

PREFACE

The CALFED Science Program, *which includes implementation of the Comprehensive Monitoring, Assessment and Research Program (CMARP)* is integral to all aspects of the CALFED Program. The scope of the CALFED Science Program will include all elements of the program –ecosystem restoration, water supply reliability, water use efficiency and conservation, water quality, and levees. The purpose of the CALFED Science Program is to provide new information and scientific interpretations necessary to implement, monitor, and evaluate the success of the CALFED Program.

An overriding principle of the Science Program is adaptive management. There are many complex interrelated problems, which must be addressed with imperfect knowledge. As such, actions are taken based on the best available information; results monitored and research performed in order to refine future actions or investments. This approach is dependent on credible and objective scientific review and evaluation to ensure that decisions are based on the best available, objective information. New information and scientific interpretations will be used to confirm or modify all aspects of the CALFED Science Program, including problem definitions, conceptual models, research, and implementation actions.

Although the scope of the CALFED Science Program will include areas of uncertainty in all CALFED programs, some programs such as the ecosystem program strongly rely on an adaptive management science program. In addition, the information from the CALFED Science Program will be available for use by other related state, federal, local and nongovernmental actions/programs in the CALFED solution area. This includes other ecosystem restoration, water quality, levee and water management activities both regulatory and nonregulatory, including water project operations.

The CALFED Science Program has made significant progress in recent years as the CALFED Ecosystem Restoration Program (ERP) has been developed and implementation begun. Agencies and stakeholders have participated in the development of ERP conceptual models, indicators of success, and the use of independent science review. All these ERP activities are all critical components of a Science Program. CALFED is now expanding these activities to include the establishment and implementation of a Science Program for all areas of the CALFED Program, and for related activities.

This technical appendix was originally completed in March 1999, and subsequently became a draft technical appendix of the Revised Draft Programmatic EIS/EIR in June 1999. The appendix includes preliminary information that has contributed to the development of a CALFED Science Program. This appendix has not been updated, and does not incorporate additional accomplishments relative to the development of a CALFED Science Program to date. This preface summarizes recent efforts and guides the reader to other appropriate sections of documents to provide an updated context for the CMARP Technical Appendix. In many cases, information on components and structure of a CALFED Science Program contained in this preface is preliminary and will continue to be refined as the Program moves to implementation.

In April 2000 the CALFED Management Group appointed a temporary Science Oversight Team

(prior to the arrival of an interim science leader) to accomplish a set of tasks for the CALFED Science Program. The term CALFED Science Program has been used to distinguish these efforts from the previous list of CMARP tasks. The name change recognizes this shift while reaffirming the recommendations of the CMARP appendix. These tasks include:

- Develop science questions associated with Stage I management decisions,
- Develop functions and structure of the CALFED Science Program,
- Draft revisions of the Programmatic EIS/EIR related to the CALFED Science Program,
- Develop initial lists of indicators and performance measures,
- Assess feasibility of a Bay-Delta science center,
- Develop coordination plans for science programs relevant to CALFED, and
- Clarify issues of implementing adaptive management in CALFED

The Science Oversight Team is currently responsible for overseeing the execution of these tasks in conjunction with other CALFED staff in all Program areas, CALFED agency staff, scientific advisors and stakeholders.

The rest of this preface describes science related accomplishments and ongoing tasks, following the same organization as the technical appendix – goals and objectives, conceptual models, monitoring and research, data assessment and reporting, structure and function of the science program, and remaining implementation tasks.

Goals and Objectives

CMARP staff created summary tables linking monitoring elements and indicators recommended by the CMARP Appendix to CALFED program objectives for all CALFED programs. These tables are accessible on the CMARP web page (<http://www.wiep.ca.gov/cmarp>), and the summary table for the ERP has been used to help create a terrestrial and amphibian baseline monitoring plan. The Science Oversight Team has begun an effort to describe specific scientific investigations and tasks needed to support management decisions by the end of Stage I. This information as it is developed and refined will provide the basis for setting priorities for scientific activities.

Conceptual Models

Many of the appendices of the CMARP appendix on monitoring/research topics contain conceptual models that were foundations for monitoring and research recommendations in Chapter 5 of the CMARP appendix. An additional need arose to develop conceptual models relevant to some of the key ecosystem restoration issues. These issues include fluvial geomorphology, riparian habitat and avifauna, tidal wetlands, aquatic contaminants, open water processes, salmonids, delta smelt, splittail, diversion effects on fish and the Environmental Water Account, and delta agricultural diversions. To meet this need, CALFED ERP staff developed an ongoing process to document these issue-oriented conceptual models and their implications for restoration actions in a series of white papers. White paper authors are using the CMARP conceptual models to help develop the issue-oriented conceptual models. This process is described in more detail in the Strategic Plan for Ecosystem Restoration.

In addition, the ERP has begun requiring description and use of conceptual models in all proposed restoration projects (Ecosystem Restoration Projects and Programs, 2001 Proposal Solicitation Package). The models are intended to help project proponents explain the technical basis and assumptions underlying their proposed work, and to formulate testable hypotheses about project consequences.

Monitoring and Research

Activities in this category include work on a) baseline and ERP project monitoring programs, b) drinking water monitoring and research, and c) Stage I research questions.

a) Work is under way to identify the baseline monitoring needs for the ERP. The effort has been divided into two areas: aquatic monitoring (includes fish, aquatic invertebrates, hydrodynamics, fish habitat) and terrestrial and amphibian monitoring (includes birds, mammals, reptiles, amphibians, habitats, and the hydrologic and geomorphic processes that affect them). The purpose of these plans is to provide essential information on status and trends of important organisms and their biological and physical habitats. Preliminary drafts of both of these plans have been assembled and will be available for review during early summer 2000. The terrestrial and amphibian monitoring effort will be conducting workshops with technical experts in summer, 2000 and expects to have a final report drafted by October, 2000. The aquatic monitoring effort expects to have a final report completed at an earlier date.

Protocols are being developed for data collected by ERP projects. These protocols are intended to ensure that project data are adequate to evaluate project performance and are compatible with data from other projects as necessary to evaluate overall program performance relative to baseline monitoring.

b) CMARP and the CALFED Water Quality Program hosted an organic carbon workshop in August 1999 and produced a workshop proceedings (Organic Carbon Drinking Water Quality Workshop Proceedings, CALFED Bay-Delta Program, October 9, 1999). The workshop was organized primarily to explore what is known about organic carbon sources, chemical qualities of the sources, and in-Delta transformations, and to identify monitoring and research needs. Nine speakers gave talks about organic carbon and drinking water issues and then the workshop participants discussed key issues and uncertainties. These proceedings provide more detail on the drinking water recommendations of this appendix.

c) As mentioned above, the Science Oversight Team, in coordination with CALFED staff, CALFED agency staff and stakeholders is developing a list of Stage I management decisions and corresponding science questions that need to be addressed. As they are developed and refined, the science questions will be compared and reconciled with the recommendations in Chapter 5 of the CMARP appendix. Using these results, the CALFED Science Program will recommend focused research priorities for participating agency science programs and research proposal solicitations. This process also is expected to provide a clear rationale for activities that the science program undertakes and a management context in which to report science results.

Data Assessment and Reporting

CALFED is contracting with DWR to add data generated by ERP projects to an existing relational data base and browser system created for the Interagency Ecological Program (IEP), Central Valley Project Improvement Act Comprehensive Assessment Monitoring Program, and the Sacramento River Watershed Program. The project entails adding CALFED monitoring data as it becomes available into the relational data base and providing an already-created "data browser" and mapping interface for querying and displaying the data over the World Wide Web. This system will enable simultaneous queries and retrievals of data from all of these programs while allowing each data provider to retain control of its own data.

CMARP staff has participated in the CALFED GIS Coordination Workgroup which was formed in spring, 1999. CMARP staff summarized CALFED's spatial analysis needs in a 6-page document based upon the CMARP Appendix and CALFED documents. CMARP staff also developed a draft set of recommendations for the development of a GIS data layer for vegetation and other land cover within the CALFED Problem and ERP Focus Study areas to meet CALFED's vegetation spatial analysis needs. Some of these recommendations have been included in the Terrestrial and Amphibian Baseline Monitoring Program Report described above.

CMARP has organized a CALFED Science Conference on October 3-5, 2000 (see web page announcement at <http://iep.water.ca.gov/calfed/sciconf/>). The conference is being designed as a forum for presenting scientific information and ideas relevant to CALFED's goals and objectives in the San Francisco Bay, Delta and watershed pertaining to ecosystem restoration, levee system integrity, and water quality. The conference program will feature a mix of plenary and contributed talks and poster presentations on topical themes relevant to CALFED. Conference organizers will write a management-oriented summary of the conference.

An effort was begun in November 1999 to develop an initial set of ecological indicators and performance measures for the ERP. It is anticipated that preliminary indicators and performance measures for all Program areas will be developed and refined as the Program moves into implementation.

Structure and Function of the Science Program

CALFED is seeking an interim science leader to precede a CALFED Chief Scientist. The interim science leader will be responsible for implementing the CALFED science program as a combination of coordinated agency science programs and a proposal solicitation process. When a more permanent CALFED structure is implemented, the interim science leader will help CALFED with a national search for a CALFED Chief Scientist.

To meet its immediate needs the ERP has established an Interim Science Board (ISB) to provide the ERP with management-oriented scientific advice, review, and guidance. In addition, an Agency-Stakeholder Ecosystem Team (ASET) has been assembled to secure agency and stakeholder technical input. The ISB and ASET will work with CALFED staff and the broader agency/stakeholder community (e.g., the Ecosystem Roundtable) to help ensure that ERP implementation is based on sound science, employs an adaptive management strategy, and

integrates with other relevant state and federal programs. For more details, see the Strategic Plan for Ecosystem Restoration.

The Science Oversight Team in coordination with CALFED staff, CALFED agency staff, scientific advisors and stakeholders has started a process to develop the primary functions of the science program and how the program will be structured to perform its functions. The following describes the initial draft key functions of a CALFED Science Program. Additional information on the functions and structure of the CALFED Science Program can be found in the governance chapter of the Implementation Plan.

Science Planning and Priorities

Develop broad science priorities to guide monitoring, research, and trial implementation actions. The priorities will support the scientific information needed to make management decisions during or at the end of Stage 1. Priorities and planning will be integrated across program elements, and developed with independent scientific review, agency and stakeholder input, and coordination among program managers. Priorities will be submitted to Policy Group or a CALFED commission for approval. Review and, if necessary, refine science based performance measures and indicators for each program on an ongoing basis to ensure the CALFED Program is effectively measuring and reporting on the program success.

Monitoring

Conduct monitoring to provide information to assess progress towards meeting goals and objectives of CALFED. Monitoring will be done at several levels:

- System-wide status and trends (baseline) of the Bay-Delta and watershed -- This monitoring helps identify long-term changes occurring as a result of human and natural factors.
- Regional level -- This monitoring helps identify changes occurring on a regional level as a result of human and natural factors. This monitoring will provide data to assess the achievement of regional objectives and targets.
- Individual projects and actions -- This monitoring helps determine if objectives of the project or action are being accomplished. This includes monitoring for enhancement actions and compliance monitoring as part of mitigation requirements. Monitoring for groups of similar projects /actions will be coordinated to provide information broader information on effectiveness of certain projects/ actions.
- Real-time monitoring for water project operations -- This near real-time monitoring of the presence of fish near the project pumps provides operators with data to adjust operations to protect fish and maintain water supply reliability.

Develop monitoring protocols for all types of monitoring to ensure data consistency for each category of project/action

Data Management.

Develop and maintain a public online coordinated and linked system for the monitoring data and other relevant data. The data in the database will be used for comprehensive analysis and reporting and will be available to agency and nonagency scientists. Data will be subject to quality assurance/quality control protocols. Data will be made available when needed for assessment and reporting requirements.

Assessment.

Perform data analysis and interpretation of the raw data generated in the monitoring programs in order to evaluate the overall performance of the CALFED Program. The data analysis and interpretation will be subject to independent peer review. Provide scientific judgements as necessary in order for decision-makers to make program decisions. The assessment will detect:

- System-wide trends of program indicators
- Regional level trends and responses of indicators
- Project level responses of indicators
- Real-time trends of indicators relevant to water operations

Research

Manage a focused research program that targets key scientific uncertainties related to program decisions. Research priorities will be based on the science priorities described above (Function #1). The purpose of the research program is to determine how consequences of actions happen, while the monitoring program describes what consequences happened. Gaining an understanding of how trends changed or why projects resulted in certain consequences is a critical element of the adaptive management process. Develop and refine conceptual biological and mathematical models that link important causes and effects.

Trial Implementation Actions (pilot and full scale).

Provide advice on the design and execution of trial implementation actions. A trial implementation action is one in which there is some level of uncertainty on the effects of the action, but the level of knowledge and information supports trial implementation. Trial actions are a partnership between science, management and the public. Trial actions will follow scientific principles and processes. Depending on the level of knowledge and information available, trial actions may be designed as pilot actions or full scale actions. Data from the trial actions will be assessed and reported as part of the Science Program and adaptive management process.

Reporting

Disseminate scientific information, including opinions, data, models, and findings, to state and federal agencies, scientific community, general public, stakeholders, and decision-makers. The scientific information will be converted to useful information for policy level interests and decision-makers and disseminated through published reports, scientific articles, briefings and conferences. Findings will be provided for all levels of monitoring (system-wide, project level and real-time) and from focused research. Reports should also be provided to regulatory agencies that summarize scientific knowledge for use in regulatory management decisions. .

Coordination and Integration.

Coordinate science functions and actions performed between the CALFED program elements (ERP, Levees, Water quality, and water management). Coordinate with all other science programs (IEP, CAMP, SFEI) that are based in the Bay-Delta and its' watershed. When appropriate, existing science programs and the CALFED Science Program will be integrated to increase the usefulness of the data generated and reduce duplication. Coordinate with related programs (such as CVPIA actions, regulatory programs, water operations) to assure that related programs use the science information in their management decisions. Related programs should provide input into all functions of the Science Program to assure the use of the information by the related programs.

Independent Science Review

Provide independent science review for the scientific aspects of the CALFED Program and related programs, (including the overall CALFED program and individual programs such as the ERP, Environmental Water Account, and water project operations). Convene independent science panels and boards to advise in the development, implementation, and results of the Science Program. Obtain peer review of published findings. Independent Science Review is needed for evaluating the basic underlying assumptions and process of the CALFED Science Program as well as evaluating the success of the programs and actions Independent Science Review is important to assuring quality and maintaining public confidence in the program

Remaining Tasks

A large number of tasks, many of which were recommended in the CMARP appendix, have been completed or are now under way: articulating goals and objectives, developing conceptual models for ecosystem restoration, developing baseline and project monitoring protocols and indicators, deriving a set of priority science questions for Stage I, developing data management and reporting tools, planning a CALFED science conference, recruiting an interim science leader, initiating the ISB-ASET process for ERP, and developing consensus on the functions and structure of the CALFED Science Program. A number of tasks remain, however, before the CALFED Science Program can be fully implemented. These include:

- Adaptive management -- CALFED has embraced an adaptive management implementation strategy because of significant uncertainties about the consequences of program actions. Active adaptive management is designing and executing trial actions as scientific experiments to learn how the actions affect the resources. Despite its appeal, active adaptive management is infrequently employed because few scientists and managers have practical experience, and because trials often require agency and public acceptance of some short-term risks to the resources or the associated economy. A management-science-stakeholder partnership process is needed for designing adaptive experiments, gaining policy approval and public acceptance, and executing and learning from the experiments.
- Coordination plan for science programs related to CALFED -- Success of the CALFED Science Program depends in part on coordination among existing research and monitoring in the San Francisco Estuary and its watershed. The Science Oversight Team recently convened a meeting of principal investigators from several of the larger monitoring and research programs in the study area to solicit ideas on how to improve coordination and make information more readily available to managers. The attendees agreed that such meetings were useful and that the CALFED science conference and an annual written report to CALFED and other interested parties would help provide a degree of coordination not now present. The Science Oversight Team will follow up on these suggestions.
- Science center feasibility -- There is general consensus among technical staff that the establishment of a Bay-Delta science center has merit and should be developed as a cornerstone of the CALFED science program. A feasibility report on this activity will be completed and presented to the CALFED Management Group for their review and input.

In addition, the June 9, 2000 "California's Water Future: A Framework for Action" identifies the additional tasks relative to the CALFED Science Program to be accomplished in Stage I:

- Appoint an Independent Science Board and an independent science panel for the EWA by the middle of 2001.
- Refine the set of ecological, operational and other predictive models that will be used in the evaluative process by the end of 2001.
- Establish performance measures and indicators for each of the program areas.
- Develop an annual science report, format and content, which includes:
 - Status of the fisheries and effectiveness of efforts to improve conditions, including EWA, ERP and water management strategies, and provide recommendations to maximize fishery benefits while minimizing impacts to water supply.
 - Assessment of progress of program element effectiveness;
 - Effectiveness of performance measures and indicators;
 - Recommended research and/or program adjustments; and
- Prepare first annual report by the end of 2001.

These tasks will be completed as CALFED progresses toward Stage I of implementation.



**CALFED
BAY-DELTA
PROGRAM**

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March 8, 1999

To Interested Parties:

The enclosed report describes the initial efforts to design CALFED Bay-Delta Program's Comprehensive Monitoring, Assessment, and Research Program (CMARP). The purpose of CMARP is to provide those facts and scientific interpretations necessary for the CALFED Program to be fully implemented and for the public to judge the program's success. The report summarizes results of a 9-month process involving 30 teams and about 300 people, and facilitated by a steering committee. The teams and steering committee were composed of people from agencies, academia, and the stakeholder community. The Interagency Ecological Program, the San Francisco Estuary Institute, and U. S. Geological Survey proposed and jointly led the effort for CALFED.

The report describes the efforts undertaken to

- Summarize CALFED goals and objectives,
- Use conceptual models in designing monitoring and research,
- Propose monitoring and focused research questions for all of the CALFED programs,
- Propose data management, assessment, and reporting, and
- Recommend organizational ingredients necessary to implement CMARP.

The report concludes by proposing refinement of the program and early implementation of high-priority program elements. Supporting the report are 50 technical appendices produced by the teams, which can be found on the World Wide Web at <http://www.calfed.ca.gov/programs.html> under the heading CMARP.

The report has been reviewed by the CALFED Bay-Delta Program, CALFED agencies, and the public, and has been modified in response thereto. However, major issues such as prioritization of research needs, recognition of scientific uncertainty, and the role of conceptual models require significant work prior to completion of the CALFED EIS/EIR.

CALFED Agencies

California

The Resources Agency
Department of Fish and Game
Department of Water Resources
California Environmental Protection Agency
State Water Resources Control Board

Federal

Environmental Protection Agency
Department of the Interior
Fish and Wildlife Service
Bureau of Reclamation
U.S. Army Corps of Engineers

Department of Agriculture
Natural Resources Conservation Service
Department of Commerce
National Marine Fisheries Service

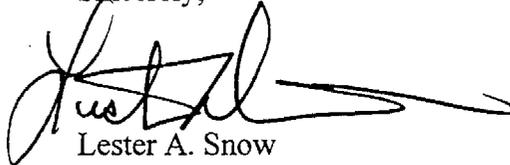
Interested Parties

March 8, 1999

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Contact persons for CMARP include Leo Winternitz (916-227-7548 or lwintern@water.ca.gov), or the co-chairs of the steering committee, Randy Brown (916-227-7531 or rbrown@water.ca.gov), Margaret Johnston (510-231-9532 or johnston@sfei.org), or Larry Smith (916-278-3195 or lhsmith@usgs.gov).

Sincerely,

A handwritten signature in black ink, appearing to read "Lester A. Snow", with a long horizontal flourish extending to the right.

Lester A. Snow
Executive Director

Enclosure

**Developed for CALFED
by
The CMARP Steering Committee**

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March 10, 1999

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RECOMMENDATIONS FOR THE IMPLEMENTATION AND CONTINUED REFINEMENT OF A COMPREHENSIVE MONITORING, ASSESSMENT AND RESEARCH PROGRAM

SUMMARY

On May 1, 1998, the CALFED Policy Group approved a joint *San Francisco Estuary Institute, Interagency Ecological Program, U.S. Geological Survey* proposal to develop a Comprehensive Monitoring, Assessment, and Research Program (CMARP) for CALFED and its member agencies. (See appendix I for the complete CMARP proposal.) CALFED allocated \$1.8 million to complete the project, with a final report due by January 31, 1999. The proposed CMARP addresses eight CALFED program elements and actions to be implemented over the next 30 years. The program elements are Long-term Levee Protection, Water Quality, Ecosystem Restoration, Water Use Efficiency, Water Transfer Framework, Watershed Management Coordination, and Delta Conveyance and Storage.

CMARP STRUCTURE

The three parties responsible for developing CMARP established a 15-person Steering Committee consisting of agency and stakeholder scientists, co-chaired by Interagency Ecological Program, San Francisco Estuary Institute, and U.S. Geological Survey representatives. The Steering Committee appointed a Chief of Staff and a small staff to facilitate the work. Most of the technical work was accomplished by 30 technical teams, which included more than 250 agency and stakeholder representatives.

CMARP

The CALFED program evolved considerably from the time the Policy Group approved the proposal until completion of this report. For

example, a report, "Developing a Draft Preferred Program Alternative," (August 5, 1998) solidified the concept of a 30-year project completed in stages. The first stage would begin in 2000 and last for seven years. The December 1998 revised CALFED Phase II report expanded on the staging concept and narrowed the options for the preferred alternative. The evolving definition of the preferred alternative and actions to be taken in Stage I have resulted in this report being more of a programmatic overview rather than a specific plan. The report recommends some interim implementation actions and proposes a process to develop a specific monitoring and research program for CALFED's Stage I.

CMARP TASKS

The proposal to develop CMARP was based on completion of five tasks. The activities under each task are discussed and include, where appropriate, references to likely interim implementation and Stage 1 actions.

Task 1. Refine the Goals, Objectives and Needs of CALFED Programs and Major Agency Goals and Objectives. The overall mission of CALFED is to develop a long-term comprehensive plan to restore ecological health and improve water management for beneficial uses of the San Francisco Bay-Delta system. The CMARP team compiled goals and objectives from numerous CALFED documents to define specific program objectives that could be used to help determine the program's information needs. Some of the documents studied for this review are from the CALFED Common Programs. Others include:

- CALFED Revised Phase II Report
- Species and Habitat Conservation Strategy
- Storage and Conveyance Refinement Process Overview
- Strategic Plan for the Ecosystem Restoration Program
- Water Transfer Program Technical Appendix

Individual program goals and objectives (Chapter 2 and Appendix IV) were provided to the workteams for their consideration in developing proposals for monitoring and research strategies within each program.

Task 2. Develop a Conceptual Framework for the CMARP Program.

Conceptual modeling is the first step in the adaptive management process. Adaptive management is an integral component of all CALFED actions. If adaptive management is “learning by doing” (Walters, 1997), conceptual modeling is an explicit summary of what we know before we begin. Conceptual modeling is an essential tool to help managers and scientists select projects and actions having the greatest potential of achieving the desired goals and objectives.

The CMARP Steering Committee sponsored a two-day conceptual modeling workshop (see Appendix V for the final report) and encouraged CMARP workteams to include conceptual models in their reports describing monitoring and research needs. At the workshop, representatives from Puget Sound, South Florida, and Chesapeake Bay monitoring programs described their experiences with conceptual models in monitoring/research program design.

Several conceptual models are described in Chapter 4 and in many of the technical appendices. From their variety and complexity, it is clear that conceptual models take many forms and that some models have better scientific support than others.

However, the process of conceptual model development has helped participants to

- articulate their understanding of key ecosystem relationships and presumed stressors, and
- identify major issues that need to be addressed and questions that need to be answered.

The articulation of explicit conceptual modeling into a multitude of existing monitoring/research programs is a significant interim accomplishment of the CMARP development process.

Task 3. Design a Monitoring Program

Monitoring is conducted for many purposes and the terminology used to describe each purpose varies considerably among agencies and programs. For this report, we use terms suggested by the National Research Council (NRC) (1990), with definitions slightly modified for the CALFED program.

- Compliance monitoring provides information needed to determine if activities are meeting permit or other regulatory requirements.
- Model verification monitoring provides information to evaluate management alternatives, e.g., for adaptive management.
- Trend monitoring helps identify long-term changes occurring as a result of human and natural factors.

Although not mentioned by the NRC, a fourth monitoring category, Operations Monitoring is used in the San Francisco Bay-Delta. This provides near real-time data to biologists and water project operators for use in adjusting project operations to help protect fish and maintain water supply reliability.

The NRC emphasized that monitoring is an integral component of environmental management and can include modeling, time series measurements, indicators research, and collection, analysis,

information. For CALFED, the synthesized information will be used to prepare a "report card" to Congress, legislators, public, stakeholders, etc. on progress towards achieving CALFED goals.

The following are elements within the monitoring program development task.

Inventory Existing Monitoring Programs.

The inventory of existing monitoring has been particularly important in identifying the scope and content of ongoing programs and exposing the gaps in coverage and content remaining because of differing objectives among individual programs. The inventory (Chapter 2 and Appendix VI) identified 622 monitoring and research programs with a total budget approaching \$30 million annually. (The inventory can be used interactively at <http://www.sfei.org/cmarpinv/>). Almost \$28 million is currently budgeted for the following seven existing large programs:

- Interagency Ecological Program
- CVPIA Comprehensive Assessment and Monitoring Program
- DWR Municipal Water-Quality Investigations
- SFEI Regional Monitoring Program for Trace Substances and SFEI Wetlands, Watersheds, and Invasive Species Programs
- Sacramento River Watershed Program
- USGS National Water Quality Assessment Program
- USGS Bay/Delta Ecosystem Project

Monitoring under CMARP will incorporate data collected by many of these existing activities and will, as necessary, augment these programs to ensure complete coverage in time and space and add critical variables.

Develop Specific Monitoring Elements. The CMARP Steering Committee charged the workteams to:

- review their (and other related) monitoring needs and research,
- develop conceptual models,

- recommend monitoring and research needed to respond to CALFED actions, increase understanding and provide for long-term trend monitoring, and
- list indicators that could be used by CALFED and others to evaluate the success of their actions.

The results of these work team efforts are summarized in Chapter 4 and are in the technical appendices of this report.

Most teams identified specific variables to be included in trend monitoring and some general research questions. CMARP is unable to recommend more specific monitoring until the CALFED preferred alternative and Stage 1 actions are better defined. The monitoring and research items have not been ranked by priority, and any cost estimates are very rough. During CMARP interim implementation (essentially calendar year 1999 and early 2000, see below).

The CMARP Steering Committee and staff will work with CALFED program managers, stakeholders, and agency staff to set priorities and refine cost estimates for the high priority projects. Priorities will depend in part on the preferred alternative and accompanying actions.

The CMARP Steering Committee will work with the ERP Strategic Plan Core Team to develop a suite of indicators to allow CALFED to assess progress toward meeting its goals and objectives. These efforts will build on the work of the CALFED-ERP Indicators Group and the Environmental Defense Fund.

Develop a Process for Data Management.

CMARP is proposing a relational database-management system that will allow individual data collectors and data providers to manage their own data locally, while providing a centralized means of uploading the data into a larger database. These data

will be fully protected by the data management structure; only the data provider will be permitted to change their data. Collected and uploaded data will be subject to a strict quality assurance/ quality control protocol. Data in the centralized database can be used for comprehensive analysis and reporting by agency and stakeholder scientists.

Develop a Process for Data Assessment and Reporting. Raw data are of little use in making management and policy decisions. A common problem of many monitoring and research programs is the failure to sufficiently analyze collected data and to make the information available to other scientists, managers, stakeholders, and the general public in a timely manner. Often, this failure results from program budgets that do not allocate sufficient staff time for data analysis and interpretation. The CMARP data assessment and analysis element identifies the means of interpreting and reporting collected information to decision-makers. External peer review will ensure that field and laboratory techniques are appropriate and that interpretations are scientifically defensible. The final CMARP budget will provide adequate staffing to ensure timely data analysis, interpretation, peer review, and reporting.

Task 4. Develop a CALFED Focused Research Program. Monitoring data can describe what happened; research is often needed to help explain why and how it happened. Focused research (also called problem-solving research or targeted research) simply means that the research will be done in areas specifically of interest to CALFED and will be essential in making adaptive management decisions. In a sense, adaptive management is focused research in that selected management actions are framed as hypotheses and data are collected and analyzed to test those hypotheses for other purposes.

The CMARP focused research program will be developed to facilitate the CALFED adaptive-management process and provide answers to critical research questions identified by CMARP teams, CALFED, and stakeholders. CMARP research will be funded through three distinct processes.

- Directed research—A specific entity, such as a university researcher, will be asked to submit a proposal for a well-defined project. The proposal will be peer reviewed and, if found acceptable, will be funded.
- Request for Proposal—A general solicitation will be made for proposals in one or more areas of interest to CALFED. Only those proposals that meet the scrutiny of anonymous peer review will be funded.
- Agency research—Agency scientists will continue to be involved in independent research. Much of this research will be conducted for purposes other than CALFED. Many of their results will be of interest to CALFED.

Appendix VII.J of this report includes a proposed proposal-solicitation process and an example solicitation package. This package and the research questions identified by the workteams have been forwarded to CALFED staff for possible use by the CALFED Integration Panel in identifying key research questions and developing a possible interim request-for-proposal package.

Task 5. Recommend an Institutional Structure for CMARP. Because of the uncertainty of CALFED's institutional structure, CMARP provides recommendations on interim and long-term structure/organization.

Interim (calendar year 1999 and early 2000) Organization and Management of CMARP. A CMARP Steering Committee will continue to manage the program until the Record of Decision and a final decision on CALFED

structure are available. The Steering Committee will report to the CALFED Management and Policy groups, through the CALFED Executive Director, and will designate a scientist, with appropriate staff support, to direct the program during this interim period. The Program Director and Steering Committee members will coordinate CMARP activities with CALFED program managers and deputy directors. Interim operation of CMARP, i.e., prior to full implementation of monitoring data collection activities, will cost about \$400,000 annually. The CMARP Steering Committee recommends that CALFED funding be allocated for some interim implementation projects in 1999. The proposals and funding requirements will be developed in early 1999.

Examples of some possible interim implementation actions under CMARP (Chapter 7) include:

- Develop a better understanding of three Delta water-quality constituents - bromides, dissolved solids, and dissolved organic carbon.
- Evaluate "flexible operations" as being discussed by the CALFED Diversion Effects on Fish Team. Flexible operations will probably involve an expanded version of IEP's real-time monitoring program, perhaps with statistically valid estimates of the numbers of fish salvaged at the Central Valley Project and State Water Project intakes.
- Determine feasibility of using new technology to map topography and bathymetry of the delta, set up a continuing process to update locations and elevations of new high-accuracy benchmarks, and extend the elevations of these benchmarks to delta streamflow gages.
- Use existing IEP Delta Fish Facilities Technical Team to develop and implement monitoring and research programs to provide CALFED management with information needed to

determine how to evaluate proposed Stage 1 fish screens.

- Take an active role in documenting introductions of non-indigenous species and determine the effects and control of these introductions. These efforts will be closely coordinated with CALFED's non-native invasive-species team, which will have an implementation plan in early 1999.
- Design a constant fractional marking program at Central Valley chinook salmon hatcheries to help evaluate hatchery contribution to spawning escapement and ocean and inland recreational fisheries. These data are essential to understanding the effect of restoration actions on chinook salmon.

Long-term structure. In the long-term, CMARP must

- have a structure to ensure that the program remains responsive, credible, and accountable
- design and direct the scientific program
- collect, manage, and distribute data
- analyze and interpret data
- report findings
- provide for extensive scientific review
- collaborate with CALFED managers on adaptive management, and
- find a way to effectively use data from existing programs that are not under the direct control of CMARP.

To accomplish this, CMARP should be directed by a Chief Scientist and an Executive Officer supported by appropriate technical staff, with all activities subject to structured scientific review. CMARP must be a partnership among agencies, stakeholders, universities, and non-profit and private contractors. The actual field and laboratory technicians, scientists, and computer specialists doing the work cannot be identified until the CALFED and CMARP structures are better defined. During the upcoming year, CMARP will develop a process to recruit a chief scientist, and will collaborate with others to develop a

permanent organizational structure to implement CMARP.

FUNDING REQUIREMENTS

Given CMARP's present programmatic level of detail, it is not possible to provide a useful estimate of the amount of funding required. Existing monitoring and research programs contribute about \$33 million per year; much of the data collected from these existing programs is already useful to CALFED. Some program restructuring may allow these existing programs to better meet CALFED needs.