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SANTA BARBARA • SANTA CRUZ

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410 Mraz Hall, One Shields Avenue  
 DAVIS, CALIFORNIA 95616-8671

April 14, 1999

CALFED Bay-Delta Program Office  
 1416 Ninth Street, Suite 1155  
 Sacramento, CA 95814

**Proposal Title: Adaptive Management Strategy for Regulatory Reservoir of Agricultural  
 Drainage Discharge: Mitigating Selenium Ecotoxic Risk by  
 Combining Foodchain Breakage with Natural Remediation  
 Principal Investigator – Teresa Fan**

Dear Colleague:

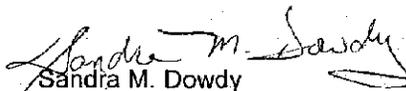
It is a pleasure to present for your consideration the referenced proposal.

It is our understanding that for purposes of determining applicant category, The Regents will be classified as "State" thereby resulting awards will only include the terms identified in Attachment D of the 1999 Proposal Solicitation Package as "Terms and Conditions for State (CALFED) Funds" and "Standard Clauses-Interagency Agreements".

The University takes exception to clauses pertaining to Substitution, Rights in Data and Indemnification as detailed in Attachment D. On behalf of The Regents of the University of California, we hereby reserve the right to negotiate said clauses as detailed in the Proposal Solicitation Package should this proposal result in a subsequent award.

Please call on the principal investigator for scientific information. Administrative questions may be directed to me or to Petrina Ho by telephone, facsimile or electronic mail at the numbers specified above. We request that correspondence pertaining to this proposal and a subsequent award be sent to the Office of Research and to the principal investigator.

Sincerely,

  
 Sandra M. Dowdy  
 Contracts & Grants Analyst

Enclosures

#### 4.5 PSP Cover Sheet (Attach to the front of each proposal)

ADAPTIVE MANAGEMENT STRATEGY FOR REGULATORY RESERVOIR OF  
AGRICULTURAL DRAINAGE DISCHARGE: MITIGATING SELENIUM ECOTOXIC RISK BY  
COMBINING FOODCHAIN BREAKAGE WITH NATURAL REMEDIATION

Proposal Title: \_\_\_\_\_  
Applicant Name: Teresa W-M. Fan and Richard M. Higashi  
Mailing Address: Dept. of Land, Air and Water Resources, One Shields Ave., Univ. of California, Davis, CA 95616  
Telephone: 530/752-1450  
Fax: 530/752-1552  
Email: twfan@ucdavis.edu

Amount of funding requested: \$ 749,386 for 3 years

Indicate the Topic for which you are applying (check only one box).

- |  |   |
|--|---|
| <input type="checkbox"/> Fish Passage/Fish Screens   | <input type="checkbox"/> Introduced Species       |
| <input type="checkbox"/> Habitat Restoration         | <input type="checkbox"/> Fish Management/Hatchery |
| <input type="checkbox"/> Local Watershed Stewardship | <input type="checkbox"/> Environmental Education  |
| <input checked="" type="checkbox"/> Water Quality    |   |

Does the proposal address a specified Focused Action?  yes  no

What county or counties is the project located in? Yolo, Merced, Fresno

Indicate the geographic area of your proposal (check only one box):

- |   |   |
|---|---|
| <input type="checkbox"/> Sacramento River Mainstem          | <input type="checkbox"/> East Side Trib: _____                  |
| <input type="checkbox"/> Sacramento Trib: _____             | <input type="checkbox"/> Suisun Marsh and Bay                   |
| <input type="checkbox"/> San Joaquin River Mainstem         | <input type="checkbox"/> North Bay/South Bay: _____             |
| <input checked="" type="checkbox"/> San Joaquin Trib: _____ | <input type="checkbox"/> Landscape (entire Bay-Delta watershed) |
| <input type="checkbox"/> Delta: _____                       | <input type="checkbox"/> Other: _____                           |

Indicate the primary species which the proposal addresses (check all that apply):

- |   |  |
|---|--|
| <input checked="" type="checkbox"/> San Joaquin and East-side Delta tributaries fall-run chinook salmon |  |
| <input type="checkbox"/> Winter-run chinook salmon  | <input type="checkbox"/> Spring-run chinook salmon           |
| <input type="checkbox"/> Late-fall run chinook salmon   | <input type="checkbox"/> Fall-run chinook salmon             |
| <input type="checkbox"/> Delta smelt  | <input type="checkbox"/> Longfin smelt                       |
| <input checked="" type="checkbox"/> Splittail   | <input type="checkbox"/> Steelhead trout                     |
| <input type="checkbox"/> Green sturgeon   | <input type="checkbox"/> Striped bass                        |
| <input type="checkbox"/> Migratory birds  | <input type="checkbox"/> All chinook species                 |
| <input type="checkbox"/> Other: _____   | <input checked="" type="checkbox"/> All anadromous salmonids |

Specify the ERP strategic objective and target (s) that the project addresses. Include page numbers from January 1999 version of ERP Volume I and II:

"Contaminant" reduction (p.421, vol. 1 of ERP). The linkage to future ERP action and goals include (see the Proposal Solicitation Package, Feb., 1999): 1) to improve Water Quality (Goal 6, p. 16) of the Bay/Delta by reducing and regulating Se load discharged into the San Joaquin river (3rd & 5th ERP actions, p. 23, 24); 2) to assist in Rehabilitation and Protection of Natural Processes (Goal 2, p. 14) by remediating Se risk in the Grassland Bypass area (2nd ERP action, p. 19; 3) to help protect Recreational and Commercial species (Goal 3, p. 15) by reducing Se impact on fish stock (e.g. splittail, sturgeon, salmon, steelhead) (1st ERP action, p. 28) and waterfowl species (e.g. those in the Grassland area).

Indicate the type of applicant (check only one box):

- |  |   |
|--|---|
| <input type="checkbox"/> State agency                    | <input type="checkbox"/> Federal agency |
| <input type="checkbox"/> Public/Non-profit joint venture | <input type="checkbox"/> Non-profit     |
| <input type="checkbox"/> Local government/district       | <input type="checkbox"/> Private party  |
| <input checked="" type="checkbox"/> University           | <input type="checkbox"/> Other: _____   |

Indicate the type of project (check only one box):

- |  |   |
|--|---|
| <input type="checkbox"/> Planning            | <input type="checkbox"/> Implementation |
| <input type="checkbox"/> Monitoring          | <input type="checkbox"/> Education      |
| <input checked="" type="checkbox"/> Research |   |

By signing below, the applicant declares the following:

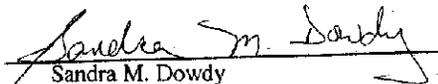
- 1.) The truthfulness of all representations in their proposal;
- 2.) The individual signing the form is entitled to submit the application on behalf of the applicant (if the applicant is an entity or organization); and
- 3.) The person submitting the application has read and understood the conflict of interest and confidentiality discussion in the PSP (Section 2.4) and waives any and all rights to privacy and confidentiality of the proposal on behalf of the applicant, to the extent as provided in the Section.

TERESA W.-M. FAN

Printed name of applicant



Signature of applicant



Sandra M. Dowdy  
Contracts and Grants Analyst  
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University of California  
One Shields Ave.  
Davis, California 95616-8671  
(530) 752-2075, FAX (530) 752-5432  
E-mail smdowdy@ucdavis.edu

**APPLICATION FOR  
FEDERAL ASSISTANCE**

OMB Approval No. 0348-0045

<b>1. TYPE OF SUBMISSION:</b> Application <input type="checkbox"/> Construction <input checked="" type="checkbox"/> Non-Construction		Preapplication <input type="checkbox"/> Construction <input type="checkbox"/> Non-Construction		<b>2. DATE SUBMITTED</b>	Applicant Identifier
				<b>3. DATE RECEIVED BY STATE</b>	State Application Identifier
				<b>4. DATE RECEIVED BY FEDERAL AGENCY</b>	Federal Identifier
<b>5. APPLICANT INFORMATION</b>					
Legal Name: Regents of the University of California				Organizational Unit: Dept. of Land, Air and Water Resources	
Address (give city, county, State, and zip code): Office of the Vice Chancellor for Research, 410 Mrak Hall Univ. of California, Davis, One Shields Ave. Davis, CA 95616 Yolo County				Name and telephone number of person to be contacted on matters involving this application (give area code): Teresa W-M. Fan, 530/752-1450	
<b>6. EMPLOYER IDENTIFICATION NUMBER (EIN):</b> 94-6036494 W				<b>7. TYPE OF APPLICANT: (enter appropriate letter in box)</b> <input type="checkbox"/> A. State <input type="checkbox"/> B. County <input type="checkbox"/> C. Municipal <input type="checkbox"/> D. Township <input type="checkbox"/> E. Interstate <input type="checkbox"/> F. Intermunicipal <input type="checkbox"/> G. Special District <input checked="" type="checkbox"/> H. Independent School Dist. <input type="checkbox"/> I. State Controlled Institution of Higher Learning <input type="checkbox"/> J. Private University <input type="checkbox"/> K. Indian Tribe <input type="checkbox"/> L. Individual <input type="checkbox"/> M. Profit Organization <input type="checkbox"/> N. Other (Specify) _____	
<b>8. TYPE OF APPLICATION:</b> <input checked="" type="checkbox"/> New <input type="checkbox"/> Continuation <input type="checkbox"/> Revision If Revision, enter appropriate letter(s) in box(es) <input type="checkbox"/> <input type="checkbox"/> A. Increase Award B. Decrease Award C. Increase Duration D. Decrease Duration Other(specify): _____				<b>9. NAME OF FEDERAL AGENCY:</b> CALFED Bay-Delta Program	
<b>10. CATALOG OF FEDERAL DOMESTIC ASSISTANCE NUMBER:</b> TITLE: _____				<b>11. DESCRIPTIVE TITLE OF APPLICANT'S PROJECT:</b> ADAPTIVE MANAGEMENT STRATEGY FOR REGULATORY RESERVOIR OF AGRICULTURAL DRAINAGE DISCHARGE: MITIGATING SELENIUM ECOTOXIC RISK BY COMBINING FOODCHAIN BREAKAGE WITH NATURAL REMEDIATION	
<b>12. AREAS AFFECTED BY PROJECT (Cities, Counties, States, etc.):</b> California					
<b>13. PROPOSED PROJECT</b>		<b>14. CONGRESSIONAL DISTRICTS OF:</b>			
Start Date Oct 1, 1999	Ending Date Sep 30, 2002	a. Applicant Third		b. Project Third	
<b>15. ESTIMATED FUNDING:</b>		<b>16. IS APPLICATION SUBJECT TO REVIEW BY STATE EXECUTIVE ORDER 12372 PROCESS?</b>			
a. Federal	\$ 310,291	a. YES. THIS PREAPPLICATION/APPLICATION WAS MADE AVAILABLE TO THE STATE EXECUTIVE ORDER 12372 PROCESS FOR REVIEW ON: DATE _____			
b. Applicant	\$	b. No. <input checked="" type="checkbox"/> PROGRAM IS NOT COVERED BY E. O. 12372 <input type="checkbox"/> OR PROGRAM HAS NOT BEEN SELECTED BY STATE FOR REVIEW			
c. State	\$	<b>17. IS THE APPLICANT DELINQUENT ON ANY FEDERAL DEBT?</b> <input type="checkbox"/> Yes If "Yes," attach an explanation. <input checked="" type="checkbox"/> No			
d. Local	\$				
e. Other	\$				
f. Program Income	\$				
g. TOTAL	\$ 310,291				
<b>18. TO THE BEST OF MY KNOWLEDGE AND BELIEF, ALL DATA IN THIS APPLICATION/PREAPPLICATION ARE TRUE AND CORRECT, THE DOCUMENT HAS BEEN DULY AUTHORIZED BY THE GOVERNING BODY OF THE APPLICANT AND THE APPLICANT WILL COMPLY WITH THE ATTACHED ASSURANCES IF THE ASSISTANCE IS AWARDED.</b>					
a. Type Name of Authorized Representative		b. Title Sandra M. Dowdy Contracts and Grants Analyst		c. Telephone Number	
d. Signature of Authorized Representative <i>Sandra M. Dowdy</i>				e. Date Signed APR 15 1999	

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Standard Form 424 (Rev. 7-97)  
Prescribed by OMB Circular A-102

I - 0 1 8 4 6 7

I-018467

BUDGET INFORMATION - Non-Construction Programs						
SECTION A - BUDGET SUMMARY						
Grant Program Function or Activity (a)	Catalog of Federal Domestic Assistance Number (b)	Estimated Unobligated Funds		New or Revised Budget		
		Federal (c)	Non-Federal (d)	Federal (e)	Non-Federal (f)	Total (g)
1 Biogeochemistry		\$	\$	\$ 419,881	\$	\$ 419,881
2 invertebrate harvest				329,505		329,505
3.						
4.						
5. Totals		\$	\$	\$ 749,386	\$	\$ 749,386
SECTION B - BUDGET CATEGORIES						
6. Object Class Categories	GRANT PROGRAM FUNCTION OR ACTIVITY				Total (5)	
	(1) Biogeochemistry	(2) invertebrate harvest	(3)	(4)		
a. Personnel	\$ 189,677	\$ 170,438	\$	\$	\$ 360,115	
b. Fringe Benefits	45,517	42,611			88,128	
c. Travel	15,000	13,800			28,800	
d. Equipment	35,000	38,800			73,800	
e. Supplies	44,000	33,900			77,900	
f. Contractual	53,426	0			53,426	
g. Construction	0	0			0	
h. Other	0	0			0	
i. Total Direct Charges (sum of 6a-6h)	382,620	299,549			682,169	
j. Indirect Charges	37,261	29,956			67,217	
k. TOTALS (sum of 6i and 6j)	\$ 419,881	\$ 329,505	\$	\$	\$ 749,386	
7. Program Income	\$	\$	\$	\$	\$	

1-018469

SECTION C - NON-FEDERAL RESOURCES					
(a) Grant Program	(b) Applicant	(c) State	(d) Other Sources	(e) TOTALS	
8.	\$	\$	\$	\$	
9.					
10.					
11.					
12. TOTAL (sum of lines 8 - 11)	\$ 0	\$ 0	\$ 0	\$ 0	
SECTION D - FORECASTED CASH NEEDS					
	Total for 1st Year	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
13. Federal	\$ 310,291	\$ 103,823	\$ 68,823	\$ 68,823	\$ 68,823
14. NonFederal					
15. TOTAL (sum of lines 13 and 14)	310,291	103,823	68,823	68,823	68,823
SECTION E - BUDGET ESTIMATES OF FEDERAL FUNDS NEEDED FOR BALANCE IN THE PROJECT					
(a) Grant Program	FUTURE FUNDING PERIODS (Years)				
	(b) First	(c) Second	(d) Third	(e) Fourth	
16. Biogeochemistry	\$ 115,868	\$ 120,178	\$	\$	
17. invertebrate harvest	99,135	103,914			
18.					
19.					
20. TOTAL (sum of lines 16-19)	\$ 215,003	\$ 224,092	\$	\$	
SECTION F - OTHER BUDGET INFORMATION					
21. Direct Charges:	682,169	22. Indirect Charges:	67,217		
23. Remarks: Please refer to Budget Justification for explanation of indirect costs.					

1-018469

**TITLE PAGE**

**ADAPTIVE MANAGEMENT STRATEGY FOR REGULATORY RESERVOIR OF  
AGRICULTURAL DRAINAGE DISCHARGE: MITIGATING SELENIUM ECOTOXIC  
RISK BY COMBINING FOODCHAIN BREAKAGE WITH NATURAL REMEDIATION**

**Primary Contact:**

Teresa W.-M. Fan, Department of Land, Air and Water Resources, University of California, Davis, One  
Shields Ave., Davis, CA 95616-8627  
Phone: 530-752-1450; Fax: 530-752-1552

**Participants and Collaborators:**

Jack Erickson, California Department of Water Resources, Fresno  
Robert Rofen, Aquatic Research Institute, Hayward  
Dennis Falaschi, Panoche Water District, Firebaugh  
Richard M. Higashi, Crocker Nuclear Laboratory, University of California, Davis

**Type of Organization and Tax Status:**

University, non-profit

**Tax Identification Number:**

94-6036494W

## EXECUTIVE SUMMARY

### CRITICAL ECOLOGICAL/BIOLOGICAL OBJECTIVES ADDRESSED

Our overall objective is to mitigate ecotoxic risk of contaminants, particularly Se, in agricultural drainage reservoirs to reduce subsequent impact on wildlife along the San Joaquin river corridor and through the Pacific Flightway for migratory birds. Drainage regulatory reservoirs are deemed to be critical for regulating the release of drain waters from the Grassland Bypass Drainage area into the San Joaquin river so that episodic exceedance of Se water quality objectives and load into the river can be circumvented. Drainage evaporation basins are currently utilized for disposing drain waters in the Southern San Joaquin Valley, which is in the direct path of the Pacific Flightway.

To achieve the overall objective, the following questions will be addressed: (1) to reduce Se and food availability to fish and birds through aggregation and exhaustive harvesting of water-column invertebrates; (2) to intercept bioavailable Se load into bottom sediment through water-column invertebrate harvest; (3) to manipulate the microphyte community to optimize Se loss through volatilization, to minimize biotransferable Se, and to sustain harvestable invertebrate production; (4) to optimize the timing of microphyte manipulation and invertebrate harvest with respect to wildlife breeding season; (5) to explore the marketability of harvested materials.

### RESULTS AND BENEFITS

If successful, the proposed approach would greatly facilitate in-valley disposal of agricultural drain waters. This is achieved by improving the management of regulatory or terminal reservoirs for disposing agricultural drain waters, both in terms of mitigating Se ecotoxic risk and economic efficacy. The same approach can also be incorporated with other drainage reuse schemes (e.g. agroforestry) to reduce Se ecotoxic risk and to remove Se before the final stage of evaporation (e.g. solar evaporation cells). Removing Se contamination from the evaporite salts can greatly improve their marketability for export out of the Valley, thereby reducing salt buildup in the Valley and discharge into the San Joaquin river. Other attendant benefits that can result from the proposed approach include downstream habitat preservation, protection of resident wildlife species along the San Joaquin river and in the Delta against Se and salinity stress, and improvement of drinking water quality.

### SUMMARY OF RESEARCH APPROACH

Our experimental approach is embodied in the following plans over a 3-year duration:

- (1) Preparation of pilot reservoirs for testing key concepts of waterborne Se removal by invertebrate harvest and optimization of invertebrate production and harvest via manipulating microphyte community;
- (2) Manipulation of microphyte community via changes in salinity and different fertilizer inputs;
- (3) Harvest and evaluation of water-column and benthic macroinvertebrate community;

- (4) Analysis of microphyte and invertebrate biomass for a broad spectrum of nutrient and contaminant elements to guide further fertilizer supplement;
- (5) Monitoring of water quality parameters and measurement of Se volatilization as a function of microphyte community;
- (6) Se Analysis of sediment, microphytes, and macroinvertebrates (water-column + benthic);
- (7) Exploring the marketability of macroinvertebrate harvest;
- (8) Project management

These tasks will be performed jointly by UC Davis (Teresa Fan and Richard Higashi), Aquatic Research Institute (Robert Rofen), and Panoche Water District (Dennis Falaschi). In addition, the Department of Water Resources, Fresno is planning to apply a similar approach in test evaporation ponds at the Lost Hills Water District.

Fan and Higashi have extensive expertise in Se biogeochemistry in San Joaquin Valley's drainage ponds and in applying the knowledge to *in situ* Se bioremediation. Rofen and Aquatic Research Institute has unique experiences in macroinvertebrate production, harvest, and marketability. Falaschi and Panoche Water District staff have extensive experience in drainage management as well as reservoir preparation and maintenance. The requested budget (see Table below) for this 3-year project is \$749,386 with a cost-sharing of \$327K in equipment and participants' effort.

TOTAL BUDGET SUMMARY			
Task	Total Direct Costs	Overhead & Indirect Costs	Total Costs
I. Biogeochemistry	382,620	37,261	419,881
II. Harvesting	299,549	29,956	329,505
<b>TOTALS</b>	<b>682,169</b>	<b>67,217</b>	<b>749,386</b>

## PROJECT DESCRIPTION

### PROPOSED SCOPE OF WORK

Our and Dr. R. Rofen's studies (see Linkages under **ECOLOGICAL/BIOLOGICAL BENEFITS**) suggest that microphyte-mediated Se biogeochemistry (e.g. volatilization) and foodchain interruption may hold keys to implementing a long-term management plan for drainage regulatory reservoirs that is both ecotoxicologically sound and economical. Therefore, one clear thrust would be to investigate these concepts in a demonstration facility so that various parameters can be optimized for full-scale operations. To achieve the objectives outlined under the section **ECOLOGICAL/BIOLOGICAL BENEFITS**, We envision the following plans over a 3-year duration:

- (1) Preparation of pilot reservoirs for testing key concepts of waterborne Se removal mechanisms and relationship between microphyte community, invertebrate production, and harvest;
- (2) Manipulation of microphyte community via changes in salinity and different fertilizer inputs;
- (3) Harvest and evaluation of water-column and benthic macroinvertebrate community;
- (4) Analysis of microphyte and invertebrate biomass for a broad spectrum of nutrient and contaminant elements to guide further fertilizer addition;
- (5) Monitoring of water quality parameters and measurement of Se volatilization as a function of microphyte community;
- (6) Se Analysis of sediment, microphytes, and macroinvertebrates (water-column + benthic);
- (7) Exploring the marketability of harvest macroinvertebrates;
- (8) Project management

### I. EXPERIMENTAL APPROACH FOR PLANS LISTED ABOVE

#### *Plan 1: Pilot Reservoir Preparation and Maintenance*

Two 2-acre each pilot reservoirs will be prepared at the Panoche Water District. These reservoirs will serve as a guide to the operation of two regulatory reservoirs currently in use at the District. The pilot reservoir will accommodate up to 6 ft of water depth with steep sides to minimize wildlife access and lined with plastic liner to prevent downward seepage into the groundwater. Movable curtains may be placed in the reservoir perpendicular to the prevailing wind direction. We found that microphytes, organic matter, and macroinvertebrate tend to accumulate at the downwind side of evaporation ponds. It may be practical to aggregate biota with curtains to facilitate harvest.

One reservoir will serve as control with no manipulation of microphyte community while the other will be tested for addition of nutrient fertilizers to alter the microphyte community profile. Drain water will be pumped into the reservoir and the system will be stabilized for at least 3 months before any manipulation is implemented. Subsequent maintenance of the reservoirs will be performed as needed including water delivery and levee maintenance.

#### *Plan 2: Manipulation of Microphyte Community*

Common hay, chicken manure, and phosphate have been tested at TLDD evaporation basin and found to be effective in enhancing algal population that favored brine shrimp production. We will start with these three fertilizer materials as well as chelated iron and test for their efficacy in altering microphyte community in the pilot reservoir. We will test the timing of the fertilization with respect to

wildlife breeding seasons to minimize Se transfer into developing embryos. The fertilizer materials will be tested for a broad spectrum of nutrient and non-nutrient elements including Se to avoid the use of contaminated materials and to relate the nutrient profile to microphyte community change. Microphyte community of reservoir waters will be documented by optical-digital microscopy coupled with pigment analysis by HPLC (Fan and Higashi, 1998a). Microphyte category (e.g. green phytoplankton, diatom, and cyanobacteria), species, and abundance (if practical) will be examined to correlate with the fertilizer nutrient profile.

Drain water will be pumped into the reservoir at flow rates and frequencies such that the salinity of the water can be maintained at desired levels for daphnia, corixid, or brine shrimp production.

#### *Plan 3: Macroinvertebrate Harvest and Evaluation*

Water-column macroinvertebrates will be harvested and sorted on a daily basis or as needed during production periods to prevent wildlife predation. This approach has been tested successfully at TLDD basin, where sustained brine shrimp harvest also led to a depletion of water-column microphyte population and waterborne Se concentration. The microphyte depletion should in turn limit detrital formation and therefore benthic productivity. This relationship will be tested by collecting and sorting benthic macroinvertebrates.

#### *Plan 4: Elemental Analysis of Biota*

Microphyte biomass will be collected from waters by passage through 10  $\mu\text{m}$  nylon screen, followed by centrifugation. Biomass of microphytes and water-column macroinvertebrates will be rinsed thoroughly to remove site water, freeze-dried, and finely ground for X-ray fluorescence (XRF) analysis. A number of elements including Mg, Al, P, S, K, Ca, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Br, Mo, Ag, Cd, Ba, and Pb can be routinely screened using XRF. These, together with the elemental profile of the fertilizers, should provide guidance for further nutrient supplements and for revealing undesirable accumulation of contaminants in the biota. In addition, the elemental profile should help facilitate the marketing of the harvested materials.

#### *Plan 5: Monitoring Water Quality and Se Volatilization*

Water samples will be collected regularly for analysis of selected water-quality parameters including pH, temperature, salinity, TDS, and total Se. Water samples will also be purged on-site with He gas and volatile Se compounds, trapped in liquid nitrogen, will be quantified by GC-MS analysis, which provides a measure of Se volatilization capacity (Fan and Higashi, 1999a). These results will be correlated with the microphyte community profile obtained from Task 2.

#### *Plan 6: Analysis of Sediments and Biota*

Newly settled sediment materials will be collected over selected durations using a sediment trap that we designed for the TLDD basin study (Fan and Higashi, 1997). We found that the trap material was much higher in Se concentration than the corresponding sediment core, which suggests that the trap material was enriched in detritus. Thus, we should be able to estimate detrital formation by following the Se and organic matter status in the trap material. We will confirm this relationship by analyzing the trap material for proteins and Se load in proteins, assuming that proteins are originated from biota. Total Se analysis using the fluorescence method and protein extraction and analysis will be performed according

to our previous procedures (Fan et al., 1998b). Sediment cores will also be analyzed for total Se for comparison with the trap analysis.

The microphytic and macroinvertebrate biomass collected under Task 3 will be prepared as in Task 4 and analyzed for total Se and Se load in proteins as described above. Se load in proteins is considered to be the bioavailable and biotransferrable fraction (EPA report, 1998). The Se load in sediment and biota will be compared with water Se concentrations, microphyte community, and Se volatilization capacity to reveal the conditions under which Se load in water and sediment is minimized, no excessive Se load in biota proteins, and Se volatilization capacity is maximized.

*Plan 7: Exploring Macroinvertebrate Marketing*

Novalek, Inc. currently has a large European and US market for brine shrimp. The quality of brine shrimp obtained from TLDD evaporation ponds is deemed to be premium and the last year shrimp production from TLDD has been exported to Europe as public and pet aquarium food. In conjunction with the Aquatic Research Institute, the marketability of other water-column macroinvertebrates as pet aquarium food and animal feed supplements will also be explored.

*Plan 8: Project Management*

All tasks will be coordinated by Drs. Teresa Fan and Richard Higashi at UC Davis. Management of specific tasks will be as follows: Plan 1 by the Panoche Water District with the assistance from the Department of Water Resources, Fresno; Plans 2, 4-6 by UC Davis; Plans 3, 7 by Dr. Robert Rofen at Aquatic Research Institute.

## II. PROJECT PHASE AND SCHEDULE

The above plans will be conducted in four phases and the phase schedule are not necessarily in sequence:

- Phase 1 – Reservoir preparation and stabilization (Plans 1&8), which is to be completed in 6 months
- Phase 2 – Reservoir maintenance and manipulation (Plans 1, 2, 8), which shall occur immediately following Phase 1 in Year 1 and be conducted periodically throughout the 3 project years; the frequency of manipulation will be determined empirically.
- Phase 3 – Reservoir monitoring (Plans 2-6), which will begin at Phase 2 in coordination with the frequency of reservoir manipulation.
- Phase 4 – Macroinvertebrate marketing test, which will begin after sufficient macroinvertebrate harvest at the Aquatic Research Institute and the test will be conducted periodically throughout the 3 project years.

Location and/or Geographic Boundaries

See **FIGURE 1**.

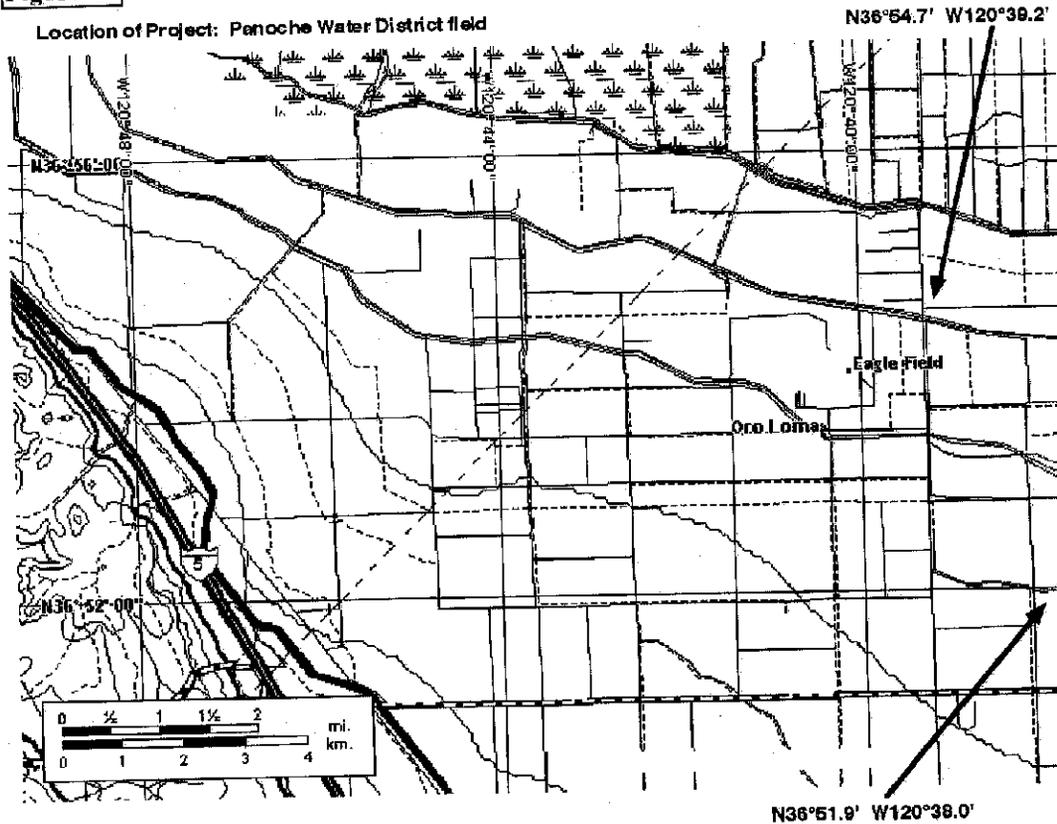
## ECOLOGICAL/BIOLOGICAL BENEFITS

Ecological/Biological Objectives

Our overall objective is to mitigate ecotoxic risk of contaminants, particularly Se, in agricultural drainage reservoirs to reduce subsequent impact on wildlife along the San Joaquin river corridor and through the Pacific flightway for migratory birds. Drainage regulatory reservoirs are deemed to be critical.

for regulating the release of drain waters from the Grassland Bypass area into the San Joaquin river so that episodic exceedance of Se load into the river can be circumvented. Drainage evaporation basins are currently utilized for disposing drain waters in the Southern San Joaquin Valley, which is in the direct path of the Pacific Flightway.

**Figure 1**



To achieve the overall objective, the following questions will be addressed: (1) to reduce Se and food availability to fish and birds through aggregation and exhaustive harvesting of water-column invertebrates; (2) to intercept bioavailable Se load into the sediment through water-column invertebrate harvest; (3) to manipulate the microphytic community to optimize Se loss through volatilization, to minimize bioavailable Se, and to sustain harvestable invertebrate production; (4) to optimize the timing of microphyte manipulation and invertebrate harvest with respect to wildlife breeding season.

After decades of research efforts on Se contamination issue, it is clear that complex Se biogeochemistry holds the key to Se ecotoxicity in aquatic ecosystems. Consequently, simple water quality parameters such as waterborne Se concentration and even Se body burden of aquatic organisms are not always reliable predictors of Se toxicity to wildlife (EPA report, 1998). The picture that is emerging is that Se biogeochemistry, particularly in the sediment, plays a pivotal role in Se fate in the environment, which in turn determines its long-term ecotoxic risk (EPA report, 1998). These

Se impact on ecosystems. For example, after a decade of restoration effort at Belews Lake (a power plant fly ash receiving reservoir), NC, Se hazard to fish population remained significant, despite the dramatic decrease in waterborne Se concentrations to well below the EPA recommended  $5 \mu\text{g/L}$  limit (Lemly, 1997). Sediment-detrital food pathway for Se was attributed as the main factor for such a slow recovery. This observation strongly suggests that simply removing Se from waters without consideration for the pathway into the sediment will not achieve the ultimate goal of Se remediation, i.e. mitigating ecotoxic risk. These hard-learned lessons must now be integrated into any long-term implementation plan for Se remediation and ecosystem restoration.

Since the outbreak of the Kesterson incident, a number of mitigation strategies for Se contamination have been tested, including drainage reduction and reuse, removal of Se from drain waters, limited discharge into the San Joaquin river, and land retirement. It is clear now each strategy has its pros and cons and no single plan can be widely implemented without major economic and/or environmental compromises. For example, drainage discharge into rivers is not an option for the Southern San Joaquin Valley due to inaccessibility, drainage reuse (e.g. via agroforestry) may not be a good option for highly salinized drainage areas such as Lost Hills Water District, or Se removal to ecologically "safe" limit in highly selenized waters is expected to be cost-prohibitive. Among all options explored, drainage discharge from the Grassland Bypass area into the San Joaquin river probably represents the most controversial issue, from the standpoint of ecological/biological benefits. This is because of the lack of an understanding of the long-term assimilatory capacity for Se "ecotoxicity" of the river and the Delta. From the lesson of Belews Lake described above, simply reducing Se load into the river is "no" assurance for mitigating long-term Se impact on the ecosystem. New concepts and approaches, in addition to total Se load reduction, must be developed to allow better adaptive management of drain water release and disposal.

Our proposed approach is designed to address this very controversial issue. We will test the feasibility of mitigating ecotoxic risk in drainage reservoirs by breaking the foodchain transfer pathway in both water column and sediment-detritus interface through harvesting of water-column invertebrates. Se load reduction in the reservoir will also be achieved by manipulating algae/microbe community for optimal Se volatilization. The conceptual framework is outlined in **FIGURE 2**. This approach should enhance our ability to operate regulatory drainage reservoirs within ecologically "safe" limits, while reducing Se discharge into the river. This approach should also facilitate the real-time management of drain water release to avoid discharge of excess Se load into the river during high drainage flow periods. Furthermore, the foodchain transfer information to be gained from the proposed study should enhance our understanding on the assimilatory capacity for Se "ecotoxicity" in both lotic and lentic systems. Finally, the economic efficacy of our approach should be self-evident since the cost of removing Se and Se risk can be defrayed by marketing of harvested macroinvertebrates.

### Linkages

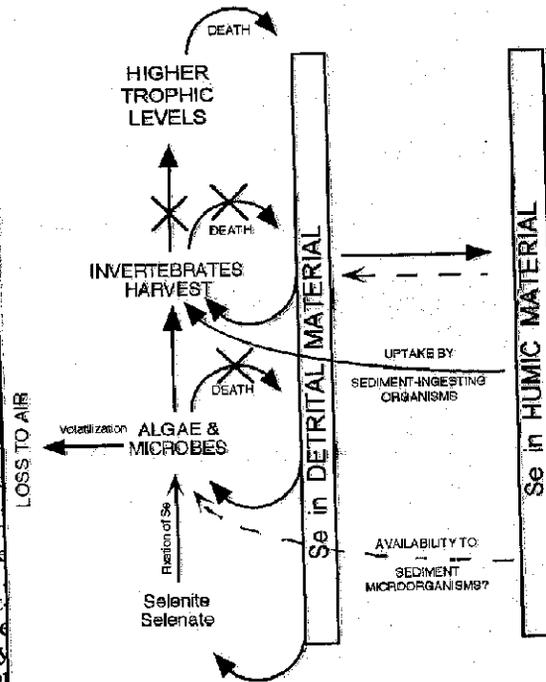
We recently learned that the Tulare Lake Drainage District's (TLDD) evaporation basin exhibited a year-round decreasing trend in waterborne Se concentrations despite the salt-concentrating effect from water evaporation (Fan et al., 1998a&b). This result is consistent with the spot sampling results obtained a decade earlier (Moore et al., 1989), so this phenomenon has persisted for at least the last 10 years (**FIGURE 3**, Appendix). In fact, these basins have been in full-scale operation (disposing approx. 12,000 acre-ft water/yr) for over 20 years and yet waterborne Se concentrations are not accumulating. If the mechanism(s) and the attendant ecotoxic risk are understood, such natural attenuation of Se may be enhanced to reduce Se load in agricultural drainage reservoirs, both in terms of short-term regulatory and long-term evaporation basins.

**Figure 2. Reducing Se ecotoxic risk in drainage reservoirs via invertebrate harvest and Se volatilization**

The inorganic Se forms are biologically fixed by aquatic algae & microbes. The fixed Se does not directly head up the foodchain in the water column. A major fraction enters into organic matter, which takes a detour through detritus (recently dead organic matter) and sediment, then re-enter the foodchain at several trophic levels. Over longer periods, part of the detrital material is converted to recalcitrant humic material, locking up the toxic elements until sediment-ingesting organisms reintroduce them to the foodchain.

Meanwhile, the unconsumed detrital material is continually breaking down to particulate and dissolved organic matter (POM and DOM), and transported downstream. Except for the initial "fixation" step, this organic matter storage reservoir scheme also applies to other persistent bioaccumulative, toxic organic chemicals such as Hg, PCBs and PAHs.

Through sustained harvesting of water-column invertebrates that consume algae and microbes, not only the bioavailable Se is removed from water, but detrital formation resulting from the death of water-column organisms is also blocked. This would in turn help minimize the sediment-detritus foodchain pathway for Se. In the meanwhile, additional Se can be removed by manipulating the algae/microbe community for optimal Se volatilization. This scheme would greatly improve the ecological "safety" of operating drainage reservoirs, while reducing Se discharge into the river. The economic efficacy of the approach is clear by marketing harvested materials for offset of operation cost.



Therefore, we have been conducting both field and laboratory studies of TLDD basin water and bottom sediment samples since Spring '96. We found that this natural attenuation of waterborne Se may be mediated via microphyte volatilization and accumulation of Se (Fan et al., 1997; Fan et al., 1998a&b). Laboratory studies on microphytes isolated from TLDD basin waters show that they volatilized and bioconcentrated Se from water, which caused water Se to be depleted (Fan et al., 1998b; Fan and Higashi, 1998). The extent of this depletion by volatilization was enhanced when the medium salinity was sharply lowered (Fan and Higashi, unpublished work funded by DWR). We also obtained both laboratory and field evidence that the Se volatilization rate varied with microphyte community and that the annual average water Se concentration of one basin cell (HEB C2) that exhibited higher volatilization rates remained lower than another comparable cell (HEB A2) (Fan and Higashi, 1999a).

We also obtained results that sediments Se concentrations did not increase with increasing salinity resulting from evaporation (Fan and Higashi, 1997), which is again consistent with the previous report (Moore et al., 1989) (FIGURE 3, Appendix). One striking observation was that the HEB C2 cell also exhibited lower sediment Se concentrations than the HEB A2 cell. In addition, the Se body burden and abundance of the benthic invertebrate population were consistently lower in the HEB C2 than A2 cells. Moreover, this trend also extended to the evaporation ponds at Lost Hills Water District, where the waterborne Se concentration was at least two orders of magnitude higher than the TLDD cells (Fan and

Highashi, 1999b). These results suggest that micophyte community plays an important role in Se volatilization, depletion from water, and fixation into the sediment as well as in controlling benthic invertebrate population.

The proposed approach integrates the knowledge that we gained from the above evaporation basin studies with the ongoing invertebrate harvest trial at TLDD conducted by Dr. Robert Rofen at the Aquatic Research Institute. The ERP strategic objective that this proposal addresses is "contaminant" reduction (p.421, vol. 1 of ERP). The linkage to future ERP action and goals include (see the Proposal Solicitation Package, Feb., 1999): 1) to improve Water Quality (Goal 6, p. 16) of the Bay/Delta by reducing and regulating Se load discharged into the San Joaquin river (3rd & 5th ERP actions, p. 23, 24); 2) to assist in Rehabilitation and Protection of Natural Processes (Goal 2, p. 14) by remediating Se risk in the Grassland Bypass area (2nd ERP action, p. 19; 3) to help protect Recreational and Commercial species (Goal 3, p. 15) by reducing Se impact on fish stock (e.g. splittail, sturgeon, salmon, steelhead) (1st ERP action, p. 28) and waterfowl species (e.g. those in the Grassland area). Since Se discharge from the Grassland Bypass area may represent a major source of Se to the Central Valley and Bay/Delta watershed, the source control measure proposed should contribute towards CALFED's overall objectives on Ecosystem Quality and Water Quality. As the Grassland Bypass area is currently regulated on EPA's total maximum daily load (TMDL) for Se, if successful, the proposed approach should contribute towards adaptive management plan for meeting this regulatory demand.

#### System-wide Ecosystem Benefits

The proposed project should help implement organized water quality management in the San Joaquin river corridor via establishing low Se-risk regulatory reservoirs for the Grassland Bypass Drainage area. It should also contribute to lowering Se risk in the long-term operation of terminal drainage reservoirs in the San Joaquin Valley watershed. In conjunction with drainage reuse programs, the proposed plan can facilitate salt utilization by reducing Se contamination of evaporite salts, which help mitigate salt load to the Bay/Delta watershed.

#### Compatibility with Non-Ecosystem Objectives

By reducing Se contamination and episodic Se overload to the San Joaquin river, the proposed plan should improve water quality of the river and the Delta while facilitating Central Valley watershed management.

### **TECHNICAL FEASIBILITY & TIMING**

#### *Relation to Other Alternative Management Options*

There have been many approaches proposed and tested for managing agricultural drain waters, including drainage reduction by changing irrigation practices, drainage reuse by cropping salt-tolerant plants, agroforestry, treatment of drain waters to remove contaminants such as Se, and discharge into the San Joaquin river. It is clear from the draft drainage report of joint UC/DWR technical committee that no single method can achieve the desired economic efficacy and mitigation of ectoxic risk simultaneously. Consequently, new approaches need to be developed that can improve existing management schemes to attain these two goals.

The proposed approach will investigate the feasibility of adapting existing management for drainage reservoir to better mitigate Se ecotoxic risk to wildlife in the Grassland Bypass area and San Joaquin

river corridor. If successful, this approach should also help reduce the current management cost for drainage reservoirs by marketing the biota harvested from the reservoir. We do not expect any major barrier to the technical feasibility or timing for the tasks described under Scope of Work. The tasks proposed are within the respective expertise of the PI's and participants. For future perspective, we also do not expect difficulty in scaling up from pilot- to full-scale operating reservoirs since this concept was originally tested in full-scale TLDD evaporation ponds.

We do not expect that CEQA, NEPA, or other environmental compliance documents are required for such pilot-scale trial, since environmental impact is expected to be negligible.

## MONITORING & DATA COLLECTION

### Biological/Ecological Objectives

The biological/ecological objectives and attendant test hypothesis is described under **ECOLOGICAL/BIOLOGICAL BENEFITS** section. The conceptual framework for the objectives is depicted in Figure 1. Water and sediment quality, microphyte community, and biota Se status will be monitored in Phase 3 of the project.

### Monitoring Parameters and Data Collection Approach

Temperature, pH, salinity, and turbidity of the pilot reservoir water at the Panoche Water District will be continuously measured using appropriate probes, sachi disk, and data logger. Waterborne Se concentration will be measured biweekly or as frequently as necessary while sediment Se status will be acquired quarterly. Se status in the biota will be determined in coordination with the microphyte manipulation and invertebrate harvest, which is expected to be on a monthly schedule. The proposed Aquatic Research Institute personnel will be responsible for macroinvertebrate collection and testing of macroinvertebrate marketability. Maintenance of field monitoring equipment, sediment sampling, microphyte community analysis, and Se analysis of water, sediment, and biota will be carried out by the UC Davis postdoctoral scientist with Fan and Higashi's assistance, while on-site Se volatilization measurement and subsequent GC-MS analysis will be performed by Higashi and Fan. References to the sampling protocols are listed under Scope of Work. The proposed work has no formal coordination with other monitoring programs. However, the data generated can add to the existing data base.

### Data Evaluation Approach

The frequency of sampling is as described above. Water samples will be acidified to pH 2 on the day of collection for Se analysis, sediment samples will be kept cold during transport, and biota samples will be frozen in liquid nitrogen on-site and transport on dry ice. Biota and sediment samples (after porewater removal) will be freeze-dried in the laboratory and stored at  $-70^{\circ}\text{C}$  before analysis. The analytical protocols are referenced under Scope of work. The monitoring data will be organized quarterly to evaluate the ecotoxic status of the reservoir and to guide further manipulation.

### Local Involvement

The proposed project will be in partnership with the Panoche Water District (Firebaugh) and Department of Water Resources (Fresno) (see letters). DWR, Fresno has plans to test a similar approach in the management of terminal drainage reservoirs at the Lost Hills Water District. US Fish & Wildlife, Regional Water Quality Control Board, and the county supervisors of the study area have been informed

of the proposed concept. Study results will be presented at appropriate meetings for outreaching to interested groups.

1) Biological/Ecological Objectives			
Hypothesis/Question to be Evaluated	Monitoring Parameter(s) and Data Collection Approach	Data Evaluation Approach	Comments/Data Priority
1) Reduce Se/food source to top predators by biota harvest	Monthly biota sampling & sorting	Assessment of invertebrate abundance, Se analysis of biota samples	
2) Interrupt sediment/detrital foodchain pathway by biota harvest	Quarterly sediment & monthly benthic biota sampling	Se analysis of sediment & benthic biota samples	
3) Reduce Se risk by manipulating microphyte community	Fertilizer addition, real-time Water quality monitoring, biweekly water sampling.	Total Se & Se volatilization analysis of water, microphyte community analysis, biota harvestability & Se analysis	
4) Minimize risk by optimizing timing of biota harvest	Adjust microphyte production before, during, & after breeding season	Assessment of invertebrate abundance, Se analysis of biota samples	

### COST

#### Budget

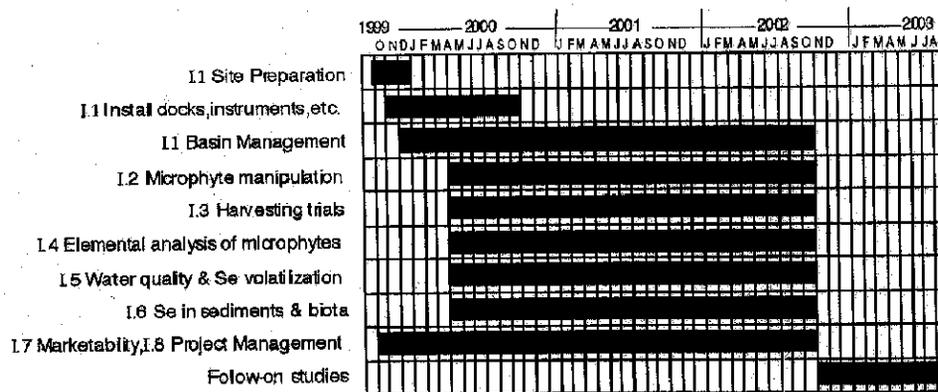
Task	Direct Labor Hours	Direct Salary & Benefits	Service Contracts	Material & Acquisition Costs	Miscellaneous & Other Direct Costs	Overhead & Indirect Costs	Total Costs
I. Biogeochemistry (UCD)	7,488	235,194	53,426	79,000	15,000	37,261 (171,404)	419,881 (554,024)
II. Harvesting (Aquatic Research Institute)	12,240	213,049	0	72,700	13,800	29,956	329,505
TOTALS	19,728	448,243	53,426	151,700	28,800	67,217 (201,360)	749,386 (883,529)

QUARTERLY BUDGET					
Year 1					
Task	Oct-Dec 99 (includes any Equipment)	Jan-Mar 00	Apr-Jun 00	Jul-Sep 00	
Biogeochemistry	72,209	37,209	37,209	37,209	
Harvesting	31,614	31,614	31,614	31,614	
TOTALS	103,823	68,823	68,823	68,823	
Year 2					
Task	Oct-Dec 00 (includes any equipment)	Jan-Mar 01	Apr-Jun 01	Jul-Sep 01	
Biogeochemistry	28,967	28,967	28,967	28,967	
Harvesting	24,784	24,784	24,784	24,784	
TOTALS	53,751	53,751	53,751	53,751	
Year 3					
Task	Oct-Dec 01 (includes any equipment)	Jan-Mar 02	Apr-Jun 02	Jul-Sep 02	TOTAL
Biogeochemistry	30,045	30,045	30,045	30,045	419,881
Harvesting	25,979	25,979	25,979	25,979	329,505
TOTALS	56,023	56,023	56,023	56,023	749,386

Funds are requested for preparing (\$35,426) and maintaining the water level (\$6,000/yr) of pilot reservoirs near the Panoche Water District Offices. At UC-Davis, one full-time postdoctoral scientist is budgeted for performing the bulk of the field monitoring, sample collection/processing, and data analysis. Two full-time personnel for the Aquatic Research Institute (ARI) is requested to perform the macroinvertebrate harvest and sorting with a 1/4 time supervisor for managing the operation. A 15% each effort is requested for the two UC Davis PI's for Se volatilization measurement, coordination of all proposed tasks, data interpretation, and report preparation. Equipment for UC-Davis consists an HPLC autosampler for Se analysis (\$10,000) and datalogging instruments (\$25,000) for the reservoirs, including pH, temperature, and EC, with long cables and signal repeater units due to the distance to the nearest power supply. Equipment for ARI consists of two harvesting boats (\$20,300), two docks (\$800), a trailer (\$2,200), water pump for the reservoir (\$7,500) and two water circulators (\$3,400) needed for invertebrate sampling; subsequent years are projected equipment costs for replacing parts of the first year equipment. For UC-Davis, 10% overhead is calculated on direct costs minus equipment, and there is a 10% overhead for the first \$25,000 subcontract to ARI. For ARI, all direct costs are subject to 10% overhead.

### Schedule

Shown below is the schedule of the project, with items listed in section I. Experimental Approach. A 4-year timeline is shown for illustrative purposes only; 3 years is proposed.



### COST-SHARING

The following cost for the project will be defrayed by resources obtained elsewhere:

- GC-MS instrumentation (\$120,000) for Se form analysis
- ED-XRF spectrometer (\$80,000) for analysis of element profile
- Fluorescence spectrophotometer (\$26,000) for total Se analysis
- HPLC and diode array spectrophotometer (\$25,000) for microphyte pigment analysis
- Ultracold freezer (-70°C) (\$10,000) dedicated for Se research
- Additional 20% effort (\$45,000) from Fan and 10% effort (\$21,000) from Higashi as supported through the Department of Water Resources and UC Salinity/Drainage Program.

### APPLICANT QUALIFICATIONS

Dr. Teresa W.-M. Fan is an associate research professor in the Department of Land, Air and Water Resources, University of California, Davis. Her research interest has been in the broad area of environmental biochemistry ranging from plant stress biochemistry and Se biogeochemistry in relation to *in situ* bioremediation, to mechanisms of aquatic ecotoxicity of agricultural and industrial discharges. Along CalFed's interest, she has been working on salinity and toxic metals stress on the Asian clam, *Potamocorbula amurensis*, in the Delta/San Pablo Bay, as well as the tradeoffs between algal phytoremediation and ecotoxic risk of selenium in San Joaquin Valley's evaporation ponds. She has served on the 9-member EPA Peer Consultation Workshop on Selenium Aquatic Toxicity and Bioaccumulation (March 1998) which concluded that selenium organic forms and foodchain biochemistry - not total Se - should be the target of ecotoxic investigations and bioremediation goal. Most recently, she was one of the authors of the Central Valley Drainage Implementation Program's comprehensive report on Discharge to the San Joaquin River.

#### Relevant Publications

- "Biotransformations of Selenium Oxyanion by Filamentous Cyanophyte-Dominated Mat Cultured from Agricultural Drainage Waters", T.W.-M.Fan, R.M. Higashi, and A.N. Lane, *Environmental Science and Technology* 32, 3185-3193 (1998).
- "Biochemical Fate of Selenium in Microphytes: Natural Bioremediation by Volatilization and Sedimentation in Aquatic Environments", T.W.-M. Fan and R.M. Higashi. In: *Environmental Chemistry of Selenium*, W.T. Frankenberger and R.A. Engberg, eds., Marcel Dekker, Inc., New York, pp. 545-563 (1998).
- "Synthesis and structure characterization of selenium metabolites", T.W.-M.Fan, A.N. Lane, D. Martens, R.M. Higashi, *Analyst* 123(5), 875-884 (1998).

Dr. Richard M. Higashi is an assistant research professor in the Crocker Nuclear Laboratory, University of California, Davis. He has worked in broad areas of environmental chemistry, ranging from toxicity identification in complex effluents such as pulpmill and oil production discharges, to DOE waste contamination remediation, to agricultural water, soil, and sediment problems of the Central Valley and San Francisco Bay/Delta, as well as air pollution (PM10 and ozone) research in the Central Valley and Sierra Nevada Range. The chemistry of humics and other organic matter plays a central role in ALL of these research areas, and he is currently engaged in organic matter chemistry investigations in relation to selenium ecotoxic remediation in evaporation ponds of the SJV.

Dr. Robert Rofen is the director of the Aquatic Research Institute and president of Novalek, Inc. and has over 40 years of experience with brine shrimp research, harvest, and marketing.

#### Relevant Publications

- "Selenium Biotransformations by a Euryhaline Microalga Isolated from a Saline Evaporation Pond", T.W.-M. Fan, A.N.Lane, and R.M. Higashi, *Environmental Science and Technology*, 31, 569-576 (1997).
- "Association of desferrioxamine with humic substances and their interaction with cadmium(II) as studied by pyrolysis gas chromatography mass spectrometry and nuclear magnetic resonance spectroscopy", R.M. Higashi, T.W.-M. Fan, A.N. Lan, *Analyst* 123(5), 911-918 (1998).
- "Microphytes-Mediated Selenium Biogeochemistry and Its Role in *In Situ* Selenium Bioremediation", T.W.-M. Fan and R.M. Higashi. In: *Phytoremediation*, N. Terry, ed., Ann Arbor Press

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## APPENDIX

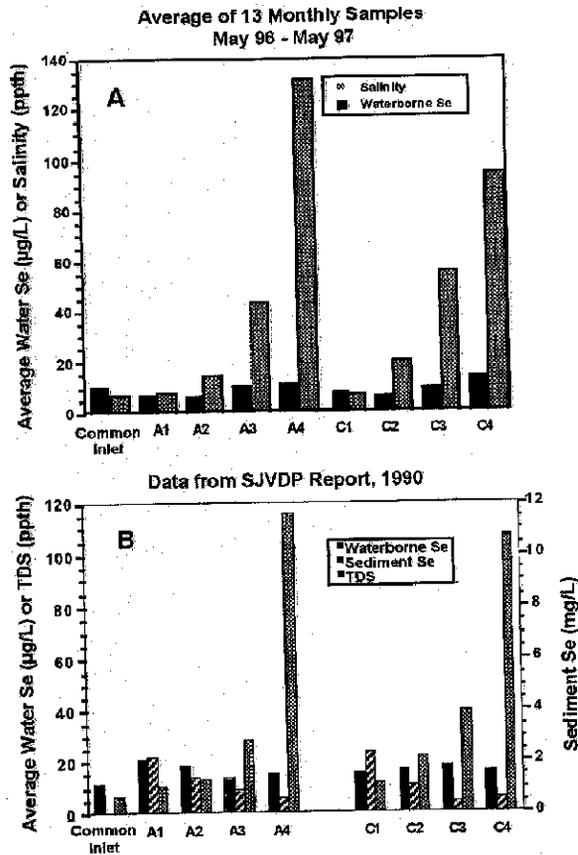


Figure 3. Waterborne Se and sediment Se concentrations at Tulare Lake Drainage Evaporation basin.

Data in A and B were compiled from Fan et al., 1998b and Moore et al., 1989, respectively. The two evaporation cell series A1-A4 and C1-C4 received the same drain water from a common inlet. Water is channelled sequentially through each cell series, and due to evaporation, a large increasing gradient in water salinity or total dissolved solid (TDS) is typically established from the 1st to the 4th cells. However, waterborne Se and sediment Se concentrations did not increase accordingly.

April 12, 1999

**Adaptive Management Strategy for Regulatory Reservoirs of  
Agricultural Drainage Discharge: Mitigating Selenium  
Ecotoxic Risk by Combining Foodchain Breakage with  
Natural Remediation**

**Foodchain Breakage Task**

by Robert Rofen

**Aquatic Research Institute** (a not-for-profit tax-exempt trust in the  
State of California)

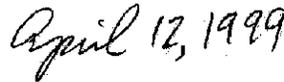
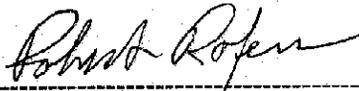
2242 Davis Ct., Hayward CA 94545

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fax 510 784-0945 510 782-0347

e-mail: rofen@prado.com

Proposal to: CALFED-Delta Program, to be subcontracted from University of  
California-Davis, Teresa W.-M. Fan, lead PI.



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Robert Rofen, co-Principal Investigator

Date

## DEPARTMENT OF WATER RESOURCES

SAN JOAQUIN DISTRICT  
3374 EAST SHIELDS AVENUE  
FRESNO, CA 93726-6913



April 13, 1999

Dr. Teresa Fan  
University of California-Davis  
Department of Land, Air and  
Water Resources  
1 Shields Avenue  
Davis, California 95616-8627

Dear Dr. Fan:

This is a letter to assure you of our intent to collaborate and express our support for your proposal to CALFED, entitled "Adaptive Management Strategy for Regulatory Reservoirs of Agricultural Drainage Discharge Mitigating Selenium Ecotoxic Risk by Combining Foodchain Breakage with Natural Remediation". The proposed management strategy is unique among schemes to remediate agricultural drainage, in that it is designed from ground-up to address your area of expertise—the *ecotoxic risk* of selenium. Since ecotoxic risk is the only regulatory issue of concern for selenium contamination of drainage water, such a project is direct and timely.

You propose a management system of reducing selenium ecotoxic risk instead of a treatment. This means that it can be readily validated on a full-scale basis without the usual problems, costs, and delays laboratory studies, field pilot trials, and costly design and construction engineering. In fact, Dr. Robert Rofen of the Aquatic Research Institute has already demonstrated the proposal's proof-of-concept on a full-scale pond in the Tulare basin. It now needs to be developed for the different water chemistry, operational conditions, and needs of the drainage waters discharged from the Grasslands area.

On behalf of the entity responsible for managing the Department of Water Resources Agricultural Drainage Program and the CALFED funded Real-time Monitoring Program for the San Joaquin River, I would like to express our District's support for this proposal. We believe that this investigation will potentially open a fast-track management alternative that will ensure that agricultural discharges from the northern San Joaquin Valley will meet the discharge requirements and ecotoxic safety limits needed to safeguard the health of the San Joaquin Valley, the San Joaquin River and the Delta.

Sincerely,

A handwritten signature in black ink that reads "Louis A. Beck" with a stylized flourish at the end.

Louis A. Beck, Chief  
San Joaquin District

# PANOCHÉ WATER DISTRICT

52027 WEST ALTHEA, FIREBAUGH, CA 93822 • TELEPHONE (209) 364-6138 • FAX (209) 364-6122



April 12, 1999

CALFED Bay-Delta Program  
Dr. Teresa W.M. Fan  
Dept. of Land, Air and Water Resources  
University of California  
One Shields Avenue  
Davis, CA 95616-8627

Subject: Proposal to CALFED entitled: "Adaptive Management Strategy for  
Regulatory Reservoirs of Agricultural Drainage Discharge: Mitigating  
Selenium Ecotoxic Risk by Combining Foodchain Breakage with  
Natural Remediation"

To Whom It May Concern:

This letter is to confirm our intent to collaborate with Dr. Teresa Fan, et al. On the above-named project. We will provide the site, and manage the site-preparation and maintenance of the proposed 2x2-acre regulatory basins.

The experimental site is located within Panoche Water District. The full-scale regulatory reservoirs mentioned in the proposal are likewise located within Panoche Water District.

If there are any site questions regarding this collaboration, please don't hesitate to contact me. Any scientific or technical questions should be directed to the PI, Dr. Fan.

Sincerely,

Dennis Falaschi  
General Manager

---

Board of Directors: Mike Linneman, *President* • Edward Koda, *Vice-President* • Michael Stearns, *Secretary*  
Suzanne LeCompte • John F. Bennett • Dennis Falaschi, *General Manager*



SOILS AND BIOGEOCHEMISTRY  
HOAGLAND HALL  
(916) 752-1406  
FAX: (916) 752-1552

DAVIS, CALIFORNIA 95616-8627

Merced County Board Administrative Offices  
2222 M St  
Merced, CA 95340-3729  
Phone: 209-385-7637

13 April, 1999

This letter is to notify your county of our intent to submit a proposal to the CALFED Bay-Delta Program, due on April 16, which will be performed in part in your county. The information is listed below. If funded, CALFED will notify you of the project after close of their confidentiality period.

If you have any questions, please feel free to contact me at the number below.

Sincerely,

A handwritten signature in black ink, appearing to read "Teresa W-M. Fan".

Teresa W-M. Fan

**Adaptive Management Strategy For Regulatory Reservoir Of Agricultural Drainage Discharge: Mitigating Selenium Ecotoxic Risk By Combining Foodchain Breakage With Natural Remediation**

**Primary Contact:**

Dr. Teresa W.-M. Fan, Department of Land, Air and Water Resources, University of California, Davis, One Shields Ave., Davis, CA 95616-8627.  
Phone: 530-752-1450; Fax: 530-752-1552

**Participants and Collaborators:**

Dr. Richard M. Higashi, Crocker Nuclear Laboratory, University of California, Davis  
Jack Erickson, California Department of Water Resources, Fresno  
Dr. Robert Rofen, Aquatic Research Institute, Hayward  
Dennis Falaschi & Marcos Hederick, Panoche Water District, Firebaugh

**Type of Organization and Tax Status:**

University, non-profit



SOILS AND BIOGEOCHEMISTRY  
HOAGLAND HALL  
(916) 752-1406  
FAX: (916) 752-1552

DAVIS, CALIFORNIA 95616-8627

Fresno County Board-Supervisor  
2281 Tulare St # 301  
Fresno, CA 93721-2105  
Phone: 559-488-3529

13 April, 1999

This letter is to notify your county of our intent to submit a proposal to the CALFED Bay-Delta Program, due on April 16, which will be performed in part in your county. The information is listed below. If funded, CALFED will notify you of the project after close of their confidentiality period.

If you have any questions, please feel free to contact me at the number below.

Sincerely,

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Teresa W.-M. Fan

**Adaptive Management Strategy For Regulatory Reservoir Of Agricultural Drainage Discharge: Mitigating Selenium Ecotoxic Risk By Combining Foodchain Breakage With Natural Remediation**

**Primary Contact:**

Dr. Teresa W.-M. Fan, Department of Land, Air and Water Resources, University of California, Davis, One Shields Ave., Davis, CA 95616-8627  
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Dr. Robert Rofen, Aquatic Research Institute, Hayward  
Dennis Falaschi & Marcos Hederick, Panoche Water District, Firebaugh

**Type of Organization and Tax Status:**

University, non-profit

## NONDISCRIMINATION COMPLIANCE STATEMENT

STD. 19 (REV. 3-85) FMC

COMPANY NAME

AQUATIC RESEARCH INSTITUTE

The company named above (hereinafter referred to as "prospective contractor") hereby certifies, unless specifically exempted, compliance with Government Code Section 12990 (a-f) and California Code of Regulations, Title 2, Division 4, Chapter 5 in matters relating to reporting requirements and the development, implementation and maintenance of a Nondiscrimination Program. Prospective contractor agrees not to unlawfully discriminate, harass or allow harassment against any employee or applicant for employment because of sex, race, color, ancestry, religious creed, national origin, disability (including HIV and AIDS), medical condition (cancer), age, marital status, denial of family and medical care leave and denial of pregnancy disability leave.

## CERTIFICATION

*I, the official named below, hereby swear that I am duly authorized to legally bind the prospective contractor to the above described certification. I am fully aware that this certification, executed on the date and in the county below, is made under penalty of perjury under the laws of the State of California.*

OFFICIAL'S NAME

ROBERT R ROFEN

DATE EXECUTED

APRIL 13 1999

EXECUTED IN THE COUNTY OF

ALAMEDA

PROSPECTIVE CONTRACTOR'S SIGNATURE

Robert R Rofen

PROSPECTIVE CONTRACTOR'S TITLE

DIRECTOR

PROSPECTIVE CONTRACTOR'S LEGAL BUSINESS NAME

AQUATIC RESEARCH INSTITUTE

State of California  
The Resources Agency  
DEPARTMENT OF WATER RESOURCES

Agreement No. \_\_\_\_\_

Exhibit \_\_\_\_\_

**STANDARD CLAUSES -  
SMALL BUSINESS PREFERENCE AND CONTRACTOR IDENTIFICATION NUMBER**

**NOTICE TO ALL BIDDERS:**

Section 14835, et. seq. of the California Government Code requires that a five percent preference be given to bidders who qualify as a small business. The rules and regulations of this law, including the definition of a small business for the delivery of service, are contained in Title 2, California Code of Regulations, Section 1896, et. seq. A copy of the regulations is available upon request. Questions regarding the preference approval process should be directed to the Office of Small and Minority Business at (916) 322-5060. To claim the small business preference, you must submit a copy of your certification approval letter with your bid.

Are you claiming preference as a small business?

\_\_\_\_ Yes\*

No

\*Attach a copy of your certification approval letter.

AQUATIC RESEARCH INSTITUTE  
2242 DAVIS CT  
Hayward CA 94545

Robert R. Rofen  
ROBERT R ROFEN

April 13, 1999

## ASSURANCES - NON-CONSTRUCTION PROGRAMS

Public reporting burden for this collection of information is estimated to average 15 minutes per response, including time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding the burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to the Office of Management and Budget, Paperwork Reduction Project (0348-0040), Washington, DC 20503.

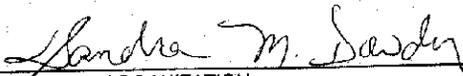
**PLEASE DO NOT RETURN YOUR COMPLETED FORM TO THE OFFICE OF MANAGEMENT AND BUDGET. SEND IT TO THE ADDRESS PROVIDED BY THE SPONSORING AGENCY.**

**NOTE:** Certain of these assurances may not be applicable to your project or program. If you have questions, please contact the awarding agency. Further, certain Federal awarding agencies may require applicants to certify to additional assurances. If such is the case, you will be notified.

As the duly authorized representative of the applicant, I certify that the applicant:

1. Has the legal authority to apply for Federal assistance and the institutional, managerial and financial capability (including funds sufficient to pay the non-Federal share of project cost) to ensure proper planning, management and completion of the project described in this application.
2. Will give the awarding agency, the Comptroller General of the United States and, if appropriate, the State, through any authorized representative, access to and the right to examine all records, books, papers, or documents related to the award; and will establish a proper accounting system in accordance with generally accepted accounting standards or agency directives.
3. Will establish safeguards to prohibit employees from using their positions for a purpose that constitutes or presents the appearance of personal or organizational conflict of interest, or personal gain.
4. Will initiate and complete the work within the applicable time frame after receipt of approval of the awarding agency.
5. Will comply with the Intergovernmental Personnel Act of 1970 (42 U.S.C. §§4728-4763) relating to prescribed standards for merit systems for programs funded under one of the 19 statutes or regulations specified in Appendix A of OPM's Standards for a Merit System of Personnel Administration (5 C.F.R. 900, Subpart F).
6. Will comply with all Federal statutes relating to nondiscrimination. These include but are not limited to: (a) Title VI of the Civil Rights Act of 1964 (P.L. 88-352) which prohibits discrimination on the basis of race, color or national origin; (b) Title IX of the Education Amendments of 1972, as amended (20 U.S.C. §§1681-1683, and 1685-1686), which prohibits discrimination on the basis of sex; (c) Section 504 of the Rehabilitation Act of 1973, as amended (29 U.S.C. §794), which prohibits discrimination on the basis of handicaps; (d) the Age Discrimination Act of 1975, as amended (42 U.S.C. §§6101-6107), which prohibits discrimination on the basis of age; (e) the Drug Abuse Office and Treatment Act of 1972 (P.L. 92-255), as amended, relating to nondiscrimination on the basis of drug abuse; (f) the Comprehensive Alcohol Abuse and Alcoholism Prevention, Treatment and Rehabilitation Act of 1970 (P.L. 91-616), as amended, relating to nondiscrimination on the basis of alcohol abuse or alcoholism; (g) §§523 and 527 of the Public Health Service Act of 1912 (42 U.S.C. §§290 dd-3 and 290 ee 3), as amended, relating to confidentiality of alcohol and drug abuse patient records; (h) Title VIII of the Civil Rights Act of 1968 (42 U.S.C. §§3601 et seq.), as amended, relating to nondiscrimination in the sale, rental or financing of housing; (i) any other nondiscrimination provisions in the specific statute(s) under which application for Federal assistance is being made; and, (j) the requirements of any other nondiscrimination statute(s) which may apply to the application.
7. Will comply, or has already complied, with the requirements of Titles II and III of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (P.L. 91-646) which provide for fair and equitable treatment of persons displaced or whose property is acquired as a result of Federal or federally-assisted programs. These requirements apply to all interests in real property acquired for project purposes regardless of Federal participation in purchases.
8. Will comply, as applicable, with provisions of the Hatch Act (5 U.S.C. §§1501-1508 and 7324-7328) which limit the political activities of employees whose principal employment activities are funded in whole or in part with Federal funds.

9. Will comply, as applicable, with the provisions of the Davis-Bacon Act (40 U.S.C. §§276a to 276a-7), the Copeland Act (40 U.S.C. §276c and 18 U.S.C. §874), and the Contract Work Hours and Safety Standards Act (40 U.S.C. §§327-333), regarding labor standards for federally-assisted construction subagreements.
10. Will comply, if applicable, with flood insurance purchase requirements of Section 102(a) of the Flood Disaster Protection Act of 1973 (P.L. 93-234) which requires recipients in a special flood hazard area to participate in the program and to purchase flood insurance if the total cost of insurable construction and acquisition is \$10,000 or more.
11. Will comply with environmental standards which may be prescribed pursuant to the following: (a) institution of environmental quality control measures under the National Environmental Policy Act of 1969 (P.L. 91-190) and Executive Order (EO) 11514; (b) notification of violating facilities pursuant to EO 11738; (c) protection of wetlands pursuant to EO 11990; (d) evaluation of flood hazards in floodplains in accordance with EO 11988; (e) assurance of project consistency with the approved State management program developed under the Coastal Zone Management Act of 1972 (16 U.S.C. §§1451 et seq.); (f) conformity of Federal actions to State (Clean Air) Implementation Plans under Section 176(c) of the Clean Air Act of 1955, as amended (42 U.S.C. §§7401 et seq.); (g) protection of underground sources of drinking water under the Safe Drinking Water Act of 1974, as amended (P.L. 93-523); and, (h) protection of endangered species under the Endangered Species Act of 1973, as amended (P.L. 93-205).
12. Will comply with the Wild and Scenic Rivers Act of 1968 (16 U.S.C. §§1271 et seq.) related to protecting components or potential components of the national wild and scenic rivers system.
13. Will assist the awarding agency in assuring compliance with Section 106 of the National Historic Preservation Act of 1966, as amended (16 U.S.C. §470), EO 11593 (identification and protection of historic properties), and the Archaeological and Historic Preservation Act of 1974 (16 U.S.C. §§469a-1 et seq.).
14. Will comply with P.L. 93-348 regarding the protection of human subjects involved in research, development, and related activities supported by this award of assistance.
15. Will comply with the Laboratory Animal Welfare Act of 1966 (P.L. 89-544, as amended, 7 U.S.C. §§2131 et seq.) pertaining to the care, handling, and treatment of warm blooded animals held for research, teaching, or other activities supported by this award of assistance.
16. Will comply with the Lead-Based Paint Poisoning Prevention Act (42 U.S.C. §§4801 et seq.) which prohibits the use of lead-based paint in construction or rehabilitation of residence structures.
17. Will cause to be performed the required financial and compliance audits in accordance with the Single Audit Act Amendments of 1996 and OMB Circular No. A-133, "Audits of States, Local Governments, and Non-Profit Organizations."
18. Will comply with all applicable requirements of all other Federal laws, executive orders, regulations, and policies governing this program.

SIGNATURE OF AUTHORIZED CERTIFYING OFFICIAL 	TITLE Sandra M. Dowdy Contracts and Grants Analyst
APPLICANT ORGANIZATION THE REGENTS OF THE UNIVERSITY OF CALIFORNIA	DATE SUBMITTED APR 15 1999

Standard Form 424B (Rev. 7-97) Back

**PART E: Certification Regarding Lobbying  
Certification for Contracts, Grants, Loans, and Cooperative Agreements**

**CHECK IF CERTIFICATION IS FOR THE AWARD OF ANY OF THE FOLLOWING AND  
THE AMOUNT EXCEEDS \$100,000: A FEDERAL GRANT OR COOPERATIVE AGREEMENT;  
SUBCONTRACT, OR SUBGRANT UNDER THE GRANT OR COOPERATIVE AGREEMENT.**

**CHECK IF CERTIFICATION IS FOR THE AWARD OF A FEDERAL  
LOAN EXCEEDING THE AMOUNT OF \$150,000, OR A SUBGRANT OR  
SUBCONTRACT EXCEEDING \$100,000, UNDER THE LOAN.**

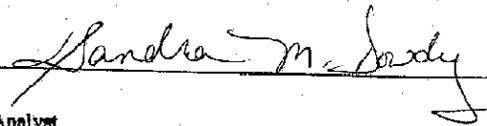
The undersigned certifies, to the best of his or her knowledge and belief, that:

- (1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of an agency, a Member of Congress, and officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.
- (2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure Form to Report Lobbying," in accordance with its instructions.
- (3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers (including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements) and that all subrecipients shall certify accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by Section 1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than \$10,000 and not more than \$100,000 for each such failure.

As the authorized certifying official, I hereby certify that the above specified certifications are true.

SIGNATURE OF AUTHORIZED CERTIFYING OFFICIAL



TYPED NAME AND TITLE

Sandra M. Dowdy  
Contracts and Grants Analyst

DATE

APR 15 1999