DRAFT
Preface: San Joaquin Watershed Indicators

This Report was funded through a grant from the U.S. Environmental Protection Agency (U.S. EPA) to the San Francisco Estuary Institute (SFEI) to develop indicators of water quality condition and management in the San Joaquin River watershed. The Institute has substantial experience in monitoring and indicators and is probably best known for work in the San Francisco Bay area. There, SFEI directs the contaminant *Regional Monitoring Program* and each year issues *The Pulse of the Estuary,* an assessment directed toward managers and the public.[1] SFEI's partner in the San Joaquin project, The Bay Institute, contributed experience in developing indicators and combining sets of indicators into environmental indices such as the *Ecological Scorecard: San Francisco Bay.*[2]

The purpose in this San Joaquin project went beyond indicators or indices of environmental (in this case, water quality) conditions and trends: The U.S. EPA is interested in testing a method for measuring conditions, linking potential causes to observed conditions considered undesirable, and tracking results of management practices designed to improve water quality. Indicators of this kind could be used to report on project results and relate the government's program expenditures to basic objectives such as clean water. The ideal indicator framework would be useful for targeting problems at the watershed or sub-watershed scale and also transferable across watersheds, allowing comparison and aggregation of information.

The project tested a "pressure-state-response" (PSR) methodology, which is explained in detail in Section 2. Basically, the PSR model relates various causal factors (Pressure) to resultant water quality conditions (State); in turn, corrective management (Response) acts to change impaired conditions. This differs somewhat from conceptual models which employ a 'driver-linkage-outcome' approach, such as the models developed for the Sacramento-San Joaquin Bay-Delta in the "Delta Regional Ecosystem Restoration Implementation Plan," or DRERIP. The 'driver-linkage-outcome' conceptual models devote substantial, explicit attention to the *linkage mechanisms or processes* through which causal 'drivers' operate, whereas in the PSR model cause-effect relationships are assumed, based on prior supporting information which is not formally articulated within the model. As a test of the PSR analytic framework using example indicators, this Report offers lessons in indicator design and application; however, it is important to keep in mind that the test cases do not constitute a complete profile of San Joaquin water quality conditions.

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[1] See: http://www.sfei.org/rmp/.
[2] See, The Bay Institute, "Ecological Scorecard: San Francisco Bay Index 2005." At http://www.bay.org/news.htm. The potential for developing San Joaquin indices is discussed in this Report, at the conclusion of the Grasslands watershed case study.
Other examples of indices come from:
-- California EPA. Office of Environmental Health and Hazard Assessment, "Environmental Protection Indicators for California," 2004 and addendum 2005. See http://oehha.ca.gov/multimedia/epic/index.html.
-- The Great Valley Center, "Assessing the Region via Indicators The Environment 2000-2005," November 2005; "Assessing the Region via Indicators: Community Well-Being," (Second Edition). See: http://www.greatvalley.org/.

The test area, the San Joaquin River Basin, has the advantage of extensive monitoring and management data for certain water quality parameters, which accounts in part for selection of salinity (basin-wide) and selenium (the Grasslands sub-watershed) as test cases. On the other hand, the Basin generally is notable for its sheer size (it is the second largest basin in California) and complexity. Highly modified and managed, the San Joaquin defies standard conceptual models of a hydrologic system. It was quickly evident that there would be no substitute for local knowledge and experience in identifying appropriate PSR parameters and their interrelationships.

To help define and interpret key PSR parameters for the San Joaquin, SFEI and The Bay Institute convened a "Steering Committee" comprising individuals selected for their familiarity with particular aspects of the San Joaquin watershed and water management practices there. *Appendix A* reports the meetings of this Committee. Guided by the Committee's advice, it was decided early on to focus on two water quality parameters (selenium and salinity) represented at different geographic scales (sub-watershed and basin level, respectively). Both case studies have proved instructive with respect to questions such as: can information about large-scale management (R) be linked to either reduction of pressure variables (P) or improvement in water quality condition variables (S), and at what scales; whether existing monitoring is directed to what we need to know (i.e., responds to management questions); what data gaps need to be filled to develop a line of evidence for identifying human-caused stressors (P) acting on a watershed; and whether we have adequately accounted for key external variables affecting water quality in the watershed, and identified impacts 'exported' from the watershed.

Additionally, near the completion of project the draft final report was sent out to individuals with expertise in indicators and/or interpretation of water quality conditions and related causes. Guided by a short list of questions, the reviewers were invited to comment on the draft Report. The reviewers' varied evaluations of the PSR framework reflect differing perspectives regarding the purposes of indicators and how they should be interpreted. The following points summarize issues brought to light in the reviewers' comments and discuss important considerations for future use of the PSR framework.

1. **Use of the PSR indicators.**
a. <u>Measures of single pressure-state-response factors (such as selenium loads, or reduction in applied water per acre) versus measuring relationships between factors:</u>
It appears that PSR indicators of the kind in this project are most readily used for reporting on single, discrete factors or combinations of these factors. In contrast, detecting presumed cause-effect relationships between factors can be problematic for a number of reasons, including failure to thoroughly consider the basis for linkages; lack of available data to test relationships; disproportionate scales—e.g., a sub-watershed response signal is 'drowned out' at larger scales.

b. <u>Status and trends applications</u>: In line with the preceding observations, assessment of status and trends for key water quality parameters is far easier than relating observed conditions to particular stressors or to management activities designed to change the water quality conditions.

c. Indices: Several reviewers remarked that the PSR indicator framework would work well for development of indices, and were quite supportive of this application. Normalizing across indicators to represent a composite assessment was judged appropriate and meaningful. Further, an index which combines water quality indicators with other measures of environmental and/or social condition can provide a good survey of the state of a watershed and its communities. (A caveat is applicability to complex, interactive systems. See discussion under # 4)

2. **Data constraints, and the value of matching monitoring with management questions**.

Often the report made use of data from monitoring designed for purposes other than the 'management objectives' posited in the test cases. Sometimes data on the results of particular management practices, as implemented in the San Joaquin, were not readily available—a point lamented by several reviewers, as well as members of the Steering Committee. This situation could be corrected: The PSR model could be used proactively to posit effects of management, help design appropriate monitoring to develop lines of evidence, and then assess the results.

3. **Geographic scales**.

a. Varying scales for factors acting within a watershed (sub-watershed): For any PSR application to the real world of open systems, the 'scales' of PSR factors relevant to the watershed of interest may differ. For example, an important water quality pressure (P) acting within a sub-watershed may be controlled by sources outside that watershed. In such situations, local efforts (R) to address this pressure may not be effective. Moreover, in focusing on a defined watershed, the PSR model may miss important effects on the broader scale (e.g., downstream). These effects could 'feed back' to further alter conditions within the watershed of interest. Several reviewers felt that the Report overlooked the importance to the San Joaquin of controlling variables outside that geographic area, as well as effects of San Joaquin inflows to the Delta.

b. Difficulties in "scaling up": Water quality *conditions* (S) may be measured and compared at various scales more easily than the effects of many management activities on these conditions (R). As one would expect, local management activities may be verifiably effective at a small scale, but the 'signal' is lost at larger scales, unless the scale of management activities corresponds to the scale at which a signal might be differentiated from the "noise" Intuitively, the number of factors affecting water quality increases with up-scaling, but documenting this complexity is difficult. The generalization regarding difficulties in detecting effects of management activities, particularly on a larger scale, depends on the extent and magnitude of management actions: Actions such as large-scale flow manipulation can have basin-wide impact.

Setting aside issues of up-scaling and reporting of program results, some members of the Steering Committee emphasized the need to take a closer look at how to select appropriate practices and document localized results—that is, to use a PSR framework to help in refine local use of 'best management practices.'

4. **Need for basin-specific expertise**: The PSR framework is basically a way of classifying conditions, and factors influencing these conditions (P and R). Its practical value for selecting factors related by cause-effect depends on adequate knowledge of the particular watershed, of management practice effectiveness, of important exogenous influences, etc. In the case of the San Joaquin, developing conceptual models from the generic 'PSR' framework required basin-specific insights as to water sources and routing, irrigation methods, return flow routing, drainage management, etc. Several reviewers noted the difficulty of using the framework in such a "complex, highly managed" environment.

5. **Caveats with complex and interactive systems**:
Some reviewers noted that the PSR model doesn't readily incorporate "functional relationships," interactions and feedback loops. Additionally, PSR is not suited to complex processes where the outcomes can vary, depending on the values of the factors. Examples of these situations would be mercury cycling processes, and synergistic effects in a mix of chemicals. As a result, even an index measuring "system condition" using the PSR framework is unlikely to capture all important processes and functions. Given these considerations, some reviewers suggested explaining limitations of the assessments.

As mentioned previously, the conceptual models being developed through CALFED's Delta Regional Ecosystem Restoration Implementation Program (DRERIP) emphasize scientifically-based detail with respect to effects mechanisms and processes. Depending on complexities and uncertainties of a project, and its information needs for adaptive management, these models possibly are more useful in tailoring specific actions—but are less readily accessible to the lay public and managers than the PSR application demonstrated in this Report. This is not to say that the PSR framework lacks scientific grounding; furthermore, the work in this Report demonstrates substantial rigor in developing and relating indicators. Rather, one objective of this project was to design and test a PSR application for its practical utility to non-scientists.

This summary is not an exhaustive evaluation of the PSR model. In general, the model is a straightforward method of displaying water quality or other environmental conditions and factors affecting those conditions. It is not intended to capture complex and variable interrelationships, and has limitations in situations with major uncertainties and information gaps. On the other hand, it can be used to organize and report information in a form which communicates to managers and the public. It can also assist in design of monitoring to improve documentation of management results.