99D-101

UNIVERSITY OF CALIFORNIA, DAVIS

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SANTA BARBARA • SANTA CRUZ

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(530) 752-2075
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410 Mrak 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:** Rapid-Response Assessment of Selenium "Fixation" Rate into the Foodchain by Analysis of Volatile Biogenic Selenium Compounds
**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

I -018414

I-018414

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

Proposal Title: **Rapid-Response Assessment of Selenium "Fixation" Rate into the Foodchain by Analysis of Volatile Biogenic Selenium Compounds**


Applicant Name: Richard M. Higashi and Teresa W-M. Fan

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: rmhigashi@ucdavis.edu


Amount of funding requested: $ 115,029 for 2 years

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

- ☐ Fish Passage/Fish Screens
- ☐ Habitat Restoration
- ☐ Local Watershed Stewardship
- ☒ Water Quality
- ☐ Introduced Species
- ☐ Fish Management/Hatchery
- ☐ Environmental Education

Does the proposal address a specified Focused Action? X yes _____ no

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

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

- ☐ Sacramento River Mainstem
- ☐ Sacramento Trib: _____
- ☒ San Joaquin River Mainstem
- ☐ San Joaquin Trib: _____
- ☐ Delta: _____
- ☐ East Side Trib: _____
- ☐ Suisun Marsh and Bay
- ☐ North Bay/South Bay: _____
- ☐ Landscape (entire Bay-Delta watershed)
- ☐ Other: _____

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

- ☒ San Joaquin and East-side Delta tributaries fall-run chinook salmon
- ☐ Winter-run chinook salmon
- ☐ Late-fall run chinook salmon
- ☐ Delta smelt
- ☒ Splittail
- ☐ Green sturgeon
- ☐ Migratory birds
- ☐ Other: _____
- ☐ Spring-run chinook salmon
- ☐ Fall-run chinook salmon
- ☐ Longfin smelt
- ☐ Steelhead trout
- ☐ Striped bass
- ☐ All chinook species
- ☒ 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. splitail, 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):

- ☐ State agency
- ☐ Public/Non-profit joint venture
- ☐ Local government/district
- ☒ University
- ☐ Federal agency
- ☐ Non-profit
- ☐ Private party
- ☐ Other: _____

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

- ☐ Planning
- ☐ Monitoring
- ☒ Research
- ☐ Implementation
- ☐ Education

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

Sandra M. Dowdy
Contracts and Grants Analyst
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I-018416

OMB Approval No. 0348-0043

# APPLICATION FOR FEDERAL ASSISTANCE

| 2. DATE SUBMITTED | Applicant Identifier |
|---|---|
| 3. DATE RECEIVED BY STATE | State Application Identifier |
| 4. DATE RECEIVED BY FEDERAL AGENCY | Federal Identifier |

**1. TYPE OF SUBMISSION:**
Application: ☐ Construction ☒ Non-Construction
Preapplication: ☐ Construction ☐ Non-Construction

**5. APPLICANT INFORMATION**

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)*:
Richard M. Higashi, 530/752-1450
Teresa W-M. Fan, 530/752-1450

**6. EMPLOYER IDENTIFICATION NUMBER *(EIN)*:**
9 4 — 6 0 3 6 4 9 4 W

**7. TYPE OF APPLICANT:** *(enter appropriate letter in box)* [ I ]

A. State — H. Independent School Dist.
B. County — I. State Controlled Institution of Higher Learning
C. Municipal — J. Private University
D. Township — K. Indian Tribe
E. Interstate — L. Individual
F. Intermunicipal — M. Profit Organization
G. Special District — N. Other (Specify) _____

**8. TYPE OF APPLICATION:**
☒ New ☐ Continuation ☐ Revision

If Revision, enter appropriate letter(s) in box(es) ☐ ☐

A. Increase Award B. Decrease Award C. Increase Duration
D. Decrease Duration Other *(specify)*: _____

**9. NAME OF FEDERAL AGENCY:**
CALFED Bay-Delta Program

**10. CATALOG OF FEDERAL DOMESTIC ASSISTANCE NUMBER:**
☐☐ — ☐☐☐
TITLE:

**11. DESCRIPTIVE TITLE OF APPLICANT'S PROJECT:**
Rapid-Response Assessment of Selenium "Fixation" Rate into the Foodchain by Analysis of Volatile Biogenic Selenium Compounds

**12. AREAS AFFECTED BY PROJECT** *(Cities, Counties, States, etc.)*:
California

**13. PROPOSED PROJECT**
Start Date: Oct 1, 1999 Ending Date: Sep 30,2001

**14. CONGRESSIONAL DISTRICTS OF:**
a. Applicant: Third b. Project: Third

**15. ESTIMATED FUNDING:** First year

| | |
|---|---|
| a. Federal | $ 59,144 .00 |
| b. Applicant | $ .00 |
| c. State | $ .00 |
| d. Local | $ .00 |
| e. Other | $ .00 |
| f. Program Income | $ .00 |
| g. TOTAL | $ 59,144 .00 |

**16. IS APPLICATION SUBJECT TO REVIEW BY STATE EXECUTIVE ORDER 12372 PROCESS?**

a. YES. THIS PREAPPLICATION/APPLICATION WAS MADE AVAILABLE TO THE STATE EXECUTIVE ORDER 12372 PROCESS FOR REVIEW ON:
DATE _____

b. No. ☒ PROGRAM IS NOT COVERED BY E. O. 12372
☐ OR PROGRAM HAS NOT BEEN SELECTED BY STATE FOR REVIEW

**17. IS THE APPLICANT DELINQUENT ON ANY FEDERAL DEBT?**
☐ Yes If "Yes," attach an explanation. ☒ No

**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.**

| a. Type Name of Authorized Representative | b. Title | c. Telephone Number |
|---|---|---|
| | Sandra M. Dowdy Contracts and Grants Analyst | |
| d. Signature of Authorized Representative | | e. Date Signed APR 15 1999 |

Sandra M. Dowdy

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

I —018417

I-018417

OMB Approval No. 0348-0044

## 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. volatile Se monitoring | | $ | $ | $ 115,029 | $ | $ 115,029 |
| 2. | | | | | | |
| 3. | | | | | | |
| 4. | | | | | | |
| 5. Totals | | $ | $ | $ | $ | $ |

### SECTION B - BUDGET CATEGORIES

| 6. Object Class Categories | GRANT PROGRAM, FUNCTION OR ACTIVITY (1) volatile Se monitoring | (2) | (3) | (4) | Total (5) |
|---|---|---|---|---|---|
| a. Personnel | $ 67,399 | $ | $ | $ | $ 67,399 |
| b. Fringe Benefits | 16,174 | | | | 16,174 |
| c. Travel | 4,000 | | | | 4,000 |
| d. Equipment | 5,500 | | | | 5,500 |
| e. Supplies | 12,000 | | | | 12,000 |
| f. Contractual | 0 | | | | 0 |
| g. Construction | 0 | | | | 0 |
| h. Other | 0 | | | | 0 |
| i. Total Direct Charges (sum of 6a-6h) | 105,073 | | | | 105,073 |
| j. Indirect Charges | 9,956 | | | | 9,956 |
| k. TOTALS (sum of 6i and 6j) | $ 115,029 | $ | $ | $ | $ 115,029 |
| 7. Program Income | $ | $ | $ | $ | $ |

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Prescribed by OMB Circular A-102

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I-018418

## SECTION B - 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 C - FORCASTED CASH NEEDS

| | Total for 1st Year | 1st Quarter | 2nd Quarter | 3rd Quarter | 4th Quarter |
|---|---|---|---|---|---|
| 13. Federal | $ 59,144 | $ 18,911 | $ 13,411 | $ 13,411 | $ 13,411 |
| 14. NonFederal | | | | | |
| 15. TOTAL (sum of lines 13 and 14) | 59,144 | 18,911 | 13,411 | 13,411 | 13,411 |

## SECTION D - BUDGET ESTIMATES OF FEDERAL FUNDS NEEDED FOR BALANCE OF THE PROJECT

| (a) Grant Program | FUTURE FUNDING PERIODS (Years) (b) First | (c) Second | (d) Third | (e) Fourth |
|---|---|---|---|---|
| 16. Volatile Se Monitoring | $ 55,885 | $ | $ | $ |
| 17. | | | | |
| 18. | | | | |
| 19. | | | | |
| 20. TOTAL (sum of lines 16-19) | $ 55,885 | $ | $ | $ |

## SECTION E - OTHER BUDGET INFORMATION

| | |
|---|---|
| 21. Direct Charges: 105,073 | 22. Indirect Charges: 9,956 |
| 23. Remarks: | |



I —0 1 8 4 1 9

I-018419

**TITLE PAGE**

# Rapid-Response Assessment of Selenium "Fixation" Rate into the Foodchain by Analysis of Volatile Biogenic Selenium Compounds

**Primary Contacts:**

Richard M. Higashi, Crocker Nuclear Laboratory, One Shields Ave, University of California, Davis, Davis, CA 95616
Phone: 530-752-1450; Fax: 530-752-0952
Terersa W.-M. Fan, Department of Land, Air and Water Resources, University of California, Davis, One Shields Ave., Davis, CA 95616
Phone: 530-752-1450; Fax: 530-752-1552

**Participants and Collaborators:**

Jack Erickson, California Department of Water Resources, Fresno

**Type of Organization and Tax Status:**

University, non-profit

**Tax Identification Number:**

94-6036494W



I-018420

## EXECUTIVE SUMMARY

The proposed investigation is an analytical add-on to the CALFED-funded San Joaquin River Real-time Water Quality Management Program (D252) (hereafter referred to as the "SJR Realtime Monitoring"), coordinated by the California Dept. of Water Resources in Fresno. Therefore, parts of the project description, such as geographic boundaries, agency coordination, and local/stakeholder involvement are deferred to the appendix which contains the CALFED-approved and funded work plan from DWR (interagency agreement #B81647).

Background: The Calfed-Funded SJR Real-Time Monitoring Project

As stated in the SJR Realtime Monitoring work plan, a primary San Joaquin River (SJR) water quality issue is "*operation of the USBR's Grassland Bypass Channel Project that regulates agricultural drainage discharge into Mud Slough near its confluence with the SJR. This project, which began in September 1996 and is scheduled to last up to five years, has a compliance monitoring program that establishes monthly load limits for salt and selenium.*" [underlines added].

The proposal goes on to state that "*the project willÖ monitor aquatic contaminants (e.g., selenium and agricultural chemicals) that may cause acute toxicity and mortality or long-term toxicity and associated detrimental physiological responses. The discharge into the SJR of agricultural drainage high in selenium is a serious contaminant problem in the lower SJR basin and Bay-DeltaÖ because it bioaccumulates in plant and animal tissue to levels that can be toxic to higher trophic organisms.*" [underlines added]

Thus, the SJR Realtime Monitoring features monitoring of rapid-to-analyze components of the river mainstem and its tributaries in combination with modeling, in an effort to provide timely feedback for dischargers. For selenium (Se), analysis of total water concentration is the only viable option. Certainly, this suits the *present-day* regulatory objectives of maximum load limits imposed on total Se in the SJR.

Ecotoxic Risk Indicators and Regulations

Unfortunately, total waterborne Se – while readily analyzed – is widely considered to be an *unreliable* indicator of ecotoxic risk to upper trophic levels, precisely because Se bioaccumulates, as stated above. This fact has been revealed by numerous scientific publications (please see discussion in the main proposal), and clearly spelled out in CALFED's own document (CALFED, 1999). Furthermore, this fact is behind the recent EPA Great Lakes ruling (EPA, 1996), and constitutes a primary conclusion of the EPA Peer Consultation Workshop on Selenium Aquatic Toxicity and Bioaccumulation (EPA, 1998). This fact is also reflected in the California Toxics Rule (EPA, 1997) suggesting site-specific Se criteria for the SJR. Thus, there are abundant signs that the regulations may align closer to the ecotoxic facts in the near future.

If not total waterborne Se, then what else should one measure? Efforts are currently underway to test the expert-panel consensus hypothesis (EPA, 1998 and references cited therein) that the proteinaceous Se in food items (e.g. water column and benthic invertebrates) may be a good measure of upper-trophic-level ecotoxic risk. This is due to the high Se concentrations typically found in protein, coupled with its high nutritional availability to the next trophic level. One such investigation is already being conducted in our laboratory. It remains to be seen whether this type of sampling and analysis

can develop into a rapid-response method, but currently the approach is relatively labor-intensive and time-consuming.

Ecotoxic Risk Indicators and "Real-Time" Water Quality Management

Suppose - for argument's sake – that methods already existed where invertebrates are readily sampled and quickly analyzed for proteinaceous Se. Would such ecotoxic risk analyses help in short-term water quality management? There is disturbing evidence that the answer would be... "NO".

All selenium monitoring – real and proposed, even advanced concepts such as proteinaceous Se - measures its *accumulation* into pools, not the *rate* at which Se is entering the foodchain. The well-known case of Belews Lake, NC, into which Se discharge was terminated in 1985, still shows significantly elevated Se levels in foodchain pools a decade later (Lemly, 1997)! This hysteresis is probably due to recycling of Se between the foodchain and detrital/sediment pools. Therefore, measurement of Se pools CANNOT (in a short time) yield the rate of entry/reentry into the foodchain, which is needed to provide the critical direction-of-change of Se ecotoxic risk. In other words, the answer to the question, "Is the Se ecotoxic risk increased or decreased when I do this or that?" is urgently needed to manage water quality on a realistic time scale.

Our Proposal -- A New Category of Se Measurement

We propose to test, at CALFED-funded SJR Realtime Monitoring sites, a potentially viable yet forseeably practical way to obtain the *rate* at which Se is entering and re-entering the foodchain. This consists of analysis of volatile, *biogenic* Se compounds in the water, using a method recently developed by us: purge-cryotraping, solid-phase microextraction gas chromatograph/mass spectrometry ("cryotrap-SPME-GC/MS"). The rationale behind this method is: (a) only the lowest foodchain organisms (algae, microbes, plants) are known to produce appreciable volatile Se; (b) these *biogenic* Se compounds are a side-product of uptake and metabolism of Se from inorganic, living, and detrital forms of Se; (c) because the biogenic Se compounds are volatile and labile, they do not accumulate, so that their concentration may indicate only recently-fixed Se (it is a "rapid-response" ecotoxic risk parameter); (d) because the analysis uses mostly off-the-shelf, automatable instruments, it has the potential for rapid analytical results (so the analysis method is also "rapid-response").

Although the above rationale *appears* to be straightforward, there are questions present at each step that must be addressed (please see main proposal for details of the work plan). For example, does higher Se volatiles correlate well with higher or lower Se levels in the infaunal invertebrates? Also, the production of biogenic volatile Se compounds is expected to be site-specific, because the algal/microbial communities are likewise site-specific. This need not be a disadvantage, if the desired information is some measure of the direction-of-change (e.g., "Is the Se fixation rate going up or down in response to my saline drainage?"). If so, each site might serve as its own historical control. Thus, much research is needed before Se volatile measurments can be interpreted reliably, which is the impetus for requesting $115,029 in CALFED support for a two-year study.

In summary, the proposed analysis of biogenic volatile Se compounds can be valuable to the SJR Realtime Monitoring project because it could provide direction-of-change (and possibly rate) of foodchain Se entry, that is currently not measureable. The ultimate objective is to measure a rapid-response parameter that is linked to Se ecotoxic risk, and do so by utilizing a potentially rapid-response analytical method.

## PROJECT DESCRIPTION

### Proposed Scope of Work

As outlined in the **Executive Summary** and discussed in **Ecological/Biological Benefits**, there is a crucial need to determine, even if it's just a direction-of-change, the rate of Se entering the aquatic foodchain. To the best of our knowledge, there is no practical method of doing so in the field. Here, we propose to measure volatile, *biogenic* Se compounds in the water. The background, rationale, and work plan for measuring volatile biogenic Se is described in this section. The work plan essentially consists of measuring the volatile biogenic Se compounds, comparing it to concentrations in biota, and challenging key assumptions in the rationale.

*Background of the Proposed Approach*

This project has its immediate roots in a mini-project to survey the biogeochemistry of Se volatilization in agricultural drainage waters of the San Joaquin Valley. We have been studying bio-volatilization by algae in evaporation ponds (Fan et al., 1997; Fan and Higashi,1998; Fan et al., 1998), while others have shown a high correlation of chlorophyll with volatile Se in estuaries (e.g. Amouroux and Donnard, 1996). In September ,1998 with funding from DWR, we joined forces with the Laboratory of Environmental and Bio-iorganic Chemistry (LCBIE) of the National Centers for Scientific Research (CNRS) in France. The LCBIE director, Dr. Olivier Donnard and a senior scientist, Dr. David Amouroux, are well-known for their work in measuring Se volatilization from water bodies around the world. Therefore, Amouroux brought his Se volatile monitoring equipment here, and we successfully measured various volatile Se compounds in the air and water.

Major findings were:

- Dimethyl-selenide (DMSe) dominated most of the volatile biogenic Se in evaporation ponds and the San Luis Drain.
- But in at least one case (one of the evaporation ponds in the Tulare basin), dimethyl-diselenide (DMDSE) and dimethyl-selenenylsulfide (DMSeS) dominated. This difference was probably due to differences in biogeochemistry between sites.
- We also jointly developed a purge-cryotraping, solid-phase microextraction gas chromatograph/mass spectrometry ("cryotrap-SPME-GC/MS") method of analyzing not just Se compounds, but in fact most volatile compounds present in water, all at once.
- Employing the technique, we discovered an excellent correlation between toluene (likely a by-product of algal/microbial metabolism) and DMSe. Since toluene is present at several million-fold higher concentration than DMSe, and it is part of BTEX analysis that is routinely measured industrially, it might serve as an easy-to-measure surrogate for volatile biogenic Se.

*Rationale for the Approach*

As stated above, we propose to measure volatile, *biogenic* Se compounds in the water as a possible measure of the rate of Se entry into the foodchain. Figure 1 illustrates (albeit greatly simplified) the concept that Se is continually entering and re-entering the foodchain. Because Se is converted to biochemical forms by biota, there is Se fixation into biota and organic matter, strictly

analogous to carbon and nitrogen fixation. This detour into the organic matter might be very significant for Se, and is now a major focus and confounding factor of ecotoxic risk issues (EPA, 1998).

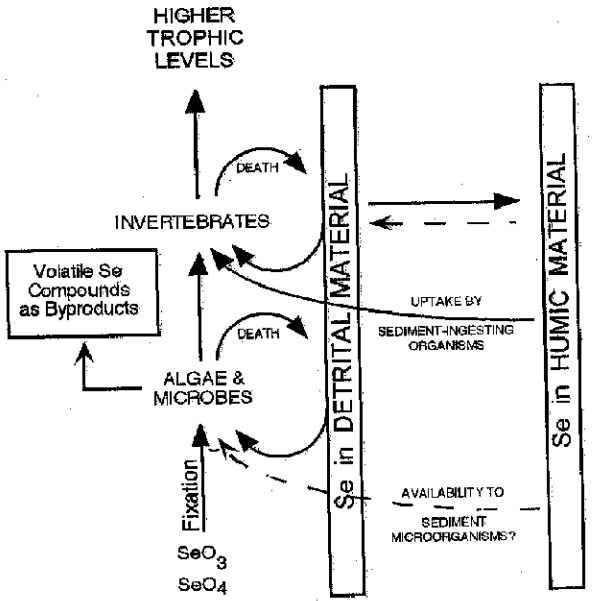



Figure 1. Biogeochemical "refluxing" of Se as it moves up the foodchain.

This is a simplified scheme - not intended to be complete - of Se cycling in aquatic systems that are devoid of vascular plants (e.g. not wetlands). In this system, the detritus (recently dead organic matter) is widely believed (EPA, 1998) to be a significant pool of bioavailable Se, while humic materials (heavily degraded organic matter) are poorly understood in this regard. The bioavailability of Se will likely depend on its chemical form in both food and detritus.

Here, we are proposing to measure the volatile biogenic Se compounds as a possible indicator of *rate* of Se "fixation" into organic forms. The indicator may be site-specific; if so, each site must serve as it's own historical control.

The rationale for measuring biogenic Se volatile compounds is:

(a) From Fig. 1 and field studies (Lemly, 1997), pools of Se might take years to reflect increase/decrease in ecotoxic risk; this time scale is not useful for Se discharge management.
(b) Only the lowest foodchain organisms (algae, microbes, plants) are known to produce appreciable volatile Se (ref);
(c) These *biogenic* Se volatiles are a side-product of uptake and metabolism of Se from feeding on inorganic, living, detrital and other forms of Se;
(d) The biogenic Se compounds are volatile and labile, hence they do not accumulate. If so, it is reasonable that their concentration indicates only recently-fixed Se (it is a "rapid-response" ecotoxic risk parameter);
(e) Because of the complex recyling of Se (Fig. 1), which is at best very poorly understood, it is not feasible to test the overall analytical approach in a contrived laboratory setting. The CALFED-funded SJR Realtime Monitoring sites present an outstanding and relevant system to test our approach.

Moreover, the rationale for how the data will be used/interpreted is:

(f) Due to (e), we expect that the relationship of volatile biogenic Se to fixation into the foodchain will be site-specific;
(g) On this basis, we hypothesize that the method is most useful for Boolean, direction-of-change of Se fixation rate measurements, with each site serving as its own historical control;

(h) Therefore, we envision that its usage will be for a preliminary assay of increase or decrease in ecotoxic risk, which can then trigger a more comprehensive analysis of the site (e.g. proteinaceous Se in invertebrates) to confirm the preliminary indication.

The rationale for cryotrap-SPME-GC/MS analysis method is:

1. GC/MS can positively identify the biogenic Se compounds, at the low detection limits required;
2. Since some non-biogenic forms of Se can also volatilize, the chemical structure I.D. capability of GC/MS is required at this phase, instead of measuring total volatile Se;
3. Because GC/MS can detect all other volatiles and also identify them, we will employ it 100% in this study to search for a convenient surrogate for volatile Se, as we (apparently) found in agricultural drainage water (see *Background*);
4. The "SPME" interface that we developed is compatible with commercial autosamplers, and furthermore is adaptable to any standard GC for future cost reductions;
5. Because of #4, it has the potential for rapid-response of analytical results.

*Work Plan*

The work plan essentially consists of measuring the volatile biogenic Se compounds, comparing it to concentrations in biota, and challenging certain key assumptions in the rationale chain.

Measurement of volatile biogenic Se – We will conduct on-site purging of a 1 L water sample for 1 hr with helium, splitting the gas flow in half and trapping the volatiles in two glass tubes immersed in liquid argon (Amouroux and Donnard, 1996). The two tubes will be duplicates, which will be stored in a liquid nitrogen vessel (–196°C) until use. For analysis, each tube, while still cryogenic, will be fitted with airtight septa, then heated to 50°C. An SPME fiber (Supelco Inc., Bellefonte, PA) will be inserted thru one septum and most volatile compounds will adsorb/condense onto the fiber over the course of 25 min. The SPME fiber will then be withdrawn and inserted into the hot (280°C) injector of the GC/MS system. Volatile compounds will desorb off the fiber, separate in the GC, and be identified and quantified by the MS.

Measurement of Se load in biota – Our results from evaporation ponds (see **Linkages** section) suggest that microphyte community plays an important role in Se volatilization, depletion from water, and fixation into the sediment as well as in controlling benthic invertebrate population. However, measuring Se load in invertebrates is not required for the present goal of this project, because it is resigned to site-specific, Boolean results for rapid-response management purposes. However, it would be desirable to learn whether the approach harbors any actual ecotoxic risk information. Therefore, if data on Se loads of invertebrates is not available thru various SJR agencies, we will measure it at the backwater sampling sites, using our established methods (Fan et al., 1998).

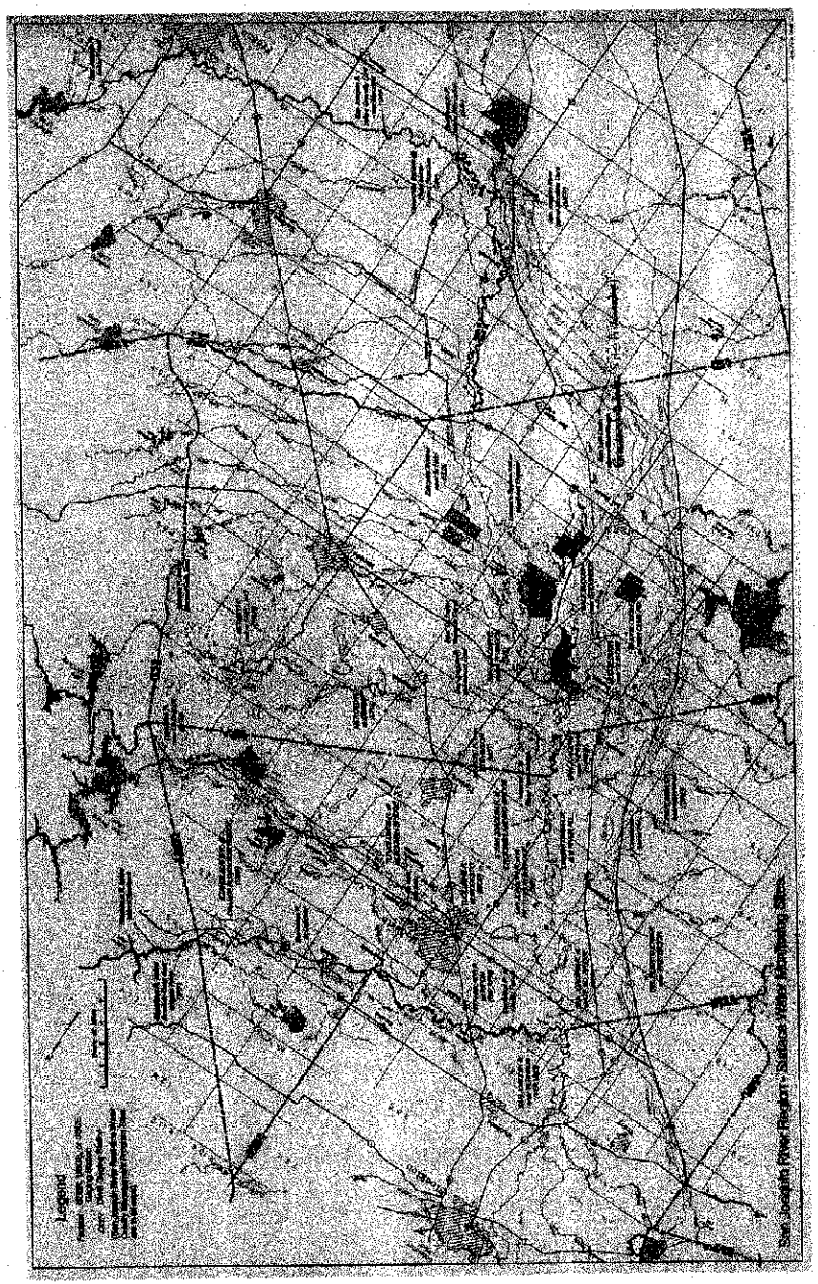
Test volatile and labile assumptions in (d) above – Actual volatility of biogenic Se, versus how much degrades back into non-volatile forms, is not known because it has not been investigated. Instead, the literature calculates the flux of DMSe based on its Henry's Law parameter; but in the presence of particulates, high TDS, and/or sediment, Henry's Law behavior may be masked by other factors. We will conduct, using SJR water and sediments, studies in the laboratory designed to detect departure from Henry's Law for DMSe. Samples will be sealed in glass bottles, spiked with an elevated amount of DMSe (such that the added DMSe is the major Se form), and the water surface purged with a slow stream of He. Experiments will be kept short (a few hours) to avoid very large changes in the

biophysical-chemistry of biota and detritus. However, some changes are unavoidable, and perhaps even desireable since it presents a more challenging test of Henry's Law. Analysis will be as described above, and recoveries of the DMSe and total (non-DMSe) Se will be compared with Henry's Law predictions under these controlled conditions.

Measurement of other volatile constituents – As stated in Rationale #3 above, we will search for a convenient surrogate for volatile Se, as we (apparently) found in agricultural drainage water (see *Background*). This will be a matter of simply compiling data for all other (non-Se) peaks from the GC/MS analysis, and plotting them against DMSe concentration. If any significant correlations appear, preliminary identification thru mass spectrum library matching will be conducted to generate candidates, and attempts to confim the chemical identity will consist of analyzing authentic standards (if commercially available) of the candidates.

**Location and/or Geographic Boundaries**

The geographic boundaries of the CALFED-funded SJR Realtime Monitoring is reproduced on the next page, from that project's proposal. We plan to sample at SJR @ Vernalis because of its significance to river management, but will also sample at two backwater sites in the hopes of obtaining a clearer relationship of the volatile biogenic Se to biota concentrations. These additional sites will be determined thru careful discussion with SJR Realtime Monitoring and other personnel/agencies familiar with details of the various stretches of the SJR mainstem and tributaries.



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## ECOLOGICAL/BIOLOGICAL BENEFITS

Ecological/Biological Objectives

It has been known that the major risk of Se toxicosis to aquatic top predators such as shorebirds occurs thru their diet, and therefore thru the foodchain (e.g. Skorupa, 1998 and references cited therein). Other routes of exposure, e.g. direct exposure to Se-contaminated water, is not considered to be significant. The chemical form(s) of Se that moves through the foodchain is not known, but a recent consensus (e.g. EPA Office of Water, 1998) proposes that protein-bound Se in food organisms may be the most available form to the next trophic level. Currently, UC Salinity/Drainage Program projects (those of Fan and Fry), as well as other agencies, are investigating these aspects.

On the other hand, little attention has been paid to the non-living forms of Se which enter the foodchain in the first place: that is, the *bioavailability* of Se to lower trophic levels. Organic forms appear to be important, as laboratory studies have shown that, directly from water, organic Se as selenomethionine (Se-Met) is much more available to algae and invertebrates than the typical inorganic forms, selenite ($SeO_3$) and selenate ($SeO_4$) (Rosetta and Knight, 1995; Maier and Knight, 1994 and references cited therein). However, commercially-available organic forms such as Se-Met occur at vanishingly low concentrations in the water (Fan and Higashi, unpublished data), so they may not be relevant model compounds. Luoma et al. (1992) have shown that more complex, but unknown organic form(s) such as Se-labeled diatoms and sediments have high bioavailability to clams. The sediment is often the largest pool of Se and considered to be an important source of foodchain Se (e.g., EPA Office of Water, 1998). In the sediment, Se is likely to be resident in all particle sizes, ranging from algal mats and detrital floc to colloidal and small-molecule sizes; but only the latter has been investigated. Thus, what is needed are studies of bioavailability of the various organic forms and sizes of Se – in water, food items, and particularly the sediment – to gain an understanding of how Se enters the foodchain.

Unfortunately, such studies are not feasible at the present stage of knowledge, because the relevant forms of Se in the sediment are simply not known. This is not a trivial list to compile, if we consider briefly the biogeochemical cycles of Se. Figure 1 illustrates a sort of biogeochemical "refluxing" of Se depiciting the relatively simple system of an evaporation basin, which is devoid of vascular plants and infaunal vertebrates. Waterborne and sediment Se as $SeO_3$ and $SeO_4$ are initially "fixed" into organic forms mostly by algae and microbes, some of which can head up the foodchain, or turn into organic material that is relatively unaltered - termed *detritus* - upon death. The detrital material can re-enter the foodchain immediately via microbes or invertebrates that are exposed (physically or thru ingestion) to the detritus. Other paths are for Se to re-enter the foodchain thru microbes or invertebrates after considerable chemical transformation has occurred to the detrital material - for the purposes of brevity, this aged material is lumped into the term *humic* material.

In any of the steps in Fig. 1, multiple chemical forms of Se are involved, and for the most part these forms are unknown. In most cases, even the physical state (gaseous, soluble, insoluble) is unknown, which is also important to bioavailability. Furthermore, the size distribution of organic Se as it converts from detritus to humic material is likewise unknown. Size is of gross importance as it determines the target organism, exposure route, and chemistry of Se uptake, ranging from direct

sorption or membrane transport for molecular-sizes, to ingestion and digestion for macroscopic particles and debris.

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 predicators of Se toxicity to wildlife (EPA, 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, 1998). These complexities associated with Se contamination makes it extremely difficult to both assess and remediate 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 µg/L limit (Lemly, 1997). Sediment-detrital food pathway for Se was attributed as the main factor for such a slow recovery.

Linkages

We recently learned that the Tulare Lake Drainage District's (TLDD) evaporation basin exhibit 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 2). In fact, these basins have been in full-scale operation (approx. 12,000 acre-ft/yr) for over 20 years and yet waterborne Se load is not increasing.

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 water show that they volatilized and bioconcentrated Se from water, which caused water Se to deplete (Fan et al., 1998b; Fan and Higashi, 1998). *Thus, the volatilization of Se compounds is a by-product of Se fixation into the biota.*

We also obtained both laboratory and field evidence that the Se volatilization rate varied with micropyte 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 Highashi, 1999a). *Not surprisingly, this indicates that volatilization of biogenic Se compounds are probably site-specific.*

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 2). 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 microphyte 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. 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. splitail, 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 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 maxium 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 water quality management in the San Joaquin River corridor by providing – if successful – a measure of ecotoxic risk in the SJR.

Compatibility with Non-Ecosystem Objectives

This project does not conflict with any CALFED objectives, and is compatible with water quality considerations.

## TECHNICAL FEASIBILITY & TIMING

*Relation to Other Alternatives*

For measuring rates of fixation, the only other viable method is the use of radio-labeled $^{75}Se$, which is not feasible for use in the environment due to it's radioactivity and cost. In addition, the label will eventually mix into mutiple fractions over time. In contrast, due to it's short half-life in the aquatic environment, the volatile biogenic Se compounds do not "mix", and therefore may be closer to reflecting the rates of fixation of Se, as already discussed above.

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

## MONITORING & DATA COLLECTION

Biological/Ecological Objectives

The biological/ecological objectives, rationale, and hypotheses is described under **Project Description** section.

Monitoring Parameters and Data Collection Approach

Since this is essentially a method development proposal, the monitoring parameters and data collection approach is described under **Project Description/Work Plan** above.

Data Evaluation Approach

Since this is essentially a method development proposal, the data evaluation approach is described under **Project Description/Work Plan** above.

Table 2. Monitoring and Data Collection Information

1) Biological/Ecological Objectives

| Hypothesis/Question to be Evaluated | Monitoring Parameter(s) and Data Collection Approach | Data Evaluation Approach | Comments/ Data Priority |
|---|---|---|---|
| 1) What are the seasonal / site differences in volatile biogenic Se? | Measurement of volatile biogenic Se quarterly, as described in Project Description/Work Plan above | Compile data to compare with the data below. | |
| 2) Does the volatile biogenic Se compare with Se load in biota? | Measurement of Se load in biota quarterly. | Se analysis of biota samples | |
| 3) Test key assumptions that volatile biogenic Se volatilizes readily and/or is labile | Laboratory experiments as described in Project Description/Work Plan above. | Evaluate departure from Henry's Law, as described in Project Description/Work Plan above | |
| 4) Does the volatile Se relate to any other volatile compounds that can be used as surrogates? | Measurement of other volatile compounds in the cryotrap, as described in Project Description/Work Plan above. | Compile data for all other (non-Se) peaks from the GC/MS analysis to compare. | |

Local Involvement

The proposed project will be in partnership with the CALFED-funded SJR Realtime Monitoring coordinated by DWR, Fresno. Their support and collaboration letter is enclosed, and their CALFED proposal is also included for reference. Since that program spans several counties, copies of notification lettters sent to each county's Board is enclosed.

Schedule

Water and biota samples will be taken and analyzed quarterly, at three locations. The project can commence immediately upon funding.

## COSTS

**BUDGET JUSTIFICATION**

Funds are requested for both years of the project, for 10% time for each of the PIs, plus a 50% time postdoctoral associate. Equipment requested are cryogenic air sampling equipment, which is an air pump/flow controller ($4000) and a pressurized liq Ar tank ($1500).

**QUARTERLY BUDGET**

| Task | Year 1 Oct-Dec 99 (includes any Equipment) | Jan-Mar 00 | Apr-Jun 00 | Jul-Sep 00 |
|---|---|---|---|---|
| #1 Se Volatilization | 18,911 | 13,411 | 13,411 | 13,411 |
| Project Management | 0 | 0 | 0 | 0 |
| TOTALS | 18,911 | 13,411 | 13,411 | 13,411 |

| Task | Year 2 Oct-Dec 00 (includes any equipment) | Jan-Mar 01 | Apr-Jun 01 | Jul-Sep 01 | TOTAL |
|---|---|---|---|---|---|
| #1 Se Volatilization | 13,971 | 13,971 | 13,971 | 13,971 | 115,029 |
| Project Management | 0 | 0 | 0 | 0 | 0 |
| TOTALS | 13,971 | 13,971 | 13,971 | 13,971 | 115,029 |

**Principal Investigator:** Teresa Fan

Title: Rapid-Response Assessment of Selenium "Fixation" Rate into the Foodchain by Analysis of Volatile Biogenic Selenium Compounds

| Task | Direct Labor Hours | Salary & Benefits | Supplies & Expenses | Travel | Equipment | Indirect Costs State 10% & (Federal 46%) | Total Cost State & Federal |
|---|---|---|---|---|---|---|---|
| Se Volatilization | 2,688 | 83,573 | 12,000 | 4,000 | 5,500 | 9,956<br>(45,804) | 115,029<br>(150,877) |
| **TOTAL** | **2,688** | **83,573** | **12,000** | **4,000** | **5,500** | **9,956**<br>**(45,804)** | **115,029**<br>**(150,877)** |

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## COST-SHARING

The following cost for the project will be defrayed by resources obtained elsewhere:
- GC-MS instrumentation for volatile Se form analysis, $120,000
- Fluorescence spectrophotometer for total Se analysis, $26,000
- Ultracold freezer (-708C) dedicated for Se research, $10,000
- 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).

"Characterization of Two Humic Acid Fractions from a Calcareous Vermiculitic Soil: Implications for the Humification Process", D.C. Olk, K.G. Cassman, and T.W.-M. Fan, *Geoderma*, 65, 195-208 (1995).

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.

Relevant Publications

Schultz, L.F., T.M. Young, and R.M. Higashi. Sorption-desorption behavior of phenanthrene elucidated by pyrolysis-GCMS studies of soil organic matter. Environmental Toxicology and Chemistry, in press.

"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).

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STATE OF CALIFORNIA -- THE RESOURCES AGENCY GRAY DAVIS, *Governor*

**DEPARTMENT OF WATER RESOURCES**
SAN JOAQUIN DISTRICT
3374 EAST SHIELDS AVENUE
FRESNO, CA 93726-6913

April 13, 1999

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

Dear Dr. Higashi:

This is a letter to assure you of our intent to collaborate and express our support for your proposal to CALFED entitled "Rapid-Response Assessment of Selenium "Fixation" Rate into the Foodchain by Analysis of Volatile Biogenic Selenium Compounds." We believe that the proposed project directly addresses a major gap of information needed to manage water quality in the San Joaquin River.

Currently, all selenium monitoring measures only its pools, not the rate at which selenium is entering the foodchain. The well-known case of Belews Lake, into which selenium discharge was terminated in 1985, still shows elevated selenium levels in the foodchain pools a decade later. Therefore, measurement of selenium pools cannot provide the critical *direction-of-change* of selenium ecotoxic risk, that is needed to manage water quality. Unfortunately, there has been no such method available.

But now, the UC-Davis group proposes to test a potentially viable, while reasonably practical, means to obtain such a measurement. While not "real-time," the proposed analysis of biogenic volatile selenium can be an invaluable "rapid-response" approach because it provides a parameter that is critical, yet currently not measurable. Possibly, the results of this work could establish correlations that would lead to an inexpensive method for real-time monitoring of selenium concentrations in drainage waters.

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 the District's

support for this proposal. We believe that this investigation opens the possibility for greatly enhancing the value and utility of the CALFED-funded "San Joaquin River Real-time Water Quality Management Program." It also has potential to enhance many other phases of selenium research and monitoring throughout the San Joaquin Valley, the San Joaquin River and the Delta.

Sincerely

Jodd Ewbank for

Louis A. Beck, Chief
San Joaquin District

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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,

Teresa W-M. Fan

**Rapid-Response Assessment of Selenium "Fixation" Rate into the Foodchain by Analysis of Volatile Biogenic Selenium Compounds**

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

**Participants and Collaborators:**
Jack Erickson, California Department of Water Resources, Fresno
Leslie Grober, Central Valley Regional Water Quality Control Board, Sacramento

**Type of Organization and Tax Status:**
University, non-profit

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Phone: 209-385-7637

13 April, 1999

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**Participants and Collaborators:**
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**Type of Organization and Tax Status:**
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Stanislaus County Board Administrative Offices
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Modesto, CA 95354-2338
Phone: 209-525-6333

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,

Teresa W-M. Fan

**Rapid-Response Assessment of Selenium "Fixation" Rate into the Foodchain by Analysis of Volatile Biogenic Selenium Compounds**

**Primary Contacts:**
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Phone: 530-752-1450; Fax: 530-752-1552

**Participants and Collaborators:**
Jack Erickson, California Department of Water Resources, Fresno
Leslie Grober, Central Valley Regional Water Quality Control Board, Sacramento

**Type of Organization and Tax Status:**
University, non-profit



I-018441

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Stockton, CA 95210-3310
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13 April, 1999

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I-018442

# San Joaquin River Real-time Water Quality Management Program

(Other Service — water quality monitoring and modeling)

Proposed by

**California Department of Water Resources**
**San Joaquin District**
3374 East Shields Avenue
Fresno, CA 93726

**In collaboration with**

San Joaquin River Management Program (SJRMP)
California Regional Water Quality Control Board, Central Valley Region (CRWQCB-CVR)
California State Water Resources Control Board (SWRCB)
California Department of Fish and Game (DFG)
United States Bureau of Reclamation, San Joaquin Valley Drainage Office (USBR-SJVD)
United States Bureau of Reclamation, Central Valley Operations (USBR-CVO)
United States Geological Survey (USGS)
Lawrence Berkeley National Laboratory (LBNL)
Local SJR basin stakeholders (reservoir operators, water and drainage districts)

**Program Co-Investigators**
San Joaquin River Management Program
Water Quality Subcommittee

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**October 1998**
**SAN JOAQUIN RIVER REAL-TIME WATER QUALITY MANAGEMENT PROGRAM**
proposed by
**California Department of Water Resources**
**San Joaquin District**

**Scope of Services**

**Background**
The San Joaquin River Real-time Water Quality Management Program (SJRRWQMP) uses telemetered stream stage and salinity data and computer models to simulate and forecast water quality conditions along the lower SJR. Its primary goal is to increase the frequency of meeting SJR water quality objectives for salinity, thereby reducing the number and/or magnitude of high quality releases made specifically for meeting SJR salinity objectives. The SJR water quality issues that are directly addressed by the Program include:

- California Regional Water Quality Control Board, Central Valley Region (CRWQCB-CVR) water quality objectives for SJR salinity near Vernalis, just upstream from the SJR's entrance into the South Delta. Current SJR salinity management involves releasing water stored in New Melones Reservoir when EC objectives are exceeded to lower the Vernalis EC and maintain compliance.
- Operation of wetlands that discharge brackish water into Mud and Salt sloughs from the periodic drawdown of specially-managed ponds.
- Operation of the USBR's Grassland Bypass Channel Project that regulates agricultural drainage discharge into Mud Slough near its confluence with the SJR. This project, which began in September 1996 and is scheduled to last up to five years, has a compliance monitoring program that establishes monthly load limits for salt and selenium.
- Release of Spring and Fall pulse flows resulting from Anadromous Fish Restoration Program (AFRP) implementation. These seasonal pulse flows temporarily enhance the SJR's assimilative capacity for salt, thereby increasing the amount of brackish wetland and/or agricultural drainage that can be discharged into SJR tributaries without exceeding Vernalis salinity objectives.

The potential application of real-time water quality management techniques to address water quality problems in the San Joaquin River (SJR) was demonstrated by the SJRMP Water Quality Subcommittee and described in a June 1997 final report fulfilling the Committee's obligations under a $250,000 USBR Challenge Grant. The project showed the feasibility of monitoring and modeling the salinity of the lower SJR on a daily basis. A series of workshops were held and technical papers were written to describe the results of 18 months of flow and water quality forecasting on the San Joaquin River. The demonstration project accomplished the following:

- Expanded the number of monitoring sites temporarily providing telemetered stage and water quality data, and reinstated full operation of gaging stations: (a) along the Merced River near Stevinson (the USGS discontinued this station in 1995); (b) at Mud Slough, (c) Salt Slough and (d) Crows Landing. Developed protocols for polling these stations twice weekly and rapidly updating flow ratings to allow real-time operation, flow and EC forecasting.
- Developed analytical tools to collect, process and display daily streamflow and salinity data (and by extension, SJR assimilative capacity).
- Executed a $50,000 service contract with Systech Engineering, Inc. to develop a Windows™-based graphical user interface (GUI) computer program to display forecast model input and results (discharge, salinity, and remaining assimilative capacity) along a 60-mile reach of the lower SJR. The GUI has Internet upload and download capabilities that expedite the collection of model inputs and the dissemination of water quality forecasts. The demonstration project established an Internet FTP (file transfer protocol) site on the DWR San Joaquin District local area network used exclusively for GUI operation.
- Developed weekly water quality forecasts of daily Vernalis discharge and salinity since February 1996, and posted forecasts in arrears on an electronic bulletin board operated and maintained by the USBR (sjrwqop@sacto.mp.usbr.gov).
- Established a memorandum of understanding (MOU) (Attachment 4) to express a commitment to the operation, maintenance and expansion of the Program's Network.

The demonstration project successfully provided a forum for information exchange among entities with an interest in managing SJR water quality. The demonstration project also established a trained interagency staff and an operational system featuring a custom GUI with Internet upload and download capabilities. Funding for continued water quality modeling and management activities ended in July 1997 with the termination of the demonstration project's USBR Challenge Grant.

Funding from the current CALFED grant will be used to restart the flow and water quality forecasting program on the San Joaquin River, upgrade the existing monitoring network, install and maintain sensors at key monitoring sites (including new west-side tributary locations and the San Luis Drain) and increase utilization of the results of these activities by CALFED organizations and beneficiaries.

**Scope of Project**

The work will be completed in two years. During the first year of the project, the surface water monitoring station network will be upgraded and expanded. Operation of the water quality model will be reinitiated while network expansion is in progress and will continue through the second year. An existing agreement with the USGS for station operation and maintenance of DWR/USGS stations will be amended to include upgrading and O & M costs for Tuolumne River

near Modesto monitoring station. A subcontract with the CRWQCB-CVR for water quality analysis and model operation will also be executed. Another subcontract will be executed with Lawrence Berkeley National Laboratory for conducting travel-time studies, model operation, conducting workshops and training sessions for stakeholders. A third subcontract will be executed with Systech Engineering Inc., for upgrading the graphical user interface to display information on the expanded monitoring network. Annual progress reports will be submitted to CALFED and MOU signatories.

**Objectives and Benefits of Project**

The primary stressor addressed by the Program is contaminants entering the lower SJR. The main objective of the project is to facilitate the control and timing of wetland and agricultural drainage to coincide with periods when dilution flow is sufficient to meet Vernalis salinity objectives. By increasing the frequency of meeting Vernalis EC objectives, the project may reduce the number and/or magnitude of high quality releases (e.g, releases of Stanislaus River flows from New Melones Reservoir) made specifically for meeting Vernalis EC objectives. The water saved can be used later to increase SJR basin streamflow during critical periods for anadromous fish restoration efforts. Besides chinook salmon and steelhead trout, species and species groups benefitting from increased SJR streamflow include delta smelt, longfin smelt, splittail, white and green sturgeon, striped bass, estuarine fishes, large invertebrates, and Bay-Delta aquatic foodweb organisms.

Other specific objectives and benefits include:

1. Reduction in conflicts between reservoir operators, wetlands managers, and agricultural drainers in meeting Vernalis salinity objectives.
2. Improved SJR and Bay-Delta water quality for agricultural, drinking water, industrial, and recreational beneficial uses. Under its authority, the project will be managed to dovetail with CALFED's Water Quality Program, the geographic scope of which is limited to the legally defined Delta.
3. Expanded and improved monitoring stations with telemetered streamflow, temperature and EC sensors capable of delivering real-time information. Streamflow temperature data from these stations will be instrumental in the development of river temperature models. Species benefitting from such adaptive stream temperature management as possible modifications to reservoir facilities and stream channels, include white and green sturgeon, chinook salmon, steelhead trout, and American shad. Additionally, EC data may be employed in monitoring adaptive management strategies that deal with use of the lower SJR by splittail.
4. Increased understanding and management of activities that affect SJR water quality. The model may qualify as a tool to assess the impact of other management practices that attempt to reduce the pollutant load into the lower SJR and Bay-Delta. The project will enhance existing water quality programs to monitor aquatic contaminants (e.g., selenium and agricultural chemicals) that may cause acute toxicity and mortality or long-term

toxicity and associated detrimental physiological responses. The discharge into the SJR of agricultural drainage high in selenium is a serious contaminant problem in the lower SJR basin and Bay-Delta. Selenium has caused reproductive failure in sensitive fish species and developmental deformities in waterfowl and shorebirds because it bioaccumulates in plant and animal tissue to levels that can be toxic to higher trophic organisms. The project plans to enhance existing sampling for selenium and boron at key locations through the purchase of portable water sampling and quality monitoring units that will be used in short-term investigations of lower SJR basin water quality by SJRMP participants (e.g., Assessment of the Stanislaus River Corridor Below Goodwin Dam.)

5. Facilitate the dissemination of shift and rating table data for Network stations. Telemetered stage data are adjusted according to shifts in the relationship between stage and discharge established at each gaging locale to generate preliminary estimates of stream discharge. Preliminary discharge data, such as that posted on CDEC's Internet site, are often significantly affected by the subsequent determination of such shifts. The preliminary estimates of SJR discharge at Network sites along the lower SJR generated by the project will help verify the accuracy of preliminary real-time data posted on CDEC.

**Cooperating Agencies**

DWR - San Joaquin District: The San Joaquin District operates and maintains several surface water monitoring stations in the San Joaquin Valley. The SJR Real-time Demonstration project utilized flow data from six DWR stations. With the proposed network expansion, this number will increase to 8 stations, and would include flow, electrical conductivity and temperature data. Installation and equipment costs attributed to these 8 stations will be funded by CalFed grant. Monthly operation and maintenance costs will be funded out of District funding sources.

USBR - SJVD: Since the 1996 Challenge Grant, Reclamation has continued to make significant commitments through staff-time and funding to support the SJR Real-time program. The SJR Real-time program compliments directly Reclamation's Grasslands Bypass Channel Project, the Refuge Water Supply Acquisition Program, the Cooperative Streamflow Program, and CVP operations in the Delta.

For the two-year SJR Real-time program, Reclamation has committed the following:

- funding and expertise to operate, maintain, and upgrade two important water quality monitoring stations at Ripon and Vernalis.
- funding LBNL to design, install, and calibrate an new station on Mud Slough to monitor water flowing from wetlands.
- funding USGS to operate and maintain five water quality monitoring stations associated with the Grasslands Bypass Channel Project.
- funding staff-time to support the collection, review, and presentation of water quality data by the SJR Real-time program.

During year one, Reclamation has committed more than $200,000 to support the SJR Real-time program.

Grasslands Water District: As an interested party, Grasslands has committed to partially fund the installation of a control structure and concrete pad at the new Mud Slough station.

**Task Order**

Seven primary sub-tasks will be accomplished through the cooperative effort of the collaborating agencies. These sub-tasks are as follows:

1. Program Management
2. Preparation of Subcontracts and Agreements
    1. Lawrence Berkeley National Laboratory contract
    2. CRWQCB-CVR contract
    3. USGS agreement
    4. Systech Engineering, Inc. contract
1. Water Quality Monitoring Plan - Quality Assurance Project Plan
2. Expand Real-time Water Quality Monitoring Network
3. Operate and Maintain New and Existing Real-time Monitoring Stations
4. Water Quality Sampling and Analysis
5. Modeling and Management Activities

A description, actions involved, schedule of deliverables, the responsible staff and agency for each sub-task is indicated below.

**Sub-Task No. 1**
**Program Management**

Act as program manager to San Joaquin River Real-Time Program. Oversee and facilitate the development of subcontracts, and the completion of program goals and objectives. Responsibilities will include assigning resources, scheduling tasks, reviewing results, and developing quarterly and annual reports (DWR Senior Engineer).

Schedule: Task is ongoing and terminates with the completion of the program. Reports will be issued on a quarterly and annual basis.
Deliverables: Satisfactory completion of the goals and objectives of the program. Quarterly and annual reports.

**Sub-Task No. 2**
**Preparation of Subcontracts and Agreements**

Sub-task 2 involves the preparation of subcontracts and agreements directly related to Program activities (DWR Senior Engr.). These subcontracts include the following:

**California Regional Water Quality Control Board - Central Valley Region Contract**

For QAQC purposes, the Program includes periodic collection and analysis of total dissolved solids (TDS), selenium and boron. CRWQCB-CVR responsibilities will include monitoring water quality at critical San Joaquin River basin sites to serve as a check on data collected at real-time monitoring stations. CRWQCB-CVR responsibilities will also include model operation, report writing, developing monitoring plans, and conducting workshops and demonstrations.
Schedule: Contract preparation is underway and will be completed by the end of January 1999.
Deliverables: Contract describing CRWQCB-CVR duties and responsibilities as they relate to the real-time monitoring program. Draft and final contract to be delivered upon completion.

**Lawrence Berkeley National Laboratory Contract**

Travel-time dye studies will help establish the timing influence of tributaries to the San Joaquin River. LBNL will serve as backup to DWR staff for such duties as station troubleshooting and data preprocessing. LBNL will also work with Systech Engineering, Inc. to modify the graphical user interface (GUI) computer program to include the expanded monitoring network. In addition these duties, LBNL responsibilities will also include model operation, report writing, developing monitoring plans, and conducting workshops and demonstrations.
Schedule: Contract preparation is underway and will be completed by the end of January 1999.
Deliverables: Contract describing LBNL duties and responsibilities as they relate to the real-time monitoring program. Draft and final contract to be delivered upon completion.

**Systech Engineering, Inc. Contract**

A Windows™-based graphical user interface (GUI) computer program to display forecast model input and results was developed for the demonstration project by Systech Engineering, Inc.. With the expansion of the monitoring network, this program will require modification to display model inputs and results for several additional monitoring stations.
Schedule: Contract preparation is underway and will be completed by the end of January 1999.
Deliverables: Contract to upgrade GUI software. Draft and final contract to be delivered upon completion.

**USGS Agreement**

DWR has an existing agreement with the USGS to cooperatively operate and maintain certain surface water monitoring stations in the San Joaquin Valley. An amendment to this agreement to include the upgrade of their Tuolumne River near Modesto station to include real time EC and temperature monitoring will be prepared. The agreement will also include regular operation and maintenance of discharge and EC/temperature sensors at this monitoring station.
Schedule: The agreement will be prepared by the end of January 1999.

Deliverables: Cooperative agreement to operate this station for real-time monitoring uses. Draft and final contract to be delivered upon completion.

**Sub-Task No. 3**
**Water Quality Monitoring Plan**
**Quality Assurance Project Plan**

A Quality Assurance Project Plan (QAPP) will be prepared to document the procedures used by the interagency project team for activities related to the collection, processing, storage, and publication of surface-water flow and water quality data (LBNL and CRWQCB-CVR staff).

Schedule: A draft document has already been prepared. The final QAPP will be completed by January 1, 1999.
Deliverables: Final Quality Assurance Project Plan report.

**Sub-Task No. 4**
**Expand Real-time Water Quality Monitoring Network.**

Sub-task No. 4 will expand the monitoring network by installing conductivity and temperature sensors at six existing telemetered gaging stations and installing telemetry and sensors at two untelemetered stations in the lower SJR basin.

Actions:

6. Plan, coordinate, prepare final equipment and manpower requirements, and schedule work to be performed (WR Engineer Associate DWR, 48 hours, first year only).
7. Acquisition of equipment (telemetry, dataloggers, EC/temperature sensors, spare equipment, and associated peripheral equipment) for expanding and upgrading monitoring station network (Associate Engineer DWR, 24 hours, first year only).
8. Equipment for network expansion:
    5. 2 - Telemetry communications ($2,100 each)
    6. 2 - Data collection platforms ($2,400 each)
    7. 2 - Stage height gauges and peripherals ($1,400 each)
    8. 8 - EC/temperature sensors and peripherals ($1,700 each)
    9. 8 - Miscellaneous materials and supplies ($500 per station)
1. Repair and upgrade station for new equipment. Install telemetry and sensors for real-time discharge and EC/temperature sensors at (W.R. Tech II, DWR, 160 hours):
    10. San Joaquin River @ Maze Road Bridge
    11. Tuolumne River @ Hickman Bridge.
2. Repair and upgrade station for new equipment. Install EC/temperature sensors at the following sites (W.R. Tech II, DWR, 324 hours, first year only):
    1. San Joaquin River near Stevinson

2. Merced River near Stevinson
3. Merced River near Cressey
4. Merced River near Snelling
5. San Joaquin River @ Patterson
6. Stanislaus River @ Orange Blossom Bridge

6. Upgrade existing telemetered monitoring station to include real-time EC and temperature at Tuolumne River near Modesto ($2,300 as per USGS agreement ).

3. Equipment for USGS station (Tuolumne River near Modesto):
   1. 1 - Data collection platforms ($2,400 each)
   2. 1 - Stage height gauge and peripheral ($1,400)
   3. 1 - EC/temperature sensor and peripheral ($1,700)
   4. 1 - Miscellaneous materials and supplies ($500)

4. Equipment for Grasslands WD station (Mud Slough below Gun Club Rd.):
   1. 1 - Telemetry communications ($2,100 each
   2. 1 - Data collection platform ($2,400 each)
   3. 1 - Stage height gauge and peripheral ($1,400)
   4. 1 - EC/temperature sensor and peripheral ($1,700)
   5. 1 - Miscellaneous materials and supplies ($500)

5. Setup and calibration of datalogger, telemetry, discharge gauge and EC/temperature sensors at following sites (Engineer DWR, 72 hours, first year only):
   1. San Joaquin River @ Maze Road Bridge
   1.
   2. Tuolumne River @ Hickman Bridge.
   3. San Joaquin River near Stevinson
   4. Merced River near Stevinson
   5. Merced River near Cressey
   6. Merced River near Snelling
   7. San Joaquin River @ Patterson
   8. Stanislaus River @ Orange Blossom Bridge

6. Spare equipment for Program when required (one full set of equipment per year).
   1. 1 - Data collection platforms ($2,400 each)
   2. 1 - Stage height gauge and peripheral ($1,400)
   3. 1 - EC/temperature sensor and peripheral ($1,700)
   4. 1 - Miscellaneous materials and supplies ($500)

Schedule: Expansion of the monitoring network will begin when CALFED funding is secured. Installation of equipment will be dependant of several factors: availability of technical staff, weather, condition of stations, and availability of equipment. Installation of equipment to upgrade and expand monitoring network will commence as soon as possible during the first year of program operation and should be completed by the end of calendar year 1999.

Deliverables:

7. Permanent upgrade to real-time EC/temperature capability for 7-stations (6-DWR, 1-USGS and 1-Grasslands WD). EC and temperature data available on DWR's California Data Exchange Center (CDEC) website.
8. The addition to real-time status of two previously untelemetered DWR stations measuring flow, EC and temperature.
9. Telemetry, data collection, sensors and miscellaneous equipment and materials for upgrade of 1-USGS, 1-Grasslands and 8-DWR stations.
10. Spare equipment for repair and maintenance of DWR stations.

**Sub-Task No. 5**
**Operate and Maintain New and Existing Real-time Monitoring Stations**

Real-time stage and conductivity data are downloaded and processed to yield preliminary estimates of current discharge. Accurate forecasts of real-time SJR assimilative capacity require accurate estimates of real-time discharge and EC, which in turn, require the periodic measurement of discharge and regular maintenance and cleaning of sensors at Network stations. Regular monthly maintenance of DWR operated stations will be funded by District flood management and basic data program sources. Regular monthly maintenance of all but one (Tuolumne River @ Modesto) of the USGS operated stations in the Real-time Program will be funded by the USBR. Regular monthly maintenance of Grasslands Mud Slough station will also be funded by the USBR during the two year program. Regular monthly maintenance of the USGS Tuloumne River @ Modesto station will be funded through the Real-time program.

Since the Real-time program requires an accurate and reliable data source on a daily basis, from time to time it will be necessary to troubleshoot and repair equipment problems that occur between the regular scheduled maintenance. The Real-time program will fund DWR staff to be responsible for troubleshooting these problems. Under their contract, LBNL staff will serve as backup when DWR staff is not available.

Actions:
11. Operate and maintain EC/temperature sensors at the following telemetered monitoring station (USGS agreement):
    1. Tuolumne River near Modesto ($10,200 per year)
12. Troubleshooting and repair of 19-stations:
    1. Engineer DWR, 152 hours per year
    2. LBNL staff, 40 hours per year (backup)

Schedule: Operation and maintenance of one USGS station (Tuolumne River near Modesto) will begin when station equipment is upgraded to include EC/temperature monitoring and will continue to the completion of the two-year program. Troubleshooting and repair of network station equipment will be initiated as required throughout the term of the program.

Deliverables: With the more intense operation and maintenance schedule that the project will provide, there will be an increase in the accuracy of stage, flow, EC and temperature data collected at network stations to the benefit all data users. Maintenance summary will be included in quarterly reports.

**Sub-Task No. 6**
**Water Quality Sampling and Analysis**

Periodic collection and analysis of water samples for total dissolved solids (TDS), selenium and boron is the focus of the project's two-year water quality sampling plan. Periodic collection and analysis of water samples for total dissolved solids (TDS) help maintain reliable site-specific correlations of TDS and EC. Although boron and selenium cannot be measured in real-time, concentration data from sampling sites will be used for retrospective model runs. Sampling will be conducted on a weekly basis for key sites and more intensive daily monitoring will be conducted periodically at specific locations. Sampling program will follow the methods and procedures established in the QAPP report.

Actions:

13. Weekly sample collection, processing, and analysis for boron and selenium at ten sites and daily sample collection, processing, and analyses for boron and selenium at select sites (CRWQCB-CVR student, 2,860 hours per year).
14. Sample processing and analyses for TDS for select samples (CRWQCB-CVR lab, 250 samples at $16 per sample per year).
15. Weekly sample processing and analyses for B and Se (CRWQCB-CVR lab, 520 samples at $35 per sample per year).
16. Daily sample processing and analyses for B and Se (CRWQCB-CVR lab, 513 samples at $35 per sample per year).
17. Time-of-travel dye studies (LBNL staff plus 100 samples at $1 per sample per year).
18. Prepare summaries of the results of water quality sampling program to be included in the quarterly and annual reports.

1.

Schedule: Water quality sampling will begin when funding is secured and will continue through the course of the 2-year program. Summaries of water quality sampling will be completed on a quarterly and annual basis.

Deliverables: Provides a check on the accuracy and reliability of real-time EC data through correlation to TDS monitoring. Analysis of B and Se monitoring will help to identify where contaminants are being introduced into the river system and the loads entering the Delta. Quarterly and annual summaries included in program reports (see sub-task 1).

**Sub-Task No. 7**
**Modeling and Management Activities**

Staff will assemble and process real-time monitoring data, poll stakeholders on upcoming river management activities, run the forecasting model and post results on the Internet on a weekly basis. Stakeholders will be consulted on a quarterly basis on opportunities to improve SJR water quality. Workshops will be conducted periodically to solicit interest and participation by new stakeholders in Program activities. Stakeholders will be instructed on how to use the Program's GUI software, and Program information will be disseminated on the SJRMP home page. Annual progress reports will be submitted to CALFED and MOU signatories.

Actions:

19. Assemble and pre-process raw stage and EC data for San Joaquin and tributary sites; weekly (DWR Engineer 624 hours, LBNL staff 24 hours).
20. Input and maintain processed data; weekly (DWR Assoc. Engineer 104 hours).
21. Poll stakeholders on current river management activities; weekly (DWR Assoc. Engineer 208 hours, LBNL staff 104 hours).
22. Run forecasting model; weekly (DWR Assoc. Engineer 520 hours, LBNL staff 295 hours, CRWQCB-CVR staff 312 hours, CRWQCB-CVR student 1040 hours).
23. Maintain and post model results on GUI (DWR Assoc. Engineer 416 hours ).
24. Maintain and post model results to USBR SJRWQOP Bulletin Board and Web Page; weekly (LBNL staff 104 hours).
25. Conduct workshops , training sessions, and demonstrations with water agencies, water districts, and the public to promote use of forecasting model interface and forecasts (DWR Assoc. Engineer 96 hours, LBNL staff 96 hours plus travel, CRWQCB-CVR staff 96 hours).
26. Attend SJRMP meetings to provide monthly updates (DWR Assoc. Engineer 96 hours, LBNL staff 96 hours plus travel, CRWQCB-CVR staff 48 hours).
27. Write quarterly and annual reports (DWR Assoc. Engineer 168 hours, LBNL staff 72 hours, CRWQCB-CVR staff 72 hours).
28. Training DWR staff in model operation (DWR Assoc. Engineer 60 hours, DWR Engineer 60 hours, LBNL staff 36 hours plus travel, CRWQCB-CVR staff 24 hours).
29. Upgrade and maintenance of GUI software (LBNL staff 24 hours plus travel, Systech Engineering Inc. contract)
30. Miscellaneous unforeseen needs (salary raises, equipment failures, additional work to upgrade stations, additional travel and perdiem costs, etc.)

1.

Schedule: Quarterly reports of progress and an annual report summarizing the results of weekly forecasts of flow and EC on the San Joaquin River. The annual report will be written in a style for publication by California Agriculture or similar journal. Web site and DWR PC will be kept current with forecast data for the period of the CALFED grant.

Deliverables:

31. Weekly water quality forecasts (posted to SJRWQOP Bulletin Board, USBR web page, and available to stakeholders on Real-time GUI).
32. Stakeholder workshop presentation materials and a schedule of workshops will be provided.
33. Quarterly and annual progress reports (see sub-task 1). Summary of workshop minutes will be included in quarterly reports.
34. Upgrade GUI software.

**Task Order Schedule of Deliverables:**

| Subtask No. | Task /Deliverable Description | Start Date (mo/yr) | Due Date (mo/yr) |
|---|---|---|---|
| 1 | **Program Management** | 1/99 | 12/00 |
| | 1. Quarterly fiscal reports. | | 4/99, 7/99, 10/99, 1/00, 4/00, 7/00, 10/00, 1/01 |
| | 2. Annual progress reports summarizing data, results and activities. | | *1/00, 1/01* |
| 2 | **Preparation of Subcontracts and Agreements** | **12/98** | **1/99** |
| | 1. Draft Subcontracts | 12/98 | 1/99 |
| | 2. Final Subcontracts | 1/99 | 2/99 |
| 3 | **Water Quality Monitoring Plan QAPP** | **7/98** | **1/99** |
| | 1. Draft QAPP report | | completed |
| | 2. Final QAPP report | | 1/99 |
| 4 | **Expand Real-time Water Quality Monitoring Network** | **1/99** | **12/99** |
| | 1. Permanent installation of telemetry, stage, and EC/temp monitoring equipment for two DWR stations and upgrade to real-time EC/temp for one USGS and six DWR stations. | 1/99 | 12/99 |
| | 2. Equipment purchased for network expansion. | 1/99 | 12/99 |
| | 3. Updates of monitoring network expansion will be included in quarterly and annual reports (see sub-task 1). | (see sub-task 1) | (see sub-task 1) |
| 5 | **Operate and Maintain New and Existing Real-time Monitoring Stations** | **1/99** | **12/00** |
| | 1. Regular monthly O & M | 1/99 | 12/00 |
| | 2. Troubleshooting and repair | 1/99 | 12/00 |
| 6 | **Water Quality Sampling** | **1/99** | **12/00** |
| | 1. Provide a check on the accuracy and reliability of real-time EC data as it correlates to TDS values. | 1/99 | 12/00 |
| | 2. Water quality summaries included in quarterly and annual reports (see sub-task 1). | (see sub-task 1) | (see sub-task 1) |
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| 7 | **Modeling and Management Activities** | **1/99** | **12/00** |
| | 1. Weekly water quality forecasts (posted to SJRWQOP Bulletin Board, USBR web page, and available to stakeholders on Real-time GUI). | 1/99 | weekly |
| | 2. Stakeholder Workshop Presentation materials. | 1/99 | 3/99 |
| | 3. Modeling progress reports included in quarterly and annual reports (see sub-task 1). | (see sub-task 1) | (see sub-task 1) |
| | | | |

**Task Order Budget - Two Year Program**

**Year Number 1**

| No. | Project Task/Sub-task | Direct Labor Hours | Direct Salary & Benefits | Overhead Labor (General Admin & Fees) | Service Contracts & Agree. | Equip. Costs | Misc., Travel & Other Direct Costs | Total Costs |
|---|---|---|---|---|---|---|---|---|
| 1 | **Program Management** (DWR Senior Engr.) | 260 | $10,720 | $4,481 | | | | $15,201 |
| 2 | **Subcontract preparation** (DWR Senior Engr.) | 60 | $2,474 | $1,034 | | | | $3,508 |
| 3 | **Prepare Quality Assurance Project Plan.** | | | | | | | |
| | LBNL staff | | | | $3,164 | | | $3,164 |
| | CRWQCB-CVR staff | | | | $1,477 | | | $1,477 |
| 4 | **Expand Real-time Monitoring Network.** | | | | | | | |
| | 1. Acquisition of equipment. Permanent installation of telemetry, stage, EC/temp equip. for two DWR stations and upgrade to real-time EC/temp for one USGS and six DWR stations. | | | | | | | |
| | DWR Engr Associate | 48.4 | $1,603 | $670 | | | $126 | $2,399 |
| | DWR Assoc. Engineer | 24 | $834 | $349 | | | $126 | $1,309 |
| | DWR Engineer | 72 | $1,527 | $638 | | | $252 | $2,417 |
| | DWR Tech II | 484 | $13,305 | $5,562 | | | $1,008 | $19,875 |
| | USGS agreement | | | | $2,300 | | | $2,300 |
| | 2. Equipment for network expansion (8-DWR stations). | | | | | | | |
| | Telemetry comm.(2) | | | | | $4,526 | | $4,526 |
| | Data collection platform (2) | | | | | $5,172 | | $5,172 |
| | Stage meter (2) | | | | | $3,017 | | $3,017 |
| | EC/temp sensor (8) | | | | | $14,654 | | $14,654 |
| | Miscellaneous materials (8) | | | | | $4,310 | | $4,310 |
| | 3. Equipment for USGS station. | | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| | EC/temp sensor (1) | | | | | $1,831 | | $1,831 |
| | Miscellaneous materials (1) | | | | | $539 | | $539 |
| | 4. Equipment for Grasslands Mud Slough near Gun Club Rd. | | | | | | | |
| | Telemetry comm.(1) | | | | | $2,263 | | $2,263 |
| | Data collection platform (1) | | | | | $2,586 | | $2,586 |
| | Stage meter (1) | | | | | $1,508 | | $1,508 |
| | EC/temp sensor (1) | | | | | $1,831 | | $1,831 |
| | Station house (1) | | | | | $1,078 | | $1,078 |
| | Miscellaneous materials (1) | | | | | $1,078 | | $1,078 |
| | 5. Spare equipment for monitoring network. | | | | | | | |
| | Telemetry comm.(1) | | | | | $2,263 | | $2,263 |
| | Data collection platform (1) | | | | | $2,586 | | $2,586 |
| | Stage meter (1) | | | | | $1,508 | | $1,508 |
| | EC/temp sensor (1) | | | | | $1,831 | | $1,831 |
| | Miscellaneous materials (1) | | | | | $539 | | $539 |
| 5 | **Operation and maintenance of monitoring stations. O&M of DWR stations will be covered under other programs.** | | | | | | | |
| | 1. Supervision, planning and scheduling of twice-monthly operation and maintenance of 8-DWR stations (DWR Engr. Associate, WR). | 78 | $2,597 | $1,085 | | | | $3,682 |
| | 2. Twice-monthly operation and maintenance of 8-DWR stations (DWR Tech II). | 784 | $21,552 | $9,009 | | | $3,024 | $33,585 |
| | 3. Operate and maintain EC/temp sensors at USGS station Tuolumne River near Modesto. | | | | $10,200 | | | $10,200 |
| | 4. Troubleshooting and repair of 19-Real-time stations. | | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| | DWR Engineer | 144 | $3,054 | $1,277 | | | | $4,331 |
| | LBNL staff (backup) | | | | $3,516 | | | $3,516 |
| 6 | **Water quality sampling.** | | | | | | | |
| | 1. Weekly & daily sample collection, processing and analysis for B and Se (CRWQCB-CVR student). | | | | $42,500 | | | $42,500 |
| | 2. Lab analysis for B and Se collected weekly (520 samples per year at $35 per sample) | | | | $18,200 | | | $18,200 |
| | 3. Lab analysis for B and Se collected dailly (513 samples per year at $35 per sample) | | | | $17,955 | | | $17,955 |
| | 4. Lab analysis for TDS samples (250 samples per year at $16 per sample). | | | | $4,000 | | | $4,000 |
| | 5. Time-of-travel dye studies (LBNL staff 24 hours + 100 samples at $1 per sample) | | | | $2,346 | | | $2,346 |
| 7 | **Modeling and general program activities.** | | | | | | | |
| | 1. Assemble and pre-process real-time data weekly from 19-stations. | | | | | | | |
| | DWR Engineer | 624 | $13,235 | $5,532 | | | | $18,767 |
| | LBNL staff (backup) | | | | $2,110 | | | $2,110 |
| | 2. Input and maintain processed data; weekly (DWR Assoc. Engineer) | 104 | $3,615 | $1,511 | | | | $5,126 |
| | 3. Poll stakeholders on current river management activities; weekly. | | | | | | | |
| | DWR Assoc. Engineer | 208 | $7,230 | $3,022 | | | | $10,252 |
| | LBNL staff | | | | $9,142 | | | $9,142 |
| | 4. Run forecasting model: data input, calibration, test run, confer, adjustments, and final run; weekly | | | | | | | |
| | DWR Assoc. Engineer | 520 | $18,075 | $7,555 | | | | $25,631 |
| | LBNL staff | | | | $25,931 | | | $25,931 |
| | | | | | | | | |

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|---|---|---|---|---|---|---|---|---|
| | CRWQCB-CVR staff | | | | $19,204 | | | $19,204 |
| | CRWQCB-CVR student | | | | $15,454 | | | $15,454 |
| | 5. Maintain and archive data. Post model results to GUI (DWR Assoc. Engineer). | 416 | $14,460 | $6,044 | | | | $20,505 |
| | 6. Maintain and post model results to USBR bulletin board and web page (LBNL staff). | | | | $9,142 | | | $9,142 |
| | 7. Conduct workshops, training sessions, and demonstrations. | | | | | | | |
| | DWR Assoc. Engineer | 96 | $3,337 | $1,395 | | | $504 | $5,236 |
| | LBNL staff | | | | $11,318 | | | $13,318 |
| | CRWQCB-CVR staff | | | | $5,909 | | | $5,909 |
| | 8. Attend meetings. | | | | | | | |
| | DWR Assoc. Engineer | 96 | $3,337 | $1,395 | | | $504 | $5,236 |
| | LBNL staff | | | | $9,494 | | | $9,494 |
| | CRWQCB-CVR staff | | | | $2,954 | | | $2,954 |
| | 9. Write reports and bulletins. | | | | | | | |
| | DWR Assoc. Engineer | 168 | $5,840 | $2,441 | | | | $8,281 |
| | LBNL staff | | | | $6,329 | | | $6,329 |
| | CRWQCB-CVR staff | | | | $4,432 | | | $4,432 |
| | 10. Training DWR staff in model operation. | | | | | | | |
| | LBNL staff (trainer) | | | | $4,172 | | | $4,172 |
| | CRWQCB-CVR staff (trainer) | | | | $1,477 | | | $1,477 |
| | DWR Assoc. Engineer (trainee) | 60 | $2,086 | $872 | | | | $2,957 |
| | DWR Engineer | 60 | $1,273 | $532 | | | | $1,805 |
| | 11. Upgrade and maintenance of GUI software. | | | | | | | |
| | LBNL staff | | | | $2,219 | | | $2,219 |
| | Systech Engineering, Inc. | | | | $5,000 | | | $5,000 |
| | 12. Contingency fund for miscellaneous unforeseen needs (i.e. salary raises, equipment | | | | | | $32,000 | $32,000 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | failures, additional work to upgrade stations, additional travel & per diem, etc.) | | | | | | | |
| **No.** | **Project Task/Sub-task** | **Direct Labor Hours** | **Direct Salary & Benefits** | **Overhead Labor (General Admin & Fees)** | **Service Contracts & Agree.** | **Equip. Costs** | **Misc., Travel & Other Direct Costs** | **Total Costs** |
| | **Total 1st Year Costs** | 4,307 | $130,153 | $54,404 | $239,944 | $53,120 | $37,544 | $515,165 |
| | **Total 2nd Year Costs** | 3,498 | $107,052 | $44,748 | $220,134 | $8,727 | $36,032 | $416,693 |
| | **Total Program Costs** | 7,805 | $237,205 | $99,152 | $460,078 | $61,847 | $73,576 | $931,857 |
| | 2nd Year costs include all 1st Year costs with the exception of sections 2, 3, 4.1-4.4, 10 and 11. | | | | | | | |
| | DWR Staff | | Direct & Benefits Hourly Rate | Indirect & Surcharge Hourly Rate | Total Hourly Rate | | | |
| | Senior Engineer | | $41.23 | $17.23 | $58.46 | | | |
| | Assoc. Engineer | | $34.76 | $14.53 | $49.29 | | | |
| | Engineer | | $21.21 | $8.87 | $30.08 | | | |
| | WR Assoc. Engineer | | $33.12 | $13.84 | $46.96 | | | |
| | WR Tech II | | $27.49 | $11.49 | $38.98 | | | |

| **Expenditure** | **First Year Costs** | **Second Year Costs** | **Total Program Costs** |
|---|---|---|---|
| LBNL | $88,882 | $79,327 | $168,208 |
| CRWQCB-CVR | $133,562 | $130,607 | $264,169 |
| USGS | $12,500 | $10,200 | $22,700 |
| Systech Engineering, Inc. | $5,000 | $0 | $5,000 |
| Equipment costs | $53,120 | $8,727 | $61,847 |
| DWR wages (direct salary, benefits, indirect costs and surcharge) | $184,558 | $151,800 | $336,357 |
| Misc., travel and other direct costs. | $37,544 | $36,032 | $73,576 |
| **Total Annual Costs** | **$515,165** | **$416,693** | **$931,857** |

**FISCAL YEAR BUDGET**

| | **Fiscal Year** | **Direct Labor Hours** | **Direct Salary & Benefits** | **Overhead Labor (General Admin &** | **Service Contracts & Agree.** | **Equip. Costs** | **Misc., Travel & Other Direct** | **Total Costs** |
|---|---|---|---|---|---|---|---|---|

| | | | | Fees) | | | Costs | |
|---|---|---|---|---|---|---|---|---|
| | 1998-99 | 2,558 | $76,627 | $32,030 | $129,877 | $48,756 | $15,528 | $306,819 |
| | 1999-00 | 3,498 | $107,052 | $44,748 | $220,134 | $8,727 | $36,032 | $416,693 |
| | 2000-01 | 1,749 | $53,526 | $22,374 | $110,067 | $4,364 | $18,016 | $208,346 |
| | **TOTALS** | **7,805** | **$237,205** | **$99,152** | **$460,078** | **$61,847** | **$75,576** | **$931,857** |