DRAFT 4/28/06

Framework for indicators for science, management and adaptive management in the CALFED Bay-Delta Program
(See Glossary for more detailed definition of terminology used in this document)

Indicators and performance measures are used to translate program goals and objectives into measurable benchmarks of program success. Indicators can also be used to help understand how actions cause results in the environment. This framework provides general background information for how indicators can be used to inform science, management and adaptive management. The framework also includes information so that indicator development and assessment will be more useful for decisions to be made at the end of Stage 1, and for formal program assessments such as the federal Program Assessment Rating Tool (PART) process.

Purpose:
Indicators will be used by the CALFED Bay Delta Program to:

- Help understand cause and effect relationships between actions and outcomes
- Track progress towards program goals
- Inform decisions to be made at the end of Stage 1 (end of 2007)
- Assess the program progress and performance, such as the federal PART process

Indicators will be used to help answer questions such as:

- Is CALFED meeting program goals?
- Is the system working the way that was expected? (e.g. are the outcomes of actions what were expected?)
- Is CALFED taking the right actions – and the highest priority actions?
- Are their other factors influencing the system that can't be controlled, or hadn't been considered?

To effectively manage the system and help understand cause and effect relationships, indicators should be closely linked to conceptual models that describe and document our current scientific knowledge of how drivers and outcomes are related. A more comprehensive set of indicators at different scales is needed for this purpose. Given the limited resources and the complexity of the issues, a lot of thought will need to go into the selection of these indicators to better understand the underlying mechanisms at work in the region, and to provide support for diagnostic capabilities. This more comprehensive and detailed set of indicators (often at different scales) are intended for a technical audience and will assist in making management decisions and doing adaptive management.

A subset of indicators can be used to assess progress and answer questions directly related to the goals and objectives of the program. This smaller set of indicators should be derived from the more technically detailed indicators and include discussion of the factors that are most likely affecting the outcome of the system. For example, adult salmon escapement may be used as an indicator to report progress towards recovering

salmon populations. To understand the "why" behind this outcome, a much broader suite of indicators is needed, such as proportion of hatchery escapement, age structure of spawning adults, conditions during spawning, rearing and migration, ocean conditions, abundance of juveniles, ocean and inland harvest.

Projects that are in the planning phase can develop predicted outcome indicators that describe how a project might contribute to program goals. Predicted outcome measures are the result of modeling efforts and can be used by decision makers to evaluate different management options to achieve goals. If a project is chosen for implementation, the monitored outcomes can be compared to previously predicted outcomes.

The terms "performance measures" and "indicators" have often been used interchangeably – but this can be misleading. Indicators are a larger group of measurements that help us understand how the system is working. Performance measures are a subset of indicators that can be used to measure the performance of a particular project, program or agency. One difficulty in choosing performance measures is that an outcome of particular interest (for example, returning salmon populations) may be affected by many different factors: some that may be influenced by management actions, and some that may not.

Evaluating outcomes using indicators and performance measures should be part of a periodic program assessment. The federal government uses the Program Assessment Rating Tool (PART) as a process for evaluating program effectiveness. This framework is compatible with the PART approach, but has a broader focus. This framework emphasizes the need for documenting the scientific basis for making decisions, and using indicators to reduce uncertainty and improve our scientific understanding through adaptive management. A program assessment should also evaluate the broader process of adaptive management. Adaptive management includes incorporating the latest science into management decisions, evaluating the effectiveness of management actions, and adjusting planning and policy based on new information.

Basic framework: levels of indicators and how they can be used:

Below is a description of some general levels of indicators, and a conceptual model of how indicators relate to management, science and adaptive management. This basic framework or approach can be used by the program elements in the development of appropriate indicators.

Levels of indicators:

The basic framework includes three general levels of indicators:

1: **Administrative indicators**. These describe what resources (funds, programs, projects) are being implemented (or plan to be implemented). These may also be called "input measures" or "input indicators".
Example: Dollars spent, number of projects implemented

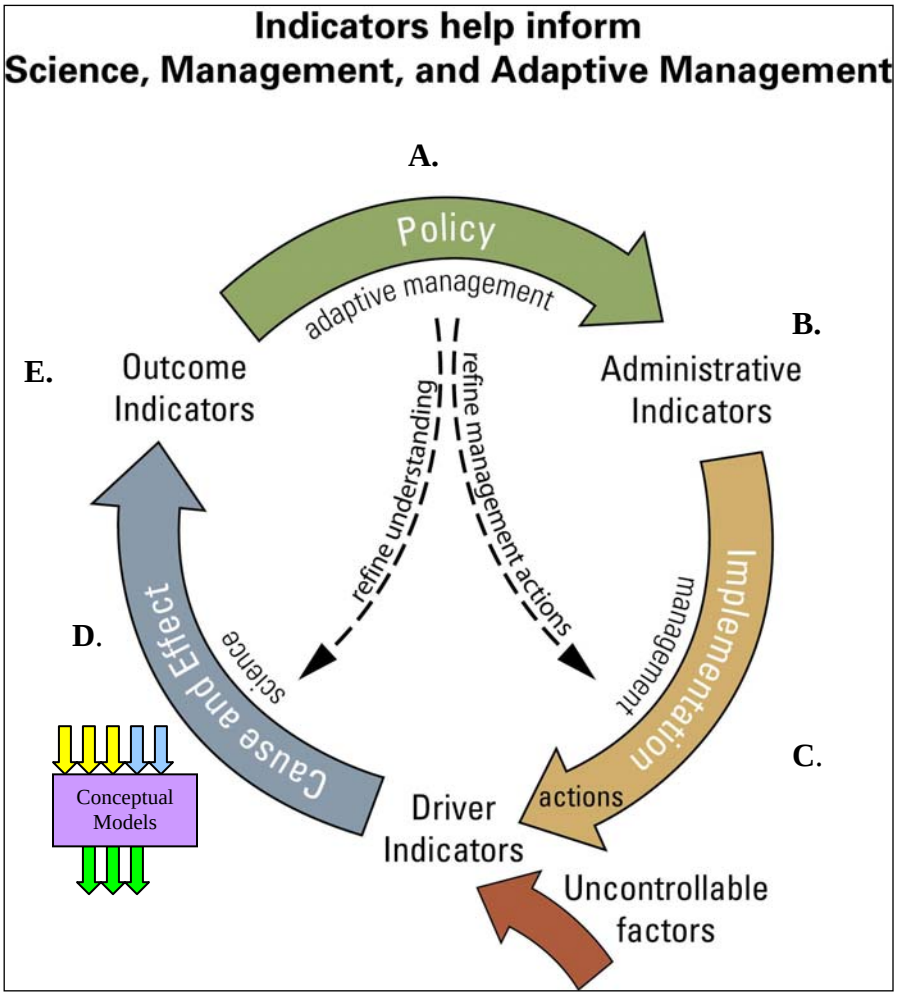
2: **Driver indicators** (can also be called "pressures," "management actions" and "other factors"). These indicators describe the factors that may be influencing outcomes. There are two types of driver indicators: 1. **Outputs** which are on-the-ground implementation of management actions, such as acres of habitat restored and 2. **Uncontrollable factors** which are often natural phenomena not caused by the management actions of the program such as weather and hydrologic fluctuations.

3. **Outcome indicators** (can also be called "response," "ecosystem status or state" or "results" indicators). This class of indicators describe measurements related to the ultimate outcome of the drivers – and should be closely related to the goals and objectives of the program. Examples: For water quality, indicators may include measures of public health protection for tap water and cost of treatment. For water supply reliability, indicators may be related to the ability of supply to meet demand. For ecosystem restoration, indicators can be population level of key species, diversity indices, or other indicators of ecosystem status and processes. Quantitative models may provide predicted outcome indicators that can be used to evaluate future management options.

These categories are flexible so that the framework can be more easily adapted to the different program elements within CALFED. The distinctions between the categories are not rigid. In some cases, an outcome indicator for one purpose may become a driver indicator for another purpose.

The PART process also recommends the development of efficiency measures. Efficiency measures reflect how well the program implements activities and achieves results while avoiding wasted resources, effort, time and/or money. An efficiency measure is the ratio of the outcome or output to the input of any program. For example, an outcome efficiency measure could be cost per acre of wetland habitat restored or cost per acre-foot of water conserved through implementation of water use efficiency measures. Other potential efficiency measures could be length of time to get contracts signed or number of projects successfully completed on time and on budget.

How indicators can be used to link science, management and adaptive management
Indicators can be an integral part of informing policy decision making, tracking implementation, and helping to improve our understanding of how the system works. Indicators can also be used during the project planning and evaluation phase to predict expected outcomes of different management actions. The predicted outcomes can then be used as performance goals (targets) if the project is implemented.



The diagram above describes the relationship between the three different levels of indicators and the activities of managing a complex system in the environment.

A. Policy decisions are made based on a desired outcome, as described in the goals and objectives of the program.

B. Administrative indicators (often called "inputs") can be used to track the financial resources allocated to address the problem, documenting how funds are spent. Management oversees implementation of the policy decisions – essentially turning financial resources into on the ground actions.

C. These actions may result in physical changes to the environment, such as levee maintenance or habitat restoration. **Driver indicators** are used to track these physical changes due to management actions (often called "outputs"). However, there may also be other uncontrollable factors in the environment that also affect an outcome of interest. Driver indicators can also track the uncontrollable factors so that we can better understand how these multiple drivers interact and affect an outcome of interest. For example, enhancing urban water use efficiency is a management action related to reducing demands on water supplies. The amount and form of precipitation

in California is an uncontrollable factor that also affects an outcome of water supply reliability. Both precipitation and water use efficiency may be used as driver indicators for the outcome of water supply reliability.

D. Science can help explain and document the relationships between drivers and outcomes, which are often quite complicated. Most management actions are taken with the intention of a specific outcome in the environment.

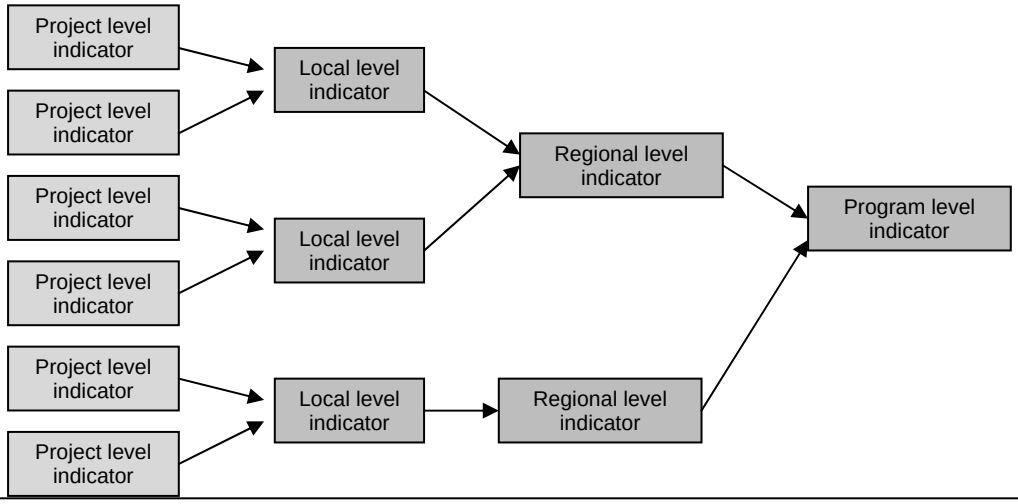
Conceptual models and quantitative models can be used to develop, refine and document a common understanding of the system, including assumptions about intended outcomes from actions. Conceptual models can provide a basis for incorporating new information and continually improving our knowledge of the system. Scientific research and monitoring of indicators play a critical role in understanding cause and effect relationships.

E. Outcome indicators need to be closely related to the goals and objectives of the program to help inform progress toward goals. Outcome indicators can also be used to evaluate the effectiveness of management actions and help refine our understanding of how the system works, or in other words – can be used to inform adaptive management.

Indicators at different scales

These classes of indicators can be used at many different scales; project-specific, local, regional or system-wide. In developing indicators, it is important to consider how indicators at smaller scales can be combined or aggregated to inform larger scale decision making. This will be a challenge for all of the program elements to consider. Figure 2 is a basic diagram depicting indicators at different scales and how they relate to one another. For example, indicators for salmon in a particular reach of a river may be combined and summarized to inform understanding about the entire river. Data on indicators from several rivers (Feather, Yuba, American) may be combined to describe salmon populations for all of the Sacramento River Region. Data on indicators from both the Sacramento and San Joaquin may be combined to describe the status of salmon populations for the entire Central Valley.

Figure 2: Indicators and conceptual models need to be appropriate for the scale being studied – and be able to "roll up" to inform larger scales.



Policy decision makers decide on desired outcomes and on the resources allocated to achieve them

Policy decision makers look at the current state of the system or environments and develop goals and objectives related to a desired outcome. For the CALFED Bay Delta Program, the mission is to develop a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses of the Bay-Delta system. The desired outcome is described in the four program objectives:

- Provide good water for all beneficial uses
- Improve and increase aquatic and terrestrial habitats and improve ecological functions in the Bay-Delta to support sustainable populations of diverse and valuable plant and animal species.
- Reduce the mismatch between Bay-Delta water supplies and current and projected beneficial uses dependent on the Bay-Delta system.
- Reduce the risk to land use and associated economic activities, water supply, infrastructure and the ecosystem from catastrophic breaching of Delta levees.

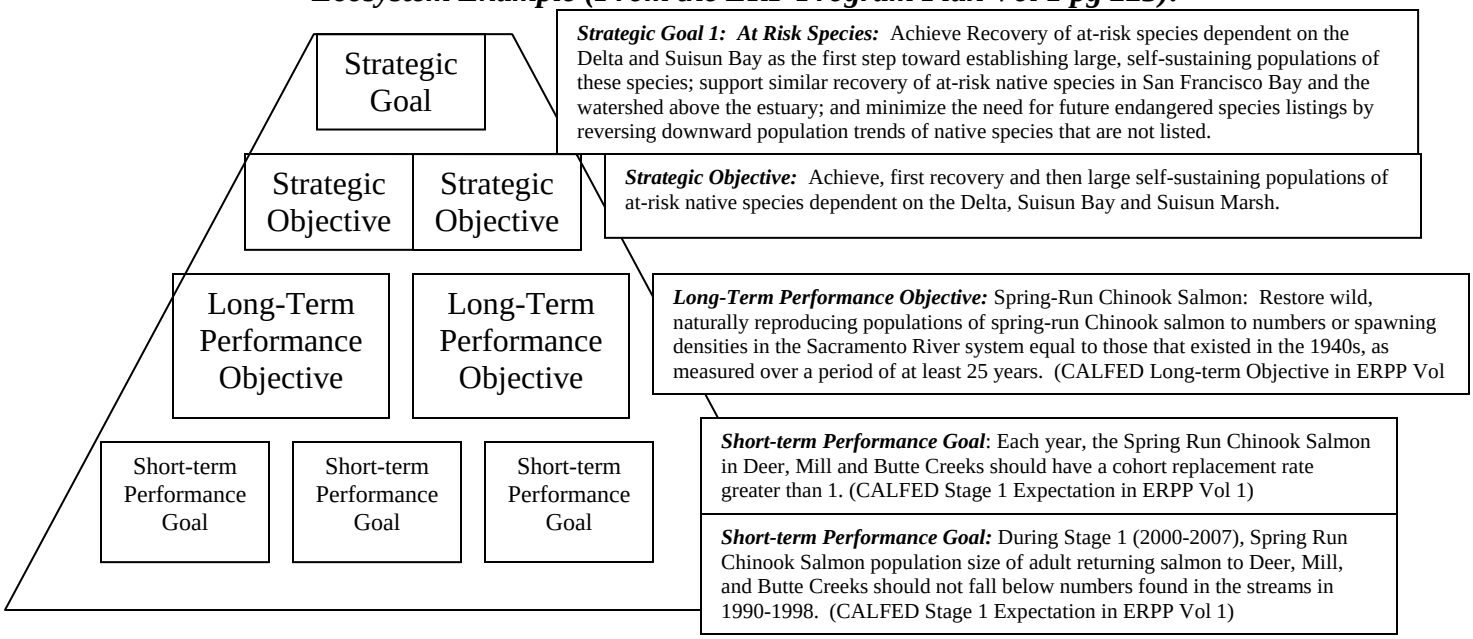
Policy makers decide on the resources to be directed toward achieving the desired outcome. These resources may include bond funds, general funds, programs and personnel. Policy makers also decide on a course of action to achieve the desired outcome.

Outcome indicators are used to inform policy makers on the current state and trends of aspects of the system related to the goals and objectives. Administrative indicators are used to track the allocation of resources and how they are spent to address the problem.

Using Strategic Goals and Performance Goals to help set direction

To translate broad goals and objectives into measurable indicators and targets, a hierarchy of strategic goals and objectives can help organize the elements and relate them to long-term and short-term performance goals and objectives. A broad strategic goal or strategic objective describes the general outcome that the program is interested in attaining. Strategic objectives may be used to break down the strategic goal into more specific parts. Once strategic goals and objectives are defined – one or more long-term performance objectives may be defined for each strategic objective. The performance objective should describe a specific measurable outcome that supports the strategic goal or objective and describe (qualitatively or quantitatively) what long-term success would look like for that performance objective. Then, if applicable, the long-term performance objective can be divided into smaller steps and shorter-term performance goals can be developed. Performance goals include a quantitative target and time frame for a specific metric and should reflect the progress needed to attain the long-term performance objective.

Ecosystem Example (From the ERP Program Plan Vol 1 pg 223):



Managers use resources to implement actions

Managers use administrative resources (funds, staff, etc.) to implement management actions, carrying out the course of action decided by policy makers. Hence management is the linkage between administrative indicators (such as dollars) and driver indicators (implemented management actions). Implementation activities might include:

- more detailed allocation of funds
- selecting program priorities and developing solicitations for proposals
- selecting projects and contract administration
- project implementation and performance

When making decisions, policy makers and managers base their decisions on either implied or explicit conceptual models of how the system behaves and what expected outcome the management actions will have. Explicit conceptual models can be beneficial for management decision-making because they can:

- document the rationale for making a specific decision related to the expected outcome
- allow for multi-disciplinary review and discussion among experts which facilitates better understanding, and reduces the chances of faulty reasoning or unintended consequences
- provide a basis for incorporating new information and improving our understanding of how the system works

It is also important to realize that there is a time lag in order to carry out implementation. A typical time frame for implementation, from fund allocation to project completion, is probably 5 to 6 years. It may be much longer for multi-phase projects, such as a restoration project that includes acquisition, planning, environmental review, and construction. Following construction, it may take many more years before the ecosystem

responds with a measurable outcome. For example it may take from years to decades before salmon spawning habitat has a measurable effect on returning adult salmon populations.

Science describes cause and effect

The relationship between management actions (measured by driver indicators) and the outcome of the actions is based on assumptions or understanding about the cause and effect relationship between drivers and outcomes. The cause and effect relationship between drivers and outcomes is informed by science. (The term "cause and effect" is used very broadly here and does not infer that there is a specific documented causal relationship, in a scientific sense.) In choosing to take an action, there is an expectation or assumption of an expected outcome. These choices are based on a current understanding of how the system works or might respond to some controlling factor.

Conceptual models document a common understanding of the system

Conceptual models are a graphic and/or narrative description of how we believe the system works and how the outcome or response might be affected by the controlling factors (drivers). These conceptual models may also be quantitative or predictive models. Research and monitoring activities are essential to develop and refine conceptual models. To optimize the linkage between drivers and outcomes, the conceptual model should be:

- as explicit and complete as possible, or as needed for the situation
- based upon the best available science
- consider all of the controlling factors, including potential management actions and other environmental or uncontrollable factors that may influence the outcome
- be a basis for discussion of expected outcomes from different management scenarios, including acknowledgement of uncertainty (lack of understanding) and predictability (uncontrollable and unpredictable factors such as weather)

Some typical frameworks for conceptual models that describe environmental outcomes include the Driver-Linkage-Outcome model, or the Pressure-State-Response model. Either type of conceptual model may be appropriate for linking drivers and outcomes, as may other frameworks.

The Driver-Linkage-Outcome (DLO) framework for conceptual models includes an analysis of all of the drivers, their interrelationship and how they are likely to affect the outcome. For example, a conceptual model related to salmon life cycle, may include drivers such as: spawning habitat, flow conditions, rearing conditions, lotic food web, ocean conditions, predation, pumps, diversions, impediments to passage and effects of contaminants. Outcomes may include: number of adults returning to spawn, number of redds, etc. DLO conceptual models should discuss the relative magnitude of the linkages (i.e. influence on the outcome) as well as uncertainty and unpredictability.

The Pressure-State-Response (PSR) framework for conceptual models is similar but is a simplified and more linear version that focuses on one driver (pressure) and its relationship to an outcome (state). The PSR model could be considered a simplification or focusing of the DLO model, which may be appropriate in some situations. For

example, discharges of a specific constituent causing toxicity in an organism of interest has a simple and linear relationship – it may not be necessary to examine it in the context of a broader conceptual model. DLO conceptual models are necessary to understand outcomes affected by many factors (such as adult salmon returning to spawn), or can provide a broader context for a number of PSR sub-models.

Indicators can be used for planning and evaluating different options

Indicators can be developed during the planning phase of projects and can be used to evaluate different options to achieve program goals and objectives. Quantitative models may be developed from the conceptual models and be used to analyze different options and scenarios and predict their potential effect on outcome indicators related to program goals. Then, if the project is implemented, the predicted outcomes can become performance goals. When comparing similar projects and their predicted outcomes, it is important that a consistent approach be used in describing the future variability of the drivers (factors influencing outcomes) and the modeling assumptions – a set of common assumptions. If outcome indicators are developed in the planning process, it is also important to collect pre-project baseline data that can be used later to evaluate improvements. The same basic framework can be used for projects in the planning and evaluation phase, but communication must clearly differentiate between predicted outcomes, baseline outcome indicators, and outcome indicators affected by implemented actions.

Monitoring and Adaptive management

Indicators can be useful tools for facilitating adaptive management by helping to answer questions such as:

- Are we meeting program goals?
- Is the system working as we expected?
- Are we implementing the right (and highest priority) management actions?

It is critical to monitor and evaluate the response of the system to management actions, as well as other controlling factors that may be affecting the outcome. This evaluation can help identify the need for refinement of the conceptual model, or underlying assumptions in taking management actions, as well as a changing system where new and uncontrollable factors may suddenly emerge and affect the desired outcome. If the outcome of management actions (or inaction) is different than expected, then the assumptions (i.e. underlying conceptual model) that the decision was based upon must be re-evaluated and future management decisions refined. These actions may result in additional resources for research and monitoring to refine the conceptual model. One consideration in this process is the time lag between a management decision, its implementation and the anticipated response of the system. This would give weight to the argument that a fairly comprehensive set of indicators would need to be monitored and quickly analyzed to allow a timely management response to changes in the system. A coordinated long-term monitoring program will be needed to provide information for adaptive management and assessing program progress.

Using indicators for program assessment:

Indicators are useful and necessary tools for doing program assessment and can be used as performance measures. Not all indicators should be considered performance measures for the program, since many may be measuring factors that are beyond the program's control, but are nonetheless affecting its outcome and progress. Program assessment should also evaluate whether the program is being effective in implementing actions, and if there are processes being used to evaluate outcomes and do adaptive management (revise conceptual models, revise management actions). Program assessment should consider whether decisions are being made on the basis of explicit conceptual models – and whether those models utilize the latest scientific understanding. In summary, a program assessment should include:

- Evaluation of performance measures – indicators at all levels and scales that are relevant to program goals and reflect program activities. There may be some value in identifying quantitative targets or goals associated with specific performance measures.
- Evaluation of whether management actions taken are based on explicit conceptual models of expected outcomes, based on the most current technical knowledge or scientific information. (Are we doing the right things?)
- Evaluation of effectiveness of implementation of management actions (Are we doing things right?)
- Are adaptive management processes working to refine conceptual models and management actions in a timely manner?

The federal government has a specific process for program assessment, known as the Program Assessment Rating Tool (PART). The PART approach is a budget-based performance evaluation with little emphasis on scientific understanding or uncontrollable factors that may affect environmental outcomes. The PART process evaluates four areas: Program Purpose and Design, Strategic Planning, Program Management, and Program Results and Accountability. The CALFED Science program framework for indicators and performance measures has a more science-based focus but is compatible with the approach of the PART process. For additional information on PART, see www.omb.gov.