Water Temperature Models for the Merced River and Reservoirs

Project Information

1. **Proposal Title:**

   Water Temperature Models for the Merced River and Reservoirs

2. **Proposal applicants:**

   David Vogel, Natural Resource Scientists, Inc.

3. **Corresponding Contact Person:**

   David Vogel
   Natural Resource Scientists, Inc.
   P.O. Box 1210 Red Bluff, CA 96080
   530 527-9587
   dvogel@resourcescientists.com

4. **Project Keywords:**

   Anadromous salmonids
   Reservoirs, Management and Modeling
   Water Quality Assessment & Monitoring

5. **Type of project:**

   Research

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

   No

7. **Topic Area**:

   Ecosystem Water and Sediment Quality

8. **Type of applicant:**

   Private for profit

9. **Location - GIS coordinates:**

Latitude:	37.514
Longitude:	-120.370
Datum:	NAD27

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

Four Merced River reservoirs and 52 river miles downstream of Crocker-Huffman Dam to the confluence with the San Joaquin River

10. **Location - Ecozone:**

    13.3 Merced River

11. **Location - County:**

    Mariposa, Merced

12. **Location - City:**

    Does your project fall within a city jurisdiction?

    No

13. **Location - Tribal Lands:**

    Does your project fall on or adjacent to tribal lands?

    No

14. **Location - Congressional District:**

    18, 19

15. **Location:**

    California State Senate District Number: 12

    California Assembly District Number: 25, 26

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

    1

17. **Requested Funds:**
    a) Are your overhead rates different depending on whether funds are state or federal?

       No

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

       Single Overhead Rate: 40

       Total Requested Funds: $179,342

b) Do you have cost share partners already identified?

Yes

If yes, list partners and amount contributed by each:

Merced Irrigation District $25,000

c) Do you have potential cost share partners?

No

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

No

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

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

No

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

Yes

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

ERP-01-N48	**Juvenile Salmon Migratory Behavior Study in North, Central and South Delta**	**ERP**
Unknown	**Delta Cross Channel Studies**	**Unknown**

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

Yes

If yes, identify project number(s), title(s) and CVPIA program (e.g. AFRP, AFSP, b(1) other).

2001-K203	**Merced River Water Temperature Management Feasibility Study**	**AFRP**

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

Yes

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

	Report Name: Losses of young anadromous salmonids at water diversions on the Sacramento and Mokelumne Rivers	**AFRP**
	Report Name: Juvenile Chinook Salmon Radio-Telemetry Study in the Northern Sacramento-San Joaquin Delta, January-February 2000	**AFRP**
	Report Name: Juvenile Chinook Salmon Radio-Telemetry Study in the Southern Sacramento-San Joaquin Delta, December 2000-January 2001	**AFRP**
FWS Agreement #113320J027	**Merced River Wing Dam Monitoring, 2000-2002**	**AFRP**

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

No

Please list suggested reviewers for your proposal. (optional)

21. **Comments:**

17a: Overhead is 40% of charge-out rate.

Environmental Compliance Checklist

Water Temperature Models for the Merced River and Reservoirs

1. **CEQA or NEPA Compliance**
   a) Will this project require compliance with CEQA?

      No

   b) Will this project require compliance with NEPA?

      No

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

      Research/modeling project

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

   CEQA Lead Agency:
   NEPA Lead Agency (or co-lead:)
   NEPA Co-Lead Agency (if applicable):

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

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

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

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

4. **CEQA/NEPA Process**
   a) Is the CEQA/NEPA process complete?

      Not Applicable

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

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

LOCAL PERMITS AND APPROVALS

Conditional use permit

Variance

Subdivision Map Act

Grading Permit

General Plan Amendment

Specific Plan Approval

Rezone

Williamson Act Contract Cancellation

Other

STATE PERMITS AND APPROVALS

Scientific Collecting Permit

CESA Compliance: 2081

CESA Compliance: NCCP

1601/03

CWA 401 certification

Coastal Development Permit

Reclamation Board Approval

Notification of DPC or BCDC

Other

FEDERAL PERMITS AND APPROVALS

ESA Compliance Section 7 Consultation

ESA Compliance Section 10 Permit

Rivers and Harbors Act

CWA 404

Other

PERMISSION TO ACCESS PROPERTY

Permission to access city, county or other local agency land. Agency Name: Merced Irrigation District	Required, Obtained
Permission to access state land. Agency Name:	
Permission to access federal land. Agency Name:	
Permission to access private land. Landowner Name:	

6. **Comments.**

Land Use Checklist

Water Temperature Models for the Merced River and Reservoirs

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

   No

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

   Yes

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

   No

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

   monitoring/research only

4. **Comments.**

Conflict of Interest Checklist

<u>Water Temperature Models for the Merced River and Reservoirs</u>

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

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

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

Applicant(s):

David Vogel, Natural Resource Scientists, Inc.

Subcontractor(s):

Are specific subcontractors identified in this proposal? Yes

If yes, please list the name(s) and organization(s):

Dr. Mike Deas	Watercourse Engineering, Inc.
None	None
None	None
None	None
None	None

Helped with proposal development:

Are there persons who helped with proposal development?

Yes

If yes, please list the name(s) and organization(s):

Keith Marine Natural Resource Scientists, Inc.

Dr. Mike Deas Watercourse Engineering, Inc.

Comments:

Budget Summary

Water Temperature Models for the Merced River and Reservoirs

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

Independent of Fund Source

Year 1												
Task No.	**Task Description**	**Direct Labor Hours**	**Salary *(per year)***	**Benefits *(per year)***	**Travel**	**Supplies & Expendables**	**Services or Consultants**	**Equipment**	**Other Direct Costs**	**Total Direct Costs**	**Indirect Costs**	**Total Cost**
1	Data Acquisition and Processing	320	7954	1591	2386		39120			51051.0	6362	57413.00
2	Model Development and Application	64	2426	485	728		83880			87519.0	1941	89460.00
3	Project Management	136	5178	1036	1554		20560			28328.0	4141	32469.00
		520	15558.00	3112.00	4668.00	0.00	143560.00	0.00	0.00	166898.00	12444.00	179342.00

Year 2												
Task No.	**Task Description**	**Direct Labor Hours**	**Salary *(per year)***	**Benefits *(per year)***	**Travel**	**Supplies & Expendables**	**Services or Consultants**	**Equipment**	**Other Direct Costs**	**Total Direct Costs**	**Indirect Costs**	**Total Cost**
		0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Year 3												
Task No.	**Task Description**	**Direct Labor Hours**	**Salary *(per year)***	**Benefits *(per year)***	**Travel**	**Supplies & Expendables**	**Services or Consultants**	**Equipment**	**Other Direct Costs**	**Total Direct Costs**	**Indirect Costs**	**Total Cost**
		0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Grand Total=179342.00

Comments.
The total for Task 1-Services or Consultants includes $25,000 for competitive bid service contracts. See detail under Budget Justification.

Budget Justification

Water Temperature Models for the Merced River and Reservoirs

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

Principal Investigator: 152 Fishery Biologist: 184 Field Biologist: 120 Data Entry/Clerical: 64

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

Principal Investigator: $48.91/hour Fishery Biologist: $26.90/hour Field Biologist: $17.45/hour Data Entry/Clerical: $16.88/hour

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

Principal Investigator: 20% of salary Fishery Biologist: 20% of salary Field Biologist: 20% of salary Data Entry/Clerical: 20% of salary

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

Travel entails transportation to and from field locations (mileage, fuel, meals and lodging). Estimated cost: $4668

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

None.

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

Three employees of Watercourse Engineering, Inc. will work on all 3 tasks: Data acquisition & processing, model development & application, and project management. Estimated amount of time required: 137 person-days at $865.40 per day. This excludes approximately $25,000 for labor under task 1 (bathymetric surveys) which will be performed under a competitive bid service contract.

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

None.

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

Project management tasks and associated costs (based on percentage of time) include: reporting requirements ($2,382), report preparation ($3,573), project meetings ($1,787) and overall project oversight ($4,169).

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

None.

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

Overhead rate is 40% of charge-out rate and includes workers compensation, office rent, phones, commercial general liability insurance, state disability insurance, utilities, computer hardware and software, furniture, office equipment and supplies, accounting payroll, and unbillable labor of support staff.

Executive Summary

Water Temperature Models for the Merced River and Reservoirs

The Merced River is presently the southern-most tributary stream in the Central Valley inhabited by anadromous salmonids and is consequently subject to longer warm seasonal periods than more northerly streams. The Merced River, its channel, watershed and riparian corridor, has been significantly altered by mining; dam construction for power production, irrigation, and flood control; agriculture; and urbanization which influence the thermal regime of the river. Elevated water temperature, particularly during the early fall and late spring months, has been identified among a set of factors as one principal factor that can limit fall-run chinook salmon production in the lower Merced. Maintaining protective water temperatures in the Merced River includes analyses of effects on food production, salmon growth, and ecological interactions. Suitable growth conditions and optimal age of outmigrating fall chinook salmon will be dependent on year-to-year differences in hydrologic and delta estuary conditions in order to optimize survival of outmigrating smolts. Provision of suitable water temperatures in the Merced River, partially a function of reservoir operation conditions, may be affected by various demands on water supplies. Crocker-Huffman Dam along with three upstream dams (Merced Falls Dam, McSwain Dam, and New Exchequer Dam proceeding in an upstream direction) regulate flows in the lower Merced River. Reservoir storage levels, dam operations, and water discharge volumes have important interactive effects on reservoir thermal conditions, and thus directly affect river temperatures along with other environmental conditions such as: solar radiation, air temperatures, riparian shade, accretion volumes and temperatures, depletion or diversions, channel width and depth, wind, humidity, and ground conduction. Identification of effective temperature management measures and complimentary restoration actions for the Merced River corridor will require a suite of analytical tools to discern the differential effects of these interactive factors affecting water temperature in the reservoir-river system. Such analytic tools would also help to resolve uncertainties associated with predicting effects of these interactions on potential temperature control measures. The objective for our proposed project is to develop and calibrate a reservoir-and-river linked water flow and temperature model for screening and evaluating the value and feasibility of alternative temperature management measures for the Merced River. Modeling efforts provide the means to systematically assess the relative contributions and value of reservoir management and riparian and channel restoration measures for improving water temperatures in anadromous fish habitats. Our proposed project will support the ongoing efforts of stakeholders and resource managers to identify and implement the most effective, cost-efficient temperature management measures for the lower Merced River.

Proposal

Natural Resource Scientists, Inc.

Water Temperature Models for the Merced River and Reservoirs

David Vogel, Natural Resource Scientists, Inc.

A. Project Description: Project Goals and Scope of Work

1. Problem

The Merced River is presently the southern-most tributary stream in the Central Valley inhabited by anadromous salmonids and is consequently subject to longer warm seasonal periods than more northerly streams. The Merced River, its channel, watershed and riparian corridor, has been significantly altered by gold and gravel mining; dam construction for power production, irrigation, and flood control; agriculture; and urbanization (CDFG 1993, USFWS 1995, USBR 1997), which influence the thermal regime of the river. Elevated water temperature, particularly during the early fall and late spring months, has been identified among a set of factors as one principal factor that can limit fall-run chinook salmon (*Oncorhynchus tshawytscha*) production in the lower Merced River and at Merced River Hatchery (CDFG 1993, USFWS 1995, USBR 1997, NMFS 1998, CALFED 1999a,b). Maintaining protective water temperatures in the Merced River includes analyses of effects on food production, salmon growth, and ecological interactions. If river temperatures are too warm, salmon growth and smoltification as well as vulnerability to predation may be negatively effected. However, constraining temperatures too much or cooling long reaches of the river may restrict growth or limit access to relatively warmer conditions for older more tolerant juvenile salmon. Since the size of outmigrant salmon smolts has been implicated in survival and seawater tolerance, any temperature management scenarios for the Merced River should include analyses of balancing protection of early life stages and providing suitable conditions for juvenile salmon growth. Suitable growth conditions and optimal age of outmigrating fall chinook salmon will be dependent on year-to-year differences in hydrologic and delta estuary conditions in order to optimize survival of outmigrating smolts. Also, designated critical habitat within the San Joaquin Basin for the federally-listed threatened Central Valley ESU (evolutionarily significant unit) steelhead (*Oncorhynchus mykiss*) may be potentially affected by seasonally elevated water temperatures in the lower Merced River as defined by that federally mandated determination (NMFS 2000).

Provision of suitable water temperatures in the Merced River, partially a function of reservoir operation conditions, may be affected by various demands on water supplies including ecosystem management flows such as the Vernalis Adaptive Management Plan (VAMP). Crocker-Huffman Dam along with three upstream dams (Merced Falls Dam, McSwain Dam, and New Exchequer Dam proceeding in an upstream direction) regulate flows in the lower Merced River (Figure 1). Reservoir storage levels, dam operations, and water discharge volumes have important interactive effects on reservoir thermal conditions, and thus directly affect river temperatures along with other environmental conditions such as: solar radiation, air temperatures, riparian shade, accretion volumes and temperatures, depletion or diversions, channel width and depth, wind, humidity, and ground conduction. Identification of effective temperature management measures and complementary restoration actions for the Merced River corridor will require a suite of analytical tools to discern the differential effects of these interactive factors affecting water temperature in the reservoir-river system. Such analytic tools would also help to resolve uncertainties associated with predicting effects of these interactions on potential temperature management measures.

A draft temperature model for the Merced River was developed in 1995 (JSA 1995) as part of California Department of Fish and Game's (CDFG) Merced River investigations; however, it is not suitable for detailed operations or design-level studies necessary to lead to improvements for the Merced River thermal regime. As such, CDFG and Merced ID have requested that new, more expansive reservoirs and river temperature models be developed (B. Loudermilk, CDFG Regional Mgr., pers. comm.). The objective for our proposed project is to develop and calibrate system-wide reservoir-and-river linked water flow and temperature models for screening and evaluating the value and feasibility of alternative temperature management measures for the Merced River. Similar modeling efforts for the Sacramento, Trinity, and Klamath river basins have provided the means to systematically assess the relative contributions and value of reservoir management and riparian and channel restoration measures for improving water temperatures in anadromous fish habitats (Deas et al. 1997, Deas and Orlob 1998, 1999, USFWS and Hoopa Valley Tribe 1999). Our proposed project will support the ongoing efforts of stakeholders and resource managers to identify and implement the most effective, cost-efficient temperature management measures for the lower Merced River.

2. Justification

a. Conceptual Model

The life history timing of fall-run salmon in the Merced River is characteristic of that for the San Joaquin River basin (Figure 2) (CDFG 1993). Elevated water temperatures in the lower Merced River may result in delayed salmon spawning, decreased egg survival, and increased juvenile mortality. Stream temperatures in some portions of the spawning reach and at Merced River Hatchery can exceed widely recognized temperature tolerances for salmon spawning and egg incubation in October and early November (Figure 3). Elevated water temperature can affect spawning migration rates, alter the incidence of disease, and delay or accelerate spawning to the detriment of reproductive performance (Marine 1993). In recent drought years, salmon have not spawned until after the first week in November, when water temperatures have cooled, through the effect of reduced day length and concomitant decreased insolation, as well as declining ambient air temperatures, to suitable levels for egg incubation. In more-recent wet years, spawning occurred in October. In late April and May, water temperature often exceeds recognized stressful levels for emigrating smolts. Elevated springtime temperatures are a more frequent and significant problem on the lower Merced River than other chinook salmon streams, even in the San Joaquin River basin, because of its most southerly latitude in the range of chinook salmon and consequent higher air temperatures. In these circumstances, salmon have to spawn later and leave the system earlier to be successful. This "compresses" their life cycle into a shorter period (Figure 2). This is likely to reduce the level of success fish have in reproducing, as well as reduce diversity in the overall population to only those fish that are successful in following that pattern. To ensure a more robust population it would be valuable to sustain an environment that provided a longer “window” to spawn, incubate, rear, and leave the system, particularly during drought years.

Warm water temperatures create conditions in the natural and hatchery environment that are conducive to many salmon pathogens resulting in many types of diseases or infections that reduce fitness or cause mortality (Piper et al. 1982, Marine 1993, Fagerlund et al. 1995, NMFS 1998). This is most evident in hatchery populations but can occur in the Merced River as well (B. Loudermilk, CDFG, pers. comm.). In many years, salmon production at Merced River Hatchery is impaired by warm water temperatures in the fall, late spring and summer months (M. Cozart, CDFG, pers. comm.).

Existing records, data, and modeling efforts addressing water temperature issues for the Merced River are insufficient at this time to allow comprehensive quantitative analysis of the potential for impacts of proposed conservation/restoration actions on Merced River temperatures.

Our approach to addressing temperature management issues for the Merced River stems from the conceptual model shown in Figure 4 which was adapted from Theurer et al. (1984). The conceptual model includes iteration so some degree. As more is learned from additional data or direct model application, the modeling effort is refined (Figure 5). This has a direct implication with reducing scientific uncertainty. A number of factors affect river temperatures below the dams on the Merced River, with the thermal conditions and operation of the reservoirs being of primary importance. Some of these factors may be manipulated to improve thermal conditions at certain times of the year to benefit anadromous salmonids restricted to spawn and rear below the dams, while balancing water supply and other ecosystem functions supported by the Merced River. The storage level of Lake McClure is a primary factor affecting temperature of water released into the Merced River at New Exchequer Dam. Reservoir levels affect the temperature of water at the dam’s outlet, as do annual runoff patterns and seasonal meteorological conditions. The level of the reservoir affects the volume of cold water in the hypolimnion that forms in the deepest layers of the reservoir upon thermal stratification during the late spring, summer, and early fall months. Surface water warmed by the air and solar radiation during the spring and summer “floats” on top of the cooler, denser water of the hypolimnion. The depth of this warmer surface layer can vary but is generally 5 and 20 meters deep (about 15 and 70 feet) in most California reservoirs. Once thermal stratification breaks down during the early fall months, the warmer surface and cooler hypolimnion waters mix and reservoir temperature becomes almost uniform throughout its depth and comes to a dynamic equilibrium with inflow and meteorological conditions until stratification reoccurs the following spring. Unlike other large Central Valley reservoirs that are relatively easy to model and control water temperatures in downstream salmon reaches (e.g., Shasta Reservoir), the three re-regulating reservoirs downstream of Lake McClure significantly increase the complexity for controlling and managing water temperatures to benefit salmon in the Merced River.

The temperature of the river as it flows downstream is primarily modulated by meteorological conditions (heat exchange at the air-water interface), flow accretions and depletions, channel morphology, and riparian shading,. Each of these factors has an incremental and interactive effect with the others on the ultimate water temperature regimes exhibited at various points and aquatic habitats along the river. So, within certain limits, incremental improvements of thermal conditions for portions of the river may be affected through dam design and flow management, return flow management, channel restoration and management, and restoration and conservation of riparian shading habitats. Restoration and management of channel morphology and its supporting physical processes, and riparian habitat are currently being addressed through projects previously funded by CALFED (Merced County's *Merced River Corridor Restoration Plan/ Project*, California Department of Water Resources's *Merced River Salmon Habitat Enhancement*, and CDFG's *Merced River Land Acquisitions* and *Phase 3 Merced River Salmon Habitat Enhancement*). Our proposed project will address the issues related to reservoir and dam operations to allow development of a comprehensive temperature management plan for the lower Merced River.

b. Research Project Hypothesis and Adaptive Management Implications

Our proposal addresses ecosystem management questions associated with managing anthropogenic alterations of riverine physical processes compatible with desired future ecosystem-state conditions for Central Valley salmon production. The Merced River as a highly altered and regulated riverine ecosystem has functionally isolated the lower, valley reach of the Merced River from its upstream watershed in the foothills and mountains of the Sierra Nevada. Dam construction has altered the flow and water temperature regime in river reaches downstream of the four mainstem dams on the Merced River. These alterations have changed the river's natural ecological processes and affected the habitat available for salmonids. Although water released into the Merced River is released from the hypolimnion at the bottom of Lake McClure, complex hydraulics and thermodynamics in the three downstream reservoirs from New Exchequer Dam significantly affect the ultimate water temperature regime in the salmon spawning and rearing reach of the lower Merced River. Effective conservation measures that avoid the impacts of warm water temperatures in the lower Merced River and at Merced River Hatchery have the potential to measurably improve chinook salmon production. With the participation of the Merced River Project in the VAMP to meet ecosystem hydrologic objectives in the Delta and planned flow augmentation in the Merced River to potentially meet the needs of early returning salmon into the Merced River, it will be important to assess if cold water supplies for release to the river and water temperatures are suitable for those fish that spawn early in the season.

The primary hypothesis to be evaluated by our proposed research project is that water temperatures in the lower Merced River can be effectively managed to benefit chinook salmon through operational and/or structural measures at the four mainstem Merced River reservoirs and dams, as well as potential restoration measures in downstream river reaches. As a modeling/simulation study, we expect to determine the relative temperature improvements that may be achieved through manipulation of operational, structural and/or restoration components of our conceptual model. The model will serve to reduce scientific uncertainty associated with identification of effective temperature management alternatives prior to selecting and initiating actions (adaptive management process described in the draft Stage 1 Implementation Plan, page 8). To a certain extent, we will rely on recent experience involved with development of temperature control for Shasta Dam (USBR 1992). The results of these analyses are expected to provide the necessary 'feedback' to our conceptual model in order to identify the most efficient and effective suite of actions for temperature management on the lower Merced River. A combination of the identified suite of actions will be pursued for implementation after completion of this proposed project, which is analogous to the adaptive management process described in the draft Stage 1 Implementation Plan.

3. Approach

In order to optimize water management on the Merced River water temperature models will be developed and used as part of an adaptive management effort. Such an effort would utilize temperature monitoring stations along with the models to adjust stream flows and guide restoration efforts to achieve temperature objectives while balancing water supply needs. Fish migration monitoring would be used to identify periods of critical life phases to refine the time frame when temperature management may be needed.

This project will result in the development of water temperature computer models for the Merced River and its reservoirs from Lake McClure to the confluence with the San Joaquin River. The models will incorporate the necessary field data to represent reservoir storage and outlet configuration, river hydrodynamics, channel geometry, inflow temperatures, meteorological data, and water management operation inputs to simulate thermal dynamics of the reservoirs and river reaches. This project will rely heavily on extensive data inputs and results from the initial Reconnaissance Investigation currently funded by the CVPIA AFRP that will be completed prior to initiation of development of the water temperature models.

Development of the models will allow evaluation of potential alternative methods of providing temperature management, such as water operations, changing channel configurations in certain reaches or improving shading by revegetating the river bank, or augmenting riparian vegetation. The models will also provide the means to identify river reaches that may benefit from such management prescriptions. The models will be incorporated as a part of a comprehensive stream temperature management program for the Merced River and be used to evaluate a broader range of water temperature management alternatives. The proposed approach for simulation modeling of system reservoirs and river reaches is outlined below.

The project is composed of three principal tasks:

Task 1. This first task will include data acquisition and processing for the four Merced reservoirs and associated river reaches. As noted above, there are ongoing monitoring efforts in the basin to collect the necessary baseline data for the modeling studies (Figure 1). These monitoring programs are being adapted to ensure that all data needs are met. A final technical report (funded by the CVPIA Anadromous Fish Restoration Program [AFRP]) that compiles all relevant data and information on the Merced River water project operations will be completed by September 2002. However, there are additional data requirements for completing temperature modeling in the Merced River system. These data on the Merced River will be collected for Task 1 to provide information to develop the water temperature models (e.g., detailed bathymetry of the reservoirs, meteorological data at Lake McClure). Task 1 will include acquisition and processing of meteorological data, flow data, water project operations data, water temperature data, riparian shading information, and geometric representation of the four reservoirs. Additionally, there is a need to quantify diversion and return flow in the lower Merced River and assess intake and diversion impacts on the thermal regime.

Task 2. Task 2 is the model development, calibration, validation, system-wide interface, and application. The following provides details on this task.

Modeling Approach
Water resources development on the Merced River system over the past century has resulted in a complex and unique system of reservoirs and free-flowing river reaches. The reservoirs dramatically vary in size and purpose, from the large storage impoundment of Lake McClure, to the small Crocker-Huffman diversion dam. River reaches likewise illustrate a wide range of characteristics as operations and diversions and return flows vary widely in space and time. Modeling the thermal regime of this system requires characterizing each of these reservoir and river reach components individually, identifying the appropriate representation for each component and selecting and implementing a suitable model. These individual models are then used in concert to simulate system response for variable hydrology, meteorology, operations, and system conditions. The approach to modeling each reservoir and Merced River reaches are outlined below. A range of potential models is presented based primarily on preliminary system characterization of the thermal regime of each system in light of the overall project objective.

<u>*Reservoirs*</u>
<u>New Exchequer</u>
New Exchequer is a large reservoir in excess of 1 million acre-feet and is prone to strong thermal stratification. The reservoir experiences long residence time, has great depth, and has modest flow through volumes during warmer periods of the year. Residence time is on the order of one-year. As such it is a candidate for temperature modeling with a one-dimensional vertical

representation. These models make the assumption that lateral variations (transverse and longitudinal) are modest compared to vertical temperature variation. There are several readily available public domain models of this type that could be applied to New Exchequer including the U.S. Army Corps of Engineers models WQRRS, HEC5-Q, and CE-QUAL R1. The heat budget formulation for each of these models is adequate for this large reservoir and all of these models accommodate multiple outlets.

Lake McSwain

Lake McSwain re-regulates peaking power releases from New Exchequer Dam. There are no appreciable diversions from this reservoir; however, hydropower production occurs at McSwain Dam. The reservoir is approximately 6 miles long, with a residence time ranging from less than three days to over three weeks during summer periods. This impoundment may exhibit weak to moderate thermal stratification throughout the warmer periods of the year when releases from New Exchequer are modest. Existing and planned monitoring will provide information on the persistence of thermal stratification. Should stratification persist through the warmer periods of the year, a one-dimensional representation as presented above can be employed. Some of the aforementioned models have the capability to represent weakly stratified impoundments (e.g., WQRRS). If longitudinal variations are apparent, a two-dimensional model may be more appropriate. Depending on the range of flow through rates the reservoir can be modeled as a slow deep river using a one-dimensional longitudinal representation. Under this assumption, lateral and vertical temperature gradients are assumed small compared to longitudinal variations. For the purposes of this proposal it is assumed that a two-dimensional representation will be necessary to effectively capture the thermal regime of Lake McSwain. A suitable model for this purpose would be the U.S. Army Corps of Engineers model CE QUAL-W2.

Merced Falls Forebay

Merced Falls Forebay is a diversion point for the North Side Canal. This diversion is relatively small compared to the diversions from Crocker Huffman dam (see below). This impoundment is approximately one mile long, with a residence time on the order of hours to a few days depending on flow conditions. Because the reservoir is relatively shallow and the residence time is short, this reservoir will be modeled as a slow deep river using a one-dimensional longitudinal representation.

Crocker Huffman Dam

Crocker Huffman Dam impounds water for diversion into the main canal and is a primary diversion point for the Merced Irrigation District (ID). Crocker Huffman Dam is the terminal dam on the Merced River, i.e., downstream reaches are accessible to anadromous fishes. This impoundment is over one mile long and has a residence time on the order of hours to days depending on the flow conditions. The intake locations for the existing canals may play a role in the thermal regime of the reservoir as well as affect downstream release temperature. The field-monitoring program will further define the thermal conditions at this lake under existing operations. Because the reservoir is relatively shallow, and the residence time is short, this system may be modeled as a slow deep river using a one-dimensional longitudinal representation. Depending on field study findings a more complex representation may be necessary.

Modeling time step will be will potentially range from sub-daily (e.g., hourly) for the smaller impoundments up to one-day for Lake McClure (New Exchequer).

River Reaches

River reaches between reservoirs and downstream of Crocker-Huffman dam will be modeled with a one-dimensional longitudinal river model. Approximately fifty-two miles of river will be represented from Crocker-Huffman Dam to the confluence with the San Joaquin River. There are several challenges in representing this river reach, including low flow conditions, variable stream geometry, and diversions and return flows. Further, it has been identified that restoration of channel form and riparian communities is desirable, thus the selected model must be able to accommodate these processes.

It is critical to note that successful representation of the thermal regime of the lower Merced River requires effective representation of both flow and temperature. To address the broadest possible range of alternatives a hydrodynamic model will be applied to represent the flow regime in the river. Output from the flow model will be passed to the temperature model to determine transport and fate of heat energy.

There are several one-dimensional river models public domain or "open[1]" models available that address both flow and temperature, including WQRRS, HEC5-Q (flow modeled with flood routing), and CE QUAL-RIV1 from the U.S. Army Corps of Engineers; the Tennessee Valley Authority flow and temperature models ADYN and RQUAL, respectively, as well as others. Review of field data and monitoring results, as well as identifying potential management actions (e.g., re-operation, channel and riparian revegetation restoration, etc.) will assist in final model selection. All river modeling will be at sub-daily time steps, e.g., one-hour.

Model Integration

Because there is the potential that different models (sub-models) will be used for different components of the system, there is the need for model integration. The models will be run in series, starting with the most upstream component (New Exchequer) and proceeding downstream

[1] "open" models refer to computer codes that are available for a fee, but unlike proprietary codes where only an executable program is supplied, their source code is provided and readily available for peer review.

to the confluence with the San Joaquin. A simple interface will be developed to aid the construction of input files, application of the various sub-models, and interpretation and presentation of output.

Task 3. Task 3 will encompass Project Management, including all written quarterly and final reports and project coordination.

4. Feasibility

Thermal loading, through heat exchange at the air-water interface, as well as thermal energy imparted on a water body via inflows is well understood and has been modeled for several decades. From this body of knowledge it is well known that reservoir operations, river flows, channel and riparian vegetation maintenance and restoration can affect thermal conditions within a river basin. The numerical models identified above have been widely applied to a broad range of reservoir and river systems to assess such issues, including several in the Central Valley. The reservoir models WQRRS has been applied to Shasta and Trinity Reservoir, HEC-5Q has been applied to New Melones reservoir as well as Tulloch Reservoir, and CEQUAL-R1 has been applied at New Bullards Bar on the Yuba River. The aforementioned river models have also been widely applied in temperature studies. Advances in computational ability and improvements in software have reduced the simulation times and allowed management of large data sets to the degree that long simulations at short time steps are now feasible, e.g., 6 month simulations at 1-hour time steps are feasible. The advances in software also allow the analyst to select the best model for each individual reservoir or river reach, adding a integrating interface to simulate entire reservoir-river systems seamlessly. Thus, rather than being tied to a single model that simulates reservoirs and rivers, multiple models of different representations, time steps, parameters, etc. can be coupled for simulation.

5. Performance Measures

Performance measures for this project will be in the form of peer-reviewed written technical documentation of the water temperature modeling project describing design, protocols, a quality assurance program plan, data collected, analyses performed, model calibration/validation process, and final results in the form of water temperature models for the Merced River and reservoirs. A written technical report will be peer reviewed by CALFED staff. Additionally, a technical presentation to CALFED will be provided, if requested.

6. Data Handling and Storage

Modeling efforts are data intensive and several types of data are necessary, including time series of flow, storage, operations, water temperature, and meteorological data. In addition, geometric data are required to describe the physical reservoir and river systems, as well as diversion locations; return flow locations; outlet locations, size, and capacity; spillway works, etc. Time series data will be maintained in a data base, while physical system data will be maintained in tables. All data will be available on electronic media both during the project, as data become available, as well as upon project completion. All electronic data will be backed up weekly and additional copies will be archived in a fireproof safe.

7. Expected Products/Outcomes

This Project aims to provide three principal products, (1) a description of the existing thermal regime of the system and inventory/database of available data, (2) a comprehensive modeling framework and associated data set and parameters, and (3) assessment of alternative operations and flow-temperature relationships for the river below the dams, as well as a suite of potential temperature prescriptions for the various alternatives.

Item (1) may be termed a description of baseline conditions. For this project the processes of seasonal thermal loading, thermal processes in the basin, impacts of water resources development (reservoirs, diversions), operations, and short- and long-term temperature response due to meteorological conditions. This deliverable is a necessary first stage to clearly identify existing conditions and how controllable and uncontrollable processes affect the thermal regime of the reservoir-river system.

Item (2) is designed to promote the level of scientific analysis within the Merced River basin, as well as other river-reservoir systems in the Central Valley. The goal of this deliverable is to provide comprehensive documentation of the model implementation and application, including all data sets, model parameter selection (and motive), calibration and validation results and methods of quantifying uncertainty. Beyond basic information required for this project, comprehensive documentation and discussion will ensure that this work lays a foundation for from which future studies can be made.

Project deliverables for item (3) include specific analyses completed using the models developed under this project. A final project report will explicitly identify the thermal impacts of alternatives formulated by stakeholders. Alternatives may range from exploring a range of hydrologic and meteorological conditions, re-operation of existing facilities, capital improvements that may include modifying outlet structures (e.g. selective withdrawal, modifying existing dams).

Development of the reservoir and river water temperature models will provide the essential information for subsequent (next phase) engineering designs to proceed.

8. Work Schedule

This project would occur over a one-year period, January through December 2003. Task 1 would occur from January through July 2003. Task 2 would occur from February through November

2003. Task 3 would occur from January through December 2003. None of the tasks are separable. The final report would be completed by December 2003.

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

1. ERP, Science Program, and CVPIA Priorities

This project specifically addresses several of CALFED's draft Stage 1 Implementation Plan priorities. First, it will contribute to Multi-Regional Priority #4 through development of a watershed scale temperature model for the lower Merced River, (including the upstream reservoirs, tributaries, channel and riparian conditions), allowing identification of temperature management constraints and measures for a wide range of hydrologic conditions. Second, San Joaquin Region Priority #1 would be supported by information generated by our proposed project regarding the relative thermal benefits of restoration changes in channel morphology and riparian shading. Third, our proposed modeling project addresses information needs required to address San Joaquin Regional Priority #3 to improve rearing and spawning habitat conditions for anadromous salmonids, through temperature management, in the Merced River. And finally, our proposal will specifically support San Joaquin Regional Priority #6 providing crucial information needed for flow-related adaptive management experiments, including the VAMP. The modeling effort we propose will provide the necessary tools for evaluating and designing thermal benefits for restoration actions, streamflow management plans, and managed flow fluctuations in the Merced River. ERPP Strategic Goals 1 and 2 will be directly addressed by pursuing: 1) to provide suitable habitat conditions to conserve and restore an at risk species (ERPP Goal 1), the San Joaquin basin fall-run chinook salmon; and 2) to evaluate system flexibility to meet other desired ecosystem objectives while ensuring that flow and water temperature can be managed to favor the native aquatic species in terms of seasonal timing, duration, and geographic scope within the Merced River basin (ERPP Goal 2). Additionally, the U.S. Fish and Wildlife Service's (USFWS) AFRP (CVPIA) has identified water temperature management on the Merced River as a high priority resource management issue (USFWS 1995). Current FY 1999-2004 project funding priorities emphasize beneficial actions for San Joaquin Basin fall-run chinook salmon, with actions that address water temperature limiting factor issues ranked among the highest in priority (CVPIA Six-Year Implementation Plan and Budget FY's 1999-2004).

2. Relationship to Other Ecosystem Restoration Projects

This proposed modeling and systems evaluation project will use the information and data resulting from the first phase of the Merced River Water Temperature Management Feasibility Study funded by the CVPIA that will be completed prior to initiating this modeling project. The proposed model's outputs are expected to be useful to the Merced County's Merced River Corridor Restoration Project that was funded by CALFED during 1998-2001. Integration of the shaded riparian habitat and channel maintenance benefits expected from stream corridor restoration projects with options for improved stream temperature management that emerge from our project's assessments will be ultimately important for achieving a coordinated temperature management solution for the lower Merced River. Our results will also directly benefit both DWR's and DFG's CALFED funded Merced River salmon habitat enhancement projects. Our proposal serves to support these ecosystem objectives and future Merced River and San Joaquin Basin restoration/management actions through comprehensive evaluation of options to assure compatible, balanced management of improved flow and water temperature regimes on the Merced River to benefit native aquatic and at-risk species.

3. Request for Next-Phase Funding

The CVPIA AFRP is funding the first phase of a Merced River Water Temperature Management Feasibility Study. The contract for that project is currently being developed. The purpose of the first phase is to compile and summarize pertinent physical project specifications, operating strategies and requirements, related agreements, and existing thermal and flow information and biological monitoring activities in the four Merced River reservoirs and the lower Merced River. The initial phase is the first step in development of comprehensive water temperature management plan for the lower Merced River. The initial project will compile all pertinent physical and biological data and analyses regarding Merced ID's Merced River Development Project and water temperature in the fall, winter, spring, and summer months. Information developed for Merced ID's reservoir characteristics and operations plan(s) and models, and all associated physical information, requirements and agreements that need to be considered will be compiled into a peer-reviewed Reconnaissance Study Report that will be completed (September 2002) prior to initiating this next proposed next phase which is development of the water temperature models (i.e., this next phase proposed CALFED project would be initiated in January 2003). Completion of the reservoir and river water temperature models is essential for the subsequent phase engineering design studies to proceed in an effective, timely manner.

4. Previous Recipient of CALFED Program or CVPIA funding

Natural Resource Scientists, Inc. has received CALFED and CVPIA funding for Central Valley projects. In 1995, a final contract peer-reviewed report entitled: "*Losses of young anadromous salmonids at water diversions on the Sacramento and Mokelumne Rivers*" was completed by NRS, Inc. under a subcontract with CVPIA AFRP funding (prime contract number is unknown). In May 2000, a contract peer-reviewed report entitled: "*Juvenile Chinook Salmon Radio-Telemetry Study in the Northern Sacramento - San Joaquin Delta, January - February 2000*" was completed for the CVPIA AFRP (open contract, order no. 101810M102). In August 2001, a draft CVPIA AFRP contract report entitled: "*Juvenile Chinook Salmon Radio-Telemetry Study in the Southern Sacramento - San Joaquin Delta, December 2000 - January 2001*" was submitted to the IEP for peer review (Contract No. 101811D027). Results of a CALFED field study of juvenile salmon at the Delta Cross Channel (DCC) during November 2000 were presented at the IEP 2001 Asilomar conference and a written report is in progress (CALFED DCC study contract no. unknown). An expanded version of the DCC studies for 2001 was recently approved by the CALFED Science Panel and funding was approved in September 2001; no funds have been expended to date. Three research projects, "*Juvenile Salmon Migratory Behavior Study in the North, Central, and South Delta*" was recently approved by CALFED (CALFED Project No. ERP-01-N48) and a contract was executed with the National Fish and Wildlife Foundation in September 2001; no funds have been expended to date. A project on the initial phase of a "*Merced River Water Temperature Management Feasibility Study*" (2001-K203) was recently approved by CALFED and a USFWS CVPIA contract is being developed with the USFWS; no funds have been expended to date. NRS, Inc. is working on the AFRP project *"Merced River Wing-Dam Monitoring, 2000-2002"* on behalf of Merced ID (FWS Agreement #113320J027).

5. System-Wide Ecosystem Benefits

Habitat and water quality degradation exacerbated by reduced flows in the lower San Joaquin River and the Delta along with the effects of the large CVP and SWP water diversions and numerous local diversions throughout the Delta have been attributed to declines in a number of fish species that inhabit or migrate through the Delta. The 1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, Delta Smelt Biological Opinion, and CVPIA's Revised Draft Anadromous Fish Restoration Plan call for increased instream flows on the lower San Joaquin River with specific seasonal flow objectives at Vernalis where the San Joaquin River enters the Delta.

The CVPIA requires that all reasonable efforts to ensure that by the year 2002 natural production of anadromous fish in Central Valley rivers will be sustainable on a long-term basis, at levels not less than twice the average levels attained during the period 1967-1991. One element of the CVPIA, the AFRP, has need for provision of water of the appropriate temperature from the San Joaquin tributaries to increase flows on the lower San Joaquin River at times to benefit fish and wildlife. The AFRP also specifically identifies the water temperature management on the Merced River as a high priority. The CVPIA authorizes the Bureau of Reclamation to obtain additional flows on the Stanislaus, Tuolumne, Merced, and lower San Joaquin rivers that will facilitate migration, attraction, production, and survival of anadromous fish on these rivers in accordance with specific fish, wildlife, and habitat restoration purposes of the Act. The Bureau of Reclamation proposes to contract water on the San Joaquin River and tributaries to meet the needs of fish and wildlife within the San Joaquin Valley while pursuing to achieve a reasonable balance among competing demands for CVP water for all authorized uses including fish and wildlife. The provision of Merced River water to downstream areas will contribute, in part, to these multi-purpose beneficial uses while concurrently ensuring that in-basin needs are met, including the appropriate thermal regime.

Merced ID is a signatory to the San Joaquin River Agreement which, among other things, implements the Vernalis Adaptive Management Plan (VAMP). Under the VAMP, effects of flow and export from the Sacramento/San Joaquin River Delta upon salmon will be investigated. As part of that agreement, increased flows in the spring and fall will be provided in the Merced, Tuolumne, and Stanislaus Rivers, more than 50 percent of which is to be supplied by Merced ID. Such flows are to be provided during an April/May pulse flow and during October. Our proposed modeling and evaluation project will provide integral information to the VAMP that will allow Merced ID to manage their water supplies in an optimal and flexible manner to meet VAMP while concurrently fulfilling other ecosystem process objectives as envisioned in the ERPP.

Since the objective of this proposed project is to improve the options for stream temperature management on the Merced River, it will contribute toward optimization of water supply management and water quality for fish habitat. This is compatible and integral to CALFED objectives for water quality and water supply reliability.

C. Qualifications

Natural Resource Scientists, Inc. will manage the project and administer the budget. NRS, Inc. has extensive expertise on water project operations interrelationships with aquatic resources. NRS, Inc. has performed numerous investigations of freshwater habitat requirements and factors limiting fish populations and the development of measures to improve river and stream conditions for fishery resources. Additionally, NRS, Inc. is thoroughly familiar with the Merced River and has been working on Merced River fishery and water resource issues for the past decade. NRS, Inc. established and maintained an extensive network of water temperature monitoring stations in the upper and lower Merced River and its reservoirs over the past four years. The CDFG, USFWS, and the National Marine Fisheries Service (NMFS) will provide technical assistance with data acquisition and resource guidance. Merced ID will collaborate and coordinate with the NRS, Inc. and the latter three agencies throughout the project. NRS, Inc. will assist in the data acquisition, processing, and analyses, project oversight and coordination, and project reporting requirements, including technical report writing. NRS, Inc. selected Dr. Mike Deas of Watercourse Engineering, Inc. to serve as a subcontractor for this project because of his extensive expertise in modeling water projects similar to the requirements for this study. Dr. Mike Deas, through a subcontract with NRS, Inc., will develop the reservoir and river temperature models. An additional subcontractor, to be selected through a competitive bid process according to CALFED guidelines, will perform the bathymetry surveys.

David A. Vogel, Project Manager
Natural Resource Scientists, Inc., Senior Scientist
M.S., 1979, Natural Resources (Fisheries), University of Michigan
B.S., 1974, Biology, Bowling Green State University

Mr. Vogel will serve as Project Manager for this project because of his expertise and knowledge of the interrelationships of Merced ID's water project operations and fishery resources. Mr. Vogel specializes in aquatic resource assessments and resolution of fishery resource issues associated with land and water development. His 25 years of work experience in fisheries has included large-scale assessments in river systems, lakes and reservoirs, and estuaries. Most of his experience has been associated with restoration of western United States fishery resources. Mr. Vogel has worked as a biological consultant for the U.S. Bureau of Reclamation to define interrelationships of salmon resources and Central Valley Project water project operations. He was the Task Manager for the Biological Assessment of the 1992 operations of the Central Valley Project (CVP) and was the principal biologist in charge of developing the long-term Biological Assessment for the CVP. Mr. Vogel has been working on Central Valley fishery resource research and management projects and interrelationships with water project operations for 20 years.

Dr. Michael Deas, Modeler
Principal, Watercourse Engineering, Inc.
Ph.D. Civil Engineering (2000) – University of California, Davis
M.S. Civil Engineering (1989) – University of California, Davis
B.S. Civil Engineering (1986) – University of California, Davis
Registered Engineer, State of California (1990)

Dr. Deas will provide professional engineering services for water temperature model implementation, and application associated with the river and reservoir systems. Dr. Deas is the principal of Watercourse Engineering, Inc, a company specializing in water quality assessment, including system definition, monitoring, model construction and application, and analysis of system response to alternative management conditions.

Relevant projects by Dr. Deas include:

- Developed and applied reservoir models for simulating temperature and/or water quality for several mainstem reservoirs in California, including Shasta Reservoir, Trinity Reservoir, Iron Gate Reservoir, and Keswick Reservoir.

- Developed and applied river models for simulating temperature and/or water quality, including the Sacramento River, Klamath River, and Shasta River.
- Other project work includes:
  - Temperature model review for the Central Valley, CA
  - Reconstruction of historic Sacramento River water temperature
  - Design, implementation, and management of the Klamath Basin monitoring program, CA/OR

Keith R. Marine, Project Ecologist
Natural Resource Scientists, Inc., Aquatic Ecologist
M.S., 1997, Ecology, University of California, Davis
B.S., 1983, Wildlife and Fisheries Biology, University of California, Davis

Mr. Marine will serve as Project Ecologist for this project because of his expertise in ecological and thermal requirements of native fishes. Mr. Marine specializes in the ecological sciences with emphasis on fisheries science, aquatic and marine biology, and physiological ecology. He has extensive experience in ecological and biological assessment and conducting research directed at resolving natural resource management problems. Mr. Marine has designed and conducted ecosystem-level investigations on fish migration and behavior associated with operation of large Central Valley Project facilities, including fish responses to stream temperature alterations resulting from project operations. His expertise includes a comprehensive research background in thermal requirements and tolerances of California's native fishes, including Pacific anadromous salmonids. He has designed and performed temperature tolerance investigations and experiments for all the freshwater life phases of chinook salmon while working for the University of California, the USFWS, and several water management agencies. Mr. Marine has performed evaluations of fish populations, fish habitat requirements, stream flow assessments and stream temperature modeling in support of fishery conservation and restoration programs.

D. Cost

1. Budget

Total budget for this project is given in the 2002 PSP web forms.

2. Cost-Sharing

Merced ID will provide $25,000 of in-kind contributions to this project. The contributions will include Merced ID support staff work and overhead costs beyond that budgeted in this proposal. Merced ID will also continue and expand its water temperature data collection program in the Merced River watershed to provide empirical data for calibration and verification of the water temperature models. In addition, CDFG, USFWS, and NMFS will provide in-kind technical assistance with data acquisition and resource guidance for the project.

E. Local Involvement

Merced ID and CDFG have jointly developed and agreed upon a 10-year study program to determine the potential factors that may limit salmon production in the Merced River. This program is designed to evaluate the habitats necessary for increased salmon production by assessing the needs for each freshwater salmon life stage (i.e., upstream migration, spawning, egg incubation, fry and juvenile rearing, and outmigration). The joint study program defines the objectives, basic experimental design, and the responsibilities for study implementation. The studies and instream flow scheduling will be coordinated with other studies throughout the San Joaquin basin and the Delta. Components of this program are presently underway. The completion of the 10-year program is intended to identify the long-term instream flow and other needs of salmon in the Merced River. To facilitate the studies, CDFG and Merced ID have established the Merced Management and Technical Advisory Committees (TAC); the latter committee establishes and coordinates study protocols, study amendments, funding issues, and information sharing and exchange. USFWS and NMFS staff also participate in the TAC meetings. This committee has endorsed the Merced River Water Temperature Management Feasibility Study. This project will be closely coordinated with the TAC. Additionally, water temperature management in the Merced River watershed was identified as a high priority issue in a CALFED San Joaquin Regional Meeting.

With funding from the USFWS AFRP and the CALFED Bay-Delta Program, the Merced County Planning and Community Development Department, with cooperation from Merced ID, have embarked on a collaborative effort to develop a restoration strategy for the Merced River corridor. This program will seek to join input from community stakeholders with a scientifically-based understanding of current river conditions and processes to identify a feasible corridor restoration strategy. Public involvement will play a key role in the restoration planning process, and public coordination will continue through the life of the project. To establish this role, the County, with Merced ID's assistance, convened a Merced River Stakeholder Group. The Stakeholder Group represents a broad array of public and private interests, including local business and property owners; state, local, and federal agencies; fish and environmental groups; and other groups or individuals. In addition to working with his Stakeholder Group, the County also conducted regular workshops to keep the public informed of the project's progress. These groups will be kept informed of this modeling project.

No third-party impacts are anticipated. Land use changes will not occur as a result of this project. Those parties who support restoration of San Joaquin fall-run chinook salmon that would benefit from the proposed project would also benefit.

F. Compliance with Standard Terms and Conditions

Natural Resource Scientists, Inc. will comply with the standard State and Federal contract terms described in Attachments D and E of the CALFED 2002 Proposal Solicitation Package.

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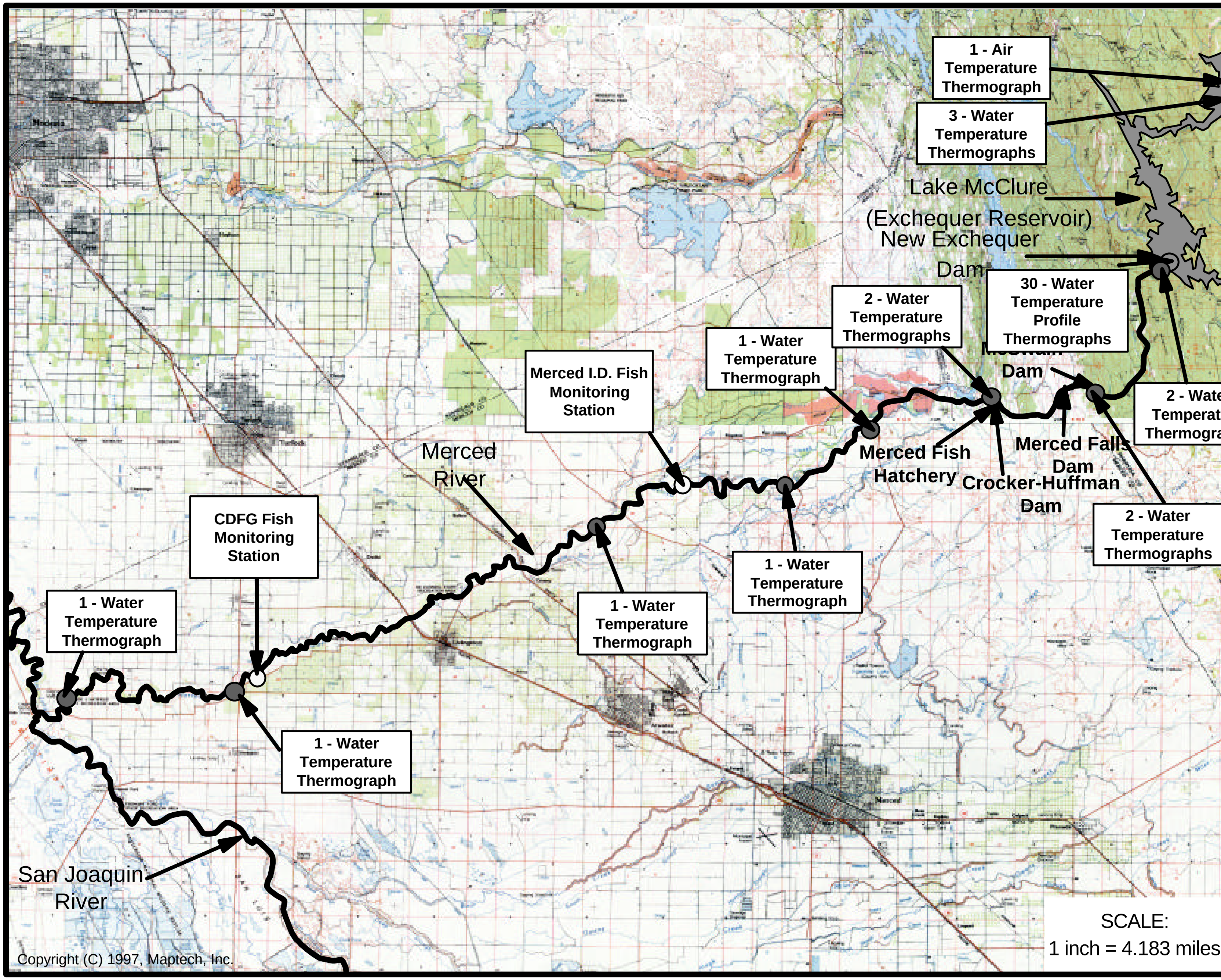

Figure 1. Locations of temperature and fish monitoring stations in the Merced River watershed and the four dams and reservoirs.

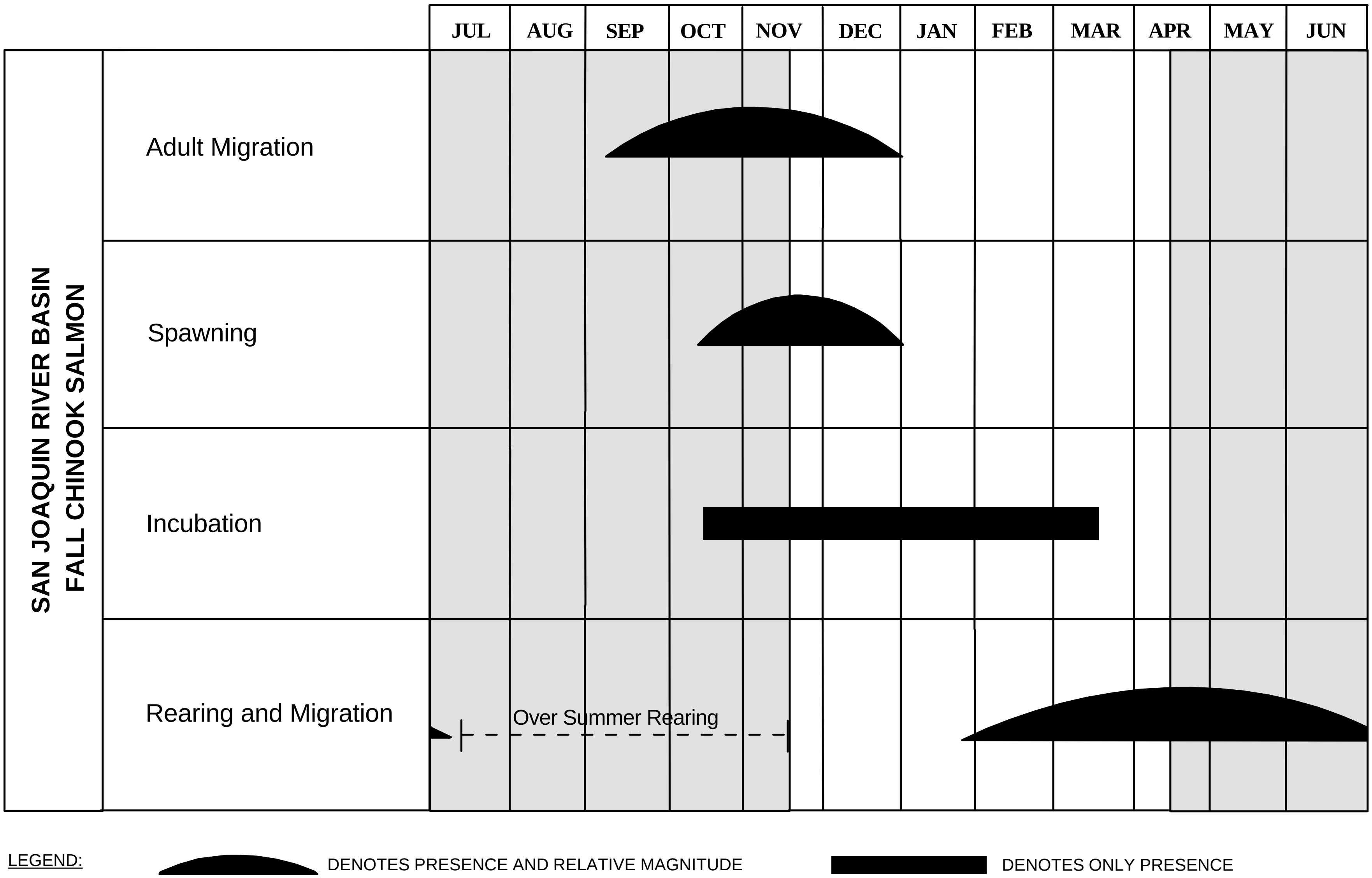

Figure 2. Life history phenology of San Joaquin Basin fall-run chinook salmon showing seasons of water temperature limitations (shaded area).

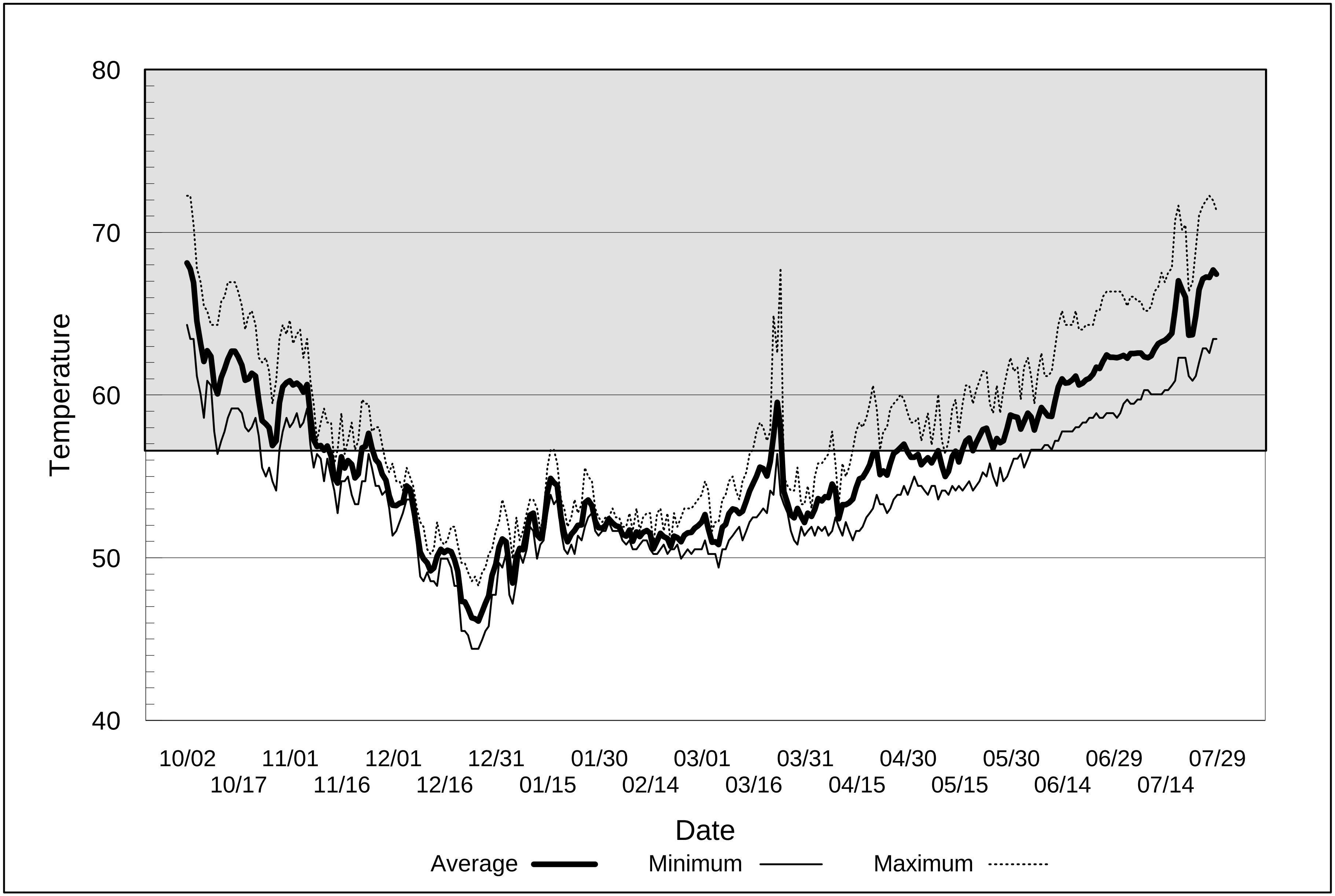

Figure 3. Water temperatures recorded at river mile 42 in the Merced River (October 1997 - July 1998) showing the range of concern for elevated temperature effects on anadromous salmonid spawning and rearing (shaded area).

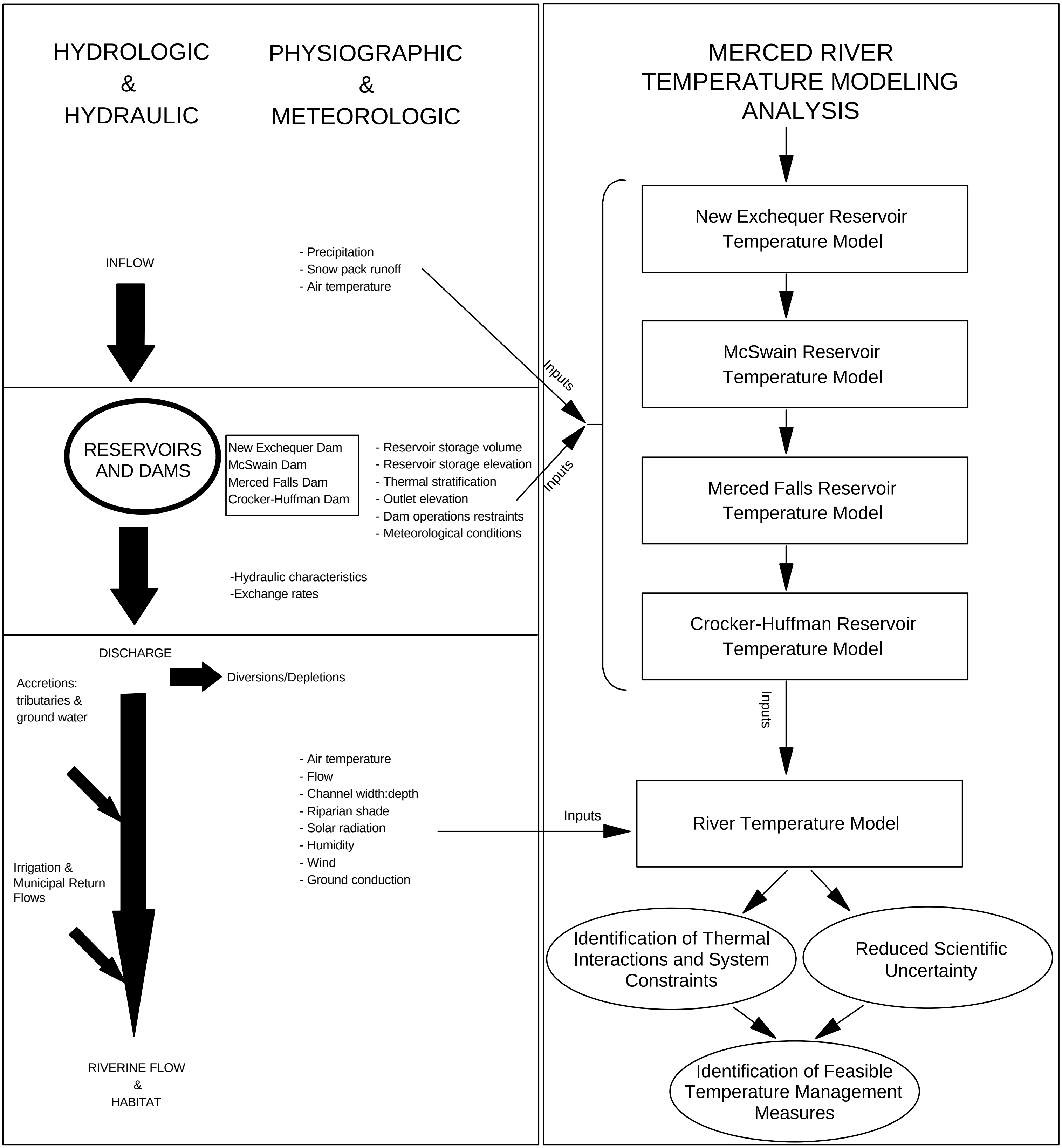

Figure 4. Conceptual model of analytic approach for evaluating prinicipal factors affecting water temperatures of the lower Merced River and identifying temperature management measures (adapted from Theurer, et al. 1984).

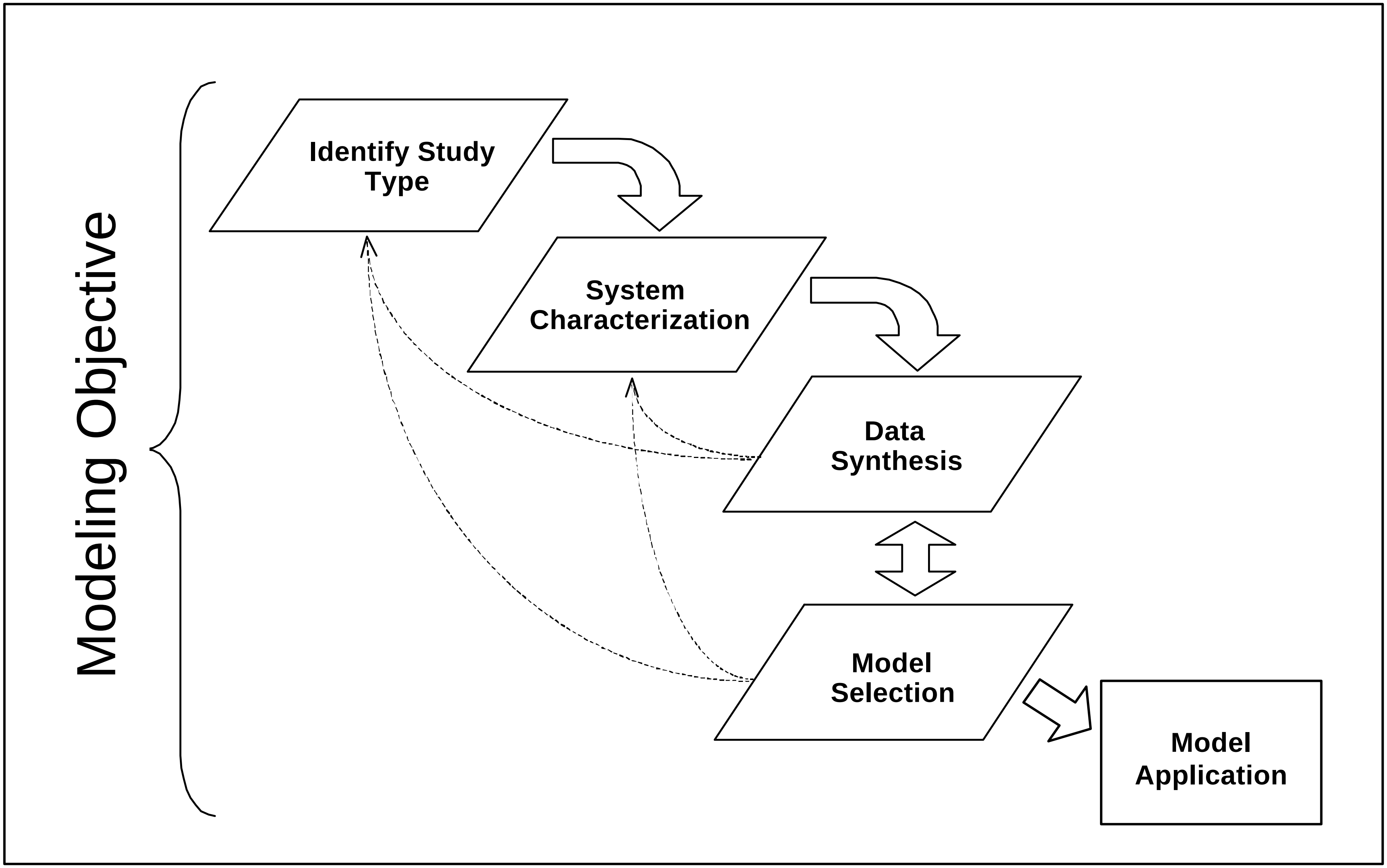

Figure 5. Water temperature study design framework (from Deas and Lowney 2001).