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Evaluation of the California State Water Resource Control Board's Bioassessment Program

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Final Report to U.S. EPA-OST and Region IX

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EXECUTIVE SUMMARY

The State of California's bioassessment, monitoring and assessment (M&A), and water quality standards (WQS) programs were reviewed in January 2008 using the U.S. EPA's Critical Technical Elements and Programmatic Review process (Barbour and Yoder 2008; Quasney and Yoder 2008), which evaluates key components of these state programs and existing and planned capacities. The review process results in technical, policy, and management recommendations for building, refining and maintaining functional and effective bioassessment and M&A tools that support the full spectrum of WQS and management programs. This review was conducted by a two-person review team with national expertise at evaluating, building, and implementing state and tribal programs.

Bioassessment, the use of resident aquatic biota as direct indicators of the biological integrity of water bodies, is a powerful tool for water resource regulatory programs. The need for state water quality agencies to develop and maintain robust bioassessment programs is underscored by the National Research Council's critical review of state TMDL, M&A, and WQS programs (National Research Council 2001). The NRC's review makes clear that all states need better biological endpoints, adequate M&A, and tiered aquatic life uses (TALU) in order to develop and refine appropriate and effective WQS that result in more accurate and appropriate protection for biological resources.

While the federal Clean Water Act (CWA) has long required states to protect and restore the chemical, physical, **and** biological integrity of the nation's waters, the California Water Boards have only recently begun to develop the tools, expertise and capacity that they will need in order to implement modernized WQS that protect biological integrity. However, because of the substantial investment in the development of bioassessment tools made since the mid-1990s by the state's Department of Fish and Game, California is now positioned to initiate the process of integrating bioassessments into its WQS and monitoring and assessment programs via the development and implementation of narrative and numeric biocriteria.

Key Findings of the Review:

1. California's bioassessment program has made great strides in recent years due primarily to investments made by the Dept. of Fish and Game's Aquatic Bioassessment Laboratory (DFG-ABL) and the Water Board's Surface Water Ambient Monitoring Program (SWAMP). With continued management support, SWAMP and DFG-ABL are capable of building, maintaining and refining the technical tools that the Water Boards will need to incorporate biological criteria and assessments into their water quality programs.

2. As determined by the U.S. EPA Critical Technical Elements methodology, California's bioassessment program is currently at an above average level of rigor (Level 3; 88.3%) and is being used in statewide 305(b) assessments, the 303(d) listing/delisting process, and in support of specific regulatory needs in some Regions. Continued investment and active management support will be needed to achieve a fully functional (CE Level 4)

program that will provide more comprehensive support for the suite of regulatory needs and in all Regions.

3. California's bioassessment program is currently capable of addressing wadeable perennial streams. Additional investment and technical development will be needed to address other waterbody types including large non-wadeable rivers, non-perennial streams, lakes, and wetlands.

4. SWAMP has invested a significant amount of financial resources to develop the current bioassessment infrastructure. However, full implementation of California's bioassessment program is constrained by the fact that most of the program is conducted by contractors. This review affirms the findings of prior peer reviews that the Water Board needs its own in-house bioassessment coordinator and staff. California cannot effectively protect the biological integrity of its water resources without dedicated expertise at the Water Boards.

5. While the DFG-ABL, SWAMP, and their contractors are building a solid technical foundation for a robust freshwater bioassessment program, they can only provide the technical tools for developing biological endpoints and Tiered Aquatic Life Uses (TALUs). The State and Regional Water Boards will need additional biologists, and more planning staff with biological expertise to develop, refine and implement narrative/ numeric biocriteria and TALUs in support of all applicable regulatory programs and at the same spatial scale at which they are being applied.

Management Recommendations:

1. The Water Boards should revise the structure and content of the beneficial uses and criteria related to aquatic life uses to more accurately reflect the natural attributes of the diversity of watersheds through the state. This is consistent with recommendations from the NRC (2001) and the SPARC (2006).

2. The Water Boards should integrate biological assessment tools into their water quality programs (i.e., WQS, core regulatory, TMDLs, nonpoint source, etc.). This represents a fundamental paradigm shift that will require strong management understanding and support.

3. The State Water Board should develop statewide narrative biocriteria as soon as possible, either along with or followed by numeric biological endpoints to interpret the narrative objectives.

4. The Water Boards should require key program units (e.g., WQS, NPDES, TMDL) to incorporate biological assessments into their programs and program evaluation. Adopting biological criteria within a framework of TALUs would enhance its implementation in these programs.

5. The Water Boards should recruit and retain staff with bioassessment expertise, and assign staff and provide training to programs incorporating biological assessments. This includes support for statewide efforts and ongoing efforts at the Regional Boards.

6. The State Water Board should create and maintain a specialist position for a state-wide bioassessment policy coordinator. This is consistent with the recommendation made in a prior external peer review of SWAMP's bioassessment program (Barbour and Hill 2003).

Technical Recommendations: [NOTE: the following recommendations are based in part on the Critical Elements evaluation conducted during the January 2008 program review and are based on elevating the technical rigor of the statewide and regional board programs to level 4.]

1. SWAMP should continue to support the technical infrastructure development strategy outlined in its FY06-07 and FY07-08 bioassessment work plans.

2. SWAMP should establish reference conditions for the objective interpretation of biological data by fully implementing its Reference Condition Management Plan. This fundamental investment will pay dividends to all water quality programs using biological assessments in California. This would also serve the development of chemical/physical endpoints and indicators as part of a program of integrated bioassessment (i.e., facilitate a robust multi-indicator "weight-of-evidence" approach to water quality regulation).

3. SWAMP should develop additional indicators of ecological condition to supplement the benthic macroinvertebrate indicators currently in use. The consistent addition of a second assemblage in the bioassessment process is needed to elevate the program to Level 4. Options for this include an algal assemblage indicator (currently in development by SWAMP), a wetland indicator (CRAM, also in development), and fish assemblage indicators (currently being explored by USGS). SWAMP should continue to support efforts to evaluate each of these potential indicators and to determine which is/are best suited to California's needs and for specific waterbody ecotypes (e.g., perennial wadeable streams, non-perennial streams, non-wadeable large rivers, wetlands).

4. SWAMP should continue to support development and maintenance of the biological component of the state's database. This provides the essential framework for statewide integration of biological and physical habitat data. Two priorities are tools to calculate biological metrics for water resource managers and tools to convey results to the public.

5. SWAMP should develop a QA/QC oversight program for the collection of ambient biological data. This would set the standard for SWAMP comparability for other Water Board programs and provide guidance to other agencies wishing to become SWAMP

compatible. Adopting biocriteria and TALUs in the WQS would contribute to the compulsory standardization of the use of biological assessment data throughout the state and between the regions.

6. SWAMP should continue to support the statewide perennial stream assessment. This addresses the need to assess the condition of a major class of surface waters in California and provides a solid framework for integrating stream monitoring with other programs in the state.

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INTRODUCTION

U.S. EPA has supported the development of state and tribal bioassessment programs via the production of methods documents, case studies, regional workshops, and evaluations of individual state and tribal programs since 1990. Since 2000, EPA has fostered a more detailed and "hands on" developmental and implementation process for incorporating tiered aquatic life uses (TALUs) and numeric biocriteria in state and tribal water quality programs. The successful development and implementation of biocriteria and TALUs is directly dependent on the rigor, comprehensiveness, and integration of monitoring and assessment (M&A) with state water quality standards (WQS) and water quality management programs. This framework can also provide measures to evaluate the effectiveness of major water quality management programs such as NPDES permitting, TMDLs, nonpoint source management, stormwater management, and watershed planning.

On January 23-24, 2008 the U.S. EPA sponsored an evaluation of the Water Board's biological assessment program. The purpose was to evaluate both the State's technical program elements and its regulatory structure in order to make recommendations that will enhance CA's ability to make informed decisions about the ecological condition and management of California's rivers and streams. The scope of the review included a range of topics about the surface water monitoring and assessment program, the structure of the existing WQS, the development of bioassessment tools to delineate impaired waters and determine stressor effects, and the use of biological data to support Water Board programs including NPDES permitting, non point source management, stormwater management, and TMDLs.

The evaluation process consisted of direct interactions with state program management and staff to evaluate the status of their bioassessment, M&A, and WQS programs and to describe how each is used to support water quality management. The following include the principal reports and products of the EPA TALU development and implementation process since 1998.

1) *Important Concepts and Elements of a State Watershed Monitoring and Assessment Program (Yoder 1998):* This document was developed as a state oriented document following the Intergovernmental Task Force on Monitoring Water Quality and the U.S. EPA environmental indicators initiatives of the 1990s. It outlines the essential concepts and elements of what is referred to as an "adequate" state monitoring and assessment program. The term adequate was chosen to represent a cost-effective, yet comprehensive approach to monitoring that assures the use and development of chemical, physical, and biological indicators collected and arrayed in a strategic manner that results in supporting water quality management decisions at all relevant scales.

2) *Use of Biological Information to Better define Designated Aquatic Life Uses in State and Tribal Water Quality Standards: Tiered Aquatic Life Uses (August 2005):* This document serves as a detailed presentation of methods for developing and implementing TALUs in state WQS. It consists of detailed descriptions of the baseline elements of TALU – the

Biological Condition Gradient, elements and milestones for the incorporation of TALUs in WQS.

3) *Critical Elements Technical Elements of a Bioassessment Program (November 2007; updated September 2008):* The rigor of a state's program is evaluated in order to determine the capacity to assess ecological condition and diagnose impairment. This evaluation consists of thirteen technical elements associated with design, methods, and interpretation features of a bioassessment program that are rated jointly with the state program management and staff. The cumulative rating of the elements provides a level of rigor (ranging from level 1, the lowest level of rigor, to level 4, the highest and best suited for full program support) of the overall bioassessment program. The capacity to accurately address a suite of management questions and issues is dependent upon the level of rigor. A critical technical elements evaluation of the California bioassessment program was completed using the standardized checklist and scoring methodology (Barbour and Yoder 2007, 2008).

Part 1. Use of Bioassessment in State Water Board Programs

1. Monitoring and Assessment Program

The Surface Water Ambient Monitoring Program (SWAMP) is a statewide effort designed to monitor and assess the conditions of surface waters throughout the state of California. SWAMP was proposed in 2000 (SWRCB 2000) in response to a legislative directive to integrate existing water quality monitoring activities of the State Water Resources Control Board and the nine Regional Water Quality Control Boards (Regional Water Boards), and to coordinate with other monitoring programs. The needs of an emerging TMDL process, inconsistencies between regional boards, and information needs for regulatory decision-making were some of the principal drivers.

SWAMP has fostered the development of biological assessments because they provide a direct and quantitative measure of aquatic life use protection. A major review of the program was conducted in 2003 (Barbour and Hill 2003). In 2005, the SWAMP Scientific Planning and Review Committee (SPARC 2006) recommended "The State Board should adjust water quality management approaches to take advantage of the more direct measures SWAMP is developing of aquatic life condition through bioassessment monitoring".

Tools for assessing biological assemblages in perennial wadeable streams are currently the most well-developed of the biological monitoring tools; this is largely the result of investments made by the Department of Fish and Game's Aquatic Bioassessment Laboratory (DFG-ABL) and SWAMP since the mid 1990s. The State has made significant progress with the use of benthic macroinvertebrates in stream bioassessments, but has recently begun to develop and implement an Algae Plan (SCCWRP 2008), and is also evaluating the utility of the California Rapid Assessment Methodology (CRAM) as a tool for assessing riparian wetland habitat. SWAMP is also considering the utility of fish bioassessments in California. It is also recognized that there are additional freshwater ecotypes and strata that need to be addressed to meet the goal of providing full water quality management program support (Table 1)

Ecotype	Habitat	Algae	Invertebrates	Fish
Ephemeral	Y			
Intermittent	Y	?	?	?
Perennial	pHab CRAM	% cover Biomass Algal IBI	IBI or O/E	?
Rivers	pHab CRAM	Y	Y	Y
Lakes/Reservoirs	pHab CRAM	Y	Y	Y
Bay/Estuaries	CRAM	Y	BRI	Y
Coast/Ocean		Y	So Cal BRI	So Cal Fish Index

Table 1. Summary of biological indicator development efforts in California by major aquatic ecotypes.

Additional investment will be needed to develop and maintain a program that is capable of addressing other waterbody types (e.g., large non-wadeable rivers, non-perennial streams, lakes, wetlands). Indicator work done on perennial streams may applicable to other waterbody types. For instance studies are underway to investigate the use of macroinvertebrate assemblages and periphyton to assess intermittent and ephemeral streams. The CRAM wetland methodologies can be applied to intermittent and ephemeral streams, but also to lakes and estuaries. California has also participated in national and regional bioassessment projects such as U.S. EPA-EMAP and Regional EMAP surveys, the National Wadeable Streams Assessment, the National Lakes Assessment, and the National Rivers and Streams Assessment each of which lends experience with these other waterbody types.

California has begun moving from conducting simple biosurveys (i.e., the collection of localized and limited sets of biological samples) to more spatially robust bioassessments of ecological condition. This has occurred within selected Regional Boards and these can serve as a template for all Water Boards. The next challenge will be the development of biological criteria to better inform and guide water quality management decision-making. While SWAMP and the selected Region Board programs have contributed the technical rigor required by this process, it will require considerations that apply within specific regions of the state. Hence it needs to be a coordinated effort with consistent participation and integration between the state and regional water boards.

2. Role of Bioassessment in Listing Decisions

Waterbody listings are presently based on exceedences of water quality criteria. The State Board's listing policy (SWRCB, 2004) provides detailed guidance on the interpretation of chemical and toxicity data. Listing and de-listing decisions are based on the frequency with which numeric water quality criteria are exceeded as defined in the listing policy and interpreted through the use of a binomial probability distribution. Assessment of physical and biological data is more difficult because there are no numeric criteria. Listings are therefore based on the interpretation of narrative criteria.

A water body may be listed if there is significant degradation in biological populations and/or assemblages as compared to reference site(s), but only if it is associated with a pollutant. The analysis of biological communities must rely on measurements conducted using published protocols from at least two stations and requires that comparisons to reference site conditions shall be made during similar seasonal and/or hydrological periods.

Regional Boards using biological information in the listing process are required to: 1) identify appropriate reference sites and document methods for the selection of reference sites, 2) document the sampling methods, index period and quality assurance/quality control procedures for the habitats being sampled, and 3) compare bioassessment data to conditions at reference sites and evaluate physical and other water quality data to support any assessment conclusions. The listing policy encourages the use of indices of biological integrity (such as the IBIs developed by SWAMP).

A significant number of waterbodies have been listed in the past for sediment, excess algae, hydromodification, and water diversions using best professional judgment to interpret narrative standards in the Basin Plans. The lack of a quantitative biological endpoint or numeric biocriteria for attainment of aquatic life can create challenges for managers.

3. Water Quality Standards

Water quality standards (WQS) provide the objectives for both developing the requirements for and judging the effectiveness of pollution controls and management programs. The California WQS are comprised of beneficial uses, numeric and narrative criteria (objectives) to protect those beneficial uses, and an antidegradation policy.

<u>Beneficial Uses</u>. At present there are 6 defined "beneficial uses" that apply to the protection of aquatic life use in fresh water across the state. These are cold fresh water habitat (COLD), warm fresh water habitat (WARM), spawning (SPAWN) and migration (MIGR) of aquatic species, habitat for wildlife in general (WILD) and for rare, threatened, and endangered species (RARE), and the preservation of biological habitats of special significance (BIOL). These uses are applied to specific watersheds through Regional Water Quality Control Plans (Basin Plans) that

are developed, administrated and enforced by the Regional Water Boards. Two Regional Boards have wetland habitat (WET) as a defined beneficial use and the State Board is considering application of the wetland use as part of a hydromodification policy.

These aquatic life use designations define the general types of organisms, assemblages and habitats that are being protected. For instance, COLD use designation protects "uses of water that support cold water ecosystems including, but not limited to, preservation and enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates". Aquatic life use support assessment is challenging in California because expectations for the aquatic life use support will naturally vary across the state. The current generic aquatic life use designations simply do not account for the natural variability in rivers and streams across the broad biogeographic regions of the state.

The SPARC recommended that the Water Boards use the National Research Council (2001) recommended framework to revise and refine the designated uses, the supporting protective criteria, and the attainment assessment procedures to more fully reflect the diversity of watersheds and their respective/desired attainable human and aquatic life uses. U.S. EPA (2005) largely followed the NRC (2001) recommendations in their methodological guidance for developing and implementing a TALU approach to WQS and monitoring and assessment. That framework and the technical developments to date are the basis for this review.

<u>Numeric and Narrative Objectives</u>. There are relatively few numeric objectives for the protection of aquatic life. The California Toxics Rule contains numeric water quality objectives for 22 chemicals. The Basin Plans have limited objectives for additional toxics. Narrative objectives in the Basin Plans related to the protection of aquatic life use are generally expressed in the form of "no toxics in toxic amounts", "no significant degradation", or "no significant deviation from reference". State and Regional Board staff engaged in assessments have little guidance on how to interpret these narrative objectives. A TALU framework and numeric biocriteria would greatly clarify these endpoints.

The biological information being generated through SWAMP can be used to establish biological expectations for different waterbodies across the state. This is a first step in the establishment of biological criteria. Such information and data may also be used to support the development or refinement of other water quality objectives (e.g. temperature, dissolved oxygen or nutrient criteria) or program applications (e.g., 401 certifications) across the state. The SWAMP Reference Condition Management Plan (Ode and Schiff, 2008) lays out a strategy for establishing biological expectations.

<u>Antidegradation</u>. The state's antidegradation policy is incorporated in the Basin Plans by reference. Biological information is not typically used in antidegradation analyses, but it has the potential to enhance their application. Biological assessment could be used as a direct measure of instream aquatic life use and to provide a trigger for antidegradation analyses when such assessments indicate that there is degradation of water quality. The biological assessment tools developed already provide a method to measure condition incrementally thus enhancing

its utility for detecting incremental changes that may not reflect a violation of standards. This capacity will enhance its usefulness in new antidegradation applications.

4. Use of Bioassessment in other Board Programs

Monitoring and assessment activities should be designed to provide information and tools to support multiple programmatic activities with the same data and information. As biological assessments provide a direct measure of aquatic life use they can help program managers prioritize management actions to protect and restore beneficial uses. They can also be used as outcome measures to evaluate the effectiveness of various programs (e.g., NPS, NPDES, and TMDLs) to protect and restore beneficial uses.

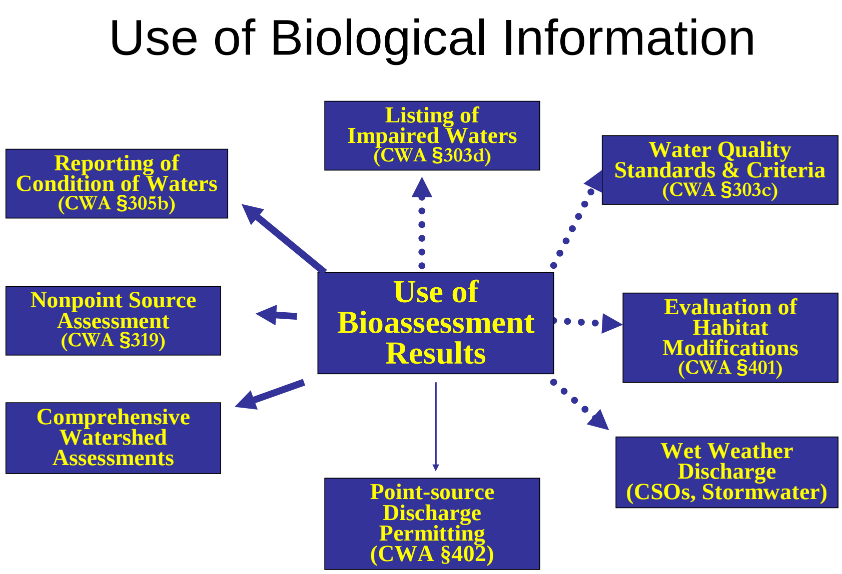

Figure 1. Efforts to develop strong monitoring and assessment programs lead to support for multiple water quality management programs.

NPDES. The use of biological data in NPDES permits and WDRs in California dates back to the early 1990's. Bioassessments have been used mostly in "upstream-downstream" designs to assess the impact of point source dischargers such as POTWs, but are also increasingly being used in stormwater permits. In Southern California alone, 323 bioassessment samples are collected by stormwater agencies each year as part of their MS4 permit requirements. The State Board's SWAMP program is developing draft permit language to assist Water Board staff that wish to incorporate freshwater bioassessment into permit requirements and/or other Water Board programs or projects. The boilerplate language will include guidance on field and lab methods, index periods for sampling, and the required QA and data submittal procedures. Interpretation of bioassessment results have largely been relative to reference site or locally derived IBIs, where available.

NPS. Bioassessments have been used in a number of nonpoint source projects to assess the effectiveness of actions on water quality (instream biota). The State Board's nonpoint source program has helped fund monitoring of perennial streams to identify the extent of the states streams that are impacted by nonpoint source pollution and to identify the stressors that are impacting streams (Ode, 2007). Funds have also been used to support development of stressor identification tools (Rehn, 2006) and improve understanding of associations between biological assemblages and key stressors associated with NPS activities (e.g., agricultural and urban land uses).

TMDLs. Bioassessments have been used primarily as targets for TMDL monitoring in California rather than as direct biological endpoints. The endpoints in most TMDLs are primarily water quality endpoints rather than biological endpoints. However, the translation of bioassessment results to relevant TMDL endpoints is a next step in increasing the programmatic uses of bioassessment information in California. It will also enhance the comprehensiveness, relevancy, and applicability of TMDLs by focusing on the most limiting factors beyond the expected impact of individual pollutants by also highlighting their associated interactions and co-occurring stressors such as habitat and land use.

Part 2. Critical Elements Evaluation

The critical technical elements of bioassessment programs are described and divided into four general levels of rigor supported by a sliding scale of resolution and development (Barbour and Yoder 2007, 2008). A level 4 program is the most rigorous and the most capable of fully addressing the myriad of management issues regarding aquatic resources that are commonly faced by states and tribes. The remaining three levels of bioassessment rigor may be appropriate for some, but not all of the water quality management program support needs of state programs. Delineating the extent and severity of aquatic life impairments and diagnosing categorical and parameter-specific stressors are the primary tasks for a TALU based approach to monitoring and assessment that is intended to support multiple water quality management programs (Yoder and Barbour 2009).

A critical elements (CE) evaluation was conducted by proceeding through the CE checklist in accordance with the methodology in Barbour and Yoder (2007). The statewide program yielded a raw score of 53 out of the maximum possible score of 60 which equates to a mid-level 3 program; the two Regional board programs that were also evaluated were borderline level 3. The results for each element are discussed below (See Appendix 2 for checklist):

1. Index Period. *An index period is a consistent seasonal time frame for sampling the assemblage that is a cost-effective alternative to sampling on a year-round basis to account for seasonal variations. Ideally, the optimal index period corresponds to recruitment cycles of the organisms (based on reproduction, emergence, growth, and migration patterns). Sampling during an index period minimizes between-year variability*.

The statewide program adheres to a standardized index period (April to October) that slides from north to south to reflect differences in temperature. In southern California the index period is from April to October for the multimetric index (April to June for the O/E models); in northern California the index period is generally from August to September. Most Regional Boards adhere to this but there is some accommodation to support program needs. A CE score of 4.0 out of 4.5 was given to the California program.

2. Spatial Coverage. *Available resources and the desired outcome of the sampling design are key determinants in achieving adequate coverage.*

The "universe" of monitoring and assessment needs in California is spatially extensive and diverse. The nine regional boards incorporate a wide diversity of hydrological, landscape, and natural regional strata. No single design can meet all the State of California's monitoring objectives.

SWAMP is using a probabilistic sampling design to obtain unbiased estimates of the biological conditions of perennial streams across the state and to track trends in biological conditions over time. The design of the SWAMP Perennial Stream Assessment (PSA) survey is cost effective because the entire resource need not be sampled – only a representative sample of streams. Another advantage of the probability-based design is that it allows the coordination/integration of other probability-based designs. In California the perennial stream survey is being coordinated with national stream assessments, regional watershed assessments being performed by Regional Boards Southern California (i.e., RB4, RB8 and RB9) and includes significant contributions from the regulated community including the Stormwater Monitoring Coalition in southern California and the Regional Monitoring Program in the San Francisco Bay area. The principal spatial designs include a statewide probabilistic network consisting of approximately 100 sampling sites per year, stratified by 6 ecological regions.

Many Regional Boards use targeted monitoring designs. These might involve watershed scale designs that include a resolution at an 8-11 digit HUC spatial scale to meet their specific needs. The designs vary from upstream/downstream sampling to bottom-of-watershed monitoring designs to more distributed networks. Some Regional Boards are using a rotating watershed approach, with a goal of sampling all watersheds in a region within a fixed time period (5 years is a common goal). The actual numbers of targeted sites are dependent on regional funding levels and annual monitoring priorities. Measurements include core chemical, physical, and biological parameters per the statewide SWAMP methodology with supplemental parameters added based on region-specific needs. The results from the statewide SWAMP perennial stream surveys provide context for local sampling.

The combined score of 4.0 reflects the practical integration of the statewide (which includes a combination of probability and targeted sites) and partial integration of Regional Board programs into the overall State Board effort.

3. Natural Classification. *In developing a bioassessment program, USEPA recommends classifying waterbodies more specifically than simply by waterbody type (e.g., river, lake, etc.), because it is highly unlikely that the biological condition of any given waterbody type is uniform throughout any anthropogenically-defined boundary. The classification of waterbodies is useful* *in partitioning natural variability and distinguishing it from variability resulting from human-induced changes. Classification of waterbodies can be based on a combination of characteristics, i.e., watershed drainage size, ecological regions, elevation, temperature, and other physical features of the landscape and/or waterbody for each waterbody type (e.g., large rivers, wadeable streams, headwater streams). The number of sites sampled and the availability of candidate reference sites within each class may limit the number of classifications*.

The challenge for the SWAMP program is to develop a program accounts for biological variation caused by natural environmental gradient and balances statewide consistency with the flexibility to adapt to California's diverse regional settings. In the present scheme, California will be divided into different geographic regions based on coarse biogeographic similarities in order to partition some of the natural variability among regions. These boundaries are consistent with those being used in the SWAMP perennial stream survey. Within the biogeographic classification, additional factors such as watershed size, elevation, and precipitation may be used to define biological expectations.

The CE score of 3.5 will be elevated to 5.0 with the developments that are already underway.

4. Criteria for Reference Sites. *A reference site should be natural or minimally disturbed while maintaining essential attributes. When reference sites are used to establish reference conditions, the State needs to document how it selects reference sites (by what criteria) and how it uses them to define regional reference conditions. Factors to be considered in selecting reference sites include human population density and distribution, road density, and the proportion of mining, logging, agriculture, urbanization, grazing, or other land uses. Candidate reference sites are evaluated for these factors to determine the degree of human modification that has occurred. Sites are eliminated if they have undergone direct human modification.*

The SWAMP strategy for selecting and sampling reference sites is documented in its Reference Condition Management Plan (RCMP, Ode and Schiff, 2008 In Prep)". The SWAMP RCMP program has proposed a general strategy for identifying reference sites. California will be classified into broad biogeographic regions. A pool of reference sites will be assembled within each region through a sequential process of identification and screening of candidate sites. This pool of reference sites will be managed through an iterative review of data to refine regional boundaries, ensure continued stability of sites and ensure adequate representation of natural gradients. Finally a monitoring design will be created for sampling this pool of reference sites to document the range of biological and physical condition at reference sites, and to monitor changes to this condition over time.

Screening of candidate sites will be done primarily through a combination of evaluation of existing data, GIS techniques, expert knowledge and site visits. It is recognized that high quality reference sites may not exist in certain areas of the state such as the agriculturally dominated Central Valley or the intensely urbanized southern California coastal plain. An alternate model for site selection will be used in these cases.

The score of 5.0 for the statewide program reflects the high degree of development of reference site selection criteria and procedures. These criteria and procedures are likely to be refined as the RCMP is implemented.

5. Reference Conditions. *The issue of reference conditions is critical to the interpretation of biological data. Generally, USEPA recommends the use of a regional reference condition based on an aggregate of sites that allows for broader application in State water resource programs than site-specific conditions. There must be a sufficient number of reference sites to capture regional stratification and the range of natural variations in biological assemblages due to geology, climate, and other natural physicochemical differences. Ideally, reference conditions represent the highest biological conditions found in waterbodies undisturbed by anthropogenic stressors. Recognizing that pristine habitats are rare or non-existent, resource managers must decide on an acceptable level of disturbance to represent an attainable or existing reference condition. Reference condition can be derived from reference sites, an empirical model of expectations that may include knowledge of historical conditions, or a model extrapolated from ecological principles. Usually, data from sites that represent best attainable conditions (i.e., least disturbed) of a waterbody are used.*

The SWAMP plan for development of reference conditions is embodied in the RCMP (Ode and Schiff 2008). Currently, reference condition is being determined from a still growing network of 300+ "least impacted" reference sites (1998-present). The reference site plan envisages sampling at 50-75 sites/year. The design includes ecoregional stratification and representation of the full range of regionally important natural gradients (e.g., elevation, precipitation, etc.). Development of regional reference condition is in progress – not yet completed for all regions. The goal is to have 50 sites per region.

The CE score of 3.5 should improve to 4.0 with the addition of regional reference sites that are being established as part of the ongoing improvements above.

6. Taxonomic Resolution. *An assemblage is defined as an association of interacting populations of organisms in a given waterbody. Although a single assemblage may be sufficient to make an attainment determination, USEPA recommends the use of at least two to enhance confidence in the assessment findings (USEPA 1996) because each assemblage serves a different function in the aquatic community and may be susceptible to stress in varying manners and degrees. Taxonomic identification of each assemblage to genus or species level provides reliable information about sensitivity, tolerance, and ecological/environmental relationships. Genus/species identifications improve assessments using richness values or metrics as key endpoints. Identification to family level requires less expertise to perform and usually speeds up the assessment process.*

For macroinvertebrate taxonomic identifications, the SWAMP program has recommended resolution to genus/species for development datasets; scoring tools are usually calibrated to work with genus level identifications. To ensure consistency and rigor in taxonomic data, SWAMP provides primary support for the Southwest Association of Freshwater Invertebrate Taxonomists (SAFIT), which establishes and maintains taxonomic standards.

SWAMP should also support the activities of an algal taxonomic workgroup, similar to SAFIT, to develop a standard algal taxonomic effort as recommended by Fetscher and McLaughlin (2008). SWAMP is currently leveraging the efforts and expertise of its partners to develop algal indices in southern California and the central coast. In both these efforts, soft algae and diatoms are currently analyzed to the lowest practicable taxonomy (usually genus/species), but recommendations for level of taxonomy for general assessment purposes are pending the results of the index development process.

The CE score of 4.5 reflects the full development of the macroinvertebrate assemblage and the in progress development of a periphyton indicator. Reaching the CE score of 5.0 is contingent on the full development and use of a second assemblage.

7. Sample Collection. *Standardization of field methods is necessary to establish the validity and reliability of biological data used in an assessment. Thorough training of investigators, coupled with rigorous certification processes, enhances the ability to provide a consistent unit of effort. Strong oversight of activities and leadership of apprentice professionals are critical. Standardization is especially important when information will be used in later trend analysis. The development of standard operating procedures (SOPs) for field and laboratory methods must include an effective quality assurance (QA) program with QC checks.*

The SWAMP program has developed a statewide protocol for macroinvertebrate sampling and physical habitat characterization that is derived from the EPA's national EMAP protocols (Ode 2007b). The SWAMP bioassessment group will work closely with the SWAMP QA Officer to develop comprehensive Quality Assurance Oversight Plan for quality assurance and quality control of bioassessment data. This guidance will cover personnel qualifications, training and field audit procedures, procedures for documenting sources of field and lab (including taxonomic data) error, procedures for chain of custody documentation, requirements for measurement precision, health and safety warnings, cautions (actions that would result in instrument damage or compromised samples), and interferences (consequences of not following the standard operating procedure). As most of the SWAMP sampling is performed by the California Department of Fish and Game, the procedures for quality assurance and quality control are currently addressed in the Quality Assurance Project Plan.

The SWAMP program is currently sampling periphyton using procedures developed for the EMAP program. However methods for field and laboratory protocols for algal sampling, identification and quantification used by various agencies have not been standardized across the state. The recently drafted SWAMP Algae Plan (Fetscher and McLaughlin, 2008) details key considerations for algae-based bioassessments, including the need to standardize sample collection and taxonomic methods across the state.

The CE score of 5.0 reflects the full development of the macroinvertebrate and partial development of the periphyton assemblage methodologies for the statewide and regional programs.

8. Sample Processing. *A systematic treatment of samples is needed to ensure the greatest extent of accuracy and precision. A strong QA/QC program is desired to ensure that (1) sample sorting procedures are being followed and no organisms are missed in the sample, and (2) the taxonomy is consistent and accurate.*

The CE score of 5.0 out of 5.0 for the statewide program reflects the full development of sample processing procedures for macroinvertebrates (Ode, 2008). The State also has a plan to develop standard statewide sample processing methods for periphyton (Fetscher and McLaughlin, 2008).

9. Data Management. *A reliable, efficient and quality assured database management system is fundamental to a program's ability to use monitoring information effectively to solve environmental problems. A proper system for aggregating data and performing the necessary quality control checks is essential. Furthermore, integration of assessment information from multiple assemblages (fish, macroinvertebrate, algae, etc) can contribute important diagnostic information. Data management includes not only proper stewardship of raw data elements but also proper computation of biological metrics and biocriteria threshold information. A strong geographic information system (GIS) linked to a well-designed relational database moves programs toward a more comprehensive watershed perspective in interpreting monitoring data and improves the ability of biological data to meet the increasing information demands of State and federal programs, responsible parties, and the public.*

The SWAMP 2.5 database is a relational database that encompasses all SWAMP monitoring data and links to a large distributed network of state and federal monitoring data (CEDEN). New bioassessment modules for entering, storing and reporting bioassessment data are nearly complete. Future work includes the development of tools to facilitate QA/QC procedures, summarize physical habitat data, and calculate bioassessment metric and IBI calculations. The CE score of 4.5 for the statewide program can be improved to 5.0 once the current data management system includes all reporting fields and calculation routines.

10. Ecological Attributes. *Ecological attributes are those aspects of an aquatic assemblage or community that correspond to the structure and function of that assemblage or community for a given condition. EPA has suggested 10 primary ecological attributes that form a continuum of responses to human disturbance (USEPA 2005). Ten primary ecological attributes have been identified as the basis for evaluating the BCG (USEPA 2005; Davies and Jackson 2006). The first six attributes relate to taxonomic identity, composition, and tolerances. They are 1) historically documented, sensitive, long-lived, or regionally endemic taxa, 2) sensitive rare taxa, 3) sensitive ubiquitous taxa, 4) taxa of intermediate tolerance, 5) tolerant taxa, and 6) non-native taxa that tend to displace endemic taxa. The seventh attribute is organism condition, which provides* *information on individual health. The remaining three attributes are functional integrity, ecosystem connectance, and spatial and temporal extent of stressors.*

The SWAMP program has developed several regional macroinvertebrate MMIs that use ecological attribute metrics in their calibration. SWAMP will continue to refine ecological attribute characterizations as it completes/ revises future MMIs. The State is also in the early stages of developing periphyton indices for coastal stream and has developed a plan for the use of periphyton in stream assessments (Fetscher and McLaughlin 2008).

The CE score of 4.0 out of 4.5 should increase with the development of the macroinvertebrate MMI and O/E model for all bioregions and the addition of a second assemblage.

11. Biological Endpoints & Thresholds. *State bioassessment programs should implement index development and threshold selection. Numerous methods are available for analyzing biological indicator data to assess attainment status, including both univariate and multivariate analysis techniques. Thresholds are the benchmarks from which the biological condition needed to support designated uses are described Selecting this threshold is perhaps the most critical aspect in reporting and documenting attainment status.*

Multimetric indices for macroinvertebrate data have been developed for perennial streams in the North Coast (Rehn and Ode, 2005), for perennial streams in Southern California (Ode et al., 2005) and for perennial streams in the Sierra Nevada (Herbst and Silldorff 2008, Rehn 2007). The State is also using a set of three predictive models based on the River Invertebrate Prediction and Classification System (RIVPACs), which compares the list of taxa observed at a site (O) to the list of taxa expected (E) to occur at a given site in the absence of human disturbance. The statewide California RIVPACs models (C. Hawkins unpublished) incorporates geographic coordinates (latitude and longitude), watershed area, average precipitation, average temperature and percent sedimentary geology into its predictions.

The SWAMP program uses statistical criteria to generate impairment thresholds. In the case of the northern and southern coastal IBIs, thresholds separating impaired from non-impaired were set at 2 standard deviations below a mean reference score. For the RIVPACS scores categorization to into “Good”, “Poor” and “Very Poor used thresholds of 1.5 and 3 standard deviations below an O/E score of 1.0 (the score expected under no impairment).

The State Board is funding projects in Southern California and the Central Coast to develop periphyton indices. The products from these two studies are expected in 2009. The State is currently testing the use of the California Rapid Assessment Methodology (CRAM) for assessment of riparian habitat. As with the macroinvertebrate scores, it is likely that threshold values for these indices will be derived statistically from reference populations.

The CE score of 3.5 out of 4 will improve with the full development of the macroinvertebrate MMI and O/E models, a second assemblage, and the derivation of appropriately detailed numeric biocriteria

12. Diagnostic Capability. *The diagnostic capacity of bioassessment data and results is dependent on the development of patterns and response signatures from a database that includes a variety of stressors and the full gradient of human disturbance and biological response. This increases the value of biological data beyond the determination of status (attainment/non-attainment) to include inferences and decisions about causal associations and elimination of candidate causes in a stressor identification process. The development and use of a diagnostic capability is only possible within programs that have specifically developed methods and for which precision and accuracy issues have been addressed.*

The SWAMP and the NPS program have made some tentative steps in this direction. With funding from the NPS program the perennial stream survey (formerly known as CMAP) was modified to investigate associations between bioassessment scores and land use using associative techniques such as relative risk assessment. The NPS program also funded research to associate benthic invertebrate assemblages with land use (e.g., agricultural, forested and urban land uses). SWAMP has also funded the development of stressor specific tolerance values for benthic macroinvertebrates. The SWAMP bioassessment program receives a score of 2.5 out of a possible 4.0. For perspective, this score is similar to that of other states that have been reviewed.

13. Professional Review and Documentation. *Subjecting documented methods and assessment reports to a rigorous peer review is ultimately the best way to ensure an agency's credible data and scientific underpinnings. Inherent in a review is that it is conducted in an objective and independent manner (outside the agency and with no vested interest in the outcome) by technical and policy experts able to provide valid critique and suggestions, and recommendations for improvement and refinement are taken in good faith. Validation of standard operating procedures for all aspects of the assessment and monitoring program by outside experts is an initial step in establishing confidence in the resulting data. Programs that do not address and implement critical recommendations fail to benefit from an independent endorsement of their procedures and assessments.*

The SWAMP has a solid peer-review process for evaluating individual technical studies and reports. The overall SWAMP program underwent a technical review in 2005 (SPARC, 2006). There was a review of the bioassessment program in 2003 (Barbour and Hill, 2003) and this critical elements review also serves as peer review. The program receives a CE score of 4.5 out of 4.5.

Summary

The SWAMP bioassessment program is presently operating a high quality program at the state level and in selected regions. The information that we gathered and reviewed shows that the program operates at level 3 and is appropriate for 305(b) assessments and to support 303(d) listings. Ongoing development activities will eventually result in a level 4 program capable of being used more rigorously in regulatory decisions in perhaps 4-5 years.

Improvements that are planned or already underway will directly affect 9 elements and increase the CE score by 5-7 points resulting in a level 4 program for both the statewide and regional programs. Achieving a L4 program is contingent on the (1) full development and use of a second assemblage, (2) developing more detailed diagnostic capabilities, (3) improving data management and (4) developing the capacity of the other regional boards and linking regional monitoring to statewide efforts. This will take time to accomplish, perhaps 4-5 years depending on the rate of progress, resources devoted to the developmental effort, etc. Making these improvements should lead to an improved delineation of condition along the BCG and an improved diagnostic capability via an increased capacity to detect biological responses to specific types of stressors, provided that adequate and concurrent data about relevant stressors are also collected and analyzed.

The consistent addition of a second assemblage in the bioassessment process is needed to elevate the program to level 4. Three commonly used bioassessment assemblages (benthic macroinvertebrates, algae and fish) all provide unique perspective on the biological condition of a stream and its watershed. To be clear we advocate the use of *a minimum* of two assemblages in a given stream or river, but recommend that all three be available to choose from as each is applicable. The decision about which assemblage(s) to use in a particular situation should be made from all perspectives in addition to the obvious logistical and resource related perspectives. SWAMP has made strong progress toward developing algal indicators as a second indicator, but options for a third indicator are still under consideration. The use of fish indicators in CA is complicated by the State's limited fish fauna and may be not be a cost-effective indicator, but this should be explored further because fish can provide information about larger scale ecological condition (e.g., watershed connectivity, loss of spawning and other habitats, impacts of introduced species, etc.) that other assemblages cannot. Alternately, riverine wetland tools (e.g., CRAM) currently being explored by SWAMP may provide a means of partially filling the need for larger scale context.

We recommend that a follow-up CE review be conducted when these decisions are being made and upon the implementation of the improvements that are more immediately attainable. We would recommend in this case that new assemblages be developed and applied alongside macroinvertebrates based on the resource and management issues at hand.

The integration of the bioassessment results with chemical/physical data and other stressor information that is already included in the SWAMP will lead to a better understanding how human disturbance influences measurable biological response and lead to better support for all water quality management programs. Case examples of how this can be accomplished are available in the EPA TALU document (U.S. EPA 2005). Finally, these improvements will enable California to more fully develop a TALU (Tiered Aquatic Life Use) framework that will improve its current WQS and enhance the utility of aquatic life designated use classes for regulatory and other management applications.

Part 3. Moving from Bioassessment to Biocriteria

California's bioassessment program has made great strides in recent years due primarily to investments made by the Dept. of Fish and Game's Aquatic Bioassessment Laboratory (DFG-ABL) and the State Water Board's Surface Water Ambient Monitoring Program (SWAMP). California's bioassessment program is currently at a fairly high level (Level 3) and is being used within the recommended scope of that level to support 305(b) assessments and 303(d) listing. Continued investment and active management support will be needed to achieve a fully functional (Level 4) program that will support other regulatory needs and at relevant spatial scales of implementation.

It is clear from the extensive and well organized documentation that was provided before and during the review that California's scientists have a solid conceptual understanding of the steps required to reach the end goal of numerical biological criteria in the state's WQS in order to provide support for all relevant water quality management programs. Timely implementation of biocriteria in California is contingent on continued strong management support.

While the DFG-ABL, SWAMP and their contractors are building a solid technical foundation for a robust freshwater bioassessment program, they can only provide the technical tools for developing biological endpoints and Tiered Aquatic Life Uses (TALUs). The State and Regional Water Boards need additional biologists and planning staff to develop, refine and implement TALUs as envisioned by the USEPA. This review affirms the findings of past peer reviews that the State Water Board needs its own in-house bioassessment coordinator and staff.

Managers at the State Water Board should be aware that the SWAMP program is, with continued management support, capable of building, maintaining and refining the technical tools that the Water Boards will need to incorporate biology into their water quality programs. Implementation of these tools including the development of TALUs, biocriteria and biological endpoints for TMDLs will be a fundamental paradigm shift that will require the detailed involvement of qualified biologists and planning staff. The Water Board's SWAMP program cannot be expected to fulfill those planning and implementation roles. Following U.S. EPA directives and the examples set by many other states, managers at the Water Boards should seek to provide the resources that are necessary to implement the technical bioassessment tools being developed by SWAMP.

As a first step, and consistent with the prior external peer review of SWAMP's bioassessment program (*see* Barbour and Hill 2003), the State Water Board should strive to create and maintain a specialist position for a state-wide bioassessment policy coordinator. The State Water Board needs a high-level in-house bioassessment policy coordinator to shepherd the implementation of the technical tools currently being developed by SWAMP into regulatory framework that is biocriteria and TALU. As the program develops, the State Board should create a team of staff that will work with the coordinator to integrate bioassessment/ biocriteria into the State's water regulatory programs.

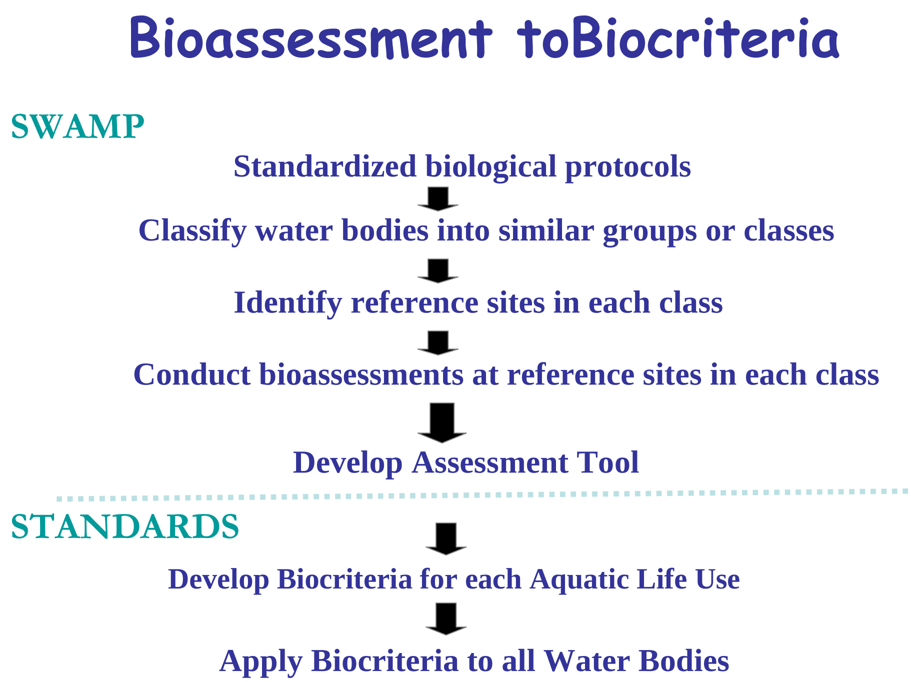

Figure 2. Schematic framework for moving from bioassessment to biocriteria n California.

1. Refine Beneficial Uses. Use refinement is a broad term that encompasses any activity undertaken by a state to review and revise the designated uses applied to its waters. A state may refine its designated uses by revising the language defining what it intends to protect with this particular designated use or by revising a designated use by adopting more refined or specific designated uses in its place.

As recommended by the NRC (2001) and the SPARC (2006), the Water Board should consider refining beneficial uses relating to aquatic life use support. Generic beneficial use designations such as cold water habitat (COLD) simply do not account for the natural variability in rivers and streams across broad biogeographic regions. Cold water habitat in the North Coast is clearly different than cold water habitat in southern California. The State Board should develop a structure for examining the existing structure of designated uses to determine what parts, if any, will need to be changed or refined. This should be consistent with the principles and structure of the Biological Condition Gradient (BCG; U.S. EPA 2005; Davies and Jackson 2006).

The State Board should consider subclassifications of waterbodies in their use refinement process. Subclassifications based on similarities in the natural conditions of the waters could be established from major flowing water classes (such as large rivers, perennial stream, intermittent streams and ephemeral streams) or ecoregions (areas of biogeographic similarity) or a combination of these.

The State Board should support regional efforts to develop tiers of aquatic life uses and expand these efforts statewide. Tiers are subdivisions within subclasses of water based on similarities in the history of anthropogenic disturbance, the resulting biological condition, and the recovery potential within a tier (Figure 3). Tiering of uses based on potential for recovery would also provide a framework for use attainability analyses. We advocate that UAAs be developed carefully and from the perspective of achieving the highest potential for each waterbody. It is tempting to plunge into a UAA process prematurely as a way to resolve impaired waters listings in the short-term, but we recommend that this be reserved for a time when the biocriteria and TALUs are sufficiently developed.

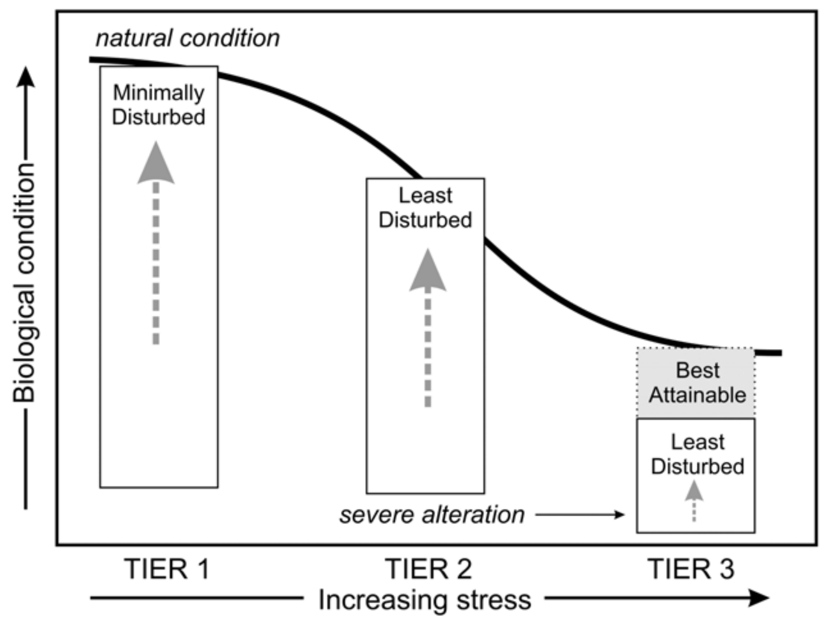

Figure 3. The biological condition gradient (BCG) used to define stream condition tiers in the TALU framework. Boxes indicate the expected range of biological condition scores at sites within each tier. Figure modified from Stoddard et al. 2006.

2. Develop Biological Objectives. The Water Board should develop statewide narrative biological objectives (biocriteria) to protect beneficial uses in Basin Plans that are associated with aquatic life use support. This should not preclude efforts by Regional Water Boards to develop biocriteria. However, many Regional Water Boards lack tools for interpreting existing narrative objectives in their Basin Plans. Currently, bioassessment data are used by Regional Water Boards in an "informal" manner where the assessments are used to support attainment decisions, but they lack any formal linkage to a designated aquatic life use. This lack of formal regulatory linkage to beneficial uses will limit the fuller use and true potential of bioassessment as a regulatory tool.

Biocriteria should be developed at both the State Board and Regional Board levels. However, development of numeric biocriteria will need to proceed in a series of phases. A key first step is the development of a statewide narrative objective that would set a common framework for the development and application of bioassessment tools to beneficial use protection. The interim step of developing statewide narrative biocriteria following the model set forth by Oregon Department of Environmental Quality (ODEQ) is likely to be an effective first step in California.

Numeric biological criteria could then be achieved with the addition of defining language that pertains to the subclassification of different types of streams and rivers, ecotype specificity, biogeographical regions, and the level of protection afforded by tiered uses. It may be possible to use the predicted taxa list generated by the RIVPACs model to help identify highest attainable use for perennial streams across the state.

ODEQ's Statewide Narrative Criterion

Waters of the State shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.

Without detrimental changes in the resident biological communities means no loss of ecological integrity when compared to natural conditions at an appropriate reference site or region.

Ecological integrity means the summation of chemical, physical, and biological integrity capable of supporting and maintaining a balanced, integrated adaptive community of organisms having a species composition, diversity, and functional organization

3. Develop Implementation Plan for Narrative Criteria: Biological criteria may appear to be more complicated to implement than traditional water quality criteria, but mostly because they achieve a congruence with natural factors that chemical criteria can not. A plan should be written which describes the technical components of the biocriteria (i.e., how to interpret biological data) as well as the policy components of the biocriteria (i.e., how they are to be used in programs. Technical tools and training will be necessary for staff, permittees and the general public. Policies will need to be developed regarding use of biocriteria in 305(b) assessments, 303(d) listings, NPDES monitoring, compliance and enforcement and in TMDLs. The State Water Board needs a high-level in-house bioassessment policy coordinator in order to shepherd the implementation of the technical tools currently being developed by SWAMP.

Part 4. Summary Conclusions

The State Board monitoring and assessment program is presently operating a high quality bioassessment program at the state level and in selected regions. The information that we gathered and reviewed shows that the statewide program operates at level 3 (the two regional board programs are borderline L3), and that the ongoing development activities will eventually result in a level 4 program in perhaps 4 - 5 years. These developmental tasks are one and the same as those that are necessary for developing biocriteria within a TALU framework. Hence this developmental process should deliver the technical capacity to support full TALU implementation.

SWAMP has and is making very effective use of their current resources to develop bioassessment tools which will support water quality programs (Figure 1). This means that SWAMP is positioned to provide data and information for more than general status assessments as required by Sections 303d and 305b, but to all Water Board programs including NPDES, NPS and TMDLs. These programs rely on monitoring and assessment information to provide an accurate and complete delineation of waterbody impairments and their associated causes. SWAMP data can also provide measures of the overall environmental outcomes produced by Water Board programs.

It is clear from examples in other States (Rankin 2003; U.S. EPA 2005) that a TALU based program will be a direct benefit to the California WQS, TMDL, NPDES permitting, and other water quality management programs (Figure 4). A TALU based approach would result in more refined aquatic life use designations that are appropriate to various water body types throughout the state. It would also lead to more specific biological objectives that are tailored to protect aquatic life in these waterbodies.

These biological objectives could be used to support listing and delisting decisions made by the Regional Boards. The tiered objectives can be used by Water Board programs to establish incremental goals for improvement for impaired waters. The objectives can also be used by the Water Boards to identify the high quality waters in the state and serve as backstops to ensure that these high quality waters are not degraded

The SWAMP program is developing a white paper to outline the technical infrastructure elements and identify current and future research needs to support bioassessments in California. A second white paper is being developed to identify the programmatic and policy issues that are necessary to move from bioassessments to biocriteria and TALU. These would provide the framework for developing TALU in California. Both Maine and Ohio provide case histories that describe the evolution of each program's WQS and monitoring and assessment program to the attainment of level 4. These case studies are included in the EPA TALU document (U.S. EPA 2005; Appendices A and B). In addition, states that are involved in detailed developmental projects (e.g., Minnesota) can also provide a measure of comparability via their experiences.

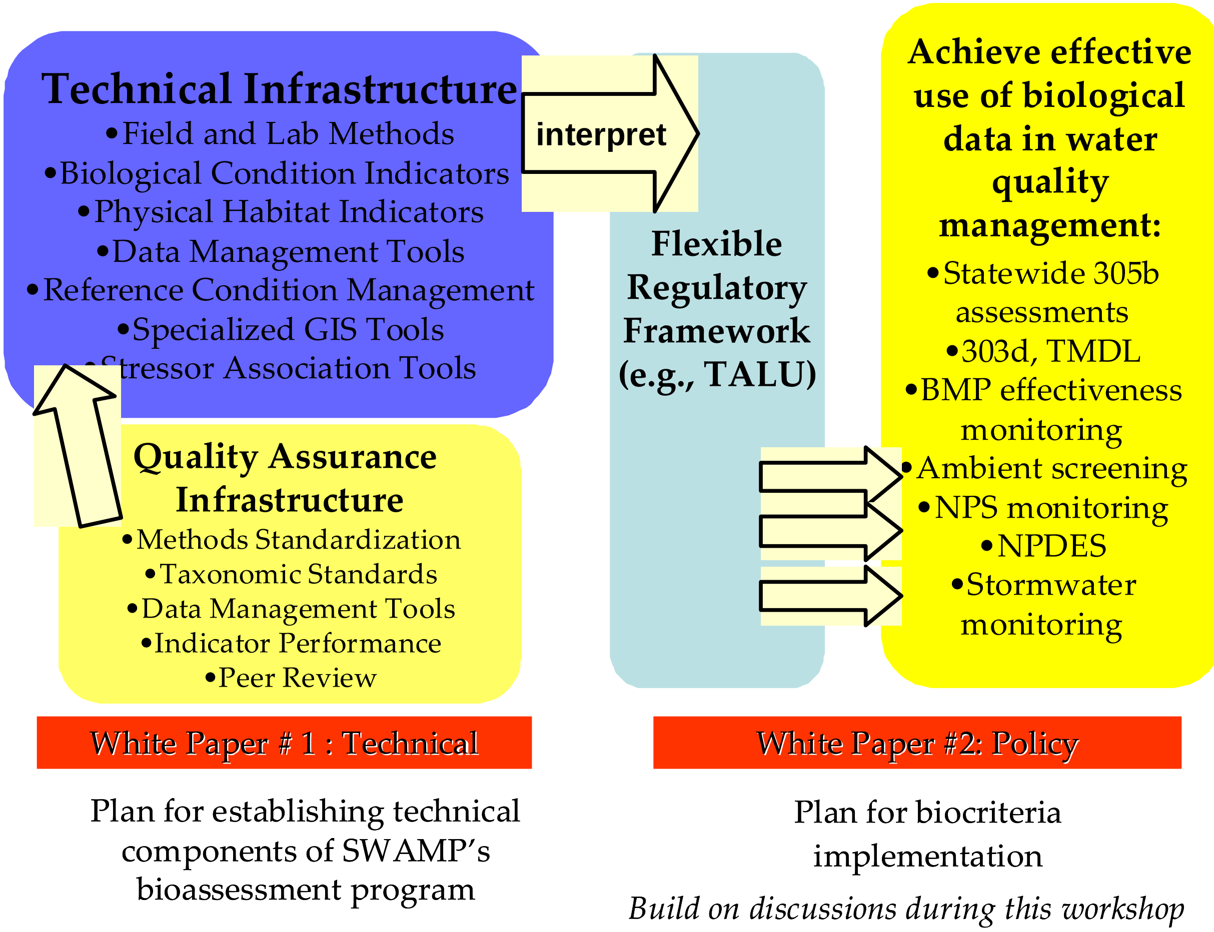

Figure 4. Process being used by the State Water Board to develop the technical infrastructure needed to use biological assessments and biocriteria within a TALU framework to provide full water quality management program support.

It is recognized here that this evaluation is a first step towards identifying the specific actions and needs of the California program to attain a level 4 program and achieve the support role for all management programs that is envisioned by the TALU process (U.S. EPA 2005; Barbour and Yoder 2007). Chapter 5 of the EPA TALU document describes the general milestones that a state program can use to gauge their own progress. This is now amplified in the 2008 update of the Critical Elements document using an active state development process as a working example (Barbour and Yoder 2008). The State Board should consider using the framework outlined in Figure 5 below to determine their existing position. This would accomplish an "inventory" of the existing program and determine what components are "TALU ready" and which areas are in need of further development and in which priority. Once this is done, a specific plan and timeline can be developed. At this time, we would estimate at least 5+ years to accomplish the tasks associated with full TALU development, but some aspects could be done more quickly if given a higher priority.

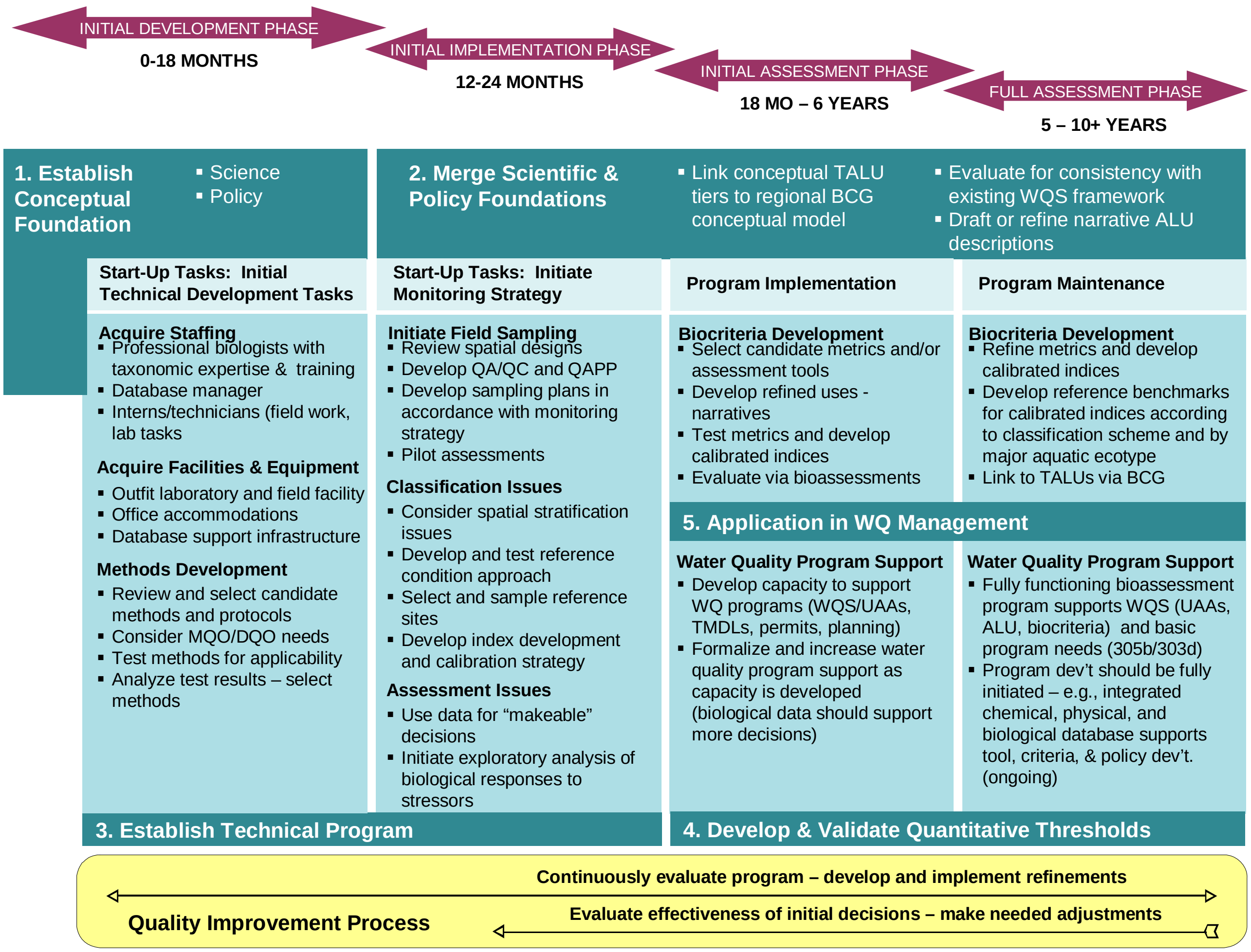

Figure 5. Hypothetical timeline for moving from bioassessment to biocriteria (U.S. EPA 2005).

The review of the California WRCB monitoring and assessment and WQS programs and the Critical Technical Elements results can be used to identify the specific technical and programmatic aspects that are in need of further development, refinement, and/or additional resources to accomplish full TALU program development. This review process is an essential component of the implementation process as generalized in *"Use of Biological Information to Better define Designated Aquatic Life Uses in State and Tribal Water Quality Standards: Tiered Aquatic Life Uses (August 2005)"* (U.S. EPA 2005). This includes general guidance and case examples for developing and implementing a TALU-based approach to monitoring and assessment and water quality standards (WQS) by States and Tribes. It contains a hypothetical timeline (Figure 5) that describes a sequence of steps including the development of a baseline bioassessment program (already in place via SWAMP), initial support for baseline management programs (partially in place and in selected Water Boards), development of narrative and numeric biocriteria (concept in place), increasingly sophisticated support for all relevant water quality management programs (yet to be accomplished), and long term maintenance of the program (the result of full TALU program development and implementation). The ultimate goal is the adoption of numeric biocriteria and Tiered Aquatic Life Uses (TALU) in the California WQS.

This template provides a framework within which the State can first determine where their program is along the timeline in Figure 5.

We expect that California will be positioned “somewhere” along the TALU timeline once a detailed exercise is undertaken to inventory the existing program. The “position” along the timeline is determined by first conducting a baseline review of the state programs and its technical elements, which is represented by this memorandum. The development of a full TALU program could take several years if a State or Tribe is starting from “scratch”. However, it is likely that States and Tribes already operate at least a basic program (i.e., Level 2; Yoder and Barbour 2009) and will likely determine that the time for implementing a more refined program consistent with Level 4 is considerably less than the 10 years depicted in Figure 5. Based on the information garnered by this baseline review we expect that the development of the bioassessment program via SWAMP and select Region Boards will show California to be further along this timeline than most states given the Level 3 status of the current program. We do recommend that this be done considering the unique roles of the statewide SWAMP program and the Regional Board programs in TALU implementation.

We recommend that the next step for California is to use this process to determine “where” the program currently stands and what tasks are yet to be accomplished to reach the above stated program goals. This process is a prerequisite to producing a detailed plan for the eventual development and adoption of TALU based narrative and numeric biocriteria in the California WQS, supported by a Level 4 program. The example in the latest draft of the Critical Technical Elements (Barbour and Yoder 2008) represents a working example of how California can use the results of the baseline program review and CE process to develop a “blueprint” for making orderly improvements and attaining full TALU status. This will include a mix of technical and policy development tasks.

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Appendix Table 1. List of Participants

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Appendix Table 2. A checklist for evaluating the degree of development for each technical element of a bioassessment program and associated comments on the elements for the California WRCB bioassessment program (both SWAMP and applicable Regional Boards). The point scale for each element ranges from lowest to highest resolution (na – not applicable).

Element 1	(Lowest) 1.5	2.0 2.5	3.0 3.5	4.0 4.5 (Highest)	**Comments**
Index Period	Collection times are variable throughout the year, and sampling is performed without regard to seasonal influences.	An index period is conceptually recognized, but sampling may take place outside of this period for convenience or to match existing programs; sampling outside of the index is not adjusted for seasonal influences.	A well-documented seasonal index period(s) is calibrated with data for reference conditions, but sampling may take place outside of this period for convenience or to match existing programs; sampling outside of the index is adjusted for seasonal influences. Index periods are selected based on known ecology to minimize natural variability, maximize gear efficiency, and maximize the information gained about the assemblage.	Same as Level 3, but administrative needs and index periods fully reconciled. Scientific basis of temporal sampling influences management decision framework.	April-October seasonal index period that "slides" from south to north: SoCal – April to early June; NoCal – August to September; most regional boards adhere to this, but some do not to accommodate program support needs. **Points** **Statewide: 4.5** **Regional: 4.0**

Element 2	(Lowest) 1.5	2.0 2.5	3.0 3.5	4.0 4.5 (Highest)	**Comments**
Spatial Coverage	An individual site is used for assessment of watershed condition; simple upstream/ downstream and fixed station designs prevail; assessments at local scale.	Multiple sites are used for watershed assessment; spatial coverage only for questions of general status or locally specific problem areas; synoptic (non-random) design at coarse scale (e.g., 8-digit HUC common); spatial extrapolation is based on "rules of thumb"; may be supplemented by simple upstream/downstream assessments.	Spatial network suitable for status assessments; statewide spatial design using rotating basins with single purpose design at coarse scale (e.g., 8 digit HUC); may be supplemented by occasional intensive surveys.	Comprehensive spatial network suitable for reliable watershed assessments in support of multiple water quality management programs at more detailed scale (e.g., 11-14 digit HUC); statewide rotating basin approach or similar scheme to complete statewide monitoring in a specified period of time; multiple spatial designs appropriate for multiple issues.	Statewide probability design (WEMAP) and "pour point" integrator sites at 8 digit HUC scale; Regional boards employ watershed scale intensive survey designs at HUC 11 scale (currently in 4 of 9 regions). **Points** **Statewide: 3.5** **Regional: 4.0** **Combined: 4.0**

Appendix Table 2. (continued)

Element 3	(Lowest) 2.0	2.5 / 3.0	3.5 / 4.0	4.5 / 5.0 (Highest)	Comments
Natural Classification	No partitioning of natural variability in aquatic ecosystems. Minimal classification limited to individual watersheds or basins with generalized stratification on a regional basis; does not incorporate differences in stream characteristics such as size, gradient.	Classification recognizes one stratum, usually a geographical or other similar organization such as fishery based cold or warmwater, and is applied statewide; lacks other intra-regional strata such as watershed size, gradient, elevation, temperature, etc.	Classification is based on a combination of landscape features and physical habitat structure (inter-regional); achieves highest level of classification possible by considering all relevant intra-regional strata and subcategories of specific stream types.	Fully partitioned and stratified classification scheme based on a true regional approach that transcends jurisdictional (i.e., State) boundaries to strengthen inter-regional classification and recognizes zoogeographical aspects of assemblages.	Classification includes intra-regional factors such as watershed size, elevation, and other stratifying factors; not yet developed for all bioregions. **Points** **Statewide: 3.5** **Regional: na**

Element 4	(Lowest) 2.0	2.5 / 3.0	3.5 / 4.0	4.5 / 5.0 (Highest)	Comments
Criteria for Reference Sites	No criteria, except informal BPJ selection of control sites. May be little documentation and supporting rationale.	Based on "best biology", i.e., BPJ on what the best biology is in the best waterbody; minimal non-biological data used.	Non-biological criteria supported by narrative descriptors only; combine BPJ with narrative description of land use and site characteristics; may use chemical and physical data thresholds as primary filters.	Quantitative descriptors used to support non-biological criteria; characteristics of sites are such that the best biological organization expected to be supported; chemical and physical characteristics of sites used only as secondary and tertiary filters to avoid circularity in other criteria.	A quantitative procedure for screening reference sites is used; **Points** **Statewide: 5.0** **Regional: na**

Appendix Table 2. (continued)

Element 5	(Lowest) 1.0 / 1.5	2.0 / 2.5	3.0 / 3.5	4.0 (Highest)	Comments
Reference Conditions	No reference condition; presence and absence of key taxa or best professional judgment. rather than established reference conditions may constitute the basis for assessment.	Reference condition based on biology of a 'best' site or waterbody; a site-specific control or paired watershed approach may be used for assessment; regional reference sites lacking.	Reference conditions based on site-specific data, but are used in watershed scale assessments; regional reference sites are conceptually recognized, but are too few in number and/or spatial density to support the deviation of biocriteria.	Applicable regional reference conditions are established within the applicable waterbody ecotypes and aquatic resource classes; consist of multiple sites that either represent reference or are along the BCG in such a manner to allow extrapolation of expected conditions for assessing and monitoring within waterbody ecotype. Re-sampling of reference sites done systematically over a period of years.	Development of regional reference condition is in progress – not yet completed for all regions. **Points** **Statewide: 3.5** **Regional: na**

Element 6	(Lowest) 2.0 / 2.5	3.0 / 3.5	4.0 / 4.5	5.0 (Highest)	Comments
Taxonomic Resolution	Gross observation of biota; single assemblage only; very low taxonomic resolution (e.g., order/family level for macro-invertebrates.; family for fish by non-biologists).	Single assemblage (usually macroinvertebrates); low taxonomic resolution (e.g., family level) by experienced biologists.	Single assemblage with high taxonomic resolution (e.g., "lowest practical" i.e., genus/species); if multiple assemblages, others are lower resolution or infrequently used.	Two or more assemblages with high taxonomic resolution (e.g., "lowest practical" i.e., genus/species); capacity to use each assemblage concurrently is maintained; practitioners are certified in accordance with available offerings (e.g., NABS, state credible data provisions).	Statewide program employs lowest practicable taxonomy (usually genus/species); SoCal employs genus level; second assemblage (periphyton) is under development; fish may be used regionally. **Points** **Statewide: 4.5** **Regional: 4.5**

Appendix Table 2. (continued)

Element 7	(Lowest) 2.0	2.5 3.0	3.5 4.0	4.5 5.0 (Highest)	Comments
Sample Collection	Approach is cursory and relies on operator skill and BPJ, producing highly variable and less comparable results; Training limited to that which is conducted annually for non-biologists who compose the majority of the sampling crew. Documentation of methods more as an overview.	Textbook methods are used rather than in-house development of detail of SOPs to specify methods; a QA/QC document may have been prepared; training consists of short courses (1-2 days) and is provided for new staff and periodically for all staff.	Methods are evaluated and refined (if needed) for State purposes; detailed and well documented; SOPs are updated periodically and supported by in-house testing and development; a formal QA/QC program is in place with field replication taken; rigorous training is for all professional staff, regardless of skill mix to raise skill levels and enhance interaction and consistency.	Same as Level 3, but methods cover multiple assemblages.	Sample collection methods are fully developed for two assemblages (macroinvertebrates, periphyton); fish methods also exist in other agencies. **Points** **Statewide: 5.0** **Regional: 5.0**

Element 8	(Lowest) 2.0	2.5 3.0	3.5 4.0	4.5 5.0 (Highest)	Comments
Sample Processing	Biological samples are processed in the field using visual guides; sorting and identification are dependent on operator skill and effort.	Organisms are identified and enumerated primarily in the field prohibiting ample QC but done by trained staff; for fish cursory examination of presence and absence only; no in-house development of SOPs.	Laboratory processing of all samples (except for fish); A formal QA/QC program is in place; rigorous training is provided; vouchering of organisms done for ID verification.	Same as Level 3, but is applicable to multiple assemblages; subsampling level tested. Notations made on fish as to diseased, erosion, lesion, tumors.	Sample processing fully developed for statewide program and for two assemblages; some regional programs are not as well developed. **Points** **Statewide: 5.0** **Regional: 4.0**

Appendix Table 2. (continued)

Element 9	(Lowest) 2.0	2.5 3.0	3.5 4.0	4.5 5.0 (Highest)	Comments
Data Management	Sampling event data organized in a series of spreadsheets e.g., (by year, by data-type, etc); QC cursory and mostly for transcription errors.	Separate quasi-databases for physical-chemical and biological data (Excel, Access, dBase, etc) with separate GIS shape files of monitoring stations; data-handling methods manuals available; QC for data entry, value ranges, and site locations.	True relational database containing biological and sampled site info (Oracle, etc); fully documented and implemented data QAPP.	Relational database of bioassessment data (including indices and biocriteria) with real-time connection to spatial data coverage showing monitored sites in relation to other relevant spatial data layers (population density; impervious surfaces; vegetation coverage, low-flight photos, nutrient concentrations, ecoregion, etc); fully documented and implemented data QAPP; data available from multiple assemblages to enable integrated analysis.	**Points** **Statewide: 4.5** **Regional: 3.0**

Element 10	(Lowest) 1.5	2.0 2.5	3.0 3.5	4.0 4.5 (Highest)	Comments
Ecological Attributes	Linkage to the BCG or adherence to the basic ecological attributes as a foundation is lacking; simple measures of presence/absence.	Only inferences can be made for a few of the comparatively simple ecological attributes, e.g., sensitive/tolerant taxa of a ubiquitous nature; single dimension measures used.	Ecological attributes used as a foundation for bioassessment, but may not be fully developed, or may be lacking. BCG incorporated into conceptual underpinnings.	The ecological attributes of the BCG form the conceptual foundation; level of rigor represents or extends to all underpinnings of the ecological attributes.	Statewide O/E model and 3 regional MMIs have been developed; periphyton index under development. **Points** **Statewide: 4.0** **Regional: na**

Appendix Table 2. (continued)

Element 11	(Lowest) 1.0 — 1.5	2.0 — 2.5	3.0 — 3.5	4.0 (Highest)	Comments
Biological Endpoints and Thresholds	Assessment may be based only on presence or absence of targeted or key species; (Some citizen monitoring groups use this level); attainment thresholds not specified; this approach may be sufficient for Coarse problem identification. Coarse method (low signal) and detects only high and low values.	A biological index or endpoint is established for specific water bodies, but is likely not calibrated to waterbody classes or statewide application; index is probably relevant only to a single assemblage; presence/absence based on all taxa; BPJ thresholds based on single dimension attributes. Limited to pass/fail determinations of attainment status that does not reflect incremental measurement along the BCG.	A biological index, or model, has been developed and calibrated for use throughout the State or region for the various classes of a given waterbody type; the index is relevant to a single assemblage; attainment thresholds are based on discriminant model or distribution of candidate reference sites, or some means of quantifying reference condition. Can distinguish 3-4 increments along the BCG; supports narrative evaluations based on multimetric or multivariate analysis that are relevant to the BCG.	Biological index(es), or model(s) for multiple assemblages is (are) developed and calibrated for use throughout the State or region and corresponds to the BCG; integrated assessments using the multiple assemblages are possible, thus improving both the assessment and diagnostic aspects of the process; multiple parameters for evaluation, based on integrated data calibrated to regional reference condition. Able to detect status (integrated signal) on a continuous scale along the BCG; power to detect at least 5-6 categories of condition.	O/E model is statewide; MMI developed for selected regions; periphyton in development. **Points** **Statewide: 3.5** **Regional: na**

Element 12	(Lowest) 1.0 — 1.5	2.0 — 2.5	3.0 — 3.5	4.0 (Highest)	Comments
Diagnostic Capability	Diagnostic capability lacking.	Coarse indications of response via assemblage attributes at gross level, i.e., general indicator groups (e.g., EPT taxa); Supporting analysis across spatial and temporal scales limited.	More detailed development of indicator guilds and other aggregations to distinguish and support causal associations; usually involves refined taxonomy (at least genus level); supported by analysis of larger datasets and/or extensive case studies; patterns repeatable across different sources; developed for a single assemblage only.	Response patterns are most fully developed and supported by organized and extensive research and case studies across spatial and temporal scales; results are actively used in biological assessment and in assigning associated causes and sources for program support purposes; involves refined taxonomy; accomplished for two assemblage groups.	Baseline research to support diagnosis has not been completed; baseline database is being developed – need to assure full range of stress:response in statewide and regional datasets. **Points** **Statewide: 2.5** **Regional: na**

Appendix Table 2. (continued)

Element 13	(Lowest) 1.5	2.0 2.5	3.0 3.5	4.0 4.5 (Highest)	Comments
Professional Review and Documentation	Review limited to editorial aspects.	Internal scientific review only, Outside review for objectivity left for higher levels.	Outside review of documentation and reports conducted. However, selection of peer review can be subjective.	Formal process for technical review to include multiple reference and documented system for reconciliation of comments and issues. Process results in methods and reporting improvements. Can include peer-reviewed journal publications.	A formal process is in place and is used; methods and protocols are in the process of being published in journals. **Points** **Statewide: 4.5** **Regional: na**

Statewide CE Score = 53 (Regional = 50.5)
Statewide CE % = 88.3% (Regional = 84.2%)
Statewide Level = L3 [85-95%] (Regional Level = L2 [70-85%])

Appendix Table 3. Summary of the critical technical elements evaluation for the California WRCB statewide bioassessment program conducted January 23-25, 2008.

Element	Comment
Element 1: Index Period Maximum score = 4.5 Statewide = 4.5 Regional = 4.0	The statewide program adheres to a standardized index period that slides from north to south. The regional board score will improve to 4.5 once the standard permit boilerplate language developed by the Lahontan Region is standardized statewide.
Element 2: Spatial Coverage Maximum score = 4.5 Statewide = 3.5 Regional = 4.0 Combined = 4.0	The current score of 3.5 for the statewide program reflects the statewide probabilistic design and "pour point" design for integrator sites. Regional boards apply watershed scale designs that include a resolution at an 8-11 digit HUC spatial scale and other designs such as upstream/downstream sampling. The regional board score of 4.0 reflects the watershed design and rotating subbasin approach applied by some, but not all boards. The combined score of 4.0 reflects the practical integration of the statewide and regional board programs as a reflection of the overall WRCB effort. Attaining a score of 4.5 will be realized when the watershed design is applied by all of the regional boards.
Element 3: Natural Classification Maximum score = 5.0 Statewide = 3.5 Regional = na	The CE score of 3.5 will be elevated to 5.0 with the developments that are already underway including the inclusion of other bioregions (the na score for the regional boards reflects the relevancy of this element to a statewide setting).
Element 4: Criteria for Reference Sites Maximum score = 5.0 Statewide = 5.0 Regional = na	The score of 5.0 for the statewide program reflects the high degree of development of reference site selection criteria and procedures (the na score for the regional boards reflects the relevancy of this element to a statewide setting).
Element 5: Reference Conditions Maximum score = 4.0 Statewide = 3.5 Regional = na	The CE score of 3.5 should improve to 4.0 with the addition of regional reference sites that are being established as part of the ongoing improvements described for elements 3 and 4 (the na score for the regional boards reflects the relevancy of this element to a statewide setting).

Appendix Table 3. (continued).

Element	Comment
Element 6: Taxonomic Resolution Maximum score = 5.0 Statewide = 4.5 Regional = 4.5	The CE score of 4.5 reflects the full development of the macroinvertebrate assemblage and the in progress development of a periphyton indicator. Fish may be applicable in certain regions pending developments by USGS. Reaching the CE score of 5.0 is contingent on the full development and use of a second assemblage.
Element 7: Sample Collection Maximum score = 5.0 Statewide = 5.0 Regional = 5.0	The CE score of 5.0 reflects the full development of the macroinvertebrate and periphyton assemblage methodologies for the statewide and regional programs. Fish methods also exist n other agencies.
Element 8: Sample Processing Maximum score = 5.0 Statewide = 5.0 Regional = 4.0	The CE score of 5.0 for the statewide program reflects the full development of the macroinvertebrate and periphyton assemblage sample processing methods. The regional boards have the capacity to apply the macroinvertebrate assemblage. Reaching the CE score of 5.0 is contingent on the full use of a second assemblage by the regional boards.
Element 9: Data Management Maximum score = 5.0 Statewide = 4.5 Regional = 3.0	The CE score of 4.5 for the statewide program can be improved to 5.0 once the current data management system includes all reporting fields and calculation routines. The regional board score should likewise improve when their data is routinely uploaded to the statewide data management system.
Element 10: Ecological Attributes Maximum score = 4.5 Statewide = 4.0 Regional = na	The CE score of 4.0 should increase with the development of the macroinvertebrate MMI and O/E model for all bioregions and the addition of a second assemblage (the na score for the regional boards reflects the relevancy of this element to a statewide setting).
Element 11: Biological Endpoints & Thresholds Maximum score = 4.0 Statewide = 3.5 Regional = na	The CE score of 3.5 will improve with the full development of the macroinvertebrate MMI and O/E models, a second assemblage, and the derivation of appropriately detailed numeric biocriteria (the na score for the regional boards reflects the relevancy of this element to a statewide setting).

Appendix Table 3. (continued).

Element	Comment
Element 12: Diagnostic Capability Maximum score = 4.0 Statewide = 2.5 Regional = na	The comparatively low CE score of 2.5 is a common characteristic of bioassessment programs that are in development and/or which have singularly been focused on status assessments. Improving the score for this element will occur as a result of addressing preceding elements 2, 3, 6, 10, and 11 and gaining a familiarity with how diagnostic capacity is developed; a familiarity with the concepts involved is encouraging. This will require some dedication to exploratory analyses in which the response of the biological assemblages is evaluated along the stressor axis of the BCG.
Element 13: Professional Review Maximum score = 4.5 Statewide = 4.5 Regional = na	The CE score of 4.5 reflects a thorough and complete peer review process. Statewide methods and procedures are in the process of being published in refereed journals.