, the Army Corps of Engineers and California Dept. of Fish and Game, and will obtain any necessary permits. Work on the Mokelumne River will be performed in conjunction with gravel restoration projects permitted to EBMUD through 2002. The DFG 1600 permit for this project includes monitoring work, and our hyporheic mesocosms will be installed to monitor subsurface flow and growth of benthic fauna in recently restored areas. It is our understanding that this will not require additional permitting.

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

   <u>CEQA Lead Agency:</u>
   <u>NEPA Lead Agency (or co-lead:)</u>
   <u>NEPA Co-Lead Agency (if applicable):</u>

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

   CEQA
   -Categorical Exemption
   -Negative Declaration or Mitigated Negative Declaration
   -EIR
   Xnone

   NEPA
   -Categorical Exclusion
   -Environmental Assessment/FONSI
   -EIS
   Xnone

   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?

      Not Applicable

   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 Required, Obtained

   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

Rivers and Harbors Act

CWA 404

Other

PERMISSION TO ACCESS PROPERTY

Permission to access city, county or other local agency land. Agency Name: Sacramento Co.,	Required
Permission to access state land. Agency Name:	
Permission to access federal land. Agency Name:	
Permission to access private land. Landowner Name: Rancho Murieta, Bill Hutchison, Leyland Schneider	Required, Obtained

6. **Comments.**

Land Use Checklist

Physical, geochemical and biological influence on spawning site selection and egg and alevin development by Fall run Chinook Salmon.

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).

   This is a research project, and land use will not be affected by the actions described in the proposal.

4. **Comments.**

   This is a research project, and methods described in the proposal are designed to have low impact on the ecosystem. Work on the American and Cosumnes rivers will not involve gravel moving or any other notable physical, biological or geochemical disturbance to the stream system. Work on the Mokelumne River will be conducted as part of stream restoration work permitted to EBMUD, and installation of hyporheic mesocosms (large in-gravel flow tubes) described in this project will help EBMUD answer questions about gravel stability and evolution of the hyporheic ecosystem in their restoration project areas. It is our understanding that this restoration project is permitted through 2003, and additional permitting will not be required for this phase of the project.

Conflict of Interest Checklist

Physical, geochemical and biological influence on spawning site selection and egg and alevin development by Fall run Chinook Salmon.

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):

Timothy Horner, California State University, Sacramento, Department of Geology
John Williams, Consultant
Kris Vyverberg, CA Dept. of Fish and Game
Joseph Merz, EBMUD
Dixon Roy, CSU Sacramento Chemistry Department

Subcontractor(s):

Are specific subcontractors identified in this proposal? No

Helped with proposal development:

Are there persons who helped with proposal development?

No

Comments:

Budget Summary

Physical, geochemical and biological influence on spawning site selection and egg and alevin development by Fall run Chinook Salmon.

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.

Federal Funds

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	Select sites	255	6560	779	20	960				8319.0	2662	10981.00
2	Install instrument	1400	23828	4168	480	17525		12000		58001.0	12984	70985.00
3	Biological surveys, spawning survey	760	13050	1296	320	2400				17066.0	5461	22527.00
4	Egg experiments	1120	30000	1440	360	9500			1000	42300.0	7296	49596.00
5	Pore water	1460	28788	6391	244	5000			9000	49423.0	15815	65238.00
6	Egg baskets	480	13800	576	360	1000				15736.0	5356	21092.00
7	Field parameters, higher flows	320	6219	1270	480	1850				9819.0	2902	12721.00
8	Geochemical samples	1460	28788	6391	244	2800			9000	47223.0	15111	62334.00
9	Statisical analysis, modeling	240	11619	838		500				12957.0	3986	16943.00
10	Project management	480	21358	2513	4500	1000				29371.0	9239	38610.00
		7975	184010.00	25662.00	7008.00	42535.00	0.00	12000.00	19000.00	290215.00	80812.00	371027.00

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	Repair monitoring points	960	22732	2702	500	2000				27934.0	8939	36873.00
2	Measure field conditions	1160	31516	5157	860	1850				39383.0	12266	51649.00
3	Biological spawning survey	800	16244	1382	320	2400				20346.0	6511	26857.00
4	Egg viability	760	17326	1229	360	3000				21915.0	4745	26660.00
5	Pre-spawning water samples	1423	29157	6353	244	2800			9000	47554.0	15217	62771.00
6	Egg baskets	480	14568	614	360	1000				16542.0	5614	22156.00
7	Field parameters; higher flows	320	6590	1341	480	1850				10261.0	3044	13305.00
8	Pore water samples	1390	28133	6026	244	2800			9000	46203.0	14785	60988.00
9	Modeling	440	24008	880		500				25388.0	7964	33352.00
10	Project Management	360	15001	2640	4500	1000				23141.0	7245	30386.00
		8093	205275.00	28324.00	7868.00	19200.00	0.00	0.00	18000.00	278667.00	86330.00	364997.00

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	Repair monitoring points	840	15646	2702	500	1000				19848.0	6351	26199.00
2	Pre-spawning field conditions	1160	31516	5157	860	1850				39383.0	12266	51649.00
3	Biological/spawning Survey	800	16244	1382	320	2400				20346.0	6511	26857.00
4	Egg viability experiments	720	14964	1229	360	3000			1000	20553.0	4745	25298.00
5	Pore water samples	1423	29157	6353	244	2800			9000	47554.0	15217	62771.00
6	Egg baskets	480	14568	614	360	1000				16542.0	5614	22156.00
7	Measure field parameters	320	6590	1341	480	1850				10261.0	3044	13305.00
8	Pore water samples	1390	28133	6026	244	2800			9000	46203.0	14785	60988.00
9	Statistics and modeling	560	31094	880		500				32474.0	10232	42706.00
10	Project management	400	17251	2640	4500	1000				25391.0	7965	33356.00
		8093	205163.00	28324.00	7868.00	18200.00	0.00	0.00	19000.00	278555.00	86730.00	365285.00

Grand Total=1101309.00

Comments.

Budget Justification

Physical, geochemical and biological influence on spawning site selection and egg and alevin development by Fall run Chinook Salmon.

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

This project is designed so that two of the principal investigators and five graduate students will receive half time support for three years. Half time support is defined as 20 hours per week for 48 weeks per year, for a total of 960 hours per year. People with half time support will conduct extensive field work, manage the project or perform modeling tasks described in the proposal. Fewer hours of support are budgeted for principal investigators with smaller roles and for hourly undergraduate assistants. In-kind contributions from California Department of Fish and Game (DFG)and East Bay Municiple Utility District (EBMUD) are not counted in these totals. We expect approximately 10% in-kind contribution (192 hours per year) from Kris Vyverberg and a DFG technician, and 4% contribution (80 hours per year) from Joe Merz (EBMUD). Summaries of direct cost hours are given below: Horner: 960 hours per year x 3 years = 2880 hours total Williams: 960 hours per year x 3 years = 2880 hours total Dixon: 640 hours for first year, 533 hours for successive years = 1706 hours total 3 Geology grad. students: 960 hours per year x 3 years = 2880 hours each 2 Biology grad. students: 960 hours per year x 3 years = 2880 hours each Hourly undergraduate assistants: 640 hours per year x 3 years = 1920 hours total

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

Salary for the two principal investigators from CSUS (Horner, Dixon) is based on equivalent hourly wages at the University, and benefits are calculated separately (see next section). The independant consultant (Williams) is compensated at a higher hourly rate that includes his benefits and travel fees. Graduate students and undergraduate student assistants are paid at hourly rates that are comparable to current industry wages. Principal investigators and graduate students are budgeted a 5% cost of living increase per year. Year one rates of compensation are given below for each group of workers: Horner: $32.74 per hour Dixon: $29.53 per hour Williams: $56.25 per hour Geology and Biology grad. students: $15.00 per hour Hourly undergraduate assistants: $12.00 per hour

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

Benefits range from 32% for faculty to 12% for graduate students and student assistants. The independant consultant (Williams) will not receive benefits from the grant. Rates are summarized below: Horner: 32% Dixon: 32% Geology and Biology graduate students: 12% Hourly undergraduate assistants: 12%

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

Travel costs consist mainly of vehicle mileage fees ($0.20 per mile) charged when a university vehicle is driven to a field area. The request for travel costs to field areas does NOT include meals or other personal expenses. Each trip to a field area is estimated at 60 miles round trip, and most of the mileage will be accumulated by graduate students under the supervision of a principal investigator. The three principal investigators with the greatest time involvement in the project (Horner, Williams, Vyverberg) are also allowed $1500 per year for travel to professional meetings, where they will present results from the project. Total travel costs are estimated below: Vehicle use fee (mileage): ($2508 year 1) + ($3368 year 2) + (3368 year 3) = $9244 Travel to meetings and conferences: $13,500 total

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

This is a field-based project, and a significant portion of the budget is devoted to expendable field supplies. Expenses for each project task are listed below. Supplies and expendables from years two and three are grouped together because of similarities in tasks for these two years. Office supplies: $500 is budgeted for office supplies for task 9 (modeling and statistical analysis) and $1000 is budgeted for office supplies for task 10 (project management) for each of the three years. This will include copying costs, telephone bills, computer supplies (disks, printer cartridges and equipment), small software purchases, mailing expenses and basic office supplies. Laboratory supplies: Laboratory supplies will be used for geochemical analysis of pore water samples. Expendables from task 5 and task 8 total $2800 per sampling run, with an additional $2200 for ion chromatograph (IC) columns for the initial sampling run. Task 5 involves pre-spawning pore water assessment, and task 8 examines the geochemistry of pore waters during higher flow post-spawning events. Sample analysis will use the following expendables: Instrument standards: $750 per sampling run = $1500 per year. Sample bottles: $600 per sampling run = $1200 per year Glassware, brushes, expendables = $500 per year QA/QC samples: $900 per sampling run = $1800 per year Two new IC columns (first year only) = $2200 Lab coats, safety glasses etc. = $300 per year Biological sampling and characterization will also use laboratory supplies. Task 3 (biological/ecological surveys) and task 6 (monitor egg and alevin development) are budgeted a total of $3400 per year in supplies and expendables. Of this, approximately $2400 per year will be spent on field supplies and egg basket placement (see below). The remaining $1000 per year will be used for: Preservatives and sample containers = $300 per year Glassware, slides, reagents = $700 per year Computing supplies: Small computing supplies are listed under the office supply category (see above). The only significant computing supplies will be two laptop computer replacements in year two of the project. Two CSUS-owned laptops will be used to control electronic data loggers (permeability and temperature studies) and enter field data during the first years of the project. This is combat duty for a laptop computer, and the CSUS computers will be replaced approximately half way through the project at an estimated cost of $2000 each. This expense is pro-rated across tasks 2 and 7 (measure field parameters) for the three year project at a cost of $1300 per year. Field supplies: Field supplies account for the bulk of the supplies and expandable materials. Supplies for each task and year are outlined below: Task 1 year 1 (select sites) will require maps and air photos that total $960. Two sets of each will be procured so that biology and geology teams can operate independantly. Task 2 (year 1) will install stainless steel monitoring tips at different locations and depths on 3 different rivers. This will total 100 monitoring points per river. Cost estimates are: 300 stainless steel drive point tips @ $15 each = $4500 1900 ft teflon tubing @ $2.00 per foot = $3800 1 additional reflector (rod) for total station = $750 3 drive rod sets, with spare rods, slide hammer = $2700 Task 4 (egg experiments in hyporheic mesocosms) will require initial construction of the mesocosms (3 ft diameter flow tubes) on the Mokelumne river. A total of $9000 is allocated to this task in year 1, and will be used to construct and bury two flow tubes. Estimated costs are: Purchase plastic tubes = $4500 Plyscore = $300 Fittings (access ports) = $3000 Shipping fees (trucking) = $500 Hand tools = $600 Hardware (stainless steel), gaskets etc = $600 This gives a total estimated cost of $9500 for installation of the hyporheic mesocosms. Tasks 2 (years 2 and 3) and 7 (all years) are designed to measure field parameters using high-end field meters (pH, conductivity, DO, turbidity). These meters are owned by CSUS, and have expendable expenses that include: Replacement pH electrodes DO meter tips Occasionally meter or cable replacement (dropped, broken or wet) Rechargeable battery replacement Calibration fluids These expendables are estimated to cost $1200 per sampling task or $2400 per year. "Tid bit" brand temperature data loggers and additional thermocouple wire will also be purchased in year one as part of the field parameter characterization (tasks 2, 7). These data loggers cost approximately $65 each, and 15 will be purchased for each of the three rivers, for a total additional cost of $2925 for task 2 year 1. Tasks 3 (biological/ecological surveys) and 6 (install egg baskets) have $2400 per year allocated for expendable field supplies. This is in addition to the $1000 per year for laboratory supplies that is listed above. Details are as follows: Construct egg baskets = $1000 per year (DFG assisted) Dip nets, buckets, field sampling gear = $800 per year Waders, life vests, safety gear = $600 per year

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.

None

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.

$12,000 has been budgeted for purchase of a K-V Associates Model 40 heat pulse groundwater flow meter. This meter measures low velocity lateral water flow, and can be used in a perforated standpipe or well to measure lateral (horizontal) seepage through a gravel bar. This instrument was chosen based on advice from Carl Mesick, who has used the Model 40 for similar applications. Lateral flow through a gravel bar is extremely difficult to estimate, and this tool provides one of the few means for direct current velocity measurements in the subsurface. Lateral movement of hyporheic water can affect oxygen flushing or nutrient distributions near egg pockets, so this instrument provides critical information for the project.

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 presentatons, reponse to project specific questions and necessary costs directly associated with specific project oversight.

Project management (task 10) will be performed by Horner, Williams, Vyverberg and Merz. In-kind contributions from Vyverberg and Merz are not charged to the project, and will consist mainly of graduate student supervision. This will include field days and review of prelimary results. Horner and Williams will spend approximately 20% of their allocated time on project management. Duties will include compilation and presentation of results, graduate student supervision in the field, and review of graduate student products. Horner will conduct bi-weekly or weekly group planning meetings with graduate students, and will directly supervise the academic progress of the group. He will also hire hourly student assistants, administer the grant and be responsible for submission of progress reports.

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

A $9000 direct cost is charged for each major geochemical sampling event. Pore water samples will be collected at all sites twice per year: one time in the late Fall before salmon begin their fall run, and one time in the middle of the winter as fry emerge from the gravel. This will provide information about geochemical conditions that attract salmon to a site, and evolving geochemical conditions as eggs and alevin develop. Additional samples will be collected at closer intervals to study the relationship betwee egg development and pore water evolution in a few selected redds. Pore water samples will be analyzed in the Chemistry Department at CSUS under the supervision of Dr. Roy Dixon, and instrument use will be billed to the project at a heavily discounted per-sample cost. The total direct cost for geochemical analysis of pore waters is summarized below: Major elements (Na,K,Ca,Fe,Mg) by atomic absorption: (100 samples per river) x (3 rivers) x (2 sampling events per year) x (3 years) x ($15 per suite of major elements) = $27,000 Nutrients and anions (nitrate, nitrite, phosphate, sulfate, chloride) by ion chromatograph: (100 samples per river) x (3 rivers) x (2 sampling events per year) x (3 years) x ($15 per suite of nutrients and anions) = $27,000 Task 4 (egg viability and installation hyporheic flow tubes is budgeted $1000 in year 1 for any necessary permitting. This is a contingency, and based on our early discussons with regulators and existing permitting on the Mokelumne River, we do not expect to encur permitting costs. An additional $1000 is budgeted in year three to remove the hyporheic flow tubes from the river bed. This removal fee is based on an hourly backhoe operator's rate of $110 per hour and a subsequent disposal fee. If the flow tubes are performing up to expectations we may seek an extension on the permits to allow further (unfunded) experimentation.

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.

The California State University Sacramento Foundation has a Federally approved and negotiated Facilities and Administrative rate of 32% Modified Total Direct Costs which is applied to State and Federal proposal submissions.

Executive Summary

Physical, geochemical and biological influence on spawning site selection and egg and alevin development by Fall run Chinook Salmon.

Many past and anticipated restoration projects seek to improve the hyporheic habitat of streams, especially for spawning by salmonids. Despite a large literature, current understanding of spawning habitat does not provide effective guidance for restoration projects or management of salmon spawning habitat. In this study, academic, agency, and independent scientists with expertise in fisheries biology, geology, fluvial geomorphology, chemistry, and modeling will work together in a multi-agency, multi-disciplinary, three-year effort to develop this needed guidance. The project will combine field studies, field experiments, mesocosm experiments, and modeling to develop increased understanding of, and practical methods for assessing, the hyporheic environment in which salmonid embryos and larvae develop and grow. Previous work by project participants shows that hyporheic conditions affect spawning site selection and that biologically significant gradients in dissolved oxygen occur along hyporheic flowpaths through spawning bars. This project will expand on earlier work on the Mokelumne, Consumnes, and American rivers, and inform future restoration projects in northern California. Biological, geochemical, and physical factors will be examined through field observations and experimental work. Field studies will include detailed characterization of areas used and not used for spawning, and mapping or measurements of topography, substrate size, substrate permeability, hyporheic water velocity, pore water temperature, and redd locations. Field experiments will track the growth and condition of eggs and alevins in sites with contrasting hyporheic conditions. Major element, dissolved oxygen, and nutrient concentrations will be measured in hyporheic pore water to document evolving conditions in the subsurface, especially near egg baskets and natural redds. Hyporheic mesocosms that will allow similar work with greater experimental control will be constructed from 0.9 m diameter corrugated plastic pipe and operated at the Mokelumne River hatchery and restoration sites. Modeling the spawning behavior of female salmon will complement statistical analyses of the field and mesocosm data. Project results will include an improved protocol for spawning habitat assessment, and will be presented in refereed journals, a symposium volume, agency reports, and talks at professional meetings; data will be posted on the web. The project will involve graduate and undergraduate students at CSUS and UC Davis and should result in at least five M.S. theses.

Proposal

California State University, Sacramento, Department of Geology

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Timothy Horner, California State University, Sacramento, Department of Geology
John Williams, Consultant
Kris Vyverberg, CA Dept. of Fish and Game
Joseph Merz, EBMUD
Dixon Roy, CSU Sacramento Chemistry Department

A. Project Description: goals and scope of work

A.1. Problem

Human activity has seriously degraded the permeable beds of alluvial streams in the Central Valley: dams have reduced supplies of coarse sediments and sediment-mobilizing high flows; agricultural and other land uses have increased inputs of fine sediments and toxics; and leveeing, bank stabilization, and clearing have reduced channel migration and simplified channel geometry. The resulting changes in *hyporheic habitat*, the saturated sands and gravels in the beds of streams that exchange significant amounts of water with the stream, adversely affect stream ecosystems. Excess fine sediments degrade spawning habitat for salmonids and habitat for many stream invertebrates, and reduced permeability affects basic lotic ecosystem processes such as nutrient spiraling. Many restoration actions are intended to improve hyporheic habitat, both directly, by adding gravel, or indirectly, by allowing channels to meander. Although general problems with spawning gravels are well recognized, detailed understanding of hyporheic processes that could provide effective guidance for restoration efforts is lacking.

Chinook salmon and other salmonids select redd sites largely on the basis of hyporheic or interstitial flow (Vronski 1972; Healey 1991; Vyverberg et al. 1997), and the quality of hyporheic water can subject embryos and larvae (alevins) to lethal or serious sublethal stress. Concentrations of dissolved oxygen (DO) in hyporheic water are typically depressed relative to surface water by metabolic activity of hyporheic microorganisms (Baker et al. 2000) and reactions with sediment and mineral matter (Horner and Bush 2000). Preliminary data from sites used by Chinook salmon for spawning in the American River show that DO levels in upwelling areas were as low as 30% of normal saturated levels (<3 mg/l), with significant oxygen depletion 30 cm below the surface (Horner and Bush 2000). Besides direct survival, DO levels affect the rate of development (Silver et al. 1963; Brannon 1965; Wells and McNeil 1970), growth rate of embryos (Silver et al. 1963), and the size at emergence of alevins or fry (Silver et al. 1963 (Figure 1); Shumway et al. 1964; Mason 1969; Merz unpublished data (Figure 2)). Chapman (1988) reviewed the literature on the relation between hyporheic water quality and the survival and condition of salmon embryos and larvae and summarized his review as follows:

> "The key inference from the body of work described above is that deprivation of dissolved oxygen leads to subtle problems often not detectable in tests of survival in various oxygen concentrations. It appears incorrect to set critical oxygen levels at any arbitrary point, or to assume that survival to time of emergence is sufficient evidence of ecological success. *Any* decremental reduction in dissolved oxygen levels from saturation probably reduces survival to emergence or post-emergent survival." (p. 9, emphasis in original)

Nevertheless, most studies of the effects of hyporheic conditions on salmonid embryos and alevins emphasize survival to emergence (e.g., Tappel and Bjorn 1983; Snowden and Power 1985; Lisle and Lewis 1992; Peterson and Quinn 1996; Wu 2000). As a result, the importance of hyporheic conditions for salmon populations may be seriously underestimated. DO levels may be particularly a problem for embryos of winter-run chinook that experience relatively warm water and therefore high metabolic rates at their most critical stage, just before hatching.

Hyporheic conditions are important for river ecosystems as well as salmonid embryos and alevins (Jones and Mulholland 2000). Microbial processing of dissolved carbon and nutrients in the biofilm covering alluvial sediments helps to retain nutrients in streams by shortening "spiraling lengths." Many of the macroinvertebrates that provide food for smaller fish utilize the hyporheic zone as habitat, as do juvenile salmonids that burrow into it for cover. Enhanced hyporheic exchange may be one of the major benefits of channel complexity for stream ecosystems. Although there as been a virtual explosion of studies of the hyporheic zone over the last 15 years, biological investigations of the hyporheic zone to date have been mainly descriptive (Boulton 2000), and the effects of flow regimes, watershed conditions and rates of channel migration on hyporheic conditions and processes remain poorly understood.

A-2. Justification

The proposed project is a critical step in a continuing investigation of hyporheic habitat in Central Valley rivers. This project will be integrated with implementation of restoration actions, on the Mokelumne River, and emphasizes developing better understanding of hyporheic habitat and better methods for assessing it. Two of the principal investigators have learned from personal experience designing spawning gravel restoration projects that existing knowledge does not provide adequate guidance; improved assessment methods are also needed. In terms of Figure 1 in the Calfed Implementation Plan, this project is "targeted research."

Within the broader context described above, the primary specific conceptual model for this project is a box-and-arrow diagram modified from Wu (2000) showing the main factors that influence hyporheic conditions in the egg pocket of a redd (Figure 3). Wu (2000) did not consider that DO concentrations and pore water geochemistry change along hyporheic flowpaths, so we have modified his conceptual model to account for subsurface processes, and to include sublethal effects of low DO or irrigation rates and concentrations of other solutes.

Project participants have done considerable work (including implementation of enhancement projects) on hyporheic conditions and salmon spawning on the American, Mokelumne, and Cosumnes rivers (Snider and Vyverberg, 1995, 1996; Horner and Fahning 1996; Vyverberg and Snider, 1997; Vyverberg et al. 1997; Bush and Horner 2000; Horner and Bush 2000; Merz, 2001). We will build on this work using field studies, mesocosm experiments, and modeling to address four related sets of questions concerning:

- Physical, biological, and geochemical factors affecting the quality of hyporheic water;
- Factors influencing selection of redd sites by chinook salmon;
- Effects of hyporheic conditions on egg and larval chinook salmon;
- Optimal spawning behavior given variation in the quality of spawning habitat.

Additionally, we plan to make basic observations of hyporheic zone processes that may lead to the development of additional hypotheses regarding hyporheic ecosystems, and to develop testable hypotheses about the effects of geomorphic processes on hyporheic habitat. We will emphasize comparisons among sets of hypotheses, using the approach of multiple working hypotheses recommended by Hilborn and Mangel (1997), to examine the relationships among biological, physical and geochemical variables in the hyporheic zone. We will collect data both in the field and in hyporheic mesocosms constructed from hemicylinders of 0.9 m diameter corrugated plastic pipe, in which greater experimental control can be realized.

Physical, biological and geochemical factors that influence hyporheic water quality:

Hyporheic water quality evolves along subsurface pathways in stream gravels based on length and time of subsurface flow and subsurface biological and geochemical reactions (Runkel and Bencalla 1995; Harvey and Wagner 2000; Jones and Mulholland 2000). We will look for patterns in the distribution of water quality in our study streams by testing:

> *Hypothesis Set 1:* **DO, major elements, trace elements and nutrients in the hyporheic zone vary with: (1) source of water (river or groundwater); (2) rate of hyporheic flow; (3) length of hyporheic flow path; (4) size distribution of substrate; (6) permeability of substrate; (7) biological activity, (8) rock/water interaction (9) geomorphic position (e.g., pool tail-out, riffle); and (10) temperature.**

Based on previous work a number of these factors will be important and there will be interactions among them, so the task is to sort out the relative importance of the factors. Following the approach of Burnham and Anderson (1998), we will use information from preliminary data (e.g., figures 4 and 5), a review of the literature, or information developed early in the project to develop sets of *a priori* predictive equations or models that will be tested and ranked by plausibility with data collected later in the project, using Akaike's information criterion (AIC). In other words, we will attempt to find the "best approximating model" for predicting the water quality factor of interest, with emphasis on variables that can be measured effectively in the field. The models selected by this approach will provide estimates of effect size, and should be of greater practical use than results of traditional tests of null-hypotheses of no effect,[1] particularly for the field data.

We will also use standard statistical techniques and hypothesis tests, especially for analyzing results of experiments in the mesocosms. Mesocosm experiments should be particularly useful for evaluating the importance of minor factors or factors that cannot be isolated in field studies. For example, particle size distributions affect substrate permeability and should indirectly affect DO, but Peterson and Quinn (1996), found no statistically significant relationship between per cent fines and DO in redds, presumably because of the confounding influence of other factors.[2] The mesocosms will also allow more detailed study of changes in hyporheic water along a controlled flowpath.

Factors influencing selection of redd sites by Chinook salmon:

Previous work (Vyverberg et al. 1997; Horner and Bush 2000) from the American River shows differences in permeability and hyporheic water geochemistry between areas selected and avoided for spawning, and similar results have been found elsewhere (e.g., Geist and Dauble 1998; Geist 2000). We will extend this work by testing:

[1] The modern trend is away from traditional hypothesis tests in analyses of environmental and ecological data (see citations in Burnham and Anderson (1998), also chapters 1 and 2 in Hilborn and Mangel (1995))

[2] See Peterson and Quinn (1996) for an example of the limitations of testing traditional null-hypotheses of no effect for analyses of data of this sort.

> ***Hypothesis Set 2*: Salmon preferentially select areas for redds in terms of: (1) DO in hyporheic water; (2) source of hyporheic water (river or groundwater); (3) permeability or subsurface flow rates; (4) upwelling or downwelling; (5) water depth; (6) water column velocity; (7) substrate size; (8) temperature of hyporheic water; (9) interactions with other salmon, and (10) site structure, such as large pieces of wood.**

Again, we expect that several of these factors will be important and there will be interactions among them, so we will use the same approach of developing *a priori* predictive equations or models from unpublished preliminary work and from a review of the literature. We also expect that the relative importance of these factors may change over the spawning season or with conditions in the river. In particular, we expect interactions with other salmon to be important if the density of spawners is high, so we will use field data to test:

> ***Hypothesis 2B*: Spawning occurs in less preferred areas if more suitable areas are occupied and defended,**

with site preference determined from data collected when the density of spawners is low. Ongoing EBMUD restoration work on the Mokelumne River will allow for experimental manipulation of spawning habitat, especially regarding large wood.

Effects of hyporheic conditions on egg and larval Chinook salmon:

We intend to verify that laboratory findings regarding the effects of dissolved oxygen and irrigation rate on embryos and alevins (e.g., Silver et al. 1963; Shumway et al. 1964) apply in field or field-like conditions. If results differ from expectations, we will attempt to identify the factors causing the difference.

> ***Hypothesis Set 3:* The size, developmental rate, condition , and survival to emergence of chinook salmon embryos and alevins vary with: (1) DO, ammonia and nitrate levels in hyporheic water; (2) the local rate of hyporheic flow; (3) water temperature.**

Again, we will develop an *a priori* set of models embodying the hypothesis set, based on existing information (e.g., figures 1and 2), and test these against the data collected from both the hyporheic mesocosm and field study elements of this project. Alternatively, we may use the data of Silver et al. (1963) to develop prior distributions for a Bayesian analysis of the effect of these factors on alevin length. Mesocosm experiments will be designed to evaluate the same hypothesis in more controlled conditions.

Optimal spawning behavior given variation in the quality of spawning habitat:

Healey (1991) suggested that limited areas of good spawning habitat may limit salmon populations in ways not apparent from superficial observations of spawning activity. We will explore this using information from the field and mesocosm studies to develop dynamic state variable models (Clark and Mangel 2000), which have been successfully used to explore analogous behavior such as oviposition in insects. Such models try to explain behavior in terms of fitness, and produce testable predictions that can be used to evaluate the results. Successful predictions indicate but do not prove that the main determinants of the behavior are understood. The basic hypothesis to be explored is that female salmon can evaluate both the quality of spawning habitat and their own condition and behave so as to maximize their reproductive potential. As a simple example, a female near death should be less "picky" about spawning habitat than one in better condition that has time to search for better sites. The results of this modeling could be integrated with salmon population modeling in future work, to evaluate the importance of spawning habitat for salmon populations.[3]

A-3. Approach

Field Studies:

Three or more study sites on each river will be selected within the study areas (Figure 6) based on existing information; each will be at least a hectare in area, and include areas favored and disfavored by spawning salmon. Experimental placements of large wood or other manipulations will be integrated into restoration work on the Mokelumne River, and particular effort will be made to determine hyporheic flowpaths adjacent to large wood. ***Detailed topography*** of wadable areas of the bed, exposed bars, and adjacent riparian areas will be mapped using a total station theodolite and tied to secure benchmarks (this has already been done on the Mokelumne). Topographic maps, cross-sections and fence diagrams of the sites will be produced using Surfer contouring software, and will be used as base maps for mapping geomorphic features, large wood, and substrate size categories as determined from previous work or by surface pebble counts complimented by bulk samples as necessary (Vyverberg et al. 1997), and for maps of redds and hyporheic conditions. ***Surface water depth and velocity*** will be measured during the spawning season using Price AA or Pigmy flow meters on wading rods, and mapped following approximately the approach of Collings et al. (1970), except on areas of the Mokelumne River where similar mapping is available from hydrodynamic modeling work associated with gravel restoration projects. The geomorphic context of the study sites will be investigated by field reconnaissance and analyses of aerial photography and other historical information.

Hyporheic water will be sampled for ***chemical analyses*** using nested sets of three small (7.5 mm diameter) stainless steel drive point piezometer tips. Fifteen to 30 sets of piezometers will be installed on each of five to ten gravel bars at each site. Tips will be installed with a hollow steel overdrive tube and slide hammer to depths of 0.3, 0.6, and 1.2 or more meters in the gravel.[4] Each drive point will be connected to the surface by a 6 mm diameter Teflon tube (figures 7 and 8), and hyporheic water will be drawn from these tubes on a quarterly sampling plan using a peristaltic pump. Paired tips will also be installed into and adjacent to the egg pockets of natural redds. During sampling, tubes will be purged of three times their internal volume, and 125 ml samples will filtered through a 0.45 micron filter, acidified to pH<2, and stored on ice for transport to the lab. Quality assurance/quality control procedures will follow Koterba et al. (1995), and will include blanks, replicate samples and spikes. Nitrate, phosphate

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[3] In terms of stock recruitment models, for example, it appears that hyporheic conditions could affect both intrinsic productivity and density-dependent mortality.

[4] These drive points have been successfully installed to depths of 3 m in previous work (Horner and Bush, 2000).

and sulfate will be measured on an ion chromatograph, and major elements (Ca, Na, K, Cl, Fe, SO4) will be analyzed with a combination of AA and ion chromatography. These analyses will be conducted in a CSUS chemistry lab under the supervision of Dr. Roy Dixon. Dissolved organic carbon (DOC) and preliminary carbon typing (to identify broad sources of carbon input) will be performed in a lab of Dr. Brian Bergamaschi at the USGS Water Resources Division, Sacramento District Office. Approximately 20% of the laboratory samples will be instrument standards and calibration checks used to verify instrument precision.

Hydraulic head will be measured at each drive point by connecting the sampling tubes to bubble manometers (Figure 9); ***upwelling and downwelling*** potential will be calculated from the vertical head gradients. ***Hyporheic temperature*** will be measured by inserting thermocouple wires down the sampling tubes to the piezometer tips, and nested strings of Tidbit brand data logging thermocouples will be installed at three locations on each river. Substrate surface temperatures will be measured as the mean of five thermocouple measurements within one m of the sampling point (Wilde and Radtke 1999). Heat flow models that use this three-dimensional temperature data will be used as an alternative method for estimating the vertical flux of water (upwelling or downwelling) and permeability of the substrate (Constanz 1998; Constanz et al. 1999).

Substrate permeability will be measured at 0.3 and 0.6 m depth, and deeper if substrate conditions permit, by slug tests in a removable, hand-driven standpipe built to the design of Terhune (1958), or a slightly larger version (50 mm inside diameter). A plastic rod will be inserted and then suddenly removed from the standpipe, causing a rapid drop in the water level in the standpipe. The recovery of the water level to static conditions will be monitored at 0.5 second intervals with a pressure transducer and data logger (Springer et al 1999; Weight and Sonderegger 2001), and evaluated by standard methods (Hvorselev 1951; Bouwer and Rice 1976). Data will be analyzed using Aquifer Test software to estimate the permeability of the sediment. Where the water table is too low to allow for slug tests, permeability will be measured following Bernard and McBain (1994; 1998), by using an adjustable pump to maintain a fixed depression in the water level in the standpipe and measuring the rate of pumping, from which permeability can be calculated. The direction and horizontal velocity of groundwater flow through the screened section of the 50 mm inside diameter standpipe will be measured at 0.3 and 0.6 m depth with a K-V Associates Model 40 heat-pulse flowmeter that uses eight thermisters to track the dissipation of pulses of heat from a central source.

Permeability and velocity will be measured 2 m downstream from the piezometer sets to minimize any influence that might occur from driving the standpipe into the hyporheic zone. Physical variables will then be related to water chemistryand vertical head gradients. Patterns of subsurface flow will be inferred from velocity, hydraulic head and permeability measurements and from heat flux modeling at coarse spatial scales, or by chloride tracer tests at finer spatial scales, e.g., around pieces of large wood.

Dissolved oxygen (DO) will be measured at the same time as permeability measurements using a YSI model 95 DO meter with a vibrating tip that works effectively in standpipes and slowly moving water. DO will also be measured with the same meter in water samples from the nested piezometers, using a peristaltic pump and flow-through chamber (Figure 10) that protects samples from atmospheric oxygen. DO data will be collected during Fall low-flow conditions (pre-spawning), and more often during egg-larval incubation.

Spawning activity and associated behavior will be monitored and mapped in instrumented areas following the general methods of Jackson (1993), as modified for local conditions by Merz and Vyverberg (unpublished methods) in preliminary work. Observations will be focused on individual females in selected areas. Estimates of river-wide spawning density will be obtained from CDFG, EBMUD, and The Nature Conservancy. Egg tubes or baskets containing 100 or 200 eggs in gravel (with controls maintained at hatcheries) will be installed in sites with varying physical and geochemical environments in the Mokelumne and American rivers, following methods used successfully in previous work by Merz and Vyverberg; Merz will conduct additional studies in 2001-2002 and final protocols for this project will be developed after evaluation of that work. Substrate size distributions, permeability, turbidity, DO and hyporheic water chemistry will be determined from samples at the installation sites and from nested sets of piezometers installed within and adjacent to egg tubes and natural redds. Samples will be collected at eyed-egg, hatching and emergence (button-up), as estimated from hatchery controls. Eyed eggs will be scored by ***survival***, and alevins and fry by length and weight. ***Condition at emergence*** will be measured by non-polar lipid content, a measure of energy reserves, as well as condition factors such as relative weight; Castleberry et al. (1993) found considerable variation in the non-polar lipid content of recently emerged (30-35 mm) chinook salmon fry in the American River, so we expect lipid content to be a useful metric. After field tests of ability to orient in current (in a stirred bucked) samples of alevins or fry will be sacrificed, placed in labeled bags and frozen on dry ice for later analyses. ***Length and weight*** will be measured to the nearest 0.5 mm and 0.1 gram, and non-polar lipid content of fry will be determined by ether extraction (Reznick and Braun 1987).

Hyporheic mesocosms:

Hyporheic mesocosms will be constructed at the Mokelumne River Hatchery from 9 m sections of 0.9 m diameter corrugated plastic pipe sliced lengthwise and topped with 29 mm plywood (1 1/8" plyscore) to create hemicylindrical units that will be filled with sand-gravel mixtures. Screens and inlet/outlet structures will be fitted to the ends to allow control of flow rates, and ports will be cut in the plywood tops for installing monitoring devices, deploying egg baskets, or collecting samples of organisms. One set of mesocosms will be operated at the Mokelumne River Hatchery in secure conditions and with opportunity for treatments with contrasting water temperatures; another set will be installed in trenches dug in gravel bars in the Mokelumne River, placed so that water will flow by gravity through the mesocosms. Units will be fitted together to make longer flowpaths if necessary.

Since the mesocosms are untested, the first year objective will be to make them operational; specific experimental designs and statistical tests will be developed for the second and third year based on preliminary results from the first year and results from the field studies. We expect that egg basket, DO, chemical, and hydraulic head analyses will be performed as in the field studies. Permeability and flow rates will be determined by measurement of outflow or by chloride dispersion. Substrate samples will be collected periodically to develop preliminary data on the rate of development of hyporheic communities in initially clean substrate, and more formal protocols will be developed based on the preliminary data.

Statistical analyses:

Statistical analyses will emphasize the ***Akaike information criterion*** (AIC), but will use other methods as well. The AIC provides an objective and theoretically well-based but relatively simple way to evaluate models in terms of the data used to estimate model parameters, and so to evaluate hypotheses expressed as models (Burnham and Anderson 1998).[5] Models are ranked by the differences in their AIC values, which are calculated after finding the maximum likelihood estimates of the parameters of the model. The AIC is -2 times the log-likelihood of the model with these parameter values, minus twice the number of estimated parameters. Heuristically, the first term measures how well the model fits the data, and the second "penalizes" the use of more parameters. Minimizing the AIC thus balances error or uncertainty from using an incomplete or simplified model against error or uncertainty from estimating parameters with imperfect data, and so identifies a "best approximating model." For example, a model (i.e., an equation) that predicts the size of emerging fry from water temperature and DO alone should fit the data less well than one that also includes hyporheic water velocity, but might well have a better (lower) AIC value. The AIC can be used for non-nested as well as nested models. Variations of the AIC for small samples sizes or for overdispersed data exist (Burnham and Anderson 1998), and will be used as appropriate.

Traditional statistical methods such as ***analysis of variance*** will also be used, especially for the mesocosm data, and spatial statistics will be considered for analyzing patterns in redd distributions. Although we will apply various methods for exploratory data analysis to our data, we will avoid "data dredging," or the uncritical search for significant relationships within our large multivariate data set; relationships discovered in this part of the analysis will be treated as hypotheses to be tested with new data. Dr. Ani Adhikari of the UC Berkeley Dept. of Statistics will provide advice on the statistical analyses.

Modeling:

Dynamic state variable (DSV) models[6] are well-established tools for exploring hypotheses in behavioral ecology (Clark and Mangel 2000). DSV models step backwards in time, evaluating the fitness value of behavioral choices (e.g., spawn or search for better spawning habitat) at each time-step, with the assumption that the organism will behave optimally from that time-step forward. This approach makes the implicit hypothesis that organisms behave so as to maximize reproductive success, and limits the behaviors evaluated to a manageable number. We will use TrueBasic and the results from the statistical analyses to develop a suite of models of increasing complexity for the behavior of female salmon, for the period from arrival on the spawning grounds to inability to spawn or defend redds. We will start with a very simple model that includes only patches of spawning habitat of varying quality, quantified as the probability of eggs surviving to adulthood in a standard habitat, given the expected size and condition of surviving fry at emergence.[7] More complex models will include interactions with other salmon and other factors such as female and egg size, temperature effects and streamwise gradients in

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[5] The terms "model' and "hypothesis" have different meanings to different authors and in different contexts; see pp. 24-32 in Hilborn and Mangel for a useful discussion. Here we take models or equations to be ways of expressing hypotheses, although typically there will be several candidate models for a single hypothesis.

[6] These are also called dynamic programming models.

[7] These probabilities will have to be estimated, but should provide biologically reasonable criteria nevertheless.

habitat quality. Modeling will be informed by a review of the literature and data from the field studies. Dr. Marc Mangel of UC Santa Cruz, who helped develop DSV modeling, will provide advice on this application of the method.

A.4. Feasibility

Except for the mesocosms, the low-impact monitoring methods proposed for this project will not require additional permitting or agreements. Existing restoration permits granted to EBMUD or post-2003 extensions will be used for installation of mesocosms on the Mokelumne River. Existing relationships with landowners will allow access through private land on the Cosumnes River (see attached letters). Participants from CDFG and EBMUD will facilitate access to public land by providing gate keys and passage through secure levee roads. Salmon eggs used in experimental phases will be obtained through CDFG. The monitoring methods proposed have been successfully used by project participants in preliminary work, so schedules and tasks are based on experience.

A.5. Performance Measures

Performance in this research project will be measured primarily by the number and quality of publications in peer-reviewed journals, presentations at significant meetings, agency and data reports, and student theses. Quality will be judged by practical as well as academic criteria. Negative results or project failures will be documented and reported in the same media as other project results. Internally, Tim Horner will monitor the progress of tasks listed in the schedule below (A8) and work with other project leaders to ensure that the objectives of the project are realized.

A.6. Data Handling and storage

Field notebooks will be archived and copied for distribution to all project members, and basic data will be posted on a web site after internal review. Copies of all public-domain peer-reviewed abstracts and publications (see below) will be available as PDF files on the world wide web through the CSUS faculty/staff server. The project may also result in DFG and EBMUD internal documents and project reports that contain summaries of field data.

A.7. Expected products/outcomes

Deliverables from the four principle investigators:

- Publications in peer-reviewed journals.
- Chapter in planned Am. Fish. Soc. symposium volume.
- Review of literature on salmonid spawning habitat, with emphasis on the Central Valley.
- Improved protocol for spawning habitat assessment.

- Abstracts at national meetings (Am. Fish. Soc., Geol. Soc. Am., etc.).
- Presentation at CalFed Conferences (Fall 2002 and later conferences).
- IEP newsletter articles (summaries of preliminary results).
- Web page summary of results and down-loadable versions of abstracts or articles.

Deliverables from 5 graduate students:
- 5 unpublished M. S. theses.
- Presentation of results at local meetings or association section meetings (at least one per year per person).
- Co-authored publications in refereed journals.

A.8. Work Schedule

Year 1: Work conducted during year one will assess spawning patterns, establish field sites, survey and instrument gravel bars, and conduct biological surveys on the American, Cosumnes and Mokelumne rivers. Hyporheic mesocosms will be installed at the Mokelumne River hatchery, and mechanical aspects of flow control will be refined in these experimental flow cells. Results from field studies will be used to begin statistical evaluation of predictive models and dynamic state variable modeling. Preliminary results will be reported at an IEP-sponsored symposium at the AFS national meeting. Work schedules for year one are as follows:

Task	Time schedule
Task 1: Order maps and air photos, formal notification of landowners and agencies concerning successful funding of project. Analyze air photographs and historic spawning information (DFG, EBMUD and Nature Conservancy data), select sites,.	July – October 2002
Task 2: Survey and instrument gravel bars and areas adjacent to large woody debris, conduct initial DO, permeability, temperature and flow measurements- all rivers.	September - October 2002
Task 3: Conduct preliminary biological/ecological surveys (macro and micro invertebrates), first arrival spawning survey, weekly spawning surveys- all rivers.	October – December 2002
Task 4: Install hyporheic mesocosms at Mokelumne River hatchery, develop and refine methods for flow control	September – 2002; January 2003
Task 5: Geochemical sampling and analysis: sample monitoring points (pore water geochemistry) on all rivers. Collect 300 preliminary samples prior to spawning, develop and refine lab procedures, analyze water chemistry at CSUS.	October – December, 2002
Task 6: Install egg baskets near spawning and non-spawning areas on the Cosumnes and Mokelumne rivers and in the experimental hyporheic mesocosm. Measure development of eggs and alevin; collect and analyze biological samples.	November 2002- January 2003
Task 7: Measure field parameters and physical conditions (temp, DO, permeability, flow) at Spring flow levels.	February 2003

Task 8: Collect and analyze 300 geochemical samples (100 pore water samples from each river) to determine the effects of Spring flow conditions on salmonid fry.	March – April 2003
Task 9: Review literature, begin statistical analysis and dynamic state variable modeling, develop *a priori* predictive models for ranking with AIC.	On-going
Task 10: Project management, student supervision, summarize and present preliminary results.	On-going

Year 2: Work conducted during year two will consist of full-scale physical, geochemical and biological monitoring at spawning and non-spawning areas on all three rivers. Egg basket studies will be conducted on the Mokelumne and Cosumnes Rivers, and experimental hyporheic mesocosms will be installed on the Mokelumne River and monitored to measure evolution of subsurface conditions as the gravel develops biological and geochemical gradients. Results from year one field studies will be used to adapt study areas or analytical methods as necessary. Statistical evaluation of predictive models and dynamic state variable modeling will continue. Tasks and work schedule are as follows:

Task	Time Schedule
Task 1: Repair field sites and install monitoring points as needed (all rivers).	August, September 2003
Task 2: Measure pre-spawning field conditions (temperature, velocity, permeability, flow) on all rivers, install large woody debris as part of restoration project on Mokelumne River, install monitoring points adjacent to woody debris.	August- October 2003
Task 3: Conduct pre-spawning biological transects (macro and micro invertebrates), monitor early spawning arrival, spawning behavior and gravel bar use.	September – December 2003
Task 4: Install mesocoms at restoration project on Mokelumne River; sample physical and biological changes and evolution of natural gradients in hyporheic mesocosms.	October 2003 - June 2004
Task 5: Geochemical sampling and analysis: Collect 300 pore water samples prior to spawning (100 samples per river), analyze water chemistry at CSUS.	August - September 2003
Task 6: Install egg baskets in natural settings and mesocosms; monitor development and condition of eggs and alevin, collect and analyze biological samples.	November 2003 – January 2004
Task 7: Measure field parameters and physical conditions (temp, DO, permeability, flow) during Spring high flow levels.	February 2004
Task 8: Collect and analyze 300 geochemical samples (100 from each river, surface water and pore water) to determine Spring high flow conditions.	February – March 2004
Task 9: Compile data and summarize results from years 1 and 2, continue statistical analysis and dynamic state variable modeling, begin testing predictive models.	On-going
Task 10: Project management, student supervision, summarize and	On-going

present intermediate results, prepare review of literature on determinants of spawning success with emphasis on Central Valley.	

Year 3: Work conducted during year three will continue quarterly geochemical and biological monitoring at spawning and non-spawning sites on all three rivers. Egg basket experiments conducted in the field and in hyporheic mesocosms will continue with a second year of detailed study, and two years of complete experimental data will be summarized and disseminated to the scientific community. Continuation of earlier tasks will allow statistical validation of results in a highly variable natural system. Tasks for year three are summarized below:

Task	Time Schedule
Task 1: Repair field sites and install monitoring points as needed (all rivers).	August, September 2004
Task 2: Measure pre-spawning field conditions (temperature, velocity, permeability, flow) on all rivers, install large woody debris as part of restoration project on Mokelumne River, install monitoring points adjacent to woody debris.	August- October 2004
Task 3: Conduct pre-spawning biological transects (macro and micro invertebrates), monitor early spawning arrival, spawning behavior and gravel bar use.	September – December 2004
Task 4: Sample physical and biological changes and evolution of natural gradients in hyporheic mesocosms at restoration project on Mokelumne River.	October 2004
Task 5: Geochemical sampling and analysis: Collect 300 pore water samples prior to spawning (100 samples per river), analyze water chemistry at CSUS.	August - September 2004
Task 6: Install egg baskets in natural settings and mesocosms; monitor development and condition of eggs and alevin, collect and analyze biological samples. Remove mesocosms when project is complete.	November 2004 – January 2005
Task 7: Measure field parameters and physical conditions (temp, DO, permeability, flow) during Spring high flow levels.	February 2005
Task 8: Collect and analyze 300 geochemical samples (100 from each river, surface water and pore water) to determine Spring high flow conditions.	February – March 2005
Task 9: Compile data and summarize results from all years, continue statistical analysis and dynamic state variable modeling, begin testing predictive models, develop field assessment protocol.	On-going
Task 10: Project management, student supervision, summarize and present final results, prepare Web page summaries.	On-going

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

B.1. ERP, Science program and CVPIA priorities

a. ERP: This project will be applicable to the following ERP priorities by elucidating the effects of hyporheic habitat quality on salmonids: MR-5 (DO); MR-5 (fine sediment); MR-6 (salmonids); SR-2 (spawning gravel); SR-2 (fine sediment); SR-3 (mechanistic models); SR-7 and DR-4 (juvenile life history requirements). It is also applicable to the CVPIA objective of doubling populations of naturally produced salmonids. Although focused on fall-run Chinook salmon, the project results should be largely applicable to other runs and, except for the behavioral modeling, to steelhead.

b. CVPIA: Several CVPIA goals are addressed by this project. The project is directly applicable to the doubling goal of CVPIA sections 3406(b)(1) and the gravel replenishment goal of 3406(b)(13). The CVPIA goal outlined in section 3402a also seeks to protect, restore and enhance fish, wildlife and associated habitats in the Central Valley. These goals will be met by identifying habitat issues associated with spawning and non-spawning areas and egg and alevin development.

B.2. Relationship to other ecosystem restoration projects

Proposed work on the Mokelumne River will be coordinated with EBMUD spawning habitat work that is managed by Joe Merz. Our work on the Cosumnes River will be of interest to UCD projects coordinated by Jeff Mount and Graham Fogg, although these groups deal more with sediment transport and groundwater/surface water modeling, respectively. UCD scientists will be briefed on this project at an early stage, and information will be shared as the project progresses. Work on the Cosumnes River will also be coordinated with a restoration project being proposed by the Sloughhouse Resource Conservation District (SRCD) and Cosumnes River Task Force. If the SRCD project is funded Tim Horner will be in charge of monitoring work; this will not conflict directly with the current fisheries research project, and will ultimately result in completion of more monitoring work on the Cosumnes River. Proposed work on the American River will inform future restoration projects, including projects contemplated by the Lower American River Task Force's management and restoration plan. Indirectly, results from the project will inform future ERP spawning habitat restoration projects.

B.3. Requests for next phase funding

None

B.4. Previous CALFED or CVPIA funding

None

B.5. System wide benefits

Permanent rehabilitation of aquatic habitat can only be accomplished by restoring the longitudinal continuity of the river, which includes a diversity of flow events and sediment supply and transport. All other habitat improvement measures — by virtue of the river's dynamic nature — are best viewed as short-term treatments that will have to be repeated with some frequency. Many river restoration actions are directly or indirectly intended to improve hyporheic habitat (e.g., by adding gravel or by development of a more dynamic post-dam hydrograph). Although general problems with spawning gravels are well recognized, detailed understanding of the hyporheic habitat is lacking.

This project has system-wide benefits in two respects. By providing basic information and understanding of spawning habitat for salmonids, and an improved protocol for assessing spawning habitat, the project will benefit spawning restoration projects in the Central Valley. Secondly, we suspect that the ecological benefits from channel meandering and channel complexity derive largely from enhanced interactions between the surface stream and their associated hyporheic zones. The project will provide basic information and understanding regarding physical and biological processes in the hyporheic zone that should be widely applicable in the Central Valley, and help provide a needed mechanistic understanding of the benefits from restoring geomorphic activity and channel complexity to Central Valley streams.

C. Qualifications

Dr. Timothy Horner is an Associate Professor in the Geology Department at CSU Sacramento, and has been a member of the department since 1993. He graduated from The Ohio State University in 1992 with a Ph.D. in Geology, and specializes in ground water/surface water interaction, field instrumentation and near-surface water geochemistry. He teaches undergraduate and graduate hydrogeology classes at CSUS, and has advised 33 senior thesis projects that deal with local hydrogeology and sedimentology. Dr. Horner is currently the graduate coordinator for the Geology Department, and has several M.S. students working on local projects that deal with ground water/ surface water interaction. He has also been a short course instructor for the Army Corps of Engineers and co-organizer for several Groundwater Resources Association (GRA) short courses and seminars. Relevant presentations on local ground water issues include Horner and Bush (2000), Bush and Horner (2000) and Horner and Fahning (1997). Dr. Horner's experience extends to grant writing, and he has authored and managed several recent hydrogeology projects:

- **2001/2003:** Key participant and contributing author for $400,000 grant from W.M. Keck Foundation for *Proposal to establish the W.M. Keck Foundation Facilities for applied hydrogeology at California State University, Sacramento.*
- **1999/2001:** Lead author on NSF CCLI A&I grant for $105,152 titled *Water quality and stream flow as teaching tools in geology.*
- **1996/97:** Co-author on $221,000 grant from W.M. Keck Foundation to *Establish Laboratories for hydrogeologic studies.*

Dr. John G. Williams is an independent consult who has worked on Central Valley salmonid issues since his 1990 appointment as special master supervising a major court-ordered research program on the American River. He has served on various scientific and technical review panels for CALFED and other agencies, and chaired the geomorphology and riparian issues work team for the Comprehensive Assessment and Monitoring Program (CMARP). He publishes regularly in refereed journals (nine publications since 1996), mainly on instream flow modeling. He has also published a critical evaluation of salmon monitoring in the Central Valley and a review of chinook salmon in the American River. Recent consulting work includes salmon-oriented geomorphic evaluations of Clear, Mill, and Butte Creeks, with Matt Kondolf, and contributions to the CALFED salmonid white paper. He works part-time as Executive Director of the Bay-Delta Modeling Forum, where he promotes the application of modern statistical and modeling approaches. He has a Ph.D. in Geography from UCLA.

Kris Vyverberg has been an Engineering Geologist with the California Dept. of Fish and Game (CDFG) for nine years, and now works with the Native Anadromous Fish and Watershed Branch. She has extensive field and regulatory experience with gravel enhancement projects, evaluation of salmonid spawning habitat in central valley streams, and sampling methods in the hyporheic zone. She is a member of DFG's Statewide Technical Advisory Team, and is responsible for providing geomorphic and geotechnical expertise to DFG headquarters and regional personnel, as well as to other State and Federal resource management agencies, with whom she works to protect and restore essential instream habitat, particularly as related to aquatic ecosystem restoration projects, channel and floodplain activities, water flow management, instream structure and diversity, sediment management programs and spawning habitat enhancement. She conducted a major study of spawning habitat in the American River, and has research interests that include human effects on near-surface water quality, and the influence of water quality on the incubation and development of salmonid eggs and alevins. She has a B.S. degree from UC Davis (1983) and is a Registered Geologist in California and Oregon.

Joe Merz has been a fisheries biologist with the East Bay Municipal Utility District (EBMUD) since 1996, where he manages spawning habitat restoration on the Mokelumne River among other duties. He studied the invertebrate fauna in the American River and their utilization as forage by fish for his 1994 M.S. thesis at CSUS. His interests include the influence of woody debris on salmonid spawning site selection, diet and feeding habits of juvenile salmon, and physical and geochemical stressors on egg and alevin development. He teaches ecology and habitat restoration for the CSUS Biology Department and UCD Extension, and is currently working on a Ph.D. in Restoration Ecology at the University of California, Davis, with degree anticipated in December 2002.

Dr. Roy Dixon has been an Assistant Professor in the Chemistry Department at CSU Sacramento since 1999, teaching analytical chemistry and instrumentation. He earned a Ph.D. in Chemistry from the University of Washington in 1991 and specializes in chromatography and atmospheric chemistry.

D. Cost

D.2. Cost sharing

Several of the agencies associated with this project will contribute in-kind or university cost-share donations of equipment, personnel or services:

CSUS:

California State University will provide a soft cost share or institutional contribution of the following items:

Field equipment
(pH, dissolved oxygen, turbidity and conductivity meters, pumps, data loggers, current velocity meters).
Current rental value: $225/day x 50 days per year x 3 years x 3 rivers = $101,250. **Institutional contribution** = not charged

Ion Chromatograph (anion analysis):
Number of samples: 200 samples per river per year x 3 rivers x 3 years = 1800 samples
Estimated market value: $35/sample x 1800 samples = $63,000
CSUS institutional contribution: at CSUS rate of $15/sample cost in chemistry department = $27,000. **Institutional subsidy** = $ 36,000

Atomic Absorption (major element analysis):
Number of samples: 200 samples per river per year x 3 rivers x 3 years x 5 elements = 9,000 samples
Estimated market value: $15/element x 9,000 samples = $135,000
CSUS institutional contribution: at CSUS rate of approx. $3/element cost in chemistry department = $27,000.
Institutional subsidy = $108,000

Half-year sabbatical contribution: 6 months fully funded matching support for sabbatical replacement (Dr. Tim Horner: 6 months salary with benefits @ $41,481 x 32% indirect costs (CSUS rate for federal funds)). Dr. Horner will devote 100% of his time to the project in the first year, with 50% of his support coming from a CSUS-sponsored sabbatical and 50% coming from Calfed support. = $ 54,756

California Department of Fish and Game:

Kris Vyverberg supervisory time:
0.10 time per year for 3 years = $18,417 per year =$ 47,540

DFG Technician's time
0.1 time per year for 3 years @ $7570 per year = $ 27,321

EBMUD:

Project Biologists, year 2 egg placement and alevin survival estimates:

10 days field work and 10 days lab or office work for 2 biologists charging $107.87 per hour = $ 34,518

Total institutional contribution and cost-share = $308,135

E. Local involvement

Government agencies (City of Sacramento, Sacramento Parks and Recreation.) will be formally notified if the project is funded, but in the meantime the following organizations are aware of our intended work: The Sloughhouse RCD (Tina Lunt), Cosumnes River Preserve and Nature Conservancy (Keith Whitener), UC Davis Graham Fogg)\, Peter Moyle, Jeff Mount, Jan Fleckenstein), local landowners on the Cosumnes river (Leyland Snyder, Bill Hutchison Jr.), Rancho Murieta (James Noller, Security Chief), and the NRCS (Mark Cocke, Sergit Toor). All have offered cooperation, and letters of suport from several of these groups are included in Appendix A.

Communication is an important part of this research project, and will be accomplished through a series of non-technical talks in community forums, presentations at meetings and other outreach efforts.

F. Compliance with standard terms and conditions

All applicants and agencies listed as key players in this proposal will comply with all State or Federal standard contracting terms and conditions. This may include additional forms and requirements depending on the source of funding.

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Appendix A: Figures

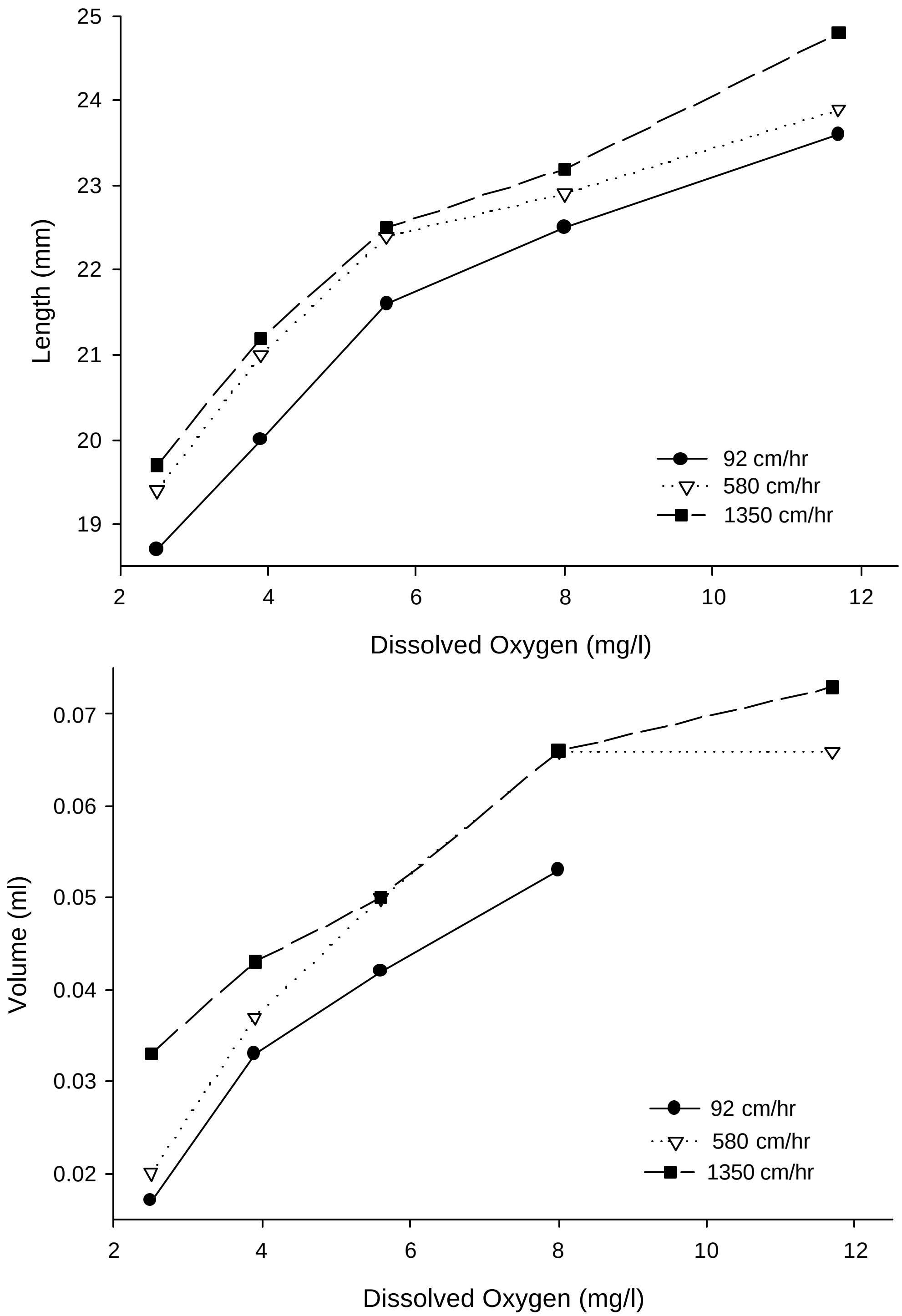


Figure 1: The relation between size of sack-fry and dissolved oxygen at three different flow rates, from data in Table 7 (Silver et al. 1963); note that size continues to increase through the dissolved oxygen concentrations typically found in the field. Data on steelhead are similar.

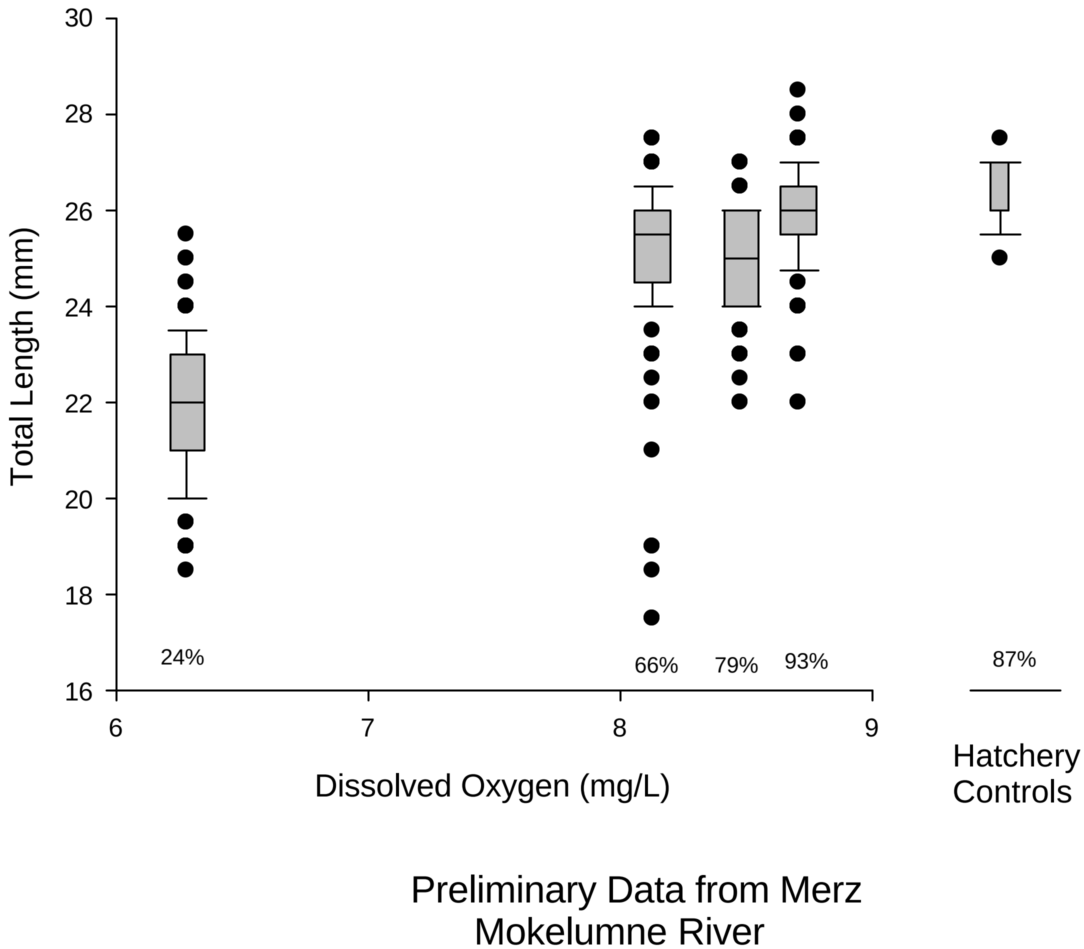


Figure 2. Preliminary data on the relation between dissolved oxygen and length at four study sites on the Mokelumne River. Percent survival for five egg tubes at each site is given above the box plots. Note that these are "censored" data, since survival varied strongly but only surviving alevins were measured. This tends to understate the differences among the sites.

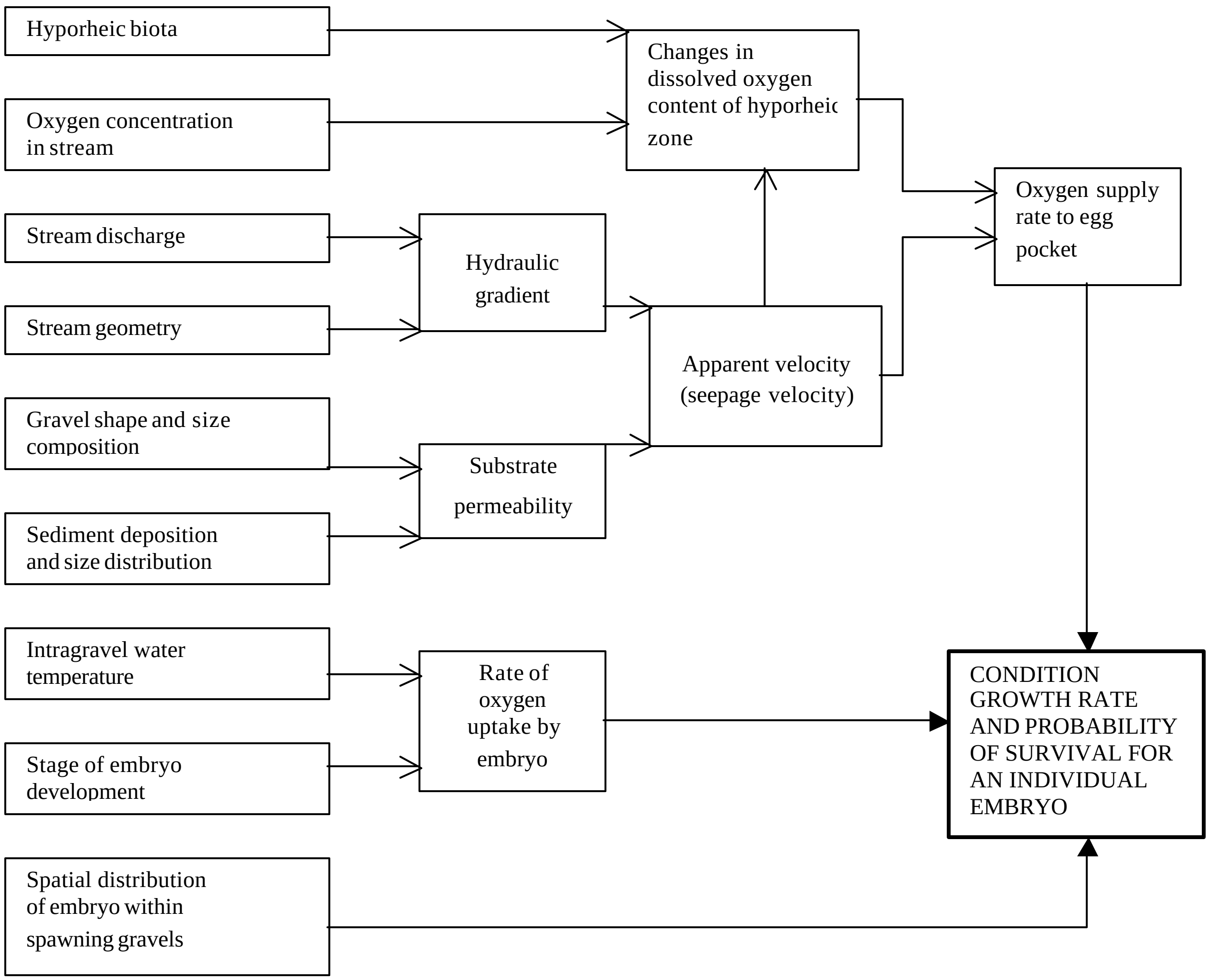


Figure 3**:** Conceptual model of factors influencing survival of salmonid embryos. Modified from Wu (2000) to include situations with groundwater upwelling that affect oxygen and nutrient supply to the egg pocket.

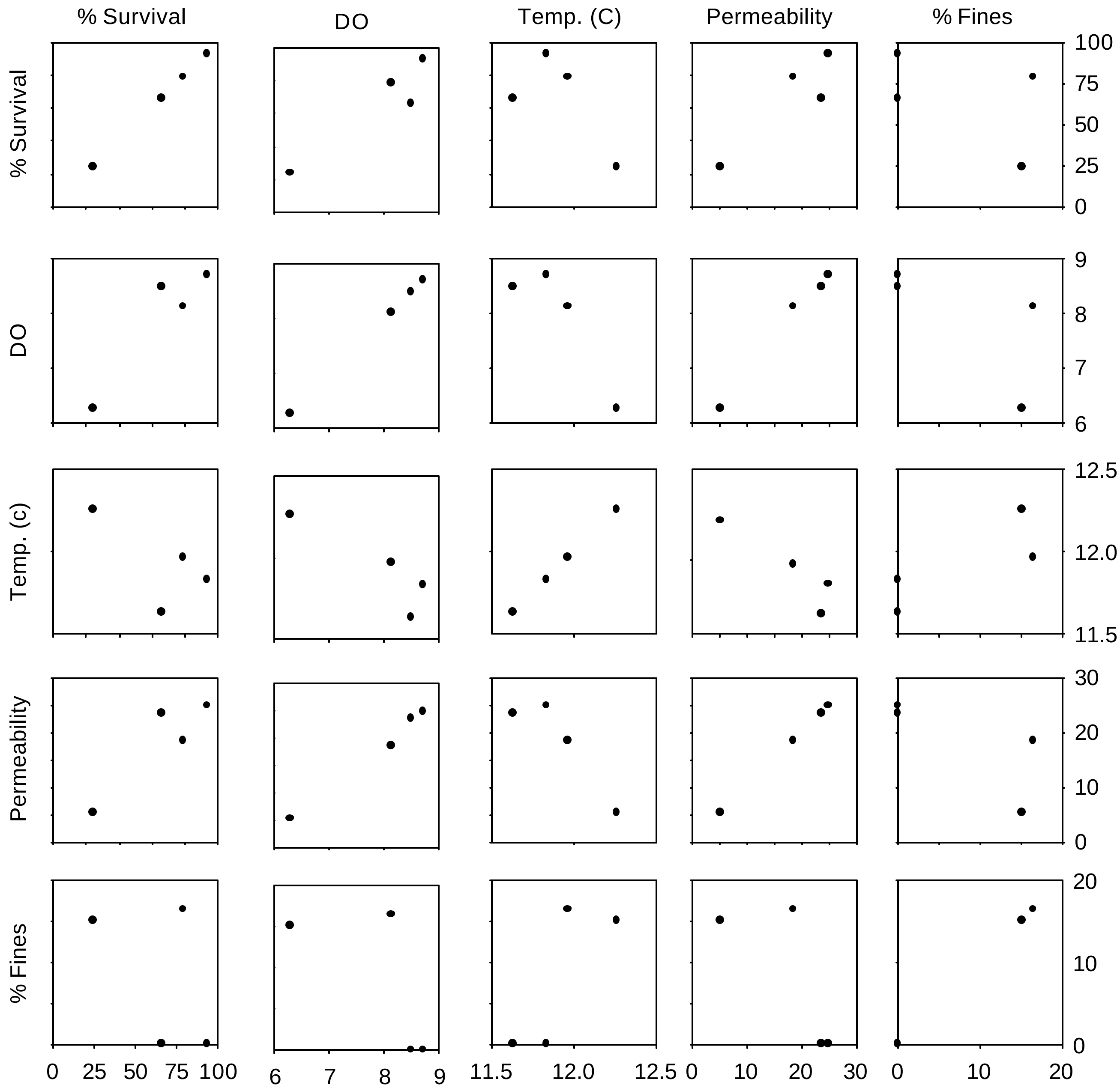


Figure 4. Preliminary data from redd studies at four sites on the Mokelumne River (Merz, in press). Each point represents the mean of one to five measurements at the each site, depending on the variable. More preliminary data of this type will be developed on the Mokelumne River in 2001-2002. In our proposed study, sets of candidate models will be developed using these data and other existing studies. Models will describe the relations among these and other variables, and tested using the data developed during the proposed project.

Figure 5: Twenty-nine nested monitoring sites have been installed on the Cosumnes River as part of preliminary work on an M.S. project by Noel Bush. Most sites have 1 ft, 2 ft and 9 ft nested piezometers as sampling points. The area includes approximately one mile of spawning habitat on the Cosumnes river, and extends southwest of the Highway 16 bridge (Jackson Highway). Sampling is designed to include a variety of geomorphic features and flow conditions, and includes longitudinal and lateral transects of the channel and proximal floodplain. Physical and geochemical sampling will begin in Fall 2001.

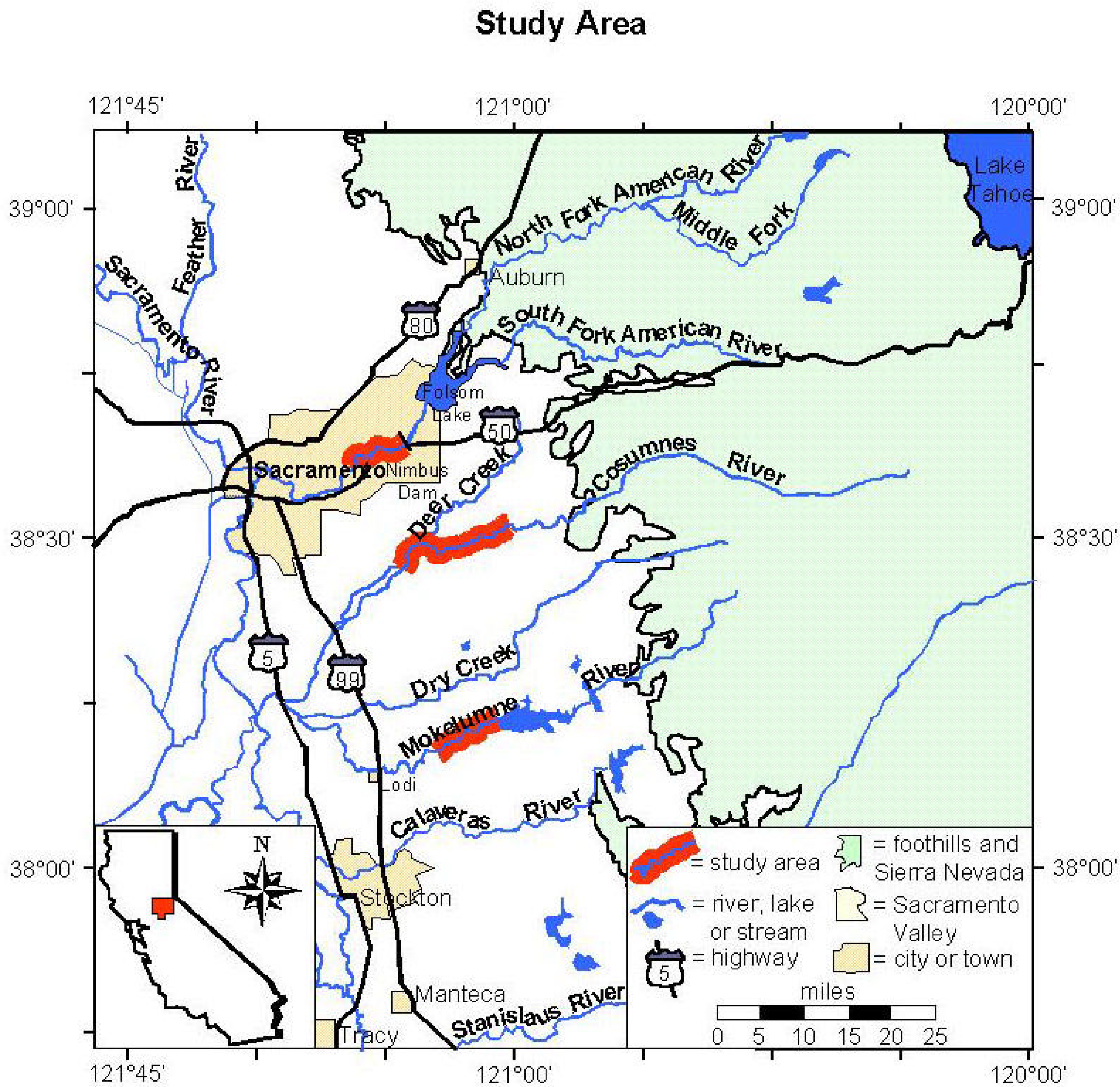


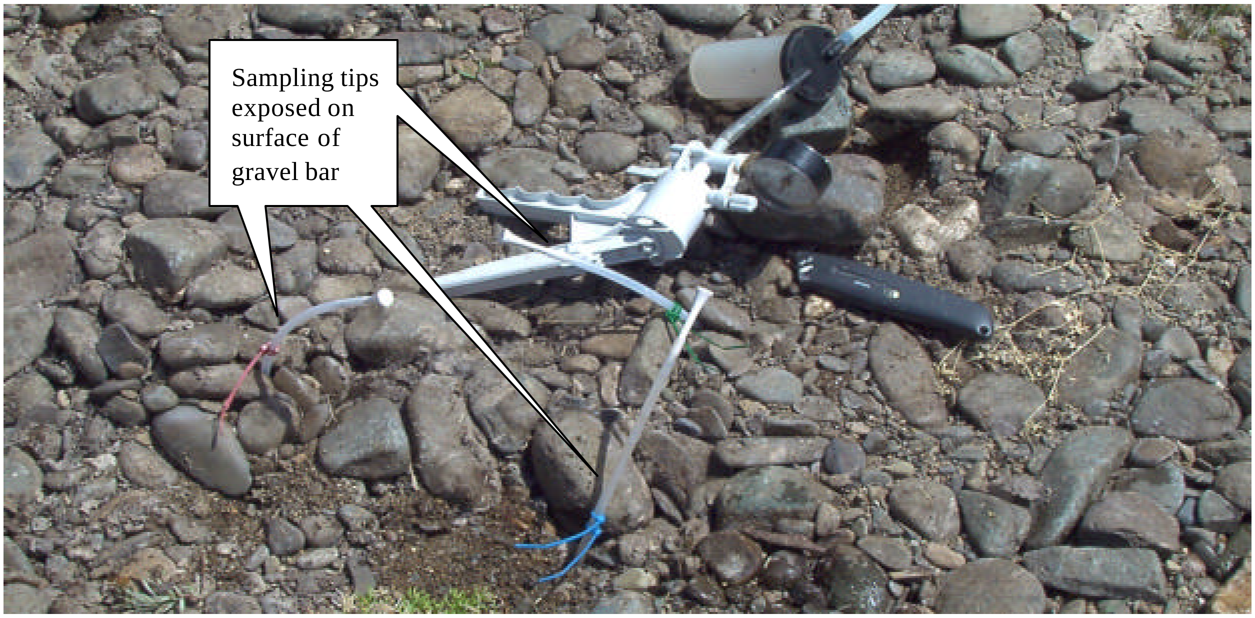
Figure 6: Location of study area and major river systems. This project focuses on known spawning sites in the lower (un-dammed) reaches of the American, Cosumnes and Mokelumne rivers. Geographic center of the project area is approximately 38° 20' N latitude, -121° 10' E longitude.

A.

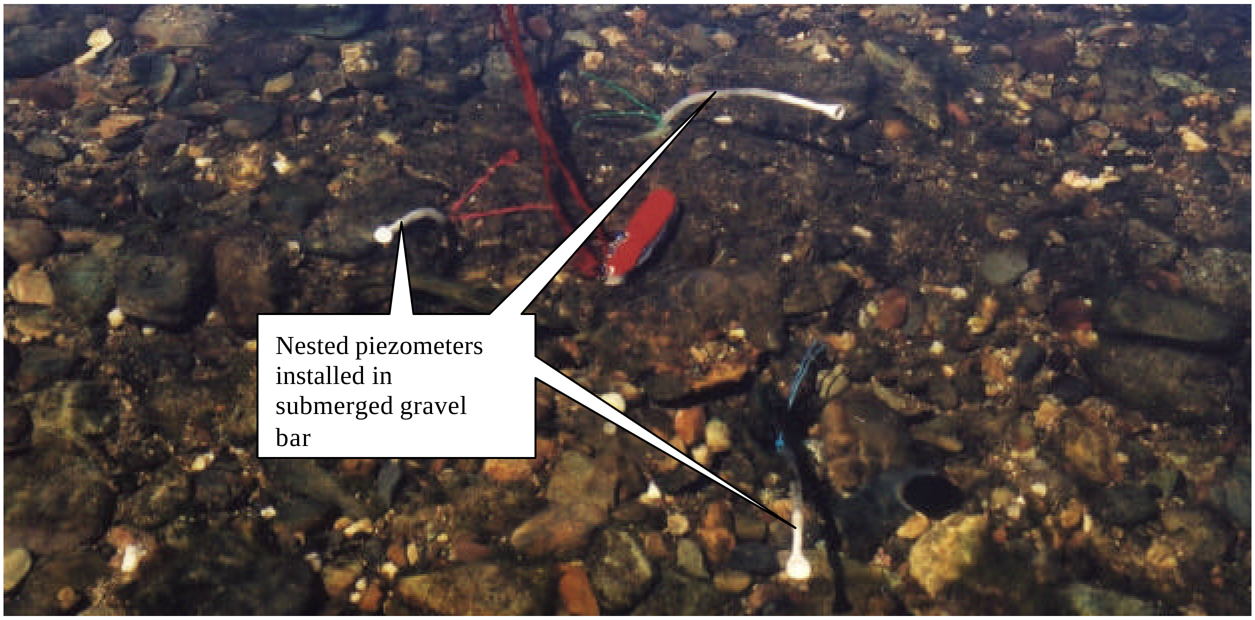
B.

C.

Figure 7A: Sampling tube used to collect water samples from measured depths in the gravel bar. Nests of these tubes are driven to different depths in the gravel. Preliminary work on the Cosumnes River includes installation of 90 of these monitoring points along a one mile reach of the river. Figure 6B: Close-up of top of tube blocked with golf tee. This prevents flow or cross-contamination between surface water and the sample interval. Figure 6C: Close-up of stainless steel tip showing perforations that allow a small volume of water to be withdrawn from a discrete interval.



A.



B.

Figure 8: 90 nested piezometers have been installed as part of a preliminary study on the Cosumnes River. Monitoring points are placed in longitudinal and lateral transects in the streambed and adjacent floodplain. **A.** Nested piezometers have small stainless steel tips that are driven to depths of 30 cm, 60 cm and 1.5 m in the gravel. A thin Teflon tube extends to the surface, allowing later pore water measurements and sampling. Tubes are marked with color-coded plastic ties to identify depth of installation, and the small hand pump is used to develop each monitoring point after installation, and tubes are capped with golf tees to prevent cross flow between intervals with different hydraulic head. **B.** Most of the 28 monitoring points in the mile-long preliminary study are located in shallow submerged portions of the stream bed.

Higher head in stream than at depth indicates losing conditions.

Figure 9: A manometer board is attached to subsurface sampling tubes to measure differences in hydraulic head. Higher head in the stream indicates losing conditions, although gaining conditions (upwelling) are common at the downstream ends of riffles and gravel bars. A baffle box is used to restrict current flow and minimize pressure differences past the open end of the tube.

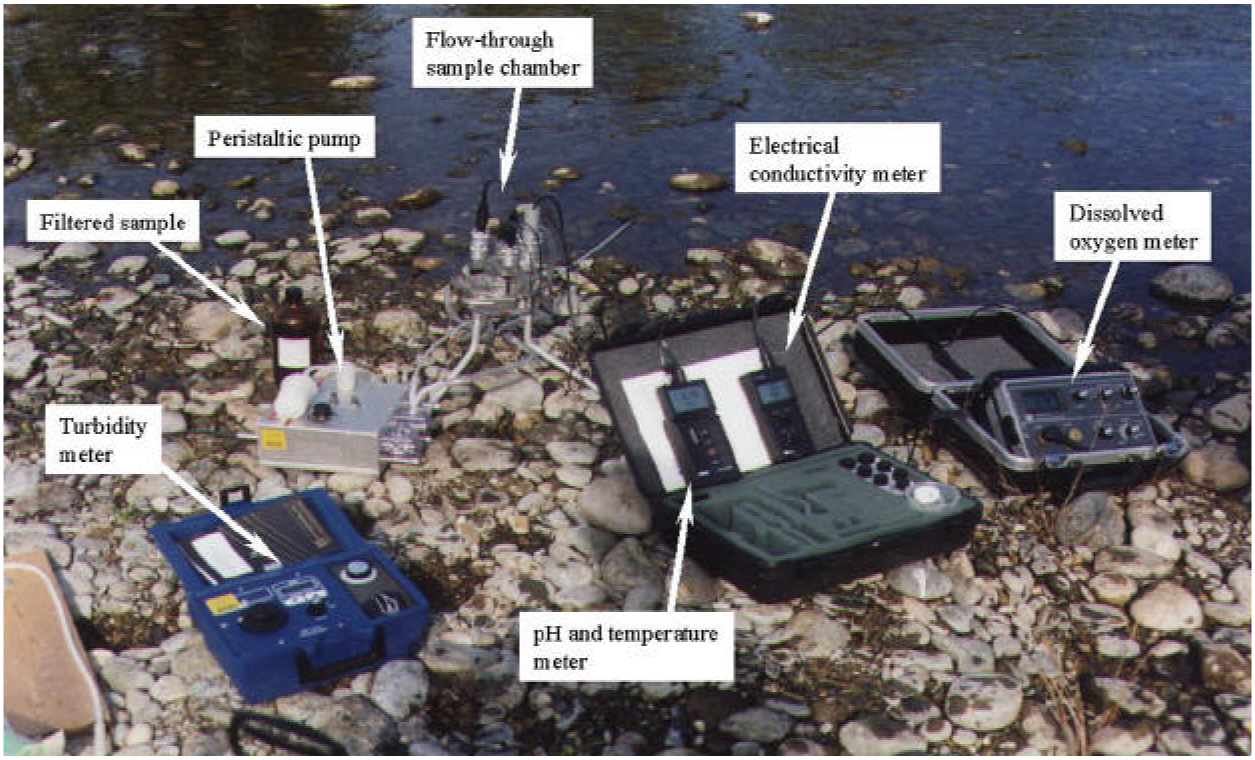


Figure 10: Peristaltic pump, flow through sampling chamber and field meters used to measure field parameters and collect water samples. The peristaltic pump is used to extract low volume water samples from drive point tips installed in the stream bed. Dissolved oxygen is measured with a different YSI meter (model 95) when DO is reported from low flow or standpipe conditions. Most samples (with the exception of total organic carbon) are filtered through a 0.45 micron filter prior to geochemical analysis, and results of metal and nutrient analyses are reported as “dissolved”.

Appendix B: Letters of support and access

EAST BAY MUNICIPAL UTILITY DISTRICT

October 1, 2001

Dr. Timothy Horner
California State University Sacramento
Geology Department
6000 J St.
Sacramento, CA 95819-6043

Dear Dr. Horner:

Thank you for the opportunity to review your proposal for the study of chinook salmon spawning habitat. East Bay Municipal Utility District is very supportive of this study and agrees that the program will add to the understanding, enhancement, and protection of spawning habitat of chinook salmon in the Central Valley of California.

Sincerely,

James R. Smith
Supervising Fisheries and Wildlife Biologist

JM:tc

1 WINEMASTERS WAY . UNIT K2 . LODI . CA 95240 . (209) 333-2095 . FAX (209) 334-3795

FROM : COSUMNES RIVER PRESERVE FAX NO. : 916-683-1702 Sep. 28 2001 12:50PM P2

The Nature Conservancy®

Cosumnes River Preserve
13501 Franklin Boulevard
Galt, California 95632

TEL 916 683 2142
FAX 916 683-1702

International Headquarters
Arlington, Virginia

September 28, 2001

Dr. Tim Horner
Associate Professor
Department of Geology, CSU Sacramento
6000 J St.
Sacramento, CA 95819-6043

Dear Dr. Horner,

I am writing on behalf of The Nature Conservancy's Cosumnes River Preserve to express our support for the Cosumnes River related tasks of your proposal, Physical, Geochemical and Biological Influence on Spawning Site Selection and Egg and Alevin Development by Fall Run Chinook Salmon. This project will address two issues that The Nature Conservancy has attempted to further through its involvement in the Cosumnes River Preserve; the protection and restoration of Cosumnes River chinook salmon and their habitats and the continuing collaboration and cooperation of a wide range of stakeholders working together to ensure the biological and hydrological health of the Cosumnes River.

Starting in 1984, The Nature Conservancy began a focused plan along the Cosumnes River to protect endangered ecosystems while accommodating appropriate growth and sustainable economic development within the region. Today, the Cosumnes River Preserve encompasses approximately 40,000 acres and includes partnerships with state and local agencies, local landowners, businesses and other private partners. TNC's involvement is this very fruitful partnership has shown how collaboration of the nature described in this proposal can ensure positive results that can benefit all stakeholders.

From a habitat restoration perspective, this project will address some of the critical information gaps relating to habitat conditions that are limiting the chinook salmon population in the Cosumnes River. Previous research on the Cosumnes has shown that deficient spawning habitat, specifically poor gravel conditions, is a threat to the future health of the Cosumnes salmon. The data resulting from this project will provide a better understanding of these deficiencies, which will help direct future restoration actions aimed at a healthy, viable chinook salmon population in the Cosumnes River.

The Nature Conservancy welcomes the opportunity to work with your project team on an ongoing basis to improve habitat conditions for chinook salmon on the Cosumnes River.

Sincerely,

Keith Whitener
Project Ecologist

SLOUGHHOUSE RESOURCE CONSERVATION DISTRICT
9701 Dino Drive, Suite 170 Elk Grove, CA 95624

September 26, 2001

Tim Horner, Associate Professor
Department of Geology,
California State University, Sacramento
2003 Placer Hall
6000 J Street
Sacramento, California 95819-6043

RE: Physical, geochemical and biological influence on spawning site selection and egg and alevin development by Fall run Chinook Salmon.

Dear Mr. Horner:

Thank you for allowing the Sloughhouse Resource Conservation District to review your proposal, Physical, geochemical and biological influence on spawning site selection and egg and alevin development by Fall run Chinook Salmon.

We believe that your proposal to study physical, geochemical and biological influences on Chinook salmon ties in well with our own, Cosumnes River Streambed and Riparian Restoration Project. The study you are proposing will also be useful in future restoration projects.

The Sloughhouse Resource Conservation District offers its full support and cooperation, and would encourage other stakeholders within the Cosumnes River Watershed to support your efforts as well. We look forward to continuing our working relationship.

Sincerely,

Bill Mosher-President
Sloughhouse RCD

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Brian A. Bergamaschi, Ph.D.
Water Resources
California District
6000 J Street
Sacramento, CA 95819-6129

Professor Timothy Horner
Geology Department
California State University, Sacramento
6000 J Street
Sacramento, CA 95819-6043

Dear Professor Horner,

This letter is to indicate that your proposal, entitled "Physical, geochemical and biological influence on spawning site selection and egg and alevin development by fall run chinook salmon," has the full support of the USGS California District Carbon Studies group. Accordingly, we will make available to you use of instrumentation to measure and characterize dissolved organic material as described in the proposal. We look forward to working with you on this research.

Sincerely,

Brian A. Bergamaschi
Research Chemist

Noller_James, 03:47 PM 9/10/01 , Access for Geology project on

To: Noller_James
From: Tim Horner <hornertc@csus.edu>
Subject: Access for Geology project on the Cosumnes river
Cc:
Bcc:
Attached:

Mr. Noller,

I am a geologist at CSU Sacramento, and I've had several of my students communicate with you about work we are doing on the Cosumnes River. We are studying Salmon habitat, and are currently spending most of our time in the 1 mile stretch of the Cosumnes River that lies just downstream from the Jackson Highway bridge. My partners in this project are the California Dept. of Fish and Game and a fisheries biologist from UC Davis. I've had students call or e-mail you whenever we are on the river, although until now we have rarely worked upstream as far as Rancho Murieta. Leyland Snyder has given us permission to park vehicles on his land, so most of our work hasn't been visible from the road.

I'm getting ready to submit a larger proposal to the CalFed Bay Delta program, and if this proposal is funded we will start to work on a larger stretch of the river. The critical salmon spawning habitat that we will study extends from the diversion dam upstream from Rancho Murieta to approximately 2 miles downstream from the bridge. CalFed requires me to get permission from private landowners before the proposals are approved, so I would like to confirm that Rancho Murieta will continue to give permission for us to access the river.

If Rancho Murieta agrees, we will continue to inform you any time we plan to work on the river, and our work will be non-destructive. We will also be sensitive to high use times or tournaments at the facility. We don't move gravel or disturb the river bed in any permanent way, and most people are unlikely to see any sign that we have made our measurements. We occasionally insert 1/4" clear plastic tubing in the gravel so that we can collect samples, but this work is approved by the Dept. of Fish and Game, and all tubing will be removed when the project is complete.

Are you in a position to give access through the Rancho Murieta complex? It would be a big help to have a note to this effect. I would be happy to visit, talk to board members, or answer questions if needed. We appreciate your cooperation when our students have asked for river access in the past, and I hope we can continue this relationship as we start a new project.

Sincerely,

Tim Horner

Printed for Tim Horner <hornertc@csus.edu> **1**

From: "Jim Noller" <jnoller@ranchomurietacsd.com>
To: <hornertc@csus.edu>
Subject: River Access
Date: Wed, 19 Sep 2001 14:34:59 -0700
X-Mailer: Microsoft Outlook IMO, Build 9.0.2416 (9.0.2911.0)
Importance: Normal

Mr. Horner,

I returned from vacation to find your email request for river access. I hope that my delay in response to you has not hindered your project in any way.

I have contacted the agencies that governs access to the community and they have agreed to allow you access through the north gate.

Please call me each time that you wish to gain access at 354-3710 and I will let the gate know of your arrival time.

Once again I hope that my delay has not inconvenienced you in any way.

Sincerely,

Chief Jim Noller

Appendix C: Resumes of Principle Investigators

Timothy C. Horner

Department of Geology, 6000 J St.
CSU Sacramento
Sacramento, CA 95819-6043
(916) 278-5635

5840 Spilman Ave.
Sacramento, CA 95819
HornerTC@CSUS.edu
(916) 736-1878

PROFESSION

Hydrogeologist and sedimentologist, Associate professor

RESEARCH INTERESTS

Field methods in hydrogeology, ground water- surface water interaction, hydrogeology and geochemistry of salmon spawning gravels, geochemical reactions in near-surface environments, Cenozoic stratigraphy of northern California, chemistry and mineralogy of sedimentary rocks, climatic indicators in sedimentary rocks, geostatistics.

EDUCATION

Ph.D.	Ph.D. Geology, Fall 1992: Ohio State University, Columbus, OH. Dissertation title: Sedimentologic, mineralogic and geochemical evaluation of the provenance and paleoclimatic record of Permian mudrocks from the Beardmore Glacier area, Antarctica.
Masters degree	M.S. Geology, August 1986: Texas Tech Univ., Lubbock, TX. Thesis title: Depositional environments, diagenesis and porosity relationships in the Mission Canyon Formation, Elkhorn Ranch Field, Billings County, North Dakota.
Bachelors degree	B.S. Geology, May 1979: Bucknell University, Lewisburg, PA.

CONTINUING EDUCATION

2000: Hydrogeology of the Lake Tahoe Basin: GSA post-meeting field trip, Nov. 17-18.
1999: Principles and applications of dating young ground water: U.S. Geological Survey Western Region Workshop, Nov. 16-18, Sacramento, CA.
1999: Groundwater modeling short course: UC Cooperative Extension Groundwater Hydrology Program, May 11-13, Sacramento, CA.
1998: Introduction to vadose zone modeling: 1998 GRA Seminar Series, June 15-17, Sacramento, CA.
1997: Innovative Soil Gas Monitoring and Remediation Applications: GRA Seminar Series, September 24-25, Sacramento, CA.
1996: Rapid site characterization: Process, Tools and data quality: Groundwater Resources Association, Nov. 20, Sacramento, CA.
1995: Engineering and environmental geophysics short course: AEG/GRA annual meeting, October 7, Sacramento, CA.

GRANTS AND AWARDS

2001/2003: Key participant and contributing author for $400,000 grant from W.M. Keck Foundation for *Proposal to establish the W.M. Keck Foundation Facilities for applied hydrogeology at California State University, Sacramento.*

1999/2001: Lead author on NSF CCLI A&I grant for $105,152 titled *Water quality and stream flow as teaching tools in geology.*

1999/2000: CSUS Research and Creative Activities award to study *Cenozoic sedimentation in the Sacramento area*; 8 units release time, one month summer fellowship and $550.

1996/97: Co-author on $221,000 grant from W.M. Keck Foundation to *Establish Laboratories for hydrogeologic studies.*

1996/97: CSUS Minigrant for *Development of long-term groundwater monitoring instrumentation at the CSUS wellfield*; 3 units release time and $650.

1995/96: CSUS Research and Creative Activities award for *Data analysis of the stratigraphy, provenance and climatic variability of the Eocene Bridger Formation, southwestern Wyoming*; 6 units release time and $650.

1995: CSUS Research and Creative Activities Summer Fellowship for *Field study of the stratigraphy, provenance and climatic variability of the Eocene Bridger Formation, southwestern Wyoming*; 2 months summer salary.

1995: California Lottery Fund award for *Hydrogeology program*; $10,000 equipment grant.

1994/95: CSUS Research and Creative Activities award for *Data analysis of the depositional environments, paleosols and marker beds of the Eocene Bridger Formation, southwestern Wyoming*; $1,500 monetary award to cover geochemical analyses.

1994/95: CSUS System-wide Scholarship and Creative Activity award to study *Variability in hydraulic conductivity and water supply in the Mehrten aquifer, Sacramento, CA*; $5,000 equipment grant.

1994: CSUS Research and Creative Activities Summer Fellowship for *Field study of the depositional environments, paleosols and taphonomy of the Eocene Bridger Formation, southwestern Wyoming*: 2 months summer salary.

PROFESSIONAL EXPERIENCE

Associate Professor: August 1993 to present. Geology Department, CSU Sacramento. Classes include hydrogeology, field methods in hydrogeology, sedimentology/ stratigraphy, field mapping, oceanography and introductory geology courses.

Short course instructor: August 17-18, 1999. Guest instructor for US Army Corps of Engineers Hydrologic Engineering short course: Wrote materials and taught field session on aquifer analysis (pumping tests) and lecture session on vadose zone transport.

Staff Scientist: May, 1993 to August, 1993: Environmental consultant with Geraghty and Miller, Inc., Dublin, Ohio. Performed analysis of sedimentologic and geochemical data and assisted in preparation of a superfund draft document.

Geology Instructor: Winter, 1993: Taught environmental science and physical oceanography at Otterbein College, Westerville, Ohio.

Research Assistant: Fall, 1990 to Fall, 1992: Analyzed fine-grained sedimentary rocks and paleosols for dissertation research. Techniques included x-ray diffraction to determine mineral composition and organic carbon analysis as an indicator of primary productivity.

Research Assistant: Fall, 1985 to Summer 1987 and Fall, 1988 to Spring, 1989: Performed laboratory analysis of fine-grained oceanic sediments at The Ohio State University. Methods included wet chemistry to remove organic material and amorphous silica, size segregation by density settling and centrifugation, semi-quantitative x-ray diffractometry to determine relative mineral abundance and carbon analysis using a Coulometrics carbon analyzer to measure organic and inorganic carbon contents.

Geologist/Engineer: Summer, 1983: Analyzed and inventoried rock quarries for the U.S. Forest Service in Baker, Oregon. Estimated existing quarry volumes and searched for gravel reserves in the Wallowa-Whitman National Forest.

Exploration Geologist: November, 1980 to September, 1981: Worked with a geophysicist and petrophysicist as part of an exploration team at J.W. Humbard and Assoc., Midland, Texas. Developed prospects in the northeastern Midland Basin and eastern shelf.

Mud Logger: November, 1979 to September, 1980 and November, 1981 to August, 1982: Employed by Core Laboratories and Advance Consultants, Midland, Texas. Analyzed and identified samples, monitored gas levels with a gas chromatograph and drafted logs during drilling of oil wells.

ABSTRACTS

Horner, T. C., and Bush, N. J., 2000, abs., Small scale gain and loss and geochemical variability of pore water in the hyporheic zone of a gravel bar used for salmon spawning in the American River, California: Geological Society of American Abstracts with Programs, v. 32, no. 7., p. 141.

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Horner, T. C., and Fahning, R. M., 1997, abs., Stream bed permeability and bank storage in the American River near Sacramento, California: Geological Society of America Abstracts with Programs, v. 29, no. 6., p. 334.

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Godwin, T. N., and **Horner, T. C.,** 1996, abs., Rapid episodic tectonic activity of the Uinta mountains as observed by stratigraphy and sedimentation of the Oligocene Bishop conglomerate, Wyoming and Utah: Geological Society of America Abstracts with Programs, v. 28, no. 6, p. 279.

Burns, D.M., **Horner, T. C.,** Godwin, T. N., Schinke, K., Baxter, WE, Affonso, J. A., and Flores, T., 1995, abs., Depositional environments and ash bed geochemistry of the Eocene Bridger Formation, southwestern Wyoming: Geological Society of America Abstracts with Programs, v. 27, no. 6, p.

Horner, T. C., 1995, abs., On-Campus wellfield at California State University, Sacramento as a teaching tool in environmental geoscience: Geological Society of America Abstracts with Programs, vol. 27, no. 6, p.

Horner, T. C., McClenahen, L. M., and Baumgarten, D. J., 1995, abs., Facies control of spatial variability in a shallow fluvial aquifer system: Association of Engineering Geologists Abstracts with Programs, p. 57.

Horner, T. C., 1994, abs., Mudrock mineralogy as an indicator of changing sediment supply in altered Permian mudrocks from the Beardmore Glacier region, Antarctica: Geological Society of America Abstracts with Programs, v. 26, no. 7, p. 243.

Horner, T. C., 1993, abs., Transition metals and trace elements as indicators of changing sediment supply in altered Permian mudrocks from the Beardmore Glacier region, Antarctica: Geological Society of America Abstracts with Programs, v. 25, no. 6, p. 466.

Krissek, L. A., and **Horner, T. C.,** 1992, abs., Paleoenvironmental controls on Permian sediment production along the paleo-Pacific margin of Antarctica: evidence from geochemistry, paleoslopes and paleosols: Geological Society of America Abstracts with Programs, v. 24, p. 193.

Horner, T. C., and Krissek, L. A., 1991, abs., Geochemical and statistical analysis of Permian mudrocks from the Beardmore Glacier region, Antarctica: Geological Society of America Abstracts with Programs, v. 23, no. 5, p. 70.

Krissek, L. A., and **Horner, T. C.,** 1991, abs., A record of Late Carboniferous (?)-Permian climatic change from the Beacon Supergroup of the central Transantarctic Mountains. Abstracts volume 13, International Sediment. Congress, Nottingham, p. 285.

Horner, T. C., and Krissek, L. A., 1990, abs., Sedimentologic implications of the geochemistry of fine-grained Permian sediments from the Beardmore Glacier region, Antarctica: Geological Society of America Abstracts with Programs, v. 22, no. 7, p. 318.

Horner, T. C., 1990, abs., Distribution of total organic carbon and controls on its occurrence within the Beacon Supergroup, central Transantarctic Mountains: Geological Society of America Abstracts with Programs, v. 22, no. 5, p. 14.

Horner, T. C., and Jacka, A. D., 1989, abs., Rock fabric as a control on dolomitization and paragenesis in the Mississippian Mission Canyon Formation of the Williston Basin: Geological Society of America Abstracts with Programs, v. 21, no. 5, p. 95.

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Krissek, L. A., and **Horner, T. C.,** 1988, abs., A preliminary study of REE distributions in mudrocks of the Permian Beacon Supergroup, Central Transantarctic Mountains: Evidence for early development and preservation of LREE enrichment: American Association of Petroleum Geologists Bulletin, v. 72, p. 208.

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PUBLICATIONS

Horner, T. C., and Giorgis, B., 2000, Sedimentology and petrography of the Mehrten, Fair Oaks and Arroyo Seco Formations: AEG Spring Field trip guidebook, Sacramento Chapter, pp. 1-21.

Masood, K. R., Taylor, T. N., **Horner, T.,** and Taylor, E. L., 1994, Palynology of the Mackellar Formation (Beacon Supergroup) of East Antarctica: Review of Palaeobotany and Palynology, v. 83, p. 329-337.

Taylor, T. N., Taylor, E. L., **Horner T.,** and Masood., K. R., 1993, Palynostratigraphy of the Mackellar Formation (Beacon Supergroup), East Antarctica: Antarctic Journal of the United States, v. 28, no. 5, p. 32-33.

Horner, T. C., 1992, Sedimentologic, Mineralogic and geochemical evaluation of the provenance and paleoclimatic record of Permian mudrocks from the Beardmore Glacier area, Antarctica: Ph.D. Dissertation, Columbus, Ohio, The Ohio State University, 354 p.

Horner, T. C., and Krissek, L. A., 1992, Statistical analysis of geochemical patterns in fine-grained Permian sediments from the Beardmore Glacier region, Antarctica: in Yoshido, Y., ed., Sixth International Symposium on Antarctic Earth Sciences, Ranzan-Machi, Japan, p. 241-248.

Krissek, L. A., **Horner, T. C.,** Elliot, D. H., and Collinson, J. W., 1992, Stratigraphy and sedimentology of vertebrate bone-bearing beds in the Triassic (and Jurassic?) Fremouw and Falla Formations, Beardmore Glacier region, Antarctica: in Yoshido, Y., ed., Sixth International Symposium on Antarctic Earth Sciences, Ranzan-Machi, Japan.

Horner, T. C., and Krissek, L. A., 1991, Sedimentology, thermal alteration and organic carbon content as factors in paleoenvironmental interpretation of fine-grained Permian clastics from the Beardmore Glacier region, Antarctica: in, Contributions to Antarctic Research II, Antarctic Research Series, v. 53, edited by D. H. Elliot, Washington, American Geophysical Union, p. 33-65.

Horner, T. C., and Krissek, L. A., 1991, Permian and Triassic Paleosols from the Beardmore Glacier region, Antarctica: Antarctic Journal of the United States, v. 26, no. 5, p. 7-8.

Krissek, L. A., and **Horner, T. C.,** 1991, Clay mineralogy and Provenance of fine grained Permian clastics, central Transantarctic Mountains: in, Geologic Evolution of Antarctica, edited by M.R.A. Thomson, J.A. Crame and J.W. Thomson, Cambridge, England, Cambridge University Press, p. 209-214.

Horner, T. C., and Krissek, L. A., 1989, Organic carbon characteristics in the Permian Mackellar Formation, central Transantarctic Mountains: Antarctic Journal of the United States, v. 24, no. 5, p. 17-19.

Krissek L. A., and **Horner, T. C.,** 1988, Geochemical record of provenance in fine-grained Permian clastics, central Transantarctic Mountains: Antarctic Journal of the United States, v. 23, no. 5, p. 19-21.

Krissek, L. A., and **Horner, T. C.,** 1987, Provenance evolution recorded by fine grained Permian clastics, central Transantarctic Mountains: Antarctic Journal of the United States, 1987 Review, v. 22, no. 5, p. 26-28.

Krissek, L. A., and **Horner, T. C.,** 1986, Sedimentology of fine-grained Permian clastics, central Transantarctic Mountains: Antarctic Journal of the United States, 1986 review, v. 21, no. 5, p. 30-32.

SENIOR THESIS PROJECTS SUPERVISED

Orlando, J., 2000, A comparison of the characteristics influencing runoff and transport of dormant spray pesticides in the Sacramento and San Joaquin River Watersheds of the Central Valley of California: Bachelor's thesis, CSUS.

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Dalton, S., 1999, Effects of sampling techniques on water level, temperature, pH, turbidity, specific conductance and dissolved oxygen measurement: unpublished Bachelor's thesis, CSUS, 40 p.

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Lewis, S., 1999, The role of the Silver Creek Fault in the hydrologic framework of the Santa Clara Valley, California: unpublished Bachelor's thesis, CSUS, 21 p.

Risse, G., 1999, Comparison of discharge at Folsom Dam vs. River stage at H St. Gaging Station, American River: unpublished Bachelor's thesis, CSUS, 23 p.

Branum, D., 1998, Determining the hydraulic conductivity of porous materials using Darcy Flow tubes: unpublished Bachelor's thesis, CSUS, 22 p.

Brown, J., 1998, Application of resistivity measurements in determining depth of water table from land surface: unpublished Bachelor's thesis, CSUS, 25 p.

Joseph, T., 1998, Determining the hydraulic conductivity and transmissivity of a confined aquifer using manual and pneumatic slug testing: unpublished Bachelor's thesis, CSUS, 36 p.

Perry, D. L., 1998, The use of a peizometer/manometer and seepage meter to determine the seasonal variations of vertical groundwater flow in relation to the lower reaches of the Cosumnes River: unpublished Bachelor's thesis, CSUS, 28 p.

Robbins, J. B., 1998, A spatial survey of pesticide detection in the Sacramento Valley using USGS rice and subunit well data: unpublished Bachelor's thesis, CSUS, 59 p.

Carey, B., 1997, Depositional environments of a marine deposit at Bodega Head, California: unpublished Bachelor's thesis, CSUS, 19 p.

Hansel, C., 1997, Comparative water-quality assessment of the Tangshan region, People's Republic of China, and the San Joaquin Basin and Sacramento River Basin of California and the Delmarva Peninsula of Delaware, Maryland and Virginia: unpublished Bachelor's thesis, CSUS, 44 p.

Affonso, J., 1996, Groundwater study of Fairplay, California: unpublished Bachelor's thesis, CSUS, 28 p.

Baxter, W. E. G., 1996, Physical and geochemical analysis of ash units from the Eocene Bridger Formation, southwestern Wyoming: unpublished Bachelor's thesis, CSUS, 21 p.

Burns, D. M., 1996, A sandstone provenance study of the Bridger Basin, Rock Springs, Wyoming: unpublished Bachelor's thesis, CSUS, 26 p.

Burns, T. A., 1996, Analysis of lower water-bearing unit at the California State University Sacramento wellfield: unpublished Bachelor's thesis, CSUS, 41 p.

Fahning, R. Martin, 1996, The use of a stream permeameter to determine variations of vertical groundwater flow in relation to the American river near the CSUS campus: unpublished Bachelor's thesis, CSUS, 19 p.

Ferry, D., 1996, Shallow seismic refraction and downhole survey at California State University, Sacramento: unpublished Bachelor's thesis, CSUS, 33 p.

Flores, Tippi, 1996, Paleocurrent indicators in the Mehrten Formation: Sacramento regional quadrangle: unpublished Bachelor's thesis, CSUS, 37 p.

Fortuna, J., 1996, Stratigraphy of lacustrine sediments of the Island at Honey Lake, LassenCounty, California: unpublished Bachelor's thesis, CSUS, 32 p.

Giorgis, R. B., 1996, A provenance study of Cenozoic formations in the Sacramento area: unpublished Bachelor's thesis, CSUS, 22 p.

Godwin, T. N., 1996, Rapid episodic tectonic activity of the Uinta Mountains as observed by stratigraphy and sedimentation of the Oligocene Bishop Conglomerate, Wyoming and Utah: unpublished Bachelor's thesis, CSUS, 16 p.

Rummler, M., 1996, Aquifer hydraulic properties determined from the frequency response of water levels in wells to earth tides and atmospheric loading: unpublished Bachelor's thesis, CSUS, 46 p.

Schreiner, D., 1996, Variations in influent vs. effluent condiitons at the lower reach of the American River: unpublished Bachelor's thesis, CSUS, 22 p.

Heberle, L. A., 1995, Use of slug test data to determine the lateral and vertical facies variability in confined and semi-confined aquifers at the CSUS wellfield: unpublished Bachelor's thesis, CSUS, 56 p.
Heineman, A., 1995, Shallow seismic reflection-refraction survey of the wellfield at California State University, Sacramento: unpublished Bachelor's thesis, CSUS, 89 p.
McClenahen, L., 1995, Temporal variability in: aquifers in the CSUS wellfield, the American river, and precipitation at the CSUS campus: unpublished Bachelor's thesis, CSUS, 34 p.
Schmitt, H., 1995, Tephrochronology from four ocean cores near southern Mexico and central America: unpublished Bachelor's thesis, CSUS, 37 p.
Baumgarten, D. J., 1994, A hydrogeologic study of Pliocene/Pleistocene sediments beneath the California State University Sacramento Campus: unpublished Bachelor's thesis, CSUS, 58 p.
Chamberlain, L., 1994, Pliocene to Recent geology beneath the CUS campus and the Fairbairn water treatment plant: unpublished Bachelor's thesis, CSUS, 38 p.
Oehrli, C., 1994, The geology of Meiss Meadows and channel morphology of Creek #4, Alpine Co., California: unpublished Bachelor's thesis, CSUS, 33 p.

John Garrett Williams
875 Linden Lane, Davis, CA 95616
530-753-7081 (voice); 530-756-3784 (fax)
jgwill@dcn.davis.ca.us

Curriculum vitae

EDUCATION

1978-1979: Postdoctoral Scholar with Dr. Park Nobel, Environmental Biology Section, Laboratory of Nuclear Medicine and Radiation Biology, University of California, Los Angeles.

1978: Ph.D., Geography, University of California, Los Angeles, with emphasis on climatology, soils, and agricultural geography; thesis title: A method for obtaining more climatological information from short observational records.

1966: B.A., History, University of California, Berkeley.

PROFESSIONAL EXPERIENCE

1990-present: Independent consultant

1997-present: Executive Director, Bay-Delta Modeling Forum (part time).

1990-present Special Master, *Environmental Defense Fund v. East Bay Municipal Utility District*.

1985-1990: Senior Associate, Philip Williams & Associates, Ltd., San Francisco.

1984-1985: Principal, Williams, Kondolf and Swanson, Carmel, California.

1982-1983: Environmental Analyst, Monterey Peninsula Water Management District.

1982: Visiting Professor, Department of Geography, Kent State University, Kent, Ohio.

VOLUNTEER TEACHING

1997: Co-taught a graduate seminar on instream flow issues with Dr. Peter Moyle, Department of Wildlife, Fish and Conservation Biology, University of California, Davis (WFC 291).

PUBLIC SERVICE

1978-1981 and 1983-1987 Director, Monterey Peninsula Water Management District (elected).

1976-1978: Member, Zone 11 Advisory Committee to the Monterey County Flood Control and Water Conservation District (appointed).

OTHER RECENT EXPERIENCE

2000 Member, CALFED scientific and geographic review panels for Ecosystem Restoration Program grant proposals.

2000 Member, peer review panel for EPA Region 10, regarding development of temperature criteria guidance for Clean Water Act implementation in the Pacific Northwest.

2000 Staff, expert review of instream flow issues in coastal watersheds for the (California)
State Water Resources Control Board.

1999-2000: Member, core teams writing white papers on Sacramento River restoration flows, Central Valley salmonids, and fluvial geomorphology for the CALFED Bay-Delta Program.

1999 Member, CALFED technical review panel for grant proposals on fish management and hatchery operations.
1998: Chair, geomorphology and riparian issues work team, Comprehensive Assessment and Monitoring Program (CMARP) of the CALFED Bay-Delta Program.
1988-Present: Representative, Ventana Chapter of the Sierra Club, in State Water Resources Control Board hearings regarding the Carmel River and other water rights proceedings.
1995-1996: Participant, Central Valley Project Improvement Act Restoration Fund Roundtable.
1994-1996: Participant, Lower American River Task Force.
1994-1995: Member, Hydromodification technical advisory committee, State Water Resources Control Board.

OTHER WORK EXPERIENCE
1980-1981: Owner/Manager, Pacific Mushroom Company, San Francisco.
1963-1971: Commercial fisherman, Alaska and California (sporadically).

AWARDS
Ventana Chapter, Sierra Club, 1999 Outstanding Service Award.

PROFESSIONAL ORGANIZATIONS
American Fisheries Society
Ecological Society of American
American Association for the Advancement of Science
Bay-Delta Modeling Forum

PUBLICATIONS
Papers published in refereed journals:
Williams, J.G. In press. Chinook salmon in the lower American River, California's largest urban stream. *In* R. Brown, editor, Contributions to the biology of anadromous salmonids of the Central Valley, California. Fish Bulletin 179. California Department of Fish and Game, Sacramento.

Kondolf, G.M., E.W. Larsen, and J.G. Williams. Measuring and modeling the hydraulic environment for assessing instream flows. In press. North American Journal of Fisheries Management.

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Williams, J.G. 1997. Testing the independence of microhabitat preferences and flow. Comment. Transactions of the American Fisheries Society 126:536-537.

Castleberry, D.T., J.J. Cech Jr., D.C. Erman, D. Hankin, M. Healey, G.M. Kondolf, M. Mangel, M. Mohr, P.B. Moyle, J. Nielsen, T.P. Speed, and J.G. Williams. 1996. Uncertainty and instream flow standards. Essay, Fisheries:21(8):20-21.

Williams, J.G. 1996. Lost in space: minimum confidence intervals for idealized PHABSIM studies. Transactions of the American Fisheries Society 125:458-465.

Kondolf, G.M., L.M. Maloney, and J.G. Williams. 1987. Effects of bank storage and well pumping on base flow, Carmel River, Monterey County, California. Journal of Hydrology 91:351-369.

Woodhouse, R.M., P.S. Nobel, and J.G. Williams. 1983. Simulation of plant temperature and water loss by the desert succulent *Agave deserti*. Oecologia (Berlin) 57:291-297.

Williams, J.G. 1981. Eigenvector filtering of three-dimensional pressure field data. Journal of Applied Meteorology 20:59-65.

Woodhouse, R.M., P.S. Nobel, and J.G. Williams. 1980. Leaf Orientation, radiation interception, and nocturnal acidity increase in the CAM plant, *Agave deserti*. American Journal of Botany 63:1179-1185.

Williams, J.G. 1976. Small variation in the photosynthetically active fraction of solar radiation. Arch. Met. Geoph. Biokl., Ser. B 24:209-21.

Williams, J.G. 1976. Change in the transmissivity parameter with atmospheric path length. Journal of Applied Meteorology 15:1321-1223.

Papers published in symposium proceedings:

Williams, J.G. and G. M. Matthews. 1990. Willow ecophysiology: implications for riparian restoration. Pages 196-202 *in* Environmental Restoration, J. Berger (ed.) Island Press, Washington, DC.

Kondolf, G.M., P. Vorster, and J.G. Williams. 1990. Hydraulic and channel stability considerations in stream habitat restoration. Pages 214-227 *in* Environmental Restoration, J. Berger, (ed.) Island Press. Washington, DC.

Williams, J.G. 1989. Interpreting physiological data from riparian vegetation: cautions and complications. Pages 381-386 *in* Proceedings of the California Riparian Systems Conference: Protection, Management in the 1990's, Sept. 22-24, 1988, Davis, California. Gen. Tech. Rept. PSW-110, Forest Service, USDA, Berkeley, CA.

Williams, M. and J.G. Williams. 1989. Avifauna and riparian vegetation in Carmel Valley, Monterey County, California. Pages 314-318 *in* Proceedings of the California Riparian Systems Conference: Protection, Management in the 1990's, Sept. 22-24, 1988, Davis, California. Gen. Tech. Rept. PSW-110, Forest Service, USDA, Berkeley, CA.

Williams, J.G. 1983. Habitat change in the Carmel River basin. Pages 5-26 *in* Channel Stability and Fish Habitat, Carmel River, California. Guidebook to symposium and field conference, June 16-18, Monterey, California.

Invited book reviews:

Williams, J.G. 1996. California Water, by A.L. Littleworth and E.L. Garner. Estuaries (Journal of the Estuarine Research Federation) 19:753

Abstracts:

Williams, J.G. and G. Matthews. 1987. The 1983 erosion event on Tularcitos Creek, Monterey County, California, and its aftermath. Proceedings of the California Watershed Management Conference, Nov. 18-20, West Sacramento, Calif. University of California Wildlands Resources Center Report No. 11.

McNeish, C., G. Matthews, and J.G. Williams. 1984. Effects of groundwater pumping on water stress in riparian trees in Carmel Valley, California. Agronomy Abstracts.

Letters in professional journals:

Fisheries 20(9):38, 1995, regarding the temperature tolerance of juvenile chinook salmon.

Edited works:

Williams, J.G., ed. 1997. Transcript of Workshop on instream flow standards, University of California-Davis, April 7, 1995. Water Resources Center Report No. 89, Centers for Water and Wildlands Resources, University of California, Davis, CA 95616.

Williams, J.G. 1993. Notes and selected abstracts from the workshop on Central Valley chinook salmon, UC Davis, January 4-5.

Williams, J.G., G.M. Kondolf, D. Lindquist, and B. Laclergue. 1989. Politics and pracitices of restoration. Guidebook for symposium and field tour, Carmel River watershed, October 6-7, sponsored by the Watershed Management Council.

Williams, J.G., and G.M. Matthews. 1983. Channel stability and fish habitat, Carmel River, California. Guidebook for symposium and field tour, June 16-18. Sponsored by the Monterey Peninsula Water Management District and the California Department of Fish and Game.

Significant works of limited distribution:

Williams, J.G. 1998. Thoughts on adaptive management. Newsletter, Interagency Ecological Program for the Sacramento-San Joaquin Estuary 11(3):5-11.

Williams, J.G. 1995. Report of the Special Master, Environmental Defense Fund v. East Bay Municipal Utility District, Alameda County (California) Action 425955.

MEETINGS AND SYMPOSIA ORGANIZED

River Ecosystems: New Directions and Challenges in Setting Instream Flows. August 1997. Symposium at the 1997 National Meeting of the American Fisheries Society, Monterey, California. (with W. Lifton and S. Williamson.)

Workshop on Instream Flow Standards: April 7, 1995. (sponsored by the Centers for Water and Wildlands Resources, University of California, Davis.) Davis, California.

Biology of the Sacramento-San Joaquin river system: life in the new regulatory environment. June 29, 1993. Special session, joint conference of the Western Association of Fish and Wildlife Agencies and Western Division, American Fisheries Society. Sacramento, California.

Workshop on Central Valley chinook salmon: Jan. 4-5, 1993. (sponsored by UC Davis Dept. of Wildlife and Fisheries Biology, organized with Joe Cech, Peter Moyle, Keith Marine, and Dan Castleberry) Davis, California.

Rivers in the city: design and management in the age of public trust. Nov. 2-3, 1990, at UC Berkeley. (sponsored by the UC Berkeley Dept. of Landscape Architecture, organized with G.M. Kondoff) Berkeley, California.

Politics and practices of restoration: symposium and field tour, Carmel River Watershed. Sponsored by the Watershed Management Council. October 6-7, 1989. (organized with G. M. Kondolf, D. Lindquist, and B. Laclergue). Carmel, California.

Channel stability and fish habitat, Carmel River, California. June 16-18, 1983. (sponsored by CDFG, Packard Foundation, and MPWMD, organized with G.M. Kondolf). Monterey, California.

INVITED TALKS

The Hodge Decision as adaptive management. 14th Annual Environmental Law Conference, Exploring the Confluence of Environmental Law and Science. University of California, Davis, March 17, 2000.

Invited participant, Instream Flow Methods Conference, Water Resources Inventory Area 1 (Northwestern Washington State), September 15-17, 1999.

Uncertainty and instream flow assessments: lessons from the American River Experience. Assessment Methods Workshop, Water Use Planning Process. B.C. Hydro. Vancouver, Canada. June 15-26, 1999.

Invited participant, International Workshop on Ecosystem-Based Management in the Coastal Zone, University of British Columbia, Vancouver, Canada. May 26-28, 1999.

Thoughts on adaptive management and its application to Clear Creek, Shasta County, California. American Fisheries Society, California-Nevada Chapter, 1999 annual meeting. March 26, Redding, California.

Future scenarios: water in and from the Carmel River. Salmonid Restoration Federation, 1999 annual meeting, session on Coordinated Basin Management for the Carmel River. February 19, Brookdale, California.

Subsurface flow and percolating groundwater: Carmel River case study. Groundwater Resources Association of California annual meeting, Walnut Creek, California, 23 October 1998.

Setting instream flows in the face of uncertainty: adaptive management, the precautionary principle, and the public trust. California-Nevada Chapter of the American Fisheries Society, 1998 annual meeting, symposium on stream flow conditions below dams: biology and law. April 23, Sacramento, California.

Setting instream flow standards in large rivers: the American River experience. 1997 National Meeting of the American Fisheries Society, symposium on instream flows. August 27. Monterey, California.

PHABSIM is a broken compass. Northeast Division of the American Fisheries Society, 1997 annual meeting, special session on instream flows. April 28, Framingham, Mass.

Research needed for effective implementation of the Central Valley Project Improvement Act. 1993 Joint conference of the Western Association of Fish and Wildlife Agencies and the Western Division, American Fisheries Society. June 29. Sacramento, California.

OTHER AREAS OF EXPERIENCE
Consulting experience with stream and wetland restoration, fluvial geomorphology, flood management, water rights, and water supply. Recent consulting project include several geomorphic assessments of Sacramento River and its tributaries that provide a framework within which to assess proposed restoration projects at specific sites.

T. Griggs, G. M. Kondolf, E. Larsen, S. McBain, M. Tompkins, J. Vick and J.G. Williams. 2000. Flow regime requirements for habitat restoration along the Sacramento River between Colusa and Red Bluff, prepared for the CALFED Bay-Delta Program, Sacramento.

G. M. Kondolf and J.G. Williams. 1999. Flushing flows: a review of concepts relevant to Clear Creek, Shasta County, California, prepared for the US Fish and Wildlife Service, Red Bluff.

J. G. Williams and G. M. Kondolf. 1999. Rehabilitation concepts for lower Clear Creek, Shasta County, California, prepared for the US Fish and Wildlife Service, Red Bluff.

G.M. Kondolf, M. Smeltzer, J.G. Williams, and N. Lassettre. 1999. Geomorphic study of Mill Creek, Tehama County, California, prepared for the US. Fish and Wildlife Service, Stockton.

J.G. Williams, G.M. Kondolf, E. Ginney and N Lassettre. In preparation. Geomorphic study of Butte Creek, Butte County, California, for the U.S. Fish and Wildlife Service, Stockton.

KRISTY ANN VYVERBERG

Geology, Geomorphology, Hydrology and Engineering Geology

Office: State Department of Fish and Game
1516 Ninth Street
Sacramento, CA 95814
(916) 653.8711
e-mail: kavberg@dfg.ca.gov

Home: 2974 Govan Way
Sacramento, CA 95818
(916) 448.7321
e-mail: kvyverberg@aol.com

KEYWORD SUMMARY

Registered geologist, fluvial geomorphologist, geotechnical expertise, watershed and floodway management, river restoration project design and construction, channel and floodplain relationships, anadromous fishery habitat monitoring and management,
instream flow evaluations, sediment management, natural resource management plan
and policy development, private sector and extensive State and Federal agency experience.

CAPABILITIES, WORK PRODUCT & SKILL SET

General:
Geologic Mapping
Geotechnical Expertise
Project Design, Construction & Evaluation
Field Project Management
Baseline & Post-Project Monitoring
Natural Resource Management Plans
Aerial Photography Analysis
Geologic & Geomorphic Field Mapping
Surface Water & Sediment Sampling
Graphical Representation of Data
Assessment
Database Management
Technical Writing
Grant Writing

Recreational Land Use:
Natural Hazard Evaluation
Natural Resource Inventories
Geologic Site Assessment

Watershed Management:
Channel Function Evaluations
Channel Stabilization
Instream Flow Analysis
Salmonid Habitat Assessment
Salmonid PopulationMonitoring
Sediment Sampling & Analysis
Sediment Management Plans
Floodplain Restoration Plans
Habitat Enhancement Projects
Aquatic Ecosystem
Aquatic Ecosystem Monitoring

Regulatory:
Stream Corridor Alterations
Instream Flow Requirements
Project Evaluation & Mitigation
CEQA & NEPA Regulations

Social:
Interdisciplinary Communication & Training
Interdisciplinary Project Development, Design, Coordination & Implementation

KRISTY ANN VYVERBERG

PROFESSIONAL EXPERIENCE

State Department of Fish and Game (DFG), Native Anadromous Fish and Watershed Branch, Sacramento, CA. Associate Engineering Geologist/Geomorphologist.

Statewide Technical Advisory Team (3/2000 to present).

- Provide geomorphic and geotechnical expertise to DFG staff and regional personnel, as well as to other State and Federal resource management agencies, with whom I work to protect and restore essential instream habitat conditions, particularly as related to aquatic ecosystem restoration projects, channel and floodplain activities, water flow management, instream structure and diversity, sediment management programs and spawning habitat enhancement.
- Provide technical expertise and training to staff and regional personnel on the geological and geomorphic aspects of watershed management and restoration.

North Fork of the American River Restoration Project.

- Represent the California Resources Agency and the DFG on the design team responsible for implementing the multi-million dollar state, federal and local effort to return the North Fork of the American River to the dewatered channel at the Auburn Dam construction site.

Clear Creek Floodway Rehabilitation Project.

- Represent the DFG on the project design team. The goal of the project is to rehabilitate the natural form and function of the channel and floodplain. To achieve this goal, the project team is designing and reconstructing selected reaches of the lower Clear Creek channel to improve fish passage, spawning, and rearing habitat, restoring connectivity between the channel and floodplain, recreating off-channel wetlands for waterfowl and other wetland species and re-establishing the native riparian plant community.

National Cooperative Highway Research Program, Federal Highway Works Administration.

- Represent the DFG on a nationwide project (Project 24-19) to develop definitive selection criteria and guidelines for state and federal transportation engineers for the design and application of environmentally sensitive channel and bank protection measures in the stream corridor.

Stream Evaluation Program (12/1992 to 3/2000).

- Conducted geomorphic studies to evaluate the relationships between channel form and function and the aquatic resources of California's Central Valley salmon and steelhead rivers and streams.
- Developed recommendations for channel and habitat maintenance flows, sediment management, and aquatic ecosystem restoration.
- Responsible for successful habitat restoration grant applications in excess of $700,000, all aspects of project-related CEQA/NEPA permitting, and project construction.

KRISTY ANN VYVERBERG

PROFESSIONAL EXPERIENCE

State Department of Parks and Recreation, Resource Protection Division, Sacramento, CA. Associate Engineering Geologist (11/88 to 11/92).
Department liaison to other state and federal agencies on issues affecting natural resources, including geologic hazard reduction projects.

- Geotechnical evaluation of proposals for statewide construction projects with potential impact on state park physical and biological resources.
- Developed effective slope protection and erosion control including implementation of environmentally compatible and cost-effective biotechnical methods in conjunction with or as alternatives to traditional structural engineering solutions.
    - General Planning Team Geologist for the Lake Tahoe Basin, Mendocino Coast, Big Sur Coast, and Santa Monica Mountains.
    - Prepared comprehensive geologic inventories by identifying, mapping, and interpreting state park geology, geologic hazards, physical land use constraints and sensitivities, and significant geologic resources to develop long-term land use plans for state park units.
- Field Monitoring and Survey Team Member.
- Interdisciplinary member in departmental survey and monitoring projects, including surveys of: spotted owl, marbled murrelet, mountain beaver, lotus blue butterfly, big horn sheep, red legged frog, and various native California fishes.

State Water Resources Control Board, Toxic Pit Cleanup Act Program, Sacramento, CA. Associate Engineering Geologist (6/86 to 11/88).
Geotechnical Specialist

- Evaluated effectiveness of ground water monitoring and cleanup proposals, and the relationship of hydrologic factors to the laws and regulations governing the disposal of liquid hazardous wastes.
- Determined source and extent of ground water contamination resulting from active and abandoned mines.
- Recommended appropriate regulatory action based upon independent analysis of private sector engineering geology and hydrogeology reports prepared in assessment of the impact to surface and ground waters by existing and proposed hazardous waste disposal facilities.

U. S. Army Corps of Engineers, Geotechnical Branch, Sacramento, CA. Engineering Geologist (6/84 to 6/86).

KRISTY ANN VYVERBERG

PROFESSIONAL EXPERIENCE

Cottonwood Creek Project Staff Engineering Geologist

- Detailed mapping of site geology, including lineation and fault location studies combining aerial photographic analysis and field reconnaissance.
- Conducted extensive subsurface investigations using disturbed and undisturbed sample collection techniques and geophysical logging of subsurface geology to determine formation and engineering characteristics.

U. S. Army Corps of Engineers
Cottonwood Creek Project Staff Engineering Geologist *(continued)*

- Compiled and interpreted geophysical and boring log data for construction of multidimensional cross-sectional stratigraphic models.
- Located and characterized potential rockfill and rip rap quarry and borrow areas, including rock coring and mapping to determine structural character, composition and suitability of rock formations as construction material.
- Assisted in development of a ground water monitoring network and aquifer testing program to determine local and regional aquifer characteristics, and a detailed hydrogeologic evaluation of the impact of the proposed reservoirs on regional groundwater.

Dam Safety Assurance Program Staff Geologist

- Collected and prepared large diameter concrete cores from dams throughout California for specific ASTM laboratory testing required to ensure concrete integrity and dam safety.

Warm Springs Dam Project Staff Geologist

- Conducted landslide study around the perimeter of Lake Sonoma including an analysis of the geologic, environmental, and temporal causes of slope movement.
- Combined field and aerial photographic analysis to identify and locate existing or potential areas of slope movement in order to prevent or correct earth and rock failures.

EDUCATION

- B.S. Geology, 1983, University of California, Davis

PROFESSIONAL REGISTRATION

- Registered Geologist California, # 5262
- Registered Geologist Oregon, #G1381

KRISTY ANN VYVERBERG

TECHNICAL REPORTS and PUBLICATIONS

Vyverberg, K. A., Bill Snider and Robert G. Titus, 2000. *The Impact of Flow Fluctuations on the Survival of Juvenile Chinook Salmon and Steehead, lower American River. An assessment of the biological effects, the relationship between flow and river morphology and juvenile salmonid losses, and recommendations for mitigation.* Calif. Dept. Fish and Game, Sacramento, CA. 112 pp.

______________, Bill Snider and Robert G. Titus, 1997. *Chinook Salmon Spawning Habitat Evaluation, lower American River, October 1994. An evaluation of the attributes used to define the quality of spawning habitat.* Calif. Dept. Fish and Game, Sacramento, CA. 112 pp.

Bill Snider and K. Vyverberg. 1996. Chinook Salmon Spawning Survey, lower American River, Fall 1995. Calif. Dept. Fish and Game, Sacramento, CA. 59 pp.

________ , K. Vyverberg, and S. Whiteman. 1996. Chinook Salmon Spawning Survey, lower American River, Fall 1994. Calif. Dept. Fish and Game, Sacramento, CA. 54 pp.

________ , K. Vyverberg. *1995. Chinook Salmon Spawning Survey, Lower American River, Fall 1993.* Calif. Dept. Fish and Game, Sacramento, CA. 45 pp.

Urquhart, K. A. F., B. Snider, and K. A. Vyverberg, 1994. *The relationship between Instream Flow and Physical Habitat availability for Fall-run Chinook Salmon in the Merced River, Merced Co., CA.* Calif. Dept. Fish and Game, Sacramento, CA. 37 pp.

K. A. Vyverberg, 1991. *Effect of Off Highway Vehicle use on Alluvial Substrate and Change in Channel Morphology in Coyote Creek, Anza-Borrego State Park.* California Department of Parks and Recreation. 19 pp. + maps.

__________, 1991. *Recommendations to Curb Erosion at Lower Willows Archeological Site Ca-SDIC133.* California Department of Parks and Recreation. 9 pp. + maps.

KRISTY ANN VYVERBERG

__________, and Brown, Syd. 1990. *Resource Protection and Beach Access Improvement Project, Garrapata State Park, Monterey County Coastal Permit.* California Department of Parks and Recreation. 22 pp. + maps.

________, 1988. *Occurrence of Acid Mine Drainage at Penn Mine, Calaveras County, CA.* State Water Resources Control Board.

__________, and DeWitt, C.B. 1986. *Cause of Spillway Erosion, Black Butte Dam, California.* U. S. Army Corps of Engineers. 20 pp. + maps.

REFERENCES

Dr. G. Mathias Kondolf, Fluvial Geomorphologist
Department of Landscape Architecture and Environmental Planning
202 Wurster Hall
University of California
Berkeley, California 94720-2000
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California Department of Parks and Recreation
1416 Ninth Street
Sacramento California 94296-0001
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Dr. Roland H. Brady, Engineering Geologist
Department of Geology
California State University
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JOSEPH E. MERZ

Fisheries Biologist and Community Ecologist

EDUCATION

Ph.D. Restoration Ecology, anticipated December 2002	University of California, Davis
M.S. Biological Conservation, 1994	California State University, Sacramento
B.S. Environmental and Systematic Biology, 1991	California Polytechnic State University, San Luis Obispo

PROFESSIONAL DEVELOPMENT COURSES AND CERTIFICATIONS

Certified Fisheries Scientist, American Fisheries Society, 1994
Rapid Bioassessment Workshop, California Department of Fish and Game, 1995 & 1996
Electrofishing Certification, US Fish and Wildlife Service, 1995
Design Procedures For Channel Protection and Streambank Stabilization, IECA, 1996
Biotechnical Erosion Control For Slopes and Streambanks, IECA, 1996
Pesticide Sampling and Monitoring, Cal EPA, 1995
Ecosystem Ecology and Management, American River College, 1984

PROFESSIONAL HISTORY

California State University, Sacramento	Part-time Faculty 2001 - present
University of California, Davis Extension	Part-time Faculty 2001 - present
East Bay Municipal Utility District	Fisheries Biologist II 1996 - present
California Department of Pesticide Regulation	Pesticide Use Specialist 1995 - 1996
ENTRIX INC.	Aquatic Ecologist 1993 - 1996
California Department of Fish and Game	Contract Biologist 1991 - 1994

PROJECT EXPERIENCE

Instructor of "Environmental Science 10". This survey course looks at the earth as an ecosystem, focusing on interactions of biotic and abiotic systems with each other and with human population, technology, and production. Students acquire a fundamental scientific understanding of the ecological implications of human activities. Specific topics treated within the course include energy flows, nutrient cycles, pollution, resource use, climate changes, species diversity, and population dynamics.

Instructor of “Instream Habitat Improvement For Regulated Rivers”. This course provides general training in the design, implementation and monitoring of spawning habitat improvements for salmonid species.

Plan and implement resources management programs for utility district waterways. Prepare and edit technical reports, letters, memos and other documents, including Environmental Impact Reports. Assist in reviewing and recommending changes in fisheries policies, management programs and angling regulations. Conduct natural resources studies on utility district waterways and compile and analyze statistical information collected.

Monitor macroinvertebrate and fisheries populations of streams throughout California. Methods used to collect data include: electrofishing, seining, trapping, direct observation (snorkeling and running fish passages), trawls, plankton tows, creel surveys, benthic samplers, and drift nets.

Stream geomorphology and spawning gravel evaluation for salmonid enhancement projects on Central Valley rivers.

Collection and analysis of data for IFIM and HSI modeling in salmonid streams.

Conduct radio telemetry, pit-tag, coded wire tag, Floy tag and ink injection tagging studies on salmonids in Central and coastal California streams.

PROFESSIONAL PUBLICATIONS

Merz, J.E. In Press. Comparison of prickly sculpin and juvenile fall-run chinook salmon diets in the lower Mokelumne River, California. South Western Naturalist.

________ 2001a. Association of fall-run chinook salmon redds and woody debris in the lower Mokelumne River, California. California Fish and Game 87(2).

________ 2001b. Diet of juvenile fall-run chinook salmon in the lower Mokelumne River, California. California Fish and Game 87(3).

Merz, J. E. and C. D. Vanicek. 1996. Comparative feeding habits of juvenile chinook salmon, steelhead, and Sacramento squawfish in the lower American River, California. California Fish and Game 82(4):149-159.

ROY W. DIXON
Chemistry Department
California State University, Sacramento
6000 J Street, Sacramento, CA 95819-6057
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Education:

Degree:	Institute:	Date Issued:
Doctor of Philosophy in Environmental Chemistry	University of Washington Seattle, Washington	7/91
Bachelor of Science in Chemistry	University of California Davis, California	6/84

Research and Professional Experience:

Starting 8/99 Assistant Professor of Chemistry, California State University, Sacramento, 6000 J Street, Sacramento, CA 95819-6057

8/94 to 8/99 Assistant Professor of Chemistry, New Mexico Institute of Mining and Technology, Socorro, NM 87801

2/94 to 7/94 Postdoctoral Assistant, Earth System Science, University of California, Irvine, CA 92717-3100

8/91 to 7/93 Postdoctoral Assistant, Laboratory for Atmospheric Physics, Swiss Federal Institute of Technology, CH-8093, Zurich, Switzerland

9/86 to 6/91 Teaching and Research Assistant, Chemistry Department, University of Washington, Seattle, WA 98195

9/84 to 7/86 Staff Research Associate, Air Quality Group, Crocker Nuclear Laboratory, University of California, Davis, CA 95616

Research Interests:
Analytical Chemistry and Environmental Chemistry

Courses Taught:
General Chemistry, Quantitative Analysis, Chemical Instrumentation, Environmental Chemistry Laboratory, Atmospheric Chemistry, Analytical Spectroscopy

Publications:

Dixon, R. W. and D. S. Peterson, "Development of a new detection method for liquid chromatography based on aerosol charging", document in preparation.

Dixon, R. W. and H. A. Aasen, "Measurements of hydroyxmethanesulfonate in atmospheric aerosols", *Atmospheric Environment*, *33,* 2023-2029, 1999.

Dixon, R., D. Peterson, K. Carr, and B. Deng, "An examination of methods to treat organic wastes using potassium superoxide", *1998 Joint Conference on the Environment, Proceedings*,WERC Administrative Office, Las Cruces, NM, 299-301, 1998.

Gaffney, J. S., N. A. Marley, R. S. Martin, R. W. Dixon, L. G. Reyes, and C. J. Popp, "Potential air quality effects of using ethanol-gasoline fuel blends: A field study in Albuquerque", New Mexico, *Environmental Science and Technology,* **31**, 3053-3061, 1997.

Dixon, R. W., L. Mosimann, B. Oberholzer, J. Staehelin, A. Waldvogel, and J. L. Collett Jr, "The effect of riming on the ion concentrations of winter precipitation. 1. A quantitative analysis of field measurements", *Journal of Geophysical Research*, **100D**, 11,517-11,527, 1995.

Dixon, R. W. and R. J. Charlson, "Development of a new real-time method for measuring S(IV) in cloud water using a counter-flow virtual impactor", *Tellus,* **46B**, 193-204, 1994.

Staehelin, J., A. Waldvogel, J. L. Collett Jr, R. Dixon, R. Heimgartner, W. Henrich, C. Hsu, L. Li, L. Mosimann, B. Oberholzer, A. Prevôt, W. Schmid, T. Schumann, M. Steiner, M. Volken, and B. Zinder, "Scientific goals and experiments of the project 'Winter Precipitation at Mount Rigi': An overview," *Water, Soil, and Air Pollution*, **68**, 1-14, 1993.

Staehelin, J., J. L. Collett Jr, R. Dixon, W. Henrich, C. Hsu, B. Oberholzer, L. Mosimann, and A. Waldvogel, "Investigations of physical and chemical processes contributing to winter precipitation chemistry using field measurements from Mount Rigi (Switzerland)," in *Photo-Oxidants: Precursors and Products, Proceedings of EUROTRAC Symposium*, 1992, P. M. Borell, P. Borell, T. Cvitas, and W. Seiler (Ed.), SPB Academic Publications, The Hague, 1993.

Dixon, R. W., "Additional mass transport considerations in the formation of hydroxyalkyl-sulfonates," *Atmospheric Environment*, **26A**, 899-905, 1992.

Recent Presentations:

Dixon, R. W. and D. S. Peterson, "A new method for determination of bulk aerosol composition using aerosol collection, extraction, separation of constituents, resuspension, and aerosol detection," American Geophysical Union, Fall Meeting, San Francisco, CA, Dec. 1999.

Dixon, R. and D. S. Peterson "Development and testing of a new detector for liquid chromatography based on aerosol charging," Eastern Analytical Symposium, Somerset, NJ, Nov., 1999.

Professional Societies:

American Chemical Society (Analytical and Environmental Division memberships)
American Geophysical Union (Atmospheric Sciences Division)