

DRAFT

Quality Assurance Project Plan

for the

Development of a Wetland Rapid Assessment Method in California: Phase II

Funding Numbers: CD-97954801-6, CD-96911101 and, CD-96911301

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Southern California Coastal Water Research Project²

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Development of a Wetland Rapid Assessment Method in California: Phase II**

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Table of Contents

Distribution List	4
Field Equipment List.....	4
1. Overall Goals and Objectives	5
2. Organizational Structure	7
2.1 Responsibilities of Principal Investigators (PIs), Core Team, and Regional Teams	7
Figure 1. Organizational Chart showing the lines of communication among project participants.	12
3. Conceptual Models	12
3.1. Wetland Form, Function, and Controlling Factors	12
Figure 2. Diagram of primary factors that control wetland form and function.....	13
3.2. The EPA Three-tiered Approach to Wetland Monitoring	13
Figure 3. Conceptual model of the EPA 3-tiered approach to wetland monitoring.....	14
3.2.1. CRAM Developmental Framework	15
4. CRAM Calibration Steps	15
4.1. Completion of Verification	15
4.2. Calibration Approach.....	15
4.3. Calibration of Overall CRAM Score	16
4.4. Calibration of CRAM Attributes	16
Table 1. Major data sets identified for initial use in calibrating CRAM at the attribute and metric levels.	17
4.5. Calibration of CRAM Metrics	18
4.6. Selection of Calibration Sites.....	19
4.7. Obtaining CRAM Data from each Calibration Site	20
4.8. Selection Criteria for Level III Data Sets for CRAM Calibration	21
4.9. Description of Existing Level-III Data Sets	22
4.9.1. MAPS Bird Data	22
4.9.2. EMAP Vegetation Data	23
4.9.3. Bioassessment Data	24
4.10. Collection of New Data for Calibration	24
4.10.1. Estuarine Vegetation Data	24
4.10.2. Riverine Channel Morphology Data	24
4.11. CRAM Phase II (Calibration) Timeline.....	25
5. Quality Assurance Methods	26
5.1. CRAM Score Variation within and among Field Teams	26
5.1.1. CRAM Training	26
5.1.2. Field Replications and Standardization	27
Table 2. CRAM Metric Data Quality Objectives.	28
5.1.3. Within Each Regional Team	28
5.1.4. Among Teams within a Region	28
5.1.5. Among Regions	29
5.1.6. CRAM Support Materials.....	29
5.2. Quality Assurance Requirements for Third-party Data Sources	29
Table 3. Quality Control Measures for Instruments.....	31

5.3.	Data sources	32
5.4.	Precision, Accuracy, and Completeness	32
5.5.	Site Selection	33
5.6.	Ground-Truthing	33
6.	Data Management	33
6.1.	CRAM Access Database Internal Quality Assurance Checks	34
6.2.	Review, Validation, and Verification of Phase II Information	34
6.3.	Uploading Field Data into the Database	34
6.4.	Report.....	35
6.5.	Assessment and Oversight	36
6.6.	Corrective Actions	36
7.	References	37
	Appendix A: List of Acronyms.....	38
	Appendix B: List of sites with Level-III data for use in CRAM calibration.....	39
	Appendix C: CRAM User’s Manual v 3.0.....	40
	Appendix D: MAPS protocol	41
	Appendix E: EMAP protocol and QAPP.....	42
	Appendix F: California Stream Bioassessment Procedure (CSBP) protocol	43
	Appendix G: Riverine Geomorphology data sheet.....	44
	Appendix H: Bioassessment QAPP	45

Distribution List

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Dario Diehl – SCCWRP
Josh Collins – SFEI
Martha Sutula – SCCWRP
Ross Clark – CCC
Don Steven – OSU
Stacey Kim – MLML
Cristina Grosso – SFEI

Field Equipment List

Digital camera
Handheld GPS
Plant taxonomic guide (Hickman, 1993)
Tape measure
Rangefinder
Plant press
Data sheets
Clipboard
Site map / imaging
Tablet computer, loaded with CRAM Access database (optional)

1. Overall Goals and Objectives

The overall goal of the project is to develop a Rapid Assessment Method (RAM¹) for wetlands in California. The California RAM (CRAM) will be based on approaches created in other states, especially Washington and Ohio, where RAMs are routinely used to assess wetland resources. The CRAM will initially focus on wetlands in the coastal watersheds in the geographic vicinity of three collaborating teams: the San Francisco Bay Area, the central coast, and the Southern California Bight. An organizational structure is in place to foster collaboration and coordination among the CRAM development teams.

The CRAM will assess individual wetlands based on visible conditions that indicate functional levels of support for beneficial uses and ecological services. A major aspect of CRAM development will therefore be field tests to identify suites of visible conditions, termed “metrics”, that indicate important wetland functions.

For each HGM class of wetland, our effort to develop the CRAM involves 3 basic analytical steps: (1) *semi-quantitative verification* of the metrics based on best professional judgment of their suitability to describe wetland conditions in the study areas (this step was completed in March 2004); (2) *quantitative calibration* using existing and new data sets to examine the relationship between the metrics and levels of the highest priority functions (this is the subject of this version of the Quality Assurance Project Plan (QAPP)); and (3) eventual *validation* of the calibrated CRAM (which would be the subject of a subsequent QAPP update, pending availability of funding for this next phase of CRAM development).

There may be regional differences in wetland function that will translate into regional modules in the CRAM, but we will strive to develop a CRAM that pertains to all wetlands of the state as a whole. We expect that calibration and validation will be ongoing to account for changes in wetland science and management priorities.

The overall goal of CRAM is to provide a rapid, scientifically defensible, and repeatable assessment methodology that can be used routinely in wetland monitoring and assessment programs. CRAM should be applicable to wetlands and streams throughout the state of California. The general framework of CRAM should be consistent across wetland types and statewide, yet allow for customization to address special characteristics of different regions and wetland classes.

CRAM is designed for routine use in local, regional, and statewide programs to monitor wetlands. It provides a consistent approach, without neglecting characteristic differences in wetland form or function between regions or between types of wetlands. CRAM is mainly intended for cost-effective, ambient monitoring and assessment at different scales, ranging from individual wetlands to watersheds, regions within the state, and to the state as a whole. The use of CRAM for ambient monitoring will, over time, help wetland managers and scientists quantify

¹ Appendix A contains a list of all the acronyms used in this document.

the relative influence of anthropogenic stress, management actions, and natural disturbance on the spatial and temporal variability in reference conditions. This information can then be used in the design, management, and assessment of wetland projects.

Additional, specific applications of CRAM could include: (1) preliminary assessments of wetland conditions and stressors to determine the need for intensive monitoring; (2) evaluation of wetland project performance under the Coastal Zone Management Act, Section 1600 of the California State Fish and Game Code, Sections 401 and 404 of the Clean Water Act, and local government wetland regulations; and (3) assessment of restoration or mitigation progress relative to ambient conditions, reference conditions, and expected ecological trajectories.

CRAM is not intended to replace any existing tools for, or approaches to, monitoring or assessment, and CRAM will be used at the discretion of governmental agencies and other organizations. For the assessment of compensatory mitigation projects and very large restoration projects, CRAM may augment standardized intensive monitoring.

The overall goals and objectives of the project are being pursued in two distinct phases.

Phase I: CRAM DEVELOPMENT AND VERIFICATION – Completed as of March 2004

- Objective 1:** Completion of a literature search and review of existing RAMs from other states and eco-regions for inclusion in a draft CRAM.
- Objective 2:** Development of a draft CRAM User's Manual for review by the Core Team and Regional Teams. The draft version (2.0) is the product of feedback and modifications by Core and Regional Teams.
- Objective 3:** Verification of the CRAM for subsequent *calibration* and *validation* by performing semi-quantitative analyses of the suitability of the draft metrics and scoring systems based on field testing by the Regional Teams. The result of the verification exercise, which was completed in March 2004, were used in making revisions to the CRAM User's Manual, resulting in CRAM version 3.0, which was completed in September 2004.

PHASE II: CRAM CALIBRATION AND VALIDATION

- Objective 4:** Calibration of CRAM at a range of reference sites. Version 4.0 of the CRAM will be developed from the draft CRAM (v 3.0) based on these calibration results. Calibration of two of the seven wetland classes recognized by CRAM (estuarine and riverine) is the subject of this QAPP update. Future calibration of additional classes will require (an) additional updates of this QAPP.
- Objective 5:** Validation of CRAM version 4.0, the intent of which is to test the ability of the CRAM to distinguish among minimal, moderate, and severe levels of anthropogenic stress. Validation will need to be preceded by an additional QAPP update. Because validation is not a part of the scope of work under current funding, it will not be completed within the time span of this project.

2. Organizational Structure

This interdisciplinary project will be conducted by the Principal Investigators from the San Francisco Estuary Institute (SFEI), the Southern California Coastal Water Research Project (SCCWRP), and the California Coastal Commission (CCC)/Moss Landing Marine Laboratory (MLML). The PIs will be advised by a Core Team of state and federal agency representatives and academic scientists, with statistical guidance and oversight by Prof. Don Stevens of Oregon State University, whose assistance in this project is currently supported through an EPA Star Grant, and overall review by three Regional Teams representing the Southern California Bight, the central coast of California, and the San Francisco Bay Area. Figure 1 depicts the key individuals involved in calibration of CRAM, which is the subject of this Quality Assurance Project Plan, and indicates the lines of communication between the various parties.

2.1 Responsibilities of Principal Investigators (PIs), Core Team, and Regional Teams

1. Principal Investigators

- a. Organize the research approach to meet the project goals and objectives.
- b. Develop plans for compiling, verifying, and transmitting field data from the Regional Teams to data managers at SFEI, SCCWRP, and MLML.
- c. Analyze data provided by the Regional Teams.
- d. Prepare CRAM documents including outreach materials, instruction manuals, and interim and final reports for calibration, demonstration and validation of the CRAM.
- e. Present CRAM development and results at scientific conferences and write manuscripts for scientific publications.

2. Core Team

- a. Advise and review the work of the PIs to standardize and integrate across CRAM development teams.
- b. Lead the Regional Teams during calibration, demonstration, and validation efforts.
- c. Organize, supervise, and provide logistical support for the Regional Teams, including securing all necessary permits and permission to access field sites.
- d. Compile, provide quality control, and transmit data to SFEI, SCCWRP, and MLML in accordance with standardized procedures.

3. Regional Teams

- a. Review and recommend revisions of the CRAM for applications of importance to a given region.
 - b. Assist in regional data collection and compilation for calibration and validation of the CRAM. The primary individuals involved in data collection will be: 1.) Letitia Grenier and Josh Collins for the Bay Area, 2.) Adam Wiskind and Bobby Jo Close for the central coast, and 3.) Betty Fetscher, Martha Sutula, and Eric Stein for southern California
 - c. Participate in regional technical workshops and outreach efforts to help foster acceptance and use of the CRAM.
4. QA Officers -- QA Officers will ensure:
- a. that the QAPP and standard operating procedures (SOPs) are implemented as written,
 - b. that technical audits are conducted when appropriate,
 - c. that corrective actions are implemented,
 - d. that data are reviewed for usability against the project's stated data quality objectives (DQOs), and
 - e. that data are appropriately qualified when they do not meet project DQOs.
 - f. QA Officers should be independent of data collection and analysis activities.

Core Team			
Aaron Allen	USACOE-LA District	Ruben Guieb	SWRCB
Richard Ambrose	UCLA	Raymond Jay	RWQCB-Region 4
Oscar Balaguer	SWRCB	Michael Jewell	USACOE-Sacramento Dist.
Andree Breaux	RWQCB-Region 2	Steven John	US EPA
Robert Burton	MLML	Paul Jones	US EPA
John Callaway	USF	Molly Martindale	USACOE – SF District
Elizabeth Chattin	County of Ventura	Dan Martel	USACOE – SF District
Ross Clark	CCC	Chris Potter	State Resources Agency
Bobby Jo Close	CCC	Eric Stein	SCCWRP
Joshua Collins	SFEI	Don Stevens	OSU
John Dixon	CCC	Richard Sumner	US EPA
A. Elizabeth Fetscher	SCCWRP	Martha Sutula	SCCWRP
Cristina Grosso	SFEI	Letitia Grenier	SFEI

San Francisco Bay Regional Team			
Louisa Squires	SCVWD	Elaine Blok	USFWS
Eric Tattersall	CDFG	Steve Culberson	CDWR
Nils Warnock	PRBO	Giselle Downard	USFWS
Lorraine Parsons	USNPS	Jules Evens	Avocet Research
Joe Didonato	EBRPD	Tom Gardali	PRBO

San Francisco Bay Regional Team (cont'd)			
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John Callaway	USF	Karl Malamud-Roam	CMVCA
Paul Jones	USEPA - Region 9	Nadav Nur	PRBO
Dan Martel	USACOE – SF Dist.	Molly Martindale	USACOE – SF Dist.
Dick Zembal	OCWD		

Southern California Regional Team			
Erik Larsen	URS Corp.	Dick Zembal	OCWD
Dave Lawhead	CDFG	Doug Gibson	SELC
David Pritchett	WRP SB Task Force	Ryan Henry	PCR
David Zoutendyk	USFWS	Sabrina Drill	UC Extension
Kelly Schmoker	RMC	Shirley Birosik	RWQCB - Region 4
Mary Loquvam	LASGRWC	Corrice Farrar	USACOE- LA District
Bob Thiel	WRP SB Task Force	Lorraine Rubin	Ventura County
Darcy Aston	WRP SB Task Force	Bruce Posthumus	RWQCB-Region 9
Bryant Chesney	NOAA	Mike Porter	RWQCB-Region 9
Karen Bane	SCC	Paul Jones	USEPA - Region 9
Mary Anne Skorpanich	OCPFRD	Jae Chung	ACOE
Liz Chattin	Ventura County	Ruben Ramirez	Cadre Environmental
Wanda Smith	RWQCB - Region 8	Rosi Dagit	RCDSMM
Mike Kleinfelter	Independent Consultant	Spencer MacNeill	Aspen Environmental

Central Coast Regional Team			
Rob Burton	Moss Landing Marine Laboratory	Cammy Chabre	Elkhorn Slough National Estuarine Research Reserve
Ross Clark	CA Coastal Commission	Becky Christensen	Elkhorn Slough National Estuarine Research Reserve
Bobby Jo Close	Central Coast CRAM/ Wetland Working Group	Chris Berry	City of Santa Cruz
Mary Adams	RWQCB, San Luis Obispo	Dave Highland	CDFG
Eric Van Dyke	Elkhorn Slough National Estuarine Research Reserve	Bill Hoffman	Morro Bay National Estuary Program
Kerstin Wasson	Elkhorn Slough National Estuarine Research Reserve	Matt Johnson	County of Santa Cruz, Planning

Central Coast Regional Team (cont'd)			
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Susie Worcester	CSU Monterey Bay	Cheryl Lesinski	Morro Bay National Estuary Program
Alyson Aquino	Cal Poly, Forestry Dept., Grad. Student	Stacey Smith	California Conservation Corps
Chris Coburn	Monterey Bay National Marine Sanctuary	David Wolff	David Wolff Environmental
Adam Wiskind	Moss Landing Marine Laboratory		

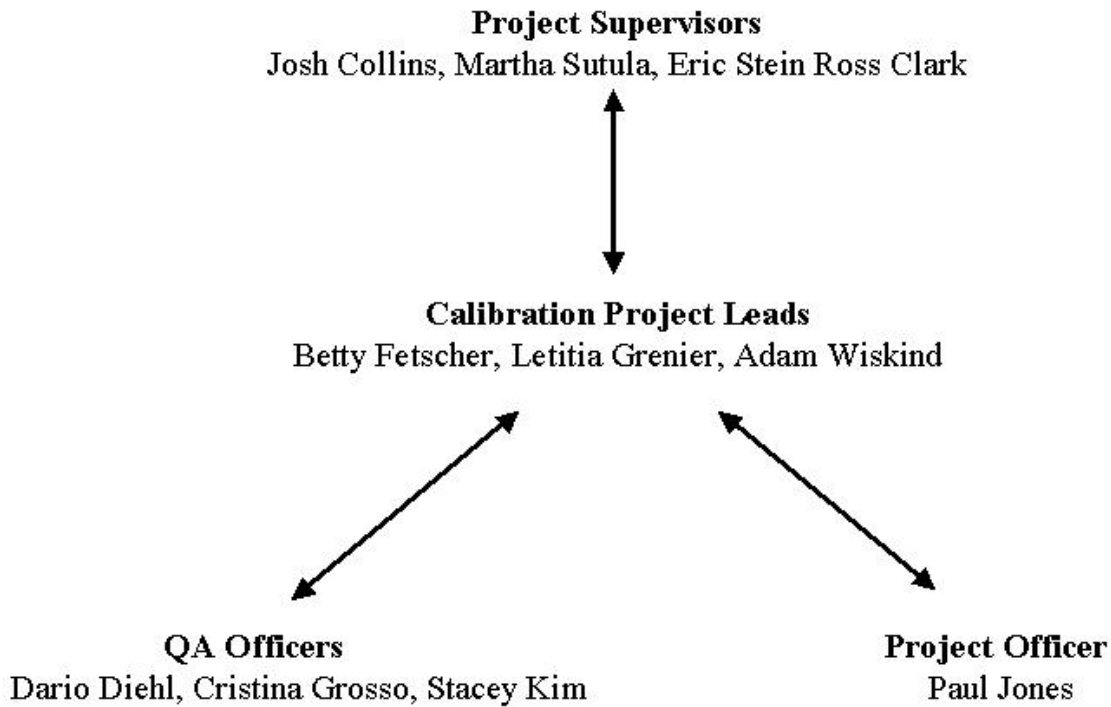


Figure 1. Organizational Chart showing the lines of communication among project participants².

3. Conceptual Models

The Core Team has tentatively adopted 3 basic conceptual models for (1) wetland form, function, and controlling factors in California; (2) the EPA 3-tiered approach to regional wetland monitoring; and (3) the technical framework to develop a Rapid Assessment Method (RAM). It is expected that these general models pertain to all wetland types and to the state of California as a whole.

3.1. Wetland Form, Function, and Controlling Factors

The evolution and natural maintenance of a wetland depend on supplies of water and sediment, as mitigated by vegetation. Water is needed to submerge the land, and sediment is needed to prevent the land from being too deeply submerged for wetland plants to survive. The quality and

² Each Calibration Project Lead is responsible for communications between regions, and also for updating Project Supervisors on all issues and problems. They are also the designated leads for all field logistics, data management, and data analysis and reporting. They are also responsible for coordinating with QA Officers in each respective region to maintain the QA Plan.

quantity of supplies of water and sediment are mainly controlled by climate, geology, and land use, but vegetation can significantly affect these supplies. Vegetation also affects the distribution and abundance of valuable wildlife by serving as habitat and food. The interactions among all these factors are dynamic because climate and land use are always changing, plant and animal species evolve, and the species composition of natural communities changes due to invasions and local extinctions.

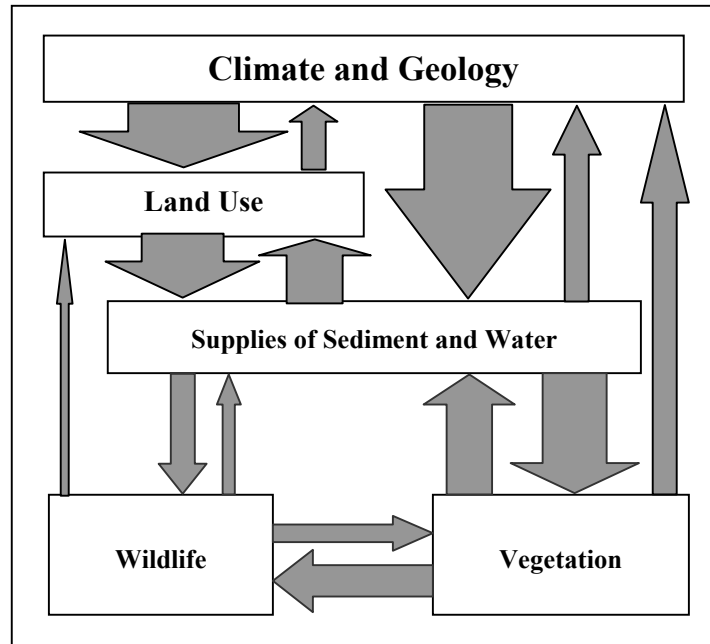


Figure 2. Diagram of primary factors that control wetland form and function.

Arrows represent hydrology (including all processes of water and sediment movement and storage), herbivory, predation, or microbial processes, and they point from what controls these processes to what they affect. The boxes can therefore represent the sources of, and responses to, natural disturbance and anthropogenic stress. The larger arrows represent greater relative importance.

3.2. The EPA Three-tiered Approach to Wetland Monitoring

US EPA is supporting a number of efforts in the nation to develop and strengthen wetland monitoring and compensatory mitigation through grant assistance under the Wetland Development Grants and policy and technical support from Headquarters and the Regions. The technical framework for EPA's support consists of three complementary levels: (1) Landscape Assessment; (2) Rapid Assessment; and (3) Intensive, Site-Specific Monitoring.

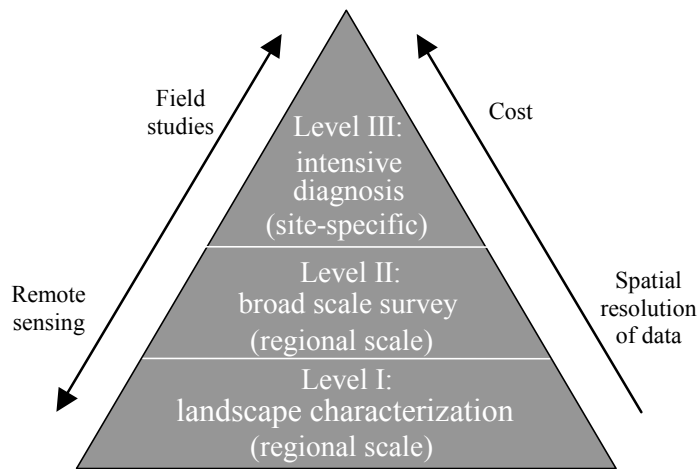


Figure 3. Conceptual model of the EPA 3-tiered approach to wetland monitoring.

The resolution of the monitoring data, its site-specificity, the amount of field work required to generate the data, and its cost all increase from Level I to Level III. The monitoring results from each level address different needs for information, and each level of monitoring can be used to verify the other levels.

Landscape Assessment (Level I) relies almost entirely on Geographic Information Systems (GIS) and remote sensing data to obtain information about watershed conditions and the distribution and abundance of wetland types within watersheds. A Level-I assessment can generate a sample frame for Level II and level III assessments of wetlands sites.

The CRAM will be an example of Level II monitoring. After the CRAM is validated through Level III studies, it can be used to rapidly assess ambient conditions and the performance of wetland projects. Level II methods can also be used to develop hypotheses about the causes of the observed conditions and to validate Level-I assessments.

Intensive Site Assessment (Level III) provides the field data necessary to validate the Level-II (rapid assessment) methods, characterize reference condition, test hypotheses about the causes of wetland conditions as observed through Level II, and develop design and performance standards for wetland projects. Wetland bio-assessment criteria (i.e., use of indices of biological integrity or IBIs) can be developed and used in Level-III assessments. CRAM can also be adapted for use as a component of Level-III monitoring.

3.2.1. CRAM Developmental Framework

There are two basic phases of CRAM development:

- I. *Initial Method Development and Field Verification of the draft method*
- II. *Calibration and Validation*

Phase I was completed in Spring 2004, and culminated in the revision of the draft CRAM document to version 3.0, in September 2004. The goal of the first part of Phase II of CRAM development, calibration, is to calibrate the two “priority” wetland classes, Riverine and Estuarine, through the use of independent data (both existing, and newly collected) to help define the relationship between wetland condition and CRAM scores. As a result of calibration, a schedule of numerical scores will be developed for each metric, along with a system of weighting the various scores into attributes. The purpose of this QAPP update is to provide lists of independent variables to be measured, guidelines for their measurement, and data-quality objectives (DQOs) for the calibration process for these two wetland classes. Additional calibration efforts will be necessary for expansion into additional wetland classes. These are not included in the current QAPP and would require an update to the QAPP, and additional funding, in order to carry out the work.

4. CRAM Calibration Steps

4.1. Completion of Verification

When new data become available through the calibration process, the thresholds for dividing the condition categories (A, B, C, D) of a continuous metric (e.g., patch richness, percent invasive plant species, buffer width, percent AA with buffer, and native plant species richness) may be altered based on the new data. For example, the physical and biotic patch type data generated from the CRAM calibration AAs will be used to generate a distribution of patch richness values across study sites. Thresholds between adjacent condition categories for the Physical and Abiotic Patch Richness metrics will be determined based on the distributions of these data and their relationship to Level III data sets.

4.2. Calibration Approach

The initial CRAM calibration effort will be an exploratory analysis that proceeds from the general (overall CRAM score) to the specific (CRAM attributes and then metrics). The reason for this hierarchical approach is to first assess the performance of the overall score, which will be used heavily by managers and regulators, and to then delve into the details of the subunits that comprise the overall score (attributes and metrics). The emphasis of calibration will be to ensure that the various components of the CRAM scores are related to empirical data as predicted by the PIs and as captured in the conceptual model. If these relationships are as predicted, then little numerical adjustment of the metrics and attributes will be required. If these relationships are not

as predicted, then metrics may be scaled and their thresholds adjusted and attributes may be weighted or otherwise recomputed as necessary to obtain the desired relationships.

4.3. Calibration of Overall CRAM Score

Overall CRAM scores will be compared to an index of landscape condition. Candidate data types for testing the performance of overall CRAM site scores include indices such as the Landscape Development Intensity (LDI) index (Brown and Vivas, 2004) now under development for application in California, human demographics data available through the US census, and individual landscape parameters, such as impervious cover and road density, that have been shown to influence aquatic and semi-aquatic habitat condition (Ode *et al.*, 2004). Initially, the overall CRAM score will be calculated as the arithmetic sum of the attribute scores. If the relationship between landscape condition indicators and overall CRAM scores is not as desired, then the CRAM attributes may be weighted or otherwise combined to improve the relationship.

Part of calibrating the overall CRAM score will be to check that scores in different wetland classes have generally the same range and distribution. For example, if estuarine overall scores are consistently lower than riverine overall scores, the reason for this difference could be attributed to either an artifact of CRAM scoring or to real differences in condition. The CRAM scoring rules will be adjusted, as appropriate, following this analysis. This same process of comparing score distributions between different wetland types will be repeated for CRAM attributes.

Other exploratory analyses will also be conducted to understand the general nature of the CRAM scores and what they signify. For example, attribute scores will be plotted against overall scores to determine which attributes consistently correspond well with overall scores. Overall CRAM scores will also be compared to Level III data sets to see if the CRAM score and Level III data from each wetland site fall into the same bin of condition (A, B, C, D).

4.4. Calibration of CRAM Attributes

CRAM attribute scores will be compared with Level III data thought to reflect the wetland condition for that attribute. Three sources of Level-III data have been identified for use in calibration of CRAM: 1.) MAPS bird data, 2.) bioassessment data, and 3.) EMAP plant data. These are described in more detail in Section 4.9 of this document (and are listed in Table 1). Direct measurement of wetland condition or function is not practical given technical and funding constraints; therefore, CRAM calibration will focus on indirect measures of condition, such as floral or faunal composition. Attribute performance will be evaluated by comparison to field data that are robust indices of community structure and high-order functioning of the ecosystem. These data integrate over time and through space in ways analogous to the attributes, according to the conceptual models used to develop CRAM.

Table 1. Major data sets identified for initial use in calibrating CRAM at the attribute and metric levels.

If these data sets do not perform as predicted, other data sets may be used.

Wetland Class	Attributes							
	Buffer/Landscape Context	Variables measured or calculated	Hydrology	Variables measured or calculated	Biotic Structure	Variables measured or calculated	Physical Structure	Variables measured or calculated
Riverine	Benthic macroinvertebrates (BMI) (BMI data; Harrington, 1999)	<ul style="list-style-type: none"> Species richness Index of Biotic Integrity (IBI) 	BMI	<ul style="list-style-type: none"> Species richness IBI 	Birds (data from MAPS)	<ul style="list-style-type: none"> Species richness Abundance of select species Number of breeding riparian species 	Birds (data from MAPS)	<ul style="list-style-type: none"> Species richness Abundance of select species Number of breeding riparian species
			Channel geomorphology (data collected by CRAM teams)	<ul style="list-style-type: none"> Entrenchment ratio Width-to-depth ratio 				
Estuarine	Vegetation (data from EMAP)	<ul style="list-style-type: none"> Species richness Percent cover (Shannon Index) Percent invasive species 	Vegetation (data from EMAP)	<ul style="list-style-type: none"> Species richness Percent cover (Shannon Index) Percent invasive species 	Vegetation (data from EMAP)	<ul style="list-style-type: none"> Species richness Percent cover (Shannon Index) Percent invasive species 	Vegetation (data from EMAP)	<ul style="list-style-type: none"> Species richness Percent cover (Shannon Index) Percent invasive species

No thresholds of association between CRAM attributes and selected Level-III data are proposed at this time. Interim results of calibration analyses will be shared with the Regional Teams and the Core Team for their feedback during this process.

Three different approaches to constructing attribute scores will initially be compared, with the goal of choosing the approach that optimizes mathematical simplicity and strong association with Level III data. Attribute scores will be constructed as arithmetic means of metric scores, geometric means of metric scores, and as more complex mathematical functions of the metric scores that are based on hypothesized ecological relationships among the metrics. Once one of these general approaches is identified as being the most useful, it may be modified by weighting or otherwise changing the metric combination rules in order to improve the relationship with the Level-III data.

Prior to combination of metric scores into an attribute score, metric scores will be converted from letter categories (A, B, C, D) into numerical values (e.g., 4, 3, 2, 1). Lower numbers will correspond with poorer condition. Users will be required to score the wetland according to these bins corresponding to condition.

4.5. Calibration of CRAM Metrics

The relationship between CRAM metric scores and Level III data will be explored. Graphical tools, such as scatter plots, will be used to characterize the relationship between empirical data and CRAM metric scores. Metric scores are expected to either bear no relationship to Level III data (in the case of metrics with no appropriate Level III data for comparison), or metric scores should relate in a relatively monotonic fashion to Level III data. In cases where these relationships are not as expected, CRAM metrics may be scaled (using effect sizes from an Analysis of Variance; ANOVA) or otherwise revised (e.g., changing the prose description of alternative categories of conditions for the metric, or collapsing or adding categories) to improve the relationship, especially if the same metric has unexpected relationships to more than one Level III data set, suggesting that there were problems with the original construction of the metric.

In most cases, CRAM metrics will be calibrated using the same data sets used to calibrate the attributes. A few metrics will be calibrated using more intensive versions of the *same type* of data that are recorded in a CRAM assessment. An example of this is estuarine plant percent-cover data quantitatively collected through the use of multiple transects, *versus* the visual estimations of cover at the level of the AA as a whole that is done in CRAM. The results of such analyses may be used to adjust the thresholds between metric categories.

It is recognized that the attributes and their metrics constitute a comprehensive framework for an expert visual inspection of wetland condition, and as such, all the metrics and attributes are important parts of CRAM, even if they are in some ways functionally interrelated and therefore redundant. Calibration is, therefore, neither intended to test the redundancy of any metrics or attributes, nor to justify their elimination.

4.6. Selection of Calibration Sites

Calibration sites will be selected from the data sets in Table 1 to represent a range of conditions along one or more disturbance gradients, from highly disturbed to relatively pristine sites. Access to a given site will also be a criterion for selection. The minimum sample size of state-wide Level III data sets used for calibration will be 30 sites, which will allow for statistical comparison among the four categories of condition (A, B, C, D). The PIs will attempt to run CRAM at additional sites per calibration data set, as time and budgets permit.

We will specifically choose calibration sites that vary across a range of condition, and assure that this range is captured across the entire study area. To do this, we will review the three sources of existing Level-III data at our disposal, and choose approximately equal quantities of low-scoring (at least three sites), intermediate-scoring (at least four sites), and high-scoring (at least three sites) sites, for each of the three teams, for a total of at least 30 sites per team, per dataset.

Because EMAP 2002 intensification was not conducted in the Central Coast, there are no existing vegetation data there to guide the selection of sites for estuarine calibration in this region. The estuarine sites for the Central Coast will therefore be chosen based on local expertise and knowledge of estuarine conditions. Newly-collected riverine data will be collected only at sites that have been chosen based on existing Level-III data, and will not, themselves, drive the site-selection process. Appendix B provides a list of sites with Level-III data that can serve as CRAM calibration sites.

4.7. Obtaining CRAM Data from each Calibration Site

CRAM metrics will be scored at each calibration site by a data-collection team consisting of members of the respective Regional Team, using the methodology detailed, and datasheets provided, in the CRAM v 3.0 User's Manual (Collins *et al.*, 2004; Appendix C). The scoring process will include office and field work, as well as completion of the CRAM stressor checklist. The following information will be also collected at each calibration site and will aid in interpreting site condition, as well as facilitate future revisions to the CRAM document:

1. A general description of each site, including on-site conditions, adjacent land uses, etc.
2. Any biotic and/or physical patch types that do not appear on the lists in CRAM 3.0
3. Any plant species that are not already listed in Appendix 5 of CRAM 3.0
4. Photographs and/or sketches of the site, including Assessment Area (AA) delineations
5. Documentation as to why the site was selected as a "high", "intermediate", or "low"-quality reference site, if applicable
6. Any existing collateral data and imaging for the site

The CRAM AA will be delineated so as to encompass, as much as possible, the spatial extent of the site of Level-III data collection, while still adhering to the rules for delineating the AA, as stipulated in CRAM v 3.0. Coordinates indicating each site of Level-III data collection to be used in the CRAM calibration study have been mapped, and will be made available to the CRAM data collector prior to the site visit. A GPS unit can be used in the field, along with aerial imaging, to help locate the exact position of the Level-III work. All data points should be taken in the NAD83 projection, for the sake of consistency among data collectors.

The CRAM AA will be delimited based on breaks in hydrology (as per CRAM v 3.0). When the breaks in hydrology delimit a space so extensive that a CRAM assessment cannot be conducted within the half-day prescribed, then the area should be broken up into smaller units based on the following formula: 1.) in the field, using the aerial imaging of the site, estimate the centroid of the polygon contained within the hydrologic breaks, 2.) divide the area into approximate halves, based on the location of the centroid, 3.) randomly select one of the areas (i.e., using the flip of a coin), 4.) if the area is still too large to conduct a CRAM assessment, repeat step (2) within this new area, 5.) if the resulting area is sufficiently small in size, then use it as the CRAM AA, and be sure to accurately draw the AA on the aerial image as a record of the AA that was used for the assessment.

Once the CRAM AA is delineated, the entire area will be walked and all physical and biological features will be noted. The "starting point" for this walk-through is arbitrary. All that matters is that the entire area is ultimately covered by the observer. Once the whole area has been examined, the data collector will begin assigning letter field scores for each of the metrics. Some of the metrics may require a second walk-through in order to confirm or modify first impressions of the condition of the site gathered from the first walk-through.

4.8. Selection Criteria for Level III Data Sets for CRAM Calibration

- State-wide coverage to allow for calibration to the same data sources across the study area.
- Minimized noise and bias in the relationship with CRAM scores
 - *Direct quantification of a single selected function.* Measures of different functions, such as avian support and plant support, should not be pooled for any wetland class or region, and indices or canonical variables based on multiple functions should not be used in calibration.
 - *Pertinence to one variable of a function.* For example, if the selected function is “avian support,” then the data should quantify that function as either species richness, number of mated pairs, or reproductive success. Data for different variables of a function should not be pooled.
 - *Minimal background variance.* Such variance is controlled by collecting data only within the spatial and temporal strata of the function. For example, if the selected function is amphibian breeding success, then the data should pertain only to the period and habitat for breeding of the amphibian species being sampled.
 - *Minimized systematic error or bias due to sampling procedure, timing, or equipment.* Proven methods of sampling for the selected function should be used to develop the calibration data set.
 - *Deemed satisfactory by the data authors based on written QA/QC procedures.*
 - *Direct pertinence to the CRAM Assessment Areas (AAs).* If an AA encompasses multiple sample sites for the calibration data, then the data for those sites will be pooled and averaged. If the sample sites for calibration data are much larger than one AA, then multiple AAs will be established within the sample site, and a set of average CRAM scores, weighted by area, will be calculated for the site. At no time will the rules for establishing a CRAM AA be altered or ignored. For Riverine wetlands, and other flow-through systems, the calibration data for in-stream conditions can pertain to the downstream or middle reaches of the AA, or to the AA as a whole, but not to just the upstream reaches.
 - *Recent enough to pertain to existing field conditions.* Data sets for functions and sites that vary little over time retain their relevance to existing conditions longer than data sets for functions and sites that are more variable over time. For the purposes of CRAM calibration, “recent enough” means that no data more than 3 years old will be used. It is assumed that this period is an acceptable interval within which to expect only negligible changes in condition at the site, assuming no major impacts (anthropogenic or natural).

- Scientifically credible
 - Metadata describing the original purpose and objectives for the data set, sampling methods and location, procedures for data collection and analysis, and quality control information should accompany the data set or be available through consultation with the data authors.
 - The locations of data collection sites should be evident on aerial imaging or maps with sufficient resolution (at least 1-m pixel resolution) and narrative description to permit reoccupation of the sample site for use in CRAM.
 - The authors of the data set should be available for consultation about such issues as missing data, filling data gaps, the meaning of zero counts, interpretation of outlier data points, and limitations on interpretation of the data set, including the degree to which the data can be extrapolated from the data-collection sites to other sites for which data do not exist.
- Readily available
 - The data set should be in an electronic format on suitable media for comparison with CRAM scores in statistical analyses.
 - The data set should be clear of any controversy about its validity, integrity, and ownership, and it should not be currently withheld from distribution because of legal or proprietary concerns.
 - The data set should come directly from the authoritative individuals or institutions responsible for its collection and analysis.

The data set should be available to the CRAM teams for at least the duration of the calibration process.

4.9. Description of Existing Level-III Data Sets

Existing data sets identified for use in CRAM calibration are described below. The rationale for their use in calibration is discussed, and the methodology used to collect the data for each of the programs is also summarized in this section. For more detailed information on the protocols, please refer to the appendices indicated within each brief description. The timing (season, water stage or tide height, etc.) for CRAM data collection will correspond to the timing of the Level III data used for calibration, so as to minimize the effect of timing on calibration analyses.

4.9.1. *MAPS Bird Data*

The Monitoring Avian Productivity and Survivorship (MAPS) Program is a nationwide effort, overseen by the Institute for Bird Populations, that collects annual data on bird populations during the breeding season using a constant-effort, mist net approach at fixed-site locations. The

strength of this approach is that it facilitates the detection of demographic trends over time by applying constant effort each year. Birds captured in the nets are banded, sexed, and aged, and their breeding status is assessed. These data allow demographic variables to be calculated (e.g. productivity and survivorship indices, estimates of adult population size, post-breeding productivity, adult survival rates, and rates of recruitment into the adult populations) in addition to providing information about species abundance and diversity. MAPS will provide two categories of data for CRAM calibration of Riverine wetlands: 1) demographic data for riparian species, and 2) diversity data at the level of guilds and species.

Because the Ohio Rapid Assessment Method (ORAM; Mack, 2001a) version 5.0 was found to produce scores that correspond well with several avian metrics, including total species richness and mean species richness of birds of conservation concern (Stepanian *et al.*, 2004), we anticipate that the MAPS bird data will prove to be an important component of CRAM calibration for the Riverine wetland class. An additional advantage of the MAPS data for our purposes is that the program covers numerous riparian sites in all three CRAM study regions, thus providing a consistent data source across the state. Details on the MAPS data-collection methodology can be found in the MAPS manual (Appendix D). Data on bird species diversity and abundance from 2003 will be used to calibrate the riverine wetlands attributes listed in Table 1.

4.9.2. *EMAP Vegetation Data*

In 2002, as part of the EPA's EMAP-Estuaries West Coast Pilot, an ambient assessment of intertidal wetlands was conducted in Washington, Oregon, and California. Part of this assessment involved collection of comprehensive plant data in southern California and the San Francisco Bay Area, as a component of an "Intensification" of data collection at 30 sites in each of these two regions (for a total of 60 sites). For this assessment, all EMAP data-collection "core stations" were selected randomly, following EMAP sample design protocols. Intensification data collection for plants consisted of assessing percent cover of plant species along a series of transects oriented relative to each of 60 core stations in a stratified manner designed to cover a variety of moisture regimes throughout the coastal marsh plain. The results of this study provide a comprehensive picture of the vegetation community of numerous intertidal wetlands throughout southern California and the San Francisco Bay Area.

An advantage of the EMAP data set for calibration of intertidal wetlands is that project Principal Investigators (PIs) for the EMAP Intensification are also the Bay Area and southern California PIs for CRAM development, and are therefore already in possession of the data and analyses. Existing data of this nature may only partially suffice for CRAM calibration, and supplemental data, following the same EMAP protocol, may need to be collected. For example, the central coast was not part of the 2002 EMAP Intensification.

Details on the EMAP Intensification data-collection methods and quality assurance measures can be found in the approved QAPP (Appendix E). Species diversity and abundance raw data and indices from 2002 (such as the Shannon Diversity Index; Shannon and Weaver, 1949), in addition to measures of the presence of invasive species, will be used to calibrate estuarine wetlands attributes (Table 1). In addition, percent invasive plant species and native plant species richness values will be calculated from these data, in order to calibrate the Percent Invasive Plant

Species and Native Plant Species Richness metrics of CRAM.

4.9.3. Bioassessment Data

Throughout the state, existing efforts are underway to collect bioassessment data in wadeable streams, for use in a variety of programs. Data collected include information about benthic macroinvertebrate (BMI) species diversity, abundance, and Index of Biotic Integrity. The primary contributor of existing bioassessment data for the state will be the California Department of Fish and Game for the years 2003 and 2004, and using the California Stream Bioassessment Procedure (Harrington; 1999; see Appendix F). The results of bioassessment provide information about water quality and instream benthic habitat condition resulting from perturbations such as contamination and sedimentation from upstream sources.

4.10. Collection of New Data for Calibration

Because existing data will not be sufficient to address all CRAM attributes, additional data will need to be collected. The rationale for the types of data, and the methodology used to collect them are summarized in this section.

4.10.1. Estuarine Vegetation Data

New data will be collected for the Central Coast using the EMAP Intensification protocol (Appendix E), and as needed for the other two teams. These new data will supplement existing data collected in 2002. In addition, percent invasive plant species and native plant species richness values will be calculated from these data, in order to verify or adjust the scaling of Percent Invasive Plant Species and Native Plant Species Richness metrics of CRAM.

4.10.2. Riverine Channel Morphology Data

Measurement of wadeable channel morphology will provide information to complement bioassessment data. Data will be recorded on the data sheet provided in Appendix G. Two measures of channel morphology will be used in CRAM calibration:

1. **Entrenchment Ratio** – The entrenchment ratio is the ratio of the width of the floodprone area of a stream to its bankfull width (W_{fpa} / W) (Rosgen, 1994). The greater the ratio, the more entrenched a stream is within its banks. An entrenched stream lacks access to a broad floodplain, usually due to chronic incision (termed stream degradation). Severely entrenched streams have abandoned their former floodplains. In such streams, the associated riparian flora and fauna are negatively impacted, stream velocity tends to increase, adjacent groundwater levels are reduced, and erosion of the bed and banks is more likely.

The floodprone contour will be estimated as twice the maximum bankfull depth, which will be estimated as the average height of the bankfull contour above the thalweg. Thalweg and bankfull contours will be determined at straight reaches within the CRAM AA (several determinations can be made and averaged, depending on the size of the AA). When the flood prone contour is above the bank top, the width of the floodprone area can be too great to

measure in the field. In such cases, the lateral extent of floodprone area will be estimated on an orthophoto or topographic map of the AA.

2. Width/depth Ratio – The width-to-depth ratio is represented as the ratio of the bankfull width to the mean bankfull depth (W/d). The sediment transport capacity of a stream is sensitive to changes in this ratio (Leopold *et al.*, 1964). Bankfull stage will be identified in the field according to proven field indicators (Harrelson *et al.* 1994, USACE 2004, Whitacre 2004). The width to depth ratio of a channel can be used as an indicator of sediment transport capacity and stream aggradation tendencies (Rosgen, 1996). This information will be derived from the same data collection effort for calculating entrenchment ratio, above. Both aspects of channel geomorphology will be used to calibrate the Hydrology attribute for Riverine wetlands.

4.11. CRAM Phase II (Calibration) Timeline

The schedule for Phase II of CRAM development is outlined below:

1. In January of 2005, a Core Team meeting was held to discuss several current CRAM issues, including calibration and implementation. The draft QAPP has been revised based on the discussion at this meeting, and then submitted to EPA for approval.
2. In February 2005, the Regional Teams began compiling existing data sets that can be used to calibrate the Riverine and Estuarine wetland classes. A matrix describing these data sets, and which wetland classes they will be used for, is provided in Table 1. These data sources have all been deemed acceptable based on calibration criteria (see *Selection Criteria for Level III Data Sets for CRAM Calibration*).
3. Sites for CRAM calibration data collection will be selected in May of 2005. The criteria for selecting sites are outlined above.
4. In mid May, the Calibration Project Leaders (see Figure 1), and other key calibration-data collectors will convene in the central coast for an initial training (see section 5.1 for more information).
5. CRAM field work will begin following QAPP approval. Where possible, CRAM 3.0 data collection will take place coincident with, or temporally close to, the collection of corresponding independent (Level III) field data. The target timeline for collection of CRAM data to be used in conjunction with any given data source will depend on that data source. For bioassessment data, springtime field visits for Level-III data collection will begin in May and end in August. For MAPS riparian bird data, field visits will begin in May and end in August. New vegetation data that will complement the other sources for Estuarine wetlands will be collected during the same time of year as when the existing data types were collected.
6. Preliminary analyses of the data will be conducted on the data in the late summer (August), as data collection ends.

5. Quality Assurance Methods

Quality Control procedures will be employed to assure that the CRAM calibration field teams are using the same approach and are obtaining information accurately when they are conducting CRAM assessments and collecting independent data. As new data will be collected during calibration of the CRAM (Phase II), this QAPP update addresses the required precision, accuracy, and completeness of the calibration data.

The objective of data management will be to assure that field and GIS data are accurately collected and verified for analysis and interpretation by SFEI, SCCWRP, and CCC/MLML. We will use procedures described herein to assure accuracy and consistency of data collection and processing. Developing and adhering to such measures will be of particular importance, because multiple investigators representing the three regional collaborating teams will be embarking on this effort in order to generate a single system of scaling and combination rules for CRAM 4.0 metrics and attributes. Furthermore, because the CRAM scaling rules for metrics that will result from the calibration effort will be combined into more complex attribute and overall CRAM scores, errors in the metric scaling could be compounded, if quality control measures are not adequately implemented.

Existing data sources that will be used for calibrating CRAM are summarized in the body of this document, and in greater detail in the attached protocols (see Appendices). Where they exist, we have also included approved QAPPs to accompany these protocols. Quality assurance measures are stipulated below for data sets that have not already undergone QAPP development and approval.

The following is a description of the basic QAPP procedures that will be followed during the calibration effort. The PIs will be responsible for making sure that all data forms that are used in calibration are filled out completely. Regional Teams will provide the PIs with completed forms for a site within three days after the site is visited. The PIs will check each form for completeness (i.e., all fields requiring information are completed). If a PI finds that data are missing or that data have been incorrectly entered onto a form, then the persons who collected the information will be notified of the specific problem within two days after the form is submitted to the PIs, and, if necessary, sites will be visited again to obtain or correct the data in question.

5.1. CRAM Score Variation within and among Field Teams

This section outlines sampling procedures and support materials to be used while conducting the CRAM v 3.0 field assessments. While the focus of the calibration effort will be on Riverine and Estuarine wetlands, these procedures apply to field assessments conducted at any of the seven CRAM wetland classes.

5.1.1. CRAM Training

A first step in the calibration effort will be to convene all of the Calibration Project Leads (see Figure 1) from each of the three teams, as well as other key individuals who will be assisting in

the data collection effort. The Leaders are members of the three data collection teams who will consistently participate in conducting CRAM assessment at the study sites in their respective regions.

When the group convenes, a CRAM training session will be held to assure that all teams are interpreting CRAM v 3.0 in a consistent manner for conducting the subsequent calibration studies. The field session will review the calibration goals, objectives, accessing sites, AA delineation, data sheets, and safety. For both riverine and estuarine wetlands, the following will also be reviewed: buffers (what qualifies and what does not), metric ratings, field indicators, and biotic and physical patch types.

5.1.2. Field Replications and Standardization

Procedures described below will ensure that CRAM scores collected in the field meet established criteria for precision. Regarding the concept of accuracy, it should be noted that, unlike a laboratory analytical method where the result can be compared to a standard of known concentration, there is no “gold standard”, *per se*, for any metric against which CRAM can unequivocally be compared. Therefore, accuracy is not a meaningful parameter against which to judge CRAM assessments, and as such is not included in the DQOs.

Each procedure will be completed as described in order to decrease sampling error and to define that error. Precision objectives are described in Table 2. Any CRAM field team that does not meet these objectives will be notified and corrective actions will be taken. Such corrective actions can include additional training in conducting CRAM AA delineation, interpretation of metric ratings, identification of field features assessed in CRAM, etc. Field CRAM scores will be compiled for use in statistical calibration exercises only after error estimates for each team are defined and determined to be acceptable. CRAM field scores that do not meet the QA requirements will not be used in any analyses other than to provide the Core Team with information regarding problematic metrics that may require modification or additional support materials.

Data compiled for all sites will be screened by the PIs. If errors and/or omissions are found, SFEI, SCCWRP, and CCC/MLML will work with their respective data collectors to determine if the data were incorrectly entered into the database tables or if the data were not correctly obtained in the field. If errors in field measurements are identified, the PIs will, when possible, return to the sites and re-collect the information in question.

The project QAOs will retain a copy of the QAPP, and will establish the quality assurance and quality control procedures found in this QAPP as part of the sampling, field analysis, and in-house analysis procedures. The QAOs will also review and assess all procedures during the life of the calibration study against QAPP requirements, and will report all findings to the project PI(s) for their respective regions, including all requests for corrective action. The QAOs may stop any and all actions if there are significant deviations from required practices or if there is evidence of a systematic failure.

Betty Fetscher, Letitia Grenier, and Adam Wiskind (the Calibration Project Leads) will be responsible for the day-to-day oversight of the project in their respective regions, and will insure that the data are passed, in a timely manner, to the appropriate persons for review. The QAOs will review data regularly. As needed, the QAOs may have conference calls to discuss the data collection status, QA, data management, and overall status of the project.

If an audit discovers any discrepancy, the QAO will discuss the observed discrepancy with the appropriate person responsible for the activity (see Organization Chart). The discussion will begin with whether the information collected is accurate, what were the cause(s) leading to the deviation, how the deviation might impact data quality, and what corrective actions might be considered. The QAOs have the power to halt all sampling if the deviation(s) noted are considered detrimental to data quality.

Table 2. CRAM Metric Data Quality Objectives.

Team Comparison	Precision	Completeness
Within each regional Field Team	+/- 20%	80%
Among Field Teams within a region	+/- 20%	80%
Among Field Teams from different regions	+/- 20%	80%

5.1.3. Within Each Regional Team

Within regions, CRAM field teams will include one or two individuals that consistently participate in running CRAM throughout the calibration phase. These field team leaders will provide consistent interpretation of the CRAM language and will train the other members of their teams in this interpretation. These same team leaders will participate in an inter-regional calibration effort (see below). Each field team will evaluate and control for field assessment error by revisiting 10% of CRAM sites within each wetland class. The sites will be chosen, at random, by the QA Officer for each team. Within the replicate sites, the team will complete the office and field CRAM evaluation during separate visits. The replicate CRAM scores should meet the +/- 20% precision objective. All CRAM score discrepancies between field visits will be evaluated and attributed to a) changes in field condition between visits, b) judgment call error between two metric categories, or c) change in Team perspective based on additional field experience. Causes for error will be tallied and reported to the CRAM Core team for evaluation and possible action.

5.1.4. Among Teams within a Region

Each regional field team will evaluate and control for between-team assessment error by visiting CRAM sites previously assessed by a separate CRAM Team. Within each region, 10% of CRAM sites will be evaluated by two or more field teams. The sites will be chosen, at random, by the QA Officer for each team. Each team will complete both the office and field CRAM evaluation for sites selected to represent a range of CRAM scores and both wetland classes. The multiple CRAM scores from calibration sites should meet the +/- 20% precision objective. All CRAM score discrepancies between field teams will be evaluated and attributed to one of the

previously defined categories of error.

5.1.5. Among Regions

The regional team leaders have been working together in CRAM development for 3 years and share a detailed understanding of CRAM methodological details. This mutual understanding about CRAM will help the regional teams meet their goals for consistency. Teams from the three regions will meet in the Central Coast area to independently use CRAM in the same two riparian AAs and the same two estuarine AAs. The teams will meet as a group after running CRAM to compare scores, identify areas of differing interpretation, and for subsequent changes to CRAM guidance to improve consistency in future application of the method. The multiple CRAM scores completed by field teams from different regions should meet the +/- 20% precision objective. All CRAM score discrepancies between field visits will be evaluated and attributed to one of the previously defined categories of error. Causes for error will be tallied and reported to the CRAM Core Team for evaluation and possible action. If this inter-team calibration identifies metrics that regularly result in inconsistent results, then the Core Team will evaluate the metrics and consider alternative language or scaling that would improve user consistency.

5.1.6. CRAM Support Materials

Each CRAM field team will read and understand CRAM v 3.0 (as well as all other protocols for collection of new, independent data). Field guides and photo reference materials will be provided to all new CRAM field teams to help them develop an understanding of the complete range of conditions for each metric.

The CRAM User's Manual v 3.0 (Appendix C) includes numerous reference tables and figures to help the practitioner better interpret metric categories (e.g., Figure 4.1, Table 4.23, Figure 4.2 of CRAM v 3.0). Several standard assessment aids are also referenced and included as appendices (Appendices 3, 4, and 5 of CRAM v 3.0). In addition, the User's Manual contains all the data sheets necessary for conducting CRAM assessments during Phase II.

Additional support materials will be generated during the course of the CRAM calibration program. Materials will include a photo-glossary intended to provide a picture example of many of the terms and wetland characteristics described or referenced, which will ultimately be made available online.

5.2. Quality Assurance Requirements for Third-party Data Sources

Wetland data sets will be acquired from third parties based on availability (Table 1) and adherence to the data-selection criteria (see Section 4.8). Along with the data sets, the data provider will submit metadata, the QAPP, or QA/QC standards by which the data sets were developed. Only data that meet data quality objectives will be used for calibrating CRAM. If data sets of unknown quality are acquired, project staff will work closely with the data provider to determine the quality of data and amend the metadata as appropriate.

The following additional measures address the specific needs of the independent data sets that

will be collected during Phase II.

Plant Data

- Quality control measures to be implemented while collecting vegetation data in estuaries are detailed in Appendix E.
- Data collectors will identify common plants in the field to species, but will not routinely validate the identifications with an expert plant taxonomist. Most species encountered will be common ones that show little variation among regions. Only unknown species, or ones that are particularly difficult to identify, such as some species in the genus *Carex*, will be validated by an expert taxonomist.
- Vouchers will be collected for any species that cannot be identified with certainty in the field. These specimens will be further examined and identified to species back at the office, if necessary, with the aid of microscopy and/or additional reference materials; alternatively, the specimen will be taken to a local herbarium or an experienced botanist with comprehensive knowledge of the local flora for identification.

MAPS Bird Data

Bird data from the MAPS Program (for Bird Populations; Appendix D) adhere to the following quality-assurance measures:

- Qualifications of data collectors: At a minimum, all MAPS data collectors possess federal bird-banding permits issued by the USGS Patuxent Bird Banding Laboratory.
- Field procedures: All MAPS interns complete a two-week intensive training course prior to beginning data collection. In addition, they are subject to a period of field supervision (equaling the first 1/3 of their first data-collection assignment) of their adherence to protocol; accuracy of species identification, sexing, aging, and breeding-status determination of captures; and accuracy of data recording.
- Post-collection data verification: Prior to use in analyses, all MAPS data collected are verified using MAPSPROG, a Windows-based computer program for entry/import, editing, verification, and error tracking of MAPS data (Froehlich *et al.* 2004). It allows the user to computerize his/her MAPS banding data; edit coding problems (codes that do not conform to Institute for Bird Populations (IBP) codes set forth in the MAPS manual, Appendix D); correct within-record inconsistencies (conflicts between codes within a record, such as juveniles in breeding condition or after-hatch-year birds with little skull pneumatization); and correct between-record inconsistencies (conflicts in species, age, or sex determinations in different capture records for a given band number). The verification procedures encoded in the program reflect the MAPS data collection guidelines described in the MAPS manual and ageing and sexing criteria presented in Pyle (1997) for the

months covered by the MAPS season.

- By providing a data entry/editing/verification program to contributors, IBP decentralizes the process of data correction, returning it to the control of those who collected the data and who should, therefore, be better situated to make necessary corrections and adjustments. As a result, the quality of MAPS data overall is improved and contributors, by verifying their own data, are better able to identify areas in which they can improve their data-collection techniques in future seasons. IBP highly encourages their data contributors to use MAPSPROG during the field season to enter and verify within-record consistency to improve data collection as the season progresses.

Riverine Channel Morphology Data

The instruments used for collecting geomorphic data include a measuring tape, a stadia rod, and a range finder. Table 3 lists the quality control measures that will be implemented when using these instruments,

Accuracy of geomorphic measurements will be improved by checking each measurement instrument to be used in the calibration study (tape measures, stadia rods, and rangefinders) against a single, metal surveyor’s tape during the initial CRAM field team training. Comparability of measurements of river channel dimensions is what is important for determining geomorphic ratios. As such, the Data Quality Objectives (DQOs) for geomorphic data are to be: 1.) within +/- 1 meters of the group mean for Stadia rods, 2.) +/- 5 meters for tape measures, and 3.) +/- 20 meters for range finders. These measurements will be compared among teams during the initial CRAM field team training. If these objectives are not met, then the “inaccurate” equipment must be replaced and retested. Also, if measuring tape is broken and repaired during the study, the repaired tape must be recalibrated with metal tape.

Table 3. Quality Control Measures for Instruments.

	Tape measure	Stadia rod	Range finder
Parameter measured	Distance (m)	Relative elevation (m)	Distance (m)
Inference and caveats	Distance (m)	Infer relative elevation change from one point to the next	Distance (m)
Calibration procedure / frequency	Use same tape; compare to other teams and metal tape measure (see above)	Use same rod; compare to other teams and metal tape measure (see above)	Use same rangefinder; compare to metal tape measure (see above)
Acceptance Criteria	satisfies DQOs	satisfies DQOs	satisfies DQOs
Action if Unacceptable	Remeasure	Remeasure	Remeasure
Preventive maintenance of instrument / frequency	N/A / N/A	N/A / N/A	Clean viewfinder / monthly

Bioassessment Data

For quality-control measures to be followed in collecting all bioassessment data, please refer to Appendix H.

GIS data

The following section provides detailed quality assurance measures for the collection and processing of GIS data.

5.3. Data sources

In addition to AA and buffer boundaries that will be hand-drawn on aerial imaging at the time of site visits, GIS data include two sources of maps to describe the locations, extent, and characteristics of wetlands: The National Wetlands Inventory (NWI) of wetlands, and standard DOQQs (digital orthogonal quarter quadrangles) of the USGS. These maps and georectified aerial photo-images will be necessary not only for locating the focal wetlands (AAs) being calibrated, but also for calibration of the Connectivity Metric, which takes into account proximity of the AA to neighboring wetlands.

The NWI data (<http://www.nwi.fws.gov>) are available for each region. The NWI uses manual photo-interpretation of aerial imaging supplemented with Soil Survey information and field checking to hierarchically place wetlands into systems, subsystems, and classes. The minimum mapping unit is usually between 1-3 acres. Additional information on data quality (attribute accuracy, logical consistency, and completeness); on data capture processes; and on the Cowardin classification is given by the NWI metadata (<ftp://www.nwi.fws.gov/metadata/>). These maps vary among the regions of the project, however, in terms of their accuracy, completeness, and vintage.

The DOQQs are a standard mapping product of the USGS. The related metadata and production protocols are available through that agency (<http://rockyweb.cr.usgs.gov/nmpstds/metastds.html>).

5.4. Precision, Accuracy, and Completeness

The primary source of error in thematic maps, such as will be used in this project, is incorrect classification rather than spatial inaccuracy, particularly for digital maps derived from high quality source materials and reviewed by local experts. Incorrect classification can occur when small wetland sites are overlooked because of limited spatial resolution and field knowledge, or when sites are delimited but incorrectly identified. Incorrect classification also results when older maps do not reflect recent changes, such as wetland loss, restoration, or mitigation. For the regions of this project, the arid nature of the landscapes adds uncertainty to the maps due to large inter-annual variations in water supply. For example, maps produced during droughts tend to show fewer wetlands or less extent of wetlands than maps produced during years of average or above-average rainfall. The PIs will use the wetland classification guidance stipulated in Section 3.2 of CRAM v 3.0 to verify and reclassify misclassified wetland in the process of CRAM calibration. When there are uncertainties about characteristics of the wetland (such as hydrology) that

are not readily apparent through a field investigation, CRAM data collectors will solicit local and regional knowledge of the Regional Teams to address these uncertainties.

The DOQQs that will be used during CRAM calibration will vary in vintage. In areas of rapid landscape change, the older DOQQs may provide incomplete or inaccurate information about wetland size, shape, or location. The depiction of wetlands in DOQQs will therefore be checked, and if necessary corrected, based on the site visits.

5.5. Site Selection

Selection of sites for CRAM calibration (see Appendix B for the list of potential sites) will be done based on where data sharers have conducted their data collection. The sites will be selected based on the scores for each type of Level III data available for each site. The site-selection procedure was described in Section 4.6 of this document. Sites selected will be identified in GIS shape files for each region.

5.6. Ground-Truthing

Our project does not have the resources to map small features missed in previous maps. However, our field visits to wetland sites that are selected for calibration of the CRAM will provide some ground truthing of the source maps, by comparing maps on aerial imaging with current site condition and extent (using a GPS unit, if necessary). We will be able to determine which of the wetland locations selected by the project participants have been correctly identified and classified. We will also gain some information on the extent of wetland loss between the time of source map production or updates and the present. Our fieldwork will also provide verification information for other mapped information in coverages, such as land use adjacent to sampled wetlands. We will correct our digital coverages when discrepancies between maps and field observations are found. Any sites found to be misclassified will be reclassified with the correct wetland class in the database, thus preventing a repeat of the same problem in any future surveys. In addition, if sites are found to be misclassified upon ground-truthing, another site of similar condition, and of the desired wetland class, will be chosen to replace the misclassified site within that region.

6. Data Management

Data management for Phase II of this project will involve maintaining various types of data and information, including hardcopy and electronic imaging and other background information for sites selected for calibration of the CRAM, completed field data sheets, and pre-existing data used in the calibration.

SFEI, SCCWRP, and MLML will each be responsible for managing the data for their region. Routine backups of the computing systems and databases at these organizations are performed regularly, and network and computer security are governed by the individual System Administrators. Backup tapes are stored in fireproof facilities off-site.

6.1. CRAM Access Database Internal Quality Assurance Checks

In addition to quality control measures governing data collection, the Access database developed to store CRAM calibration field data will also incorporate numerous measures to assure accurate data entry and processing. The following measures will be implemented:

1. Each field in the Access database that requires a value will be checked for null or missing values.
2. Standard codes will be provided in look-up lists for use in populating the data table fields.
3. The entry of duplicate records will be prevented, based on a unique combination of fields that define the primary key.
4. If the record set is related to another table in the database, it will be checked for orphan records (i.e., all parent records have child records and all child records have parent records).
5. All of the calibration sites will be checked for having corresponding records in each data table.

6.2. Review, Validation, and Verification of Phase II Information

Field crews will complete the field data sheets for CRAM calibration, either on hardcopy forms or electronically using a tablet programmed with the individual field data sheets. Before leaving a site, field crews will check the data sheets for completeness. If, for some reason, the field data sheets are lost prior to entry in the database, or the electronic database is lost through computer failure, etc., the site will need to be revisited so that the data may be collected again.

As previously stated (under Section 5), the PIs will be responsible for making sure that all data forms that are used in calibration are filled out completely. Regional Teams will provide the PIs with completed forms for a site within three days after the site is visited. The PIs will check each form for completeness (i.e., all fields requiring information are completed). If a PI finds that data are missing or that data have been incorrectly entered onto a form, then the persons who collected the information will be notified of the specific problem within two days after the form is submitted to the PIs, and, if necessary, sites will be visited again to obtain or correct the data in question.

6.3. Uploading Field Data into the Database

Depending upon the method used to collect field data, results will be uploaded into the CRAM calibration database by one of the following methods:

- If data are recorded electronically using a programmed tablet, a standard procedure is being developed as part of CRAMIT's (CRAM Information Technology) integrated data

management system for transferring field data from an individual tablet into the CRAM calibration database. Standard operating procedures, including procedures for the retrieval and exchange of results, will also be developed as part of CRAMIT. In addition, for data that are recorded electronically, hard copies of the data will be printed out, as backup, in case of failure of the electronic system and loss of data.

- If hardcopy field data sheets are used, the original data sheets will be transferred to the region's PIs and checked for completeness and correctness. Information from the data sheets will be entered into the CRAM calibration Access database by data management staff at SFEI, SCCWRP, and CCC/MLML. The electronic forms will be compared to the original hardcopy data sheets and any errors in the database will be corrected. The original data field sheets for the Southern California Bight, the San Francisco Bay Area, and the Central Coast will be retained by SCCWRP, SFEI and CCC/MLML, respectively.

The data are uploaded only after they have been checked by the CRAM data collectors in the field, and, for completeness, by a PI belonging to the region. Once the regional teams have compiled and verified their calibration results in a database, the three databases will be integrated into one final CRAM calibration database and checked for consistency among the regions.

Through funding from a Section 104 EPA grant, CRAM results will be integrated into the Wetland Tracker (www.wetlandtracker.org) for the San Francisco Bay Area. Funding is also available to explore adapting the Wetland Tracker to the Southern California Bight and Central Coast regions.

6.4. Report

SFEI, SCCWRP, and CCC/MLML will prepare a joint, final Report that documents how the results of the field tests conducted during the calibration effort were used to finalize the CRAM metrics and attributes scoring systems. This report will include, as a chapter, the QA/QC activities undertaken for the calibration. This chapter will evaluate the quality of the data based on the QAPP for CRAM calibration. Project reports and peer-reviewed publications will include, as deemed appropriate, analyses of the calibration data, as described in this version of the QAPP. The Report will discuss the sources of all data used, metadata for those data when available, how the data were assembled and manipulated in our analyses, estimates of data quality, statistical methods used in the calibration analyses, and statistical significance and uncertainties in relationships between CRAM scores and independent data.

Data analysis will begin with exploratory exercises, such as generating descriptive statistics and histograms for each of the CRAM metrics, in order to understand the distribution of scores. This is important to confirm that the sample of sites truly reflected a meaningful distribution of condition. In addition, the Level-III data of each type will be plotted against CRAM scores, individually for each metric. This will allow investigators to confirm assumptions about the relative nature of successive metric rating narratives in the draft CRAM. Either a monotonic relationship, or no relationship at all, is expected between the CRAM metrics scores and Level-III data. If more than one Level-III dataset corresponds to the CRAM scores in a non-monotonic fashion for any given metric, then the metric narratives may need to be adjusted.

Analysis of variance (ANOVA) will be used, as necessary, to scale the metrics and/or attributes. To this end, Level-III data scores will be collapsed into four bins corresponding to the letter scores (A – D). The “A” bin will arbitrarily be given a score of 4. The slope resulting from a series of ANOVAs will be used to determine numeric scores for each of the remaining categorical bins (scaled to A = 4). Since the metric and/or attribute scores should have a linear relationship with the data, actual scores associated with each bin will be adjusted so they fall on the line. The significance level for all statistical analyses will be $\alpha = 0.05$.

6.5. Assessment and Oversight

The PIs will work in cooperation with the Core Team and Regional Teams throughout the course of this project. Paul Jones will provide general oversight.

6.6. Corrective Actions

Data compiled for all sites will be screened by the PIs. If errors and/or omissions are found, SFEI, SCCWRP, and CCC/MLML will work with their respective data collectors to determine if the data were incorrectly entered into the database tables or if the data were not correctly obtained in the field. If errors in field measurements are identified, the PIs will, when possible, return to the sites and re-collect the information in question. If procedural errors that could affect the entire calibration effort (e.g., a problem with the guidance in CRAM v 3.0) any team that discovers the error will immediately notify the other two teams so that the problem can be rectified in a concerted manner.

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Appendix A: List of Acronyms

AA	Assessment Area
ANOVA	Analysis of Variance
BMI	Benthic macroinvertebrates
CCC	California Coastal Commission
CRAM	California Rapid Assessment Method for wetlands
CSBP	California Stream Bioassessment Procedure
DOQ	Data-Quality Objective
DOQQ	Digitally Orthorectified Quarter Quadrangle
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
GIS	Geographic Information System
HGM	Hydrogeomorphic Method
IBI	Index of Biotic Integrity
IBP	Institute for Bird Populations
LDI	Landscape Development Intensity
MAPS	Monitoring Avian Productivity and Survivorship
MAPSPROG	Windows-based computer program for entry/import, editing, verification, and error tracking of MAPS data
MLML	Moss Landing Marine Laboratory
NWI	National Wetlands Inventory
ORAM	Ohio Rapid Assessment Method
OSU	Oregon State University
PI	Principal Investigator
QAO	Quality Assurance Officer
RAM	Rapid Assessment Method
RPD	Relative Percent Difference
SCCWRP	Southern California Coastal Water Research Project
SFEI	San Francisco Estuary Institute
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
US ACE	U. S. Army Corps of Engineers

Appendix B: List of sites with Level-III data for use in CRAM calibration

Appendix C: CRAM User's Manual v 3.0

Appendix D: MAPS protocol

Appendix E: EMAP protocol and QAPP

**Appendix F: California Stream Bioassessment Procedure (CSBP)
protocol**

Appendix G: Riverine Geomorphology data sheet

Appendix H: Bioassessment QAPP