FINAL REPORT ON
"DEVELOPMENT OF A STATEWIDE NETWORK OF REFERENCE WETLANDS FOR CALIFORNIA"-PHASE I

A PROJECT FUNDED BY US EPA SECTION 104
GRANT NO. CD-96924501

Submitted By:

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FINAL REPORT ON
"DEVELOPMENT OF A STATEWIDE NETWORK OF REFERENCE WETLANDS FOR CALIFORNIA"-PHASE I
EPA GRANT NO. CD-96924501

I. Introduction and Purpose

This is the draft final report for EPA Grant No. CD-96924501 entitled "Development of a Statewide Network of Reference Wetlands for California – Phase I". This report applies to Task 7 in the original scope of work for this project and is intended to provide a summary of the status of each of the tasks and recommended next steps for the development of a statewide network of reference wetlands for California and elements of quality assurance and control (QA/QC) for the California Rapid Assessment Method (CRAM). This report is structured according to the tasks in the original scope of work.

Reference Wetland Sites

A key element of California's Wetland and Riparian Area Monitoring Program *(*WRAMP) is the identification and maintenance of a set of State wetland reference sites that represent minimally-disturbed (least impacted) conditions. The reference condition provides the standard against which protection efforts, including restoration and compensatory mitigation projects, and changes in ambient conditions can be evaluated. According to The WRAMP, the State's wetland reference network will be comprised of coordinated and comparable regional networks of wetland reference sites. These sites will be used to support the calibration and validation of core WRAMP assessment methods, such as the California Rapid Assessment Method (CRAM),

The regional networks will be used for a wide range of applications to meet the needs of a variety of State monitoring programs and policies in several ways:

- Support the Development and Implementation of Standardized Wetland Assessment Methods (including core WRAMP methods such as CRAM);
- Characterize Wetland Beneficial Uses;
- Improve Decision Making for Wetland Restoration and Mitigation Projects;
- Support the Development of Biological Objectives for all Wetland Types;
- Assess the Effects of Climate Change and Other Long-term Changes.

The Role of Audits in CRAM Quality Assurance/Control (QA/QC)

The California Wetland Monitoring Workgroup (CWMW) recognizes the need to develop a coordinated quality assurance and quality control (QAQC) plan that includes audits of selected monitoring data and reports. Audits are expected to be a key component of the QAQC program for each of the core methodologies of the WRAMP, such as CRAM. The primary goal of these audits is to help maintain the highest possible standards of accuracy and precision of WRAMP output by helping to: (1) evaluate the efficacy of the WRAMP methodologies and (2) evaluate how well CRAM practitioners follow the instructions and guidance documents for the methodologies. This will help in identifying and correcting misuse and misapplication of core WRAMP methodologies, especially as they relate to project assessment and regulatory decisions.

II. Status of Major Tasks

Work completed on each of the seven major project tasks is given below.

Task 1 – Prepare a quality assurance project plan

A quality assurance project plan (QAPP) was prepared for this project in accordance with Version 2.0 of the EPA Region 9 Quality Assurance Project Plan Guidance (USEPA Region 9, July 9, 2010). Because this project did not include off-site laboratory analyses, only Sections 1-4 of the QAPP guidance document were required. The project QAPP (Appendix A) was submitted to and accepted by the EPA Project Manager for this grant.

Task 2 – Develop a reference network white paper and vete with the Statewide Steering Committee.

Purpose: The original purpose of this task was to produce a white paper that describes the process for establishing a network of reference sites and how this reference network and the regional audit teams would be used in the state's CRAM quality assurance quality control procedures. The draft white paper would be vetted before the Level 2 Committee of the CWMW. The final version of the white paper, reflecting the Level 2 Committee's input, would serve as the workplan governing the selection of the initial suite of reference sites and intercalibration exercises among regional audit teams.

Status: A final white paper was produced that describes the conceptual framework and overall process for establishing a network of wetland reference sites for California (Appendix B). This document was vetted with the Level 2 Committee of the CWMW and served as the workplan governing the selection of the initial suite of reference sites for Phase 1 of the network's development. This document builds upon the concepts and process outlined by the State Water Board's Reference Condition Management Program (RCMP) for wadeable streams and rivers in California.

Next Steps: Although criteria for wetland reference site identification has been developed, appropriate Level 1 wetland maps for additional wetlands types and associated screening tools are needed. An approach similar to the one outlined by the RCMP that employs a series of successive filters to screen and identify potential reference condition sites for wadeable perennial streams in California should be developed for additional wetland classes. The general approach, using a combination of landscape-scale and local condition information (based on aerial imagery and site visits), can be used to identify reference sites for other wetland types. Having a screening tool based on independent, landscape-level data would reduce the issue of circularity associated with biological reference sites being established with biological data (as is the case to some degree with CRAM).

<u>Task 3 – Facilitate the development of a regional audit teams in selected California bioregions</u>

<u>Purpose:</u> The purpose of this task was to expand the capacity for training and CRAM QA/QC to inland parts of California by facilitating the development of regional audit teams in the Sacramento Valley, San Joaquin Valley, Sierras.

<u>Status:</u> The project technical advisory team recognized that it was unrealistic to initiate the development of audit teams in the Central Valley and Sierra regions due to the limited capacity for CRAM training and implementation in these regions. The method is still in the initial stages of being introduced to local agency staff. It was determined that focus on regional audit team development should continue to focus on the four coastal regions of the State (North Coast/Klamath, Bay-Delta, Central Coast and South Coast). However, outreach, development, and training in CRAM would continue in the Central Valley and Sierra regions.

The L2 Committee recognizes that the formation of a regional audit teams is likely to happen in "phases" (Table 1; also see deliverable for Task 6). This approach will ensure that these teams develop in a controlled manner as practitioners and agency staff gain familiarity with CRAM and develop a sufficient level of expertise and comfort level with its application for regulatory, restoration, and management projects within the region. As CRAM is implemented more frequently in a region, formal audit teams will evolve over time.

Table 1. Phased-in approach for the formation of regional audit teams in California.

<u>Phase I: Development Team.</u> At this phase, some regional and local regulatory and management agencies have some experience with CRAM but none are using it as a regular part of wetland or stream assessment. The development team coordinates the regional roll out of CRAM.

<u>Phase II</u>: <u>Regional CRAM Roll Out</u>. At this phase, the Regional Water Board or other agencies?? has begun to explore the use of CRAM for ambient surveys or other applications, and/or recognizes the benefits of CRAM to other agencies within the region.

<u>Phase III</u>: <u>Advanced Training</u>. At this phase, the Regional Water Board has decided to proceed with the establishment of a regional audit team, based in part on the outcomes of Phases 1 and 2. The development team now transitions into the audit team.

<u>Phase IV: Audit Team.</u> At this phase, CRAM is an integral part of project assessment and/or ambient surveys of wetland and stream condition. There is a regional pool of 5-10 auditors who work through the L2 Committee to maintain their qualifications by being re-trained on new or revised CRAM modules and by serving as trainers.

As it currently stands, each region of California is at a different stage of its wetland program development (including implementation of CRAM; Table 2). At this time, no region of the State has a formal audit team for CRAM, but advanced training teams have been assembled for several regions (Appendix C). In addition, four new trainers for CRAM been identified during the project period can eventually serve as regional audit team members:

- Alexis Kessans (Senior Project Manager, ICF)
- John Markham (Project Manager, Regulatory,US Army Corps of Engineers)
- Wendy Renz (Consultant, Vollmar Consulting)
- April Robinson (Biologist, San Francisco Estuary Institute)
- Glenn Sybil (Environmental Scientist, California Department of Fish and Game)

Table 2. Current status of regional audit team development in California.

Regional Water Board	USACE District	Phase I: Development Team	Phase II: Regional CRAM Roll-out	Phase III: Advanced Training	Phase IV: Audit Team
North Coast (Region 1)	San Francisco	Y	Y	Y	N
SF Bay (Region 2)	San Francisco	Y	Y	Y	N
Central Coast (Region 3)	San Francisco	Y	Y	Y	N
Los Angeles (Region 4)	Los Angeles	Y	Y	Y	N
Central Valley (Region 5)	Sacramento	Y	Y	Y	N
Lahontan (Region 6)	Los Angeles	N	N	N	N
Colorado River (Region 7)	Los Angeles	N	N	N	N
Santa Ana (Region 8)	Los Angeles	Y	Y	Y	N
San Diego (Region 9)	Los Angeles	Y	Y	Y	N

Next Steps: Agency and practitioner trainings in the Sacramento area and Sierra bioregion have been conducted in 2011 and will continue into 2012. In 2012, outreach to wetland managers and experts in the Central Valley will occur through a Technical Advisory Team that has been assembled for a project to calibrate the CRAM depressional module across statewide range in hydroperiod (Coastal Impact Assistance Program-CIAP). In the Sierra bioregion, outreach and development of CRAM continues through the Tahoe Science Consortium. The Level 2 Committee of the CWMW will be engaged in this process. Through these coordinated efforts, CRAM development, training, and audit team members for other regions of California will be identified.

Task 4 – Initiate the establishment of regional networks of reference wetlands for CRAM

Purpose: The purpose of this task was to initiate the establishment of regionally based networks of reference sites for selected wetland types. For Phase 1, the goal was to indentify 95 reference standard sites to be distributed among the various regions of the state according to the wetland typology developed for CRAM (Table 3). The use of CRAM typology was considered appropriate at the time because CRAM provided a standardized approach for wetland condition assessment (Collins et al. 2008), accounted for many rare wetland types for California (such as vernal pools) and is a core methodology of the WRAMP. Because CRAM modules are based on defined, hydrogeomorphic (HGM) wetland types, a cross-walk of this classification to the proposed aquatic resource classification system developed for the State Water Board's Wetland Area Protection Policy (WAPP) (Policy Development Team Memo #5) is possible. The proposed State classification system is based on a functional classification approach similar to HGM and CRAM. In addition, the use of HGM and CRAM terminology and definitions will help to maintain continuity with existing agency programs in California.

Table 3. Summary of reference wetland sites targeted for initial development of California's reference wetland network.

Wetland Type	Target Number of Sites	Number of Regions	Total Target No. of Sites
Perennially Tidal Estuarine	8	4	32
Seasonally Tidal Estuarine	3	3	9
Vernal Pool	3	4	12
Riverine	3	7	21
Depressional	3	7	21
Total			95

Status: A total of 119 reference standard wetland sites for selected wetland classes and bioregions were identified over the course of this project (Table 4; Figure 1; Appendix D). Reference standard sites were identified and selected as eligible for inclusion in the network using the suite of criteria described in the concept white paper (see Task 2; Appendix B). CRAM was used to verify the condition of candidate reference sites. Two types of reference standard sites based on CRAM were identified: (1) sites where the Overall CRAM Index Score indicated very good overall condition; and (2) sites where one or one or more of the CRAM Attribute Scores indicated very good condition. The 90th percentile of statewide CRAM Index and Attribute scores was used as the threshold for identifying Index Reference Sites and Attribute reference sites for the perennial estuarine and riverine wetland classes based on available ambient data.

Figure 1. Map of reference wetland sites by wetland class and region identified for Phase 1 of California's reference wetland network.

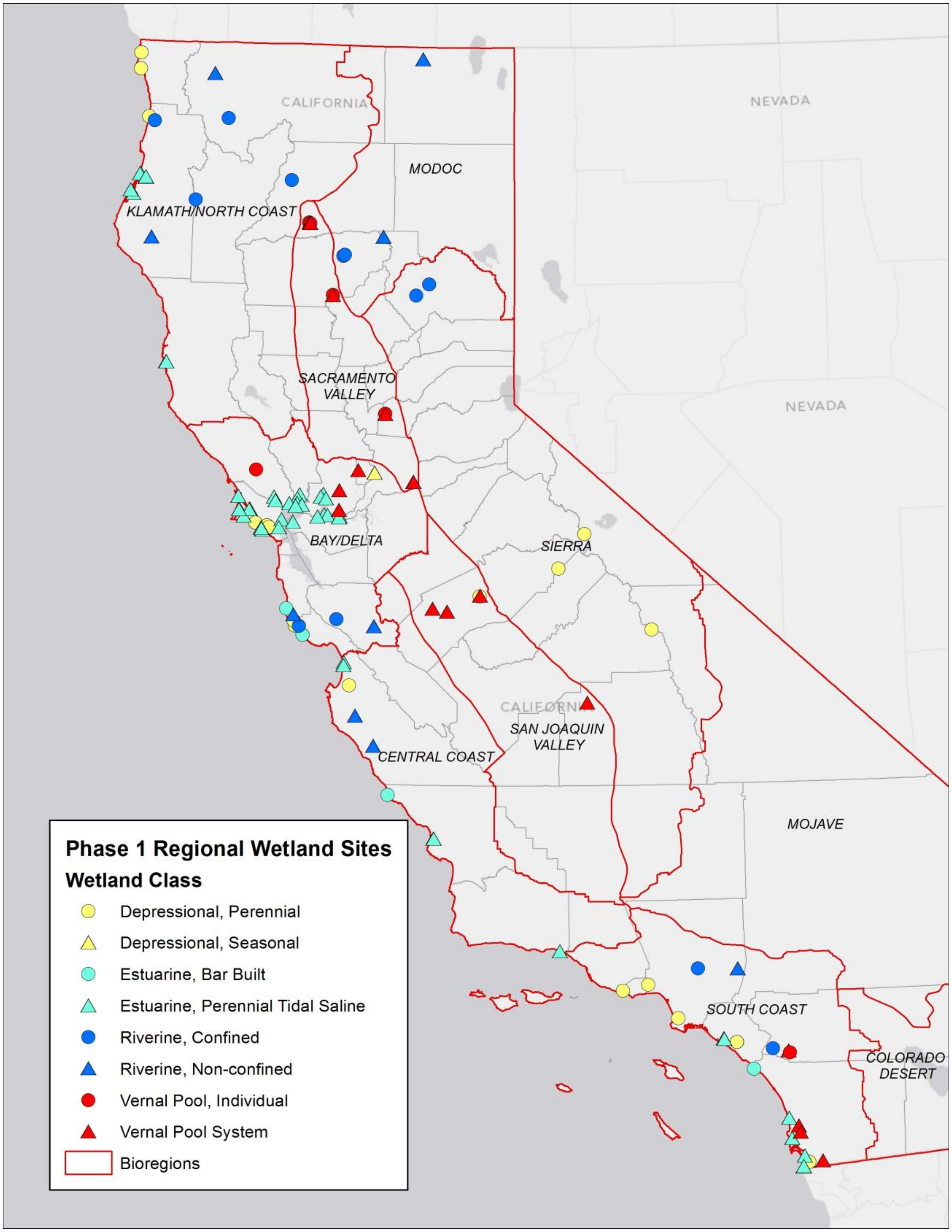

Table 2. Summary of the 119 reference wetland sites by wetland class and region identified for Phase 1 of California's reference wetland network.

Wetland Class	Wetland subclass	South Coast	SF Bay-Delta	Central Coast	North Coast	Sierras-Modoc	San Joaquin Valley	Sacramento Valley	Total Sites by Wetland Class
Estuarine	Perennial tidal saline	8	30	4	9	NA	NA	NA	**51**
Estuarine	Bar-built (seasonal)	1	0	3	0	NA	NA	NA	**4**
Riverine	Confined	1	1	1	4	4	0	0	**11**
Riverine	Nonconfined	2	2	2	2	2	0	0	**10**
Vernal Pool	Complex	4	3	0	0	0	4	6	**17**
Vernal Pool	Individual Pool	1	1	0	0	0	0	4	**6**
Depressional	Perennial	5	4	3	3	3	1	0	**19**
Depressional	Seasonal	0	0	0	0	0	0	1	**1**
	Total Sites by Region	**22**	**41**	**13**	**18**	**9**	**5**	**11**	**119**

Reference standard sites for Perennial Tidal Saline Estuaries were identified through the following efforts:

- Bay Area model for comprehensive wetland assessment in watershed context (SWRCB Prop 50). This project established a network of perennial estuarine wetland reference sites in the San Francisco Bay Area.

- Status of Perennial Estuarine Wetlands in the State of California (SWAMP and USEPA Region 9, California Coastal Conservancy). Data from this statewide ambient assessment of perennial estuarine wetlands with CRAM were used to identify reference standard sites in the coastal regions of California.

Reference standard sites for wadeable streams were identified through the following efforts:

- Reference condition management program (RCMP) to support biological assessment of California's wadeable streams (SWAMP). This effort includes CRAM as an indicator in its monitoring program. Several reference standard sites in the Sierra and Modoc Regions were identified using these data.

- Development of integrated measures of ecosystem condition to support biological objectives for riverine wetlands (EPA 104(3)(b). This effort includes CRAM as an indicator in its monitoring program. Riverine sites throughout California were identified using these data.

Reference standard sites for bar-built (seasonal) estuaries were identified through the following effort:

- Using new methodologies to assess seasonally tidal estuaries along the California coastline (EPA 104(3)(b). This effort identified reference sites for bar-built estuaries in the Central and South Coast regions of California.

Reference standard sites for perennial depressional wetlands were identified through the following effort:

- Assessment of Extent and Condition of Depressional Wetlands in southern California (SWAMP). This effort identified reference sites for perennial depressional wetlands in the south coast region of California.

Assessment area boundaries, CRAM metric scores, and associated site stressors for all 118 reference sites identified for Phase I were entered into the eCRAM database (www.cramwetlands.org). Detailed site information on these 118 sites has been included on the California Wetlands Portal (www.CaliforniaWetlands.net). This information includes:

- Characterization of land use in catchment or perimeter of the site;
- Site history with sufficient detail for the office portion of the CRAM assessment;
- Information on site ownership and current management;
- Anticipated future changes in adjacent land uses or other stressors;
- Site access instructions and general directions to site;
- CRAM condition and stressor score justification (when appropriate);
- Site photo documentation.

Although most reference standard sites were based on high condition as measured by CRAM, reference condition for several riverine sites was also established based on a landscape-level stressor analysis (GIS) conducted through the RCMP effort. In some of these cases, sites did not meet the score threshold criteria for CRAM (90^{th} percentile of Overall and Attribute scores), but passed the RCMP landscape-level GIS screen as appropriate reference condition for wadeable streams.

A minimum number of reference sites for the riverine, depressional, and bar-built estuarine wetland classes could not be identified for Phase 1. In the Sacramento and San Joaquin Valley, the lack of riverine and depressional reference was mainly due to the absence of undisturbed, high quality wetland sites in a region where natural landscapes have been almost entirely converted to agricultural and/or urban land uses. Most natural stream reaches in this region, for example, have been channelized or otherwise modified to support irrigation and flood control. Where depressional wetlands exist, these tended to be type-converted from a riverine system (e.g. artificial stock ponds) or artificially flooded for waterfowl management (e.g. duck ponds). The lack of public access to lands in Central Valley with depressional wetlands was another factor.

For bar-built estuarine sites, this module of CRAM was still being revised and it was determined that the additional sites for this wetland class would be identified in spring 2012 (see Next Steps). Identification of the regional wetland networks leveraged off several concurrent and complementary statewide and regional efforts.

Next Steps:

- Additional reference standard sites for bar-built estuaries in the South and North Coast regions will be identified in 2012 via the USEPA-funded project "Using new methodologies to assess seasonally tidal estuaries along the California coastline". Once these have been identified and assessed with the revised bar-built estuarine module of CRAM, this information will be uploaded to the eCRAM database and the California Wetlands Portal.

- Additional reference sites for depressional wetlands for all regions of the State (for both perennial and seasonal subtypes) will be identified in 2012 in association with a project funded through the Coastal Impact Assistance Program (CIAP). One of the tasks of this project is to calibrate the CRAM Depressional Module across statewide range in hydroperiod and land use type. As appropriate reference sites are identified via this effort, this information will be uploaded to the eCRAM database and the California Wetlands Portal.

- In coordination with the SWAMP RCMP, efforts will continue to identify appropriate riverine reference sites for the Central Valley and Sierra foothills bioregions.

- The California Wetland Monitoring Council should direct the CWMW to establish a technical subcommittee to develop and guide a plan for long-term management of the State reference wetland network, including a process for adding sites to and removing sites from the regional networks.

Task 5 – Train new audit teams and conduct 2 statewide audit team intercalibration workshops

Purpose: The purpose of this task was to conduct a series of intercalibration exercises with regional CRAM trainer and potential audit members. These would be used to update the CRAM Users Manual, field books, and eCRAM to reflect changes and/or clarifications made to the method during the intercalibration exercises.

Status: Several intercalibration sessions were conducted with the regional CRAM assessment team members during the project period. Revisions to the CRAM user's manual, and field books for estuarine (perennial saline and bar-built), riverine, and depressional we made as a result of the intercalibration exercise (Appendix E1).

August 16-17, 2010: A member of the Central Coast CRAM training team (Cara Clark) participated in a field day with members of the National Park Service and the Sierra Nevada Research Institute. CRAM was conducted at several wet meadow sites alongside intensive (Level 3) protocols that were being developed for wet meadows by the NPS.

July 2011: Riverine intercalibration at Redwood Creek (Central Coast Region) with Central and South Coast CRAM trainers. Participants included: Cara Clark, Ross Clark, Kevin O'Connor, Chris Solek, and Betty Fetcher.

October 19-23, 2012: A multi-day intercalibration exercise was held in southern California. Formal intercalibration was conducted using the perennial tidal saline estuary module of CRAM on October 21, 2012 at Upper Newport Bay. An intercalibration for the riverine module of CRAM was conducted at Big Canyon Creek in Newport Beach, CA on October 22, 2012. The CRAM training team agreed to focus intercalibration efforts on modules that were fully validated. Additionally, group assessment and consultation was conducted at two riverine sites on October 19, 2012 (Santiago and Aliso Creeks, Orange Co.), a bar-built estuary site on October 23, 2012 (San Mateo Lagoon, Orange Co.) and perennial depressional wetland on October 23, 2012 (Laguna Lake, Orange Co.). Attendees included:

- Cliff Harvey (State Water Resources Control Board, 401 Cert. & Wetlands Unit)[1]
- Alexis Kessans (Senior Project Manager, ICF)[1]
- John Markham (Project Manager, Regulatory,US Army Corps of Engineers)[1]
- Wendy Renz (Consultant, Vollmar Consulting)[1]
- Sarah Pearce (Biologist, San Francisco Estuary Institute)
- Mike Klinefelter (Principal, M.J. Klinefelter GIS & Environ. Consulting Services)
- Kevin O’Connor (Program Manager, Central Coast Wetlands Group)
- Cara Clark (Senior Scientist, Central Coast Wetlands Group)
- Kevin Lunde (Regional Water Quality Control Board-San Francisco)[2]
- April Robinson (Biologist, San Francisco Estuary Institute)[1]
- Chris Solek (Scientist, Southern California Coastal Water Research Project)
- Ayzik Solomesheh (Researcher, UC Davis)
- Carol Witham (Principal, Witham Consulting)

[1] attended formal intercalibration only (October 21, 2011)
[2] attended depressional field day only (October 23, 2011)

Overall, the regional training teams exceeded the known precision for estuarine and riverine modules of CRAM (Appendix E2). For the estuarine site, the three teams came within 2 CRAM points for the Overall Index Scores. Attribute scores were almost identical for all teams. For riverine, the three teams came within eight CRAM points of each other for Overall Index score. This is less precision than for estuarine, but still within the 10% known precision for the method. One group differed from others on the Physical Structure metrics and on. The difference on the Biotic Structure metrics can be explained by differences in the assessment areas. Clarifications to the field book on how to delineate the CRAM AA for riverine with large floodplains has corrected this. Difference in Physical Structure Attribute scores was based on differences in the number of patch types and the number of topographic benches. The group agreed that better definitions and diagrams in the field book would improve upon this.

Next steps:

Work will continue on developing capacity for WRAMP (including CRAM) in the Central Valley and Sierra bioregions. Outreach to the Central Valley on depressional CRAM development and implementation is progressing via the CIAP effort and will continue into 2014.

WRAMP implementation in the Sierra bioregion is occurring via the development of the wet meadow module of CRAM and will continue until at least 2014. Through these efforts, core CRAM development team members, trainers, and audit team members will continue to be identified. All efforts are being coordinated via the Level 2 Committee of the CWMW.

Intercalibration exercises involving both new and existing CRAM development and training team members will continue to be conducted opportunistically in various regions of the state.

Task 6 – Produce a technical memo providing options and cost estimates for funding of CRAM QAQC via regional audit teams

Purpose: The purpose of this task was to draft a technical memo outlining the proposed role of the audit team and costs associated with utilizing the regional audit teams for CRAM QAQC. This document would articulate a formal process for the development of regional audit teams in California and provide estimates of the funding stream required to establish a CRAM QAQC program needed for CRAM implementation with State wetland regulatory programs.

Status: The L2 Committee of the CWMW drafted recommendations for a program to audit CRAM scores (Appendix F). This document addresses the role of regional audit teams in providing adequate CRAM QAQC. It is intended for use by Federal, State, and local agencies that employ CRAM in regulatory or management decisions about wetlands. The purpose of the document is to:

- Describe the process for the development of regional CRAM audit teams;
- Define the composition, role, and responsibilities of a regional CRAM audit team and its relationship with aquatic resource regulatory and management agencies;
- Articulate the audit process for CRAM and describe the outcome of the process;
- Describe the likely annual costs and potential funding mechanisms to utilize regional audit teams.

Next Steps: This document was drafted with the expectation that these recommendations will be revised based on input from the CWMW and thereafter incorporated into the quality control and quality assurance (QAQC) document for the Wetland and Riparian Area Monitoring Plan (WRAMP).

Recommended Next Steps for California's Network of Reference Wetlands

The following is a list of recommendations for subsequent phases of the development of California's Wetland Reference Network:

1. Adding sites to the regional networks: The regional wetland reference networks should continue to be populated with sites as they are identified throughout the State based upon

the criteria described in the concept white paper (see Task 2). Reference sites will eventually be needed for other wetland types not assessed for Phase 1 (e.g. lacustrine, wet meadows). The California Wetland Monitoring Council should direct the CWMW to establish a technical subcommittee to develop and guide a plan for long-term management of the State reference wetland network, including a process for adding sites to and removing sites from the regional networks.

2. Wetland classification for reference condition: Although Phase 1 efforts classified wetlands according to a typology developed for CRAM, any new reference sites that are added to the regional networks should be classified according to the proposed aquatic resource classification system developed for the State Water Board's Wetland Area Protection Policy (WAPP) Policy Development Team (TAT memo #5) and the California Wetlands Monitoring Workgroup (CWMW). Development of the classification system will support and be consistent with WRAMP, including the California Aquatic Resources Inventory (CARI) and the California Rapid Assessment Method (CRAM).

   The proposed aquatic resource classification system is based on a functional classification approach similar to HGM and CRAM. In addition, HGM and CRAM terminology and definitions would be used to maintain continuity with existing agency programs in California. By not basing the system solely on CRAM, the result is both consistent with existing assessment tools (e.g., CRAM), and indicates where additional tool development is needed. This approach also reduces the likelihood the classification system will require revision as assessment tools are developed, revised, and expanded. A classification system consistent with the wetland classification in CRAM provides for a seamless integration between Level 1 mapping and Level 2 condition assessment, as called for by the CWMW and the SB 1070 Monitoring Council in the WRAMP and the State Water Board in the WRAPP.

   2. Using CRAM to assess site condition: Currently, CRAM modules are not comprehensive for all wetland types in California, modification and refinement of existing modules are ongoing, and new modules will be created with time. For example, the vernal pool module of CRAM has just undergone a major revision, and bar-built estuarine module of CRAM is still being refined. It will be important that any identified reference sites assessed with outdated CRAM modules during Phase 1 (e.g. some vernal pool sites) be reassessed in the future using the revised protocols.

3. Number of reference sites: A statewide framework for consistent selection of wetland reference sites must be able to account for California's complexity and the natural gradients within each ecoregion. Identifying a sufficient number of reference sites for the State's wetlands and streams will be complicated by the State's size, diverse ecological settings, extreme natural temporal cycles of dry and wet years, and anthropogenic settings. Human-dominated landscapes can be so pervasive in locations such as urban southern California and the agriculturally dominated Central Valley, for example, that no undisturbed reference sites may currently exist in these regions.

For these regions, selective relaxation of reference screening criteria and thresholds may be the only effective means of identifying the best available sites. For example, acceptable amounts of road densities in southern coastal California or local agricultural landuse percentages in the Central Valley (determined using Level 1 data) are likely to be higher than in less modified regions of California.

Reference site identification in these highly modified regions will also require a much larger amount of Level 2 and 3 data collected from direct site visits (rather than remote sensing data) to verify their reference status than in less modified regions. Increased emphasis on riparian condition, instream habitat condition, and water column chemistry will be needed. In some cases, additional Level 3 data (e.g., sediment and or water column toxicity) will be necessary to verify sites. Specific cutoffs such as >15% local impervious surface, or toxin concentrations greater than the standards set by the California Toxic Rule may be more appropriate in these heavily modified landscapes. While less stringent thresholds may help identify some of the best sites in highly modified regions, safeguards are needed to avoid accepting unacceptably low thresholds for reference condition.

4. Follow-up monitoring, assessment, and data management needs: Reference condition sites provide the foundation for developing biological objectives and defining beneficial uses for all wetland and aquatic resource types. Sites identified through Phase 1 should continue to be monitored and evaluated. Monitoring (both Level 2 and Level 3) should be conducted at all sites at least annually to document annual variation in reference condition. Level 3 data collection (intensive site assessment) will be needed at all sites to fully characterize the reference condition for the region, develop indices of biological integrity for specific wetland types, and validate any information gathered at the Levels 1 and 2.

   In addition, it is recommended that the reference site data be compiled and eventually made available on the State's developing Aquatic Resource Atlas.

5. Funding:

   Reference Sites: A stable source of funding for long-term monitoring and assessment of reference sites for all wetland types should be identified, including a minimum level of funding needed to support at least annual monitoring of sites. Opportunities to build partnerships with other state and federal agencies (e.g., USFS, State and Regional Waterboards, USGS) to help support the on-going development of the State's regional networks of reference wetland sites should be pursued. Some of these entities have current reference programs, while others would benefit from joining an established reference program (e.g. USACE, State Parks, Irrigated Lands Program, Agricultural Coalitions, etc.). In addition, the State should explore ways to combine its wetland program with other program components that would benefit from reference condition (e.g. SWAMP bioassessment, USACE Compensatory Mitigation Program, nutrient and sediment criteria monitoring).

CRAM QA/QC: The QA/QC aspects of CRAM as they relate to the development of regional audit teams is complicated by two primary issues: (1) existing agency structures do not have the internal capacity to establish these regional teams and implement recommended QAQC procedures as recommended by the Level 2 Committee of the CWMW, and (2) funding sources for the audit teams and other CRAM QAQC procedures are still undefined. Agencies that employ CRAM as a monitoring element of their program will need to include ways to implement the QAQC aspects associated with CRAM. Agencies budgets will need to include line items to cover staff costs or the hiring consultants to actually implement the QAQC procedures.

Intercalibration exercises involving all regional CRAM training/audit team members are a vital component of CRAM QA/QC and their importance should not be undervalued. It will be important to identify a funding mechanism to conduct these sessions, at least on an annual basis as revisions are made to the method. Grants that address any aspect of CRAM QA/QC, especially as it relates to the statewide training program for CRAM, should specifically include line items for inter-team calibrations.

Appendix A. Quality Control and Assurance Plan

TITLE
AND
APPROVAL PAGE

Title:
Development of a Statewide Network of Reference Wetlands for California – Phase I (EPA Grant No. CD-96924501)

Name and Address of Organization:
Southern California Coastal Water Research Project (SCCWRP)
3535 Harbor Blvd., Suite 110, Costa Mesa, CA 92626

1. Approved by Project Manager: Date:

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2. Approved by Project QA Manager: Date:

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3. Approved by Region 9 Quality Assurance Manager: Date:

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4. Approved by EPA Project Officer: Date:

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TABLE OF CONTENTS

1.0 PROJECT DESCRIPTION

1.1 Project Purpose and Problem Definition

The primary purpose of this project is to develop the conceptual framework for regionally-based networks of reference wetland sites in California and begin populating the network with wetland reference sites for targeted wetland classes. Specifically, a reference wetland network will be used to:

- Support the Development and Implementation of Standardized Wetland Assessment Methods;
- Assist in Characterizing Wetland Beneficial Uses;
- Improve Decision Making for Wetland Restoration and Mitigation Projects;
- Support the Development of Biological Objectives for all Wetland Types;
- Assess the Effects of Climate Change and Other Long-term Changes

A crucial component of California's wetland assessment program is the development of a network of wetland reference sites. At the present time, no such network exits. This core element of the assessment toolkit is needed to facilitate the on-going development of the State's wetland assessment programs and smooth implementation of existing statewide programs. This project will focus exclusively on Region 9 priority areas and align existing monitoring programs in the coastal regions with inland bioregions of the state (i.e. Sacramento Valley, San Joaquin Valley and the Sierra). Establishing a firm conceptual approach to wetland reference condition will not only aid in the design of a wetland monitoring and assessment programs throughout the state, but the ecological understanding derived from this characterization can be applied to other regions of the state.

The reference condition provides the standard against which changes in current biological conditions are evaluated. Most commonly, these expectations are defined by a range of indicator or index scores, with the range of values a result of natural variability in time and in space (Stoddard *et al*. 2006). The various definitions of reference condition have been discussed extensively (Hughes and Larsen 1988, Hughes 1995, Stoddard *et al*. 2006). The concept is flexible and can be approached in multiple ways depending on the management objectives, available resources, and accuracy required by a particular program.

The State network of reference wetlands will be organized by region and by wetland type to support both ambient assessments and project evaluations of wetland condition. The regional reference networks are intended to support the efforts of various State and Federal agency-specific programs that require the use of reference wetland sites. It is expected that over time, various types of data will be collected at the wetland sites comprising the regional reference networks. The types of methods used and the indicators to be monitored at these sites will ultimately depend upon the nature of monitoring needed at the site in question and the resources available to carry out the monitoring. Because the regional networks will be used by various agencies for a variety of programs, they will require cooperative strategies for their support and maintenance. Therefore, phased development and implementation of the reference networks are envisioned. Regional expertise, agreement on regional priorities, defining the most appropriate methodologies, data sharing, and cost sharing will be critical for all phases of the network's development.

In addition, this project will contribute to quality assurance and control for the California Rapid Assessment Method for Wetlands (CRAM) by facilitating the development of a regional audit teams in the San Francisco Bay-Delta and Central Valley bioregions of California and providing options and cost estimates for long-term funding of these audit teams. To date, efforts to build State capacity to assess wetlands have focused on CRAM) as a standardized wetland assessment method (Collins *et al*. 2008). The regional wetland reference networks have an important role to play in the quality assurance of CRAM. Specifically, reference sites will 1) assure that CRAM practitioners and agency staff are using the same internal frame of reference for scoring CRAM for all wetland types across all regions of the state, 2) document the accuracy of CRAM in capturing the gradient of disturbance across the state, 3) provide sites to train CRAM practitioners with regional examples of high scoring wetlands, and 4) provide information about the recovery trajectory for wetland types assessed with CRAM.

1.2 Project Area Description

Phase 1 efforts will begin to populate the regional networks with reference sites for six broad regions of California**:** 1) North Coast (as a subsection of Klamath), 2) Bay-Delta, 3) Central Coast, 4) South Coast, 5) Central Valley (San Joaquin and Sacramento Valleys), and 7) Sierras (Figure 2). These regions represent a combination of Omernik Level III ecoregions and Regional Water Quality Control Board (RWQCB) boundaries (Ode and Schiff 2008). Because these delineations include significant ecological gradients that could contribute to natural variability in wetland condition, they are appropriate to use as the initial boundaries for this first phase of the network's development.

1.3 Responsible Agency and Participating Organizations

The Southern California Coastal Water Research Project (SCCWRP) is the lead organization for this project. The three primary regional contractors/collaborators include the San Francisco Estuary Institute (SFEI), Central Coast Wetlands Group at Moss Landing Marine Laboratories (MLML), and the Humboldt Bay Harbor Recreation and Conservation District (HBHRCD). SCCWRP is responsible for all project administration and technical coordination; each regional collaborator will be responsible for conducting coordination, assessment and outreach activities within their respective regions. SCCWRP and SFEI will lead the effort to identify and establish new reference sites new in the Sacramento Valley, San Joaquin Valley and Sierra bioregions. These entities will also work to establish new regional audit teams. These tasks will be conducted in close coordination with EPA, the SWRCB and members of the CWMW.

1.4 Project Organization Roles and Responsibilities (Laboratory Contact NA)

Title/ Key Tasks or Responsibility(ies)	Name	Organizational Affiliation	Training/ Qualifications*	Telephone number/ email
EPA Project Officer/Oversees Direction of Project	Paul Jones	USEPA Region 9	Wetland Scientist; trained CRAM Practitioner	415-972-3470
Project Manager/Directs Day-to-Day Work of Project	Dr. Christopher Solek	SCCWRP, Scientist	Ph.D Biologist; CRAM Technical Lead: trained CRAM practitioner	714-755-3244
Project QA Manager/Oversees QA Activities for Field, Lab, Data Review	Dr. Christopher Solek	SCCWRP, Scientist	Ph.D Biologist; CRAM Technical Lead: trained CRAM practitioner	714-755-3244
Staff/Performs Project Tasks (List Tasks)	Dr. Betty Fetscher	SCCWRP, Senior Scientist	Ph.D Biologist; CRAM Technical Lead: trained CRAM practitioner	714-755-3237
Staff/Performs Project Tasks (List Tasks)	Jeff Brown	SCCWRP, Senior Research Technician	Trained CRAM practitioner	714-755-3226
Contractor I (Company Name)/Oversees Special Work (Describe Work)	SFEI	Non-Governmental Research Organization	CRAM field assessments and data management (SF Bay-Delta)	510-746-7334
Contractor I Staff	Letitia Grenier	SFEI, Program Manager	Ph.D Biologist; CRAM Technical Lead	510-746-7388
Contractor I Staff	Sarah Lowe	SFEI, Environmental Scientist	Project Coordinator	510-746-7384
Contractor I Staff	Aroon Melwani	SFEI, Associate Environmental Scientist	Field Coordinator	831-917 4277
Contractor II (Company Name)/Oversees Special Work (Describe Work)	CCWG at MLML	Non-Governmental Research Organization	CRAM field assessments and data management (Central and North Coast)	831-771-4463
Contractor II Staff	Ross Clark	Program Director, CCWG at MLML	CRAM Technical Lead	831- 771-4495
Contractor II Staff	Kevin O’Connor	Habitat Restoration Project Manager, CCWG at MLML	Project Coordinator and CRAM Technical Lead; CRAM practitioner and trainer	831- 771-4495
Contractor II Staff	Cara Clark	Technician, CCWG at MLML	CRAM Technical Lead and Trainer	831- 771-4428
Contractor III (Company Name)/Oversees Special Work (Describe Work)	Roberts Environmental and Conservation Planning LLC	Private Consulting Firm	CRAM field assessments and data management (Central Valley and North Coast)	530-758-3062
Contractor III Staff	Dr. Chad Roberts	Appointed officer of the HBHRCD	Independent professional wetland scientist; CRAM Technical lead; CRAM practitioner and trainer	530-758-3062

1.5 Permit Requirements for Collection of Environmental Measures

No special permits are required for this project. Appropriate access permission to sites will be obtained in advance of visiting sites.

1.6 History, Previous Studies, Regulatory Involvement

Although the use of reference sites is not novel to the science of wetland monitoring in the State, the procedures for defining reference conditions have been largely driven by project or program specific objectives and sites have not been selected using standardized criteria and methods. This allows for selection of reference sites that are closely related to the comparison site, but is an often difficult and costly approach to developing and managing a coordinated reference network over the long term. Developing a reference network for wetlands based on standardized criteria and site screening procedures is particularly important for California, where natural variability among wetland types is compounded by a tremendous variability in topography, climate, and land use.

In 2008, the bioassessment committee of the State Water Board's Surface Water Ambient Monitoring Program (SWAMP) drafted the framework for a comprehensive reference condition management program (RCMP) for wadeable perennial streams in California (Ode and Schiff 2008). However, it was recognized that reference conditions must be established for all wetland and aquatic resource types in the State. Since that time, the California Wetland Monitoring Workgroup (CWMW) was endorsed as a subcommittee of the California Water Quality Monitoring Council (Senate Bill 1070; Kehoe 2006). The CWMW has drafted a Wetlands and Riparian Assessment Monitoring Program (WRAMP) to coordinate all regional and statewide efforts in order to develop a set of standardized practices and methods for monitoring wetlands (CWMW 2009). The WRAMP highlights the importance of establishing a standardized network of reference wetland sites in order to calibrate its core assessment methodologies to reference conditions to account for the natural regional variations in wetland condition.

2.0 PROJECT DATA QUALITY OBJECTIVES

2.1 Data Quality Objectives (DQOs)

A. What are the questions to be answered by the study? How do these questions relate to specific decisions to be made, actions to be taken, and/or hypotheses to be tested?

Most wetland programs and policies in California include a goal of maintaining or restoring wetland condition or function. The ability to determine proximity to this goal depends, in part, on having well defined assessment targets. In order to establish these targets, reference conditions must be clearly defined. Defining reference conditions (based on reference sites) provides a scientifically defensible basis upon which to define attainable biological expectations for natural, wetland ecosystems (Kentula *et al*. 1992, Reynoldson *et al*. 1997, Karr and Chu 1999, Bailey *et al.* 2005). The first phase of this effort will focus on identifying reference standard sites, defined as "minimally disturbed" wetland sites (those most approximating natural or near-natural conditions). These sites will be used to answer a fundamental question: "what is the expected reference condition of wetlands in the various biogeographical regions of California"?

B. Identify the general categories of information needed to answer the questions.

Phase 1 of the network's development will focus on identifying a subset of reference standard sites for coastal tidal estuarine wetlands (perennial and seasonal), wadeable streams, perennial depressional wetlands, and vernal pools in selected biogeographical regions of California, including the South Coast, Central Coast, Bay-Delta Area, North Coast, Central Valley and the Sierra.

Reference sites will be identified and selected using existing wetland inventories and maps, including the USFWS National Wetland Inventory (NWI), the National Hydrography Dataset (NHD), and the California Statewide Wetlands Inventory. When available, updated and more detailed regional wetland maps, including the southern California wetlands mapping project (http://www.socalwetlands.com) and the Bay Area Aquatic Resource Inventory (http://www.sfei.org/BAARI), will also be used.

Phase 1 efforts will classify the wetlands to comprise the regional networks according to wetland typology developed for CRAM. The use of CRAM wetland typology for Phase 1 of the reference network's development is appropriate because efforts to build State capacity to assess wetlands have focused on CRAM as a standardized wetland assessment method. Furthermore, crosswalks from the CRAM typology to other wetland classifications systems (e.g. NWI and HGM) are available.

C. What specific measurements and observations are needed to answer the questions?

For Phase 1, the California Rapid Assessment Method for Wetlands (CRAM) will be used to assess the condition of the proposed reference sites (Collins *et al.* 2008). CRAM assesses wetland condition based on four overarching *Attributes*: Buffer/Landscape Context, Hydrology, Physical Structure, and Biotic Structure. Within each of these attributes are a number of *Metrics* that address more specific aspects of wetland condition. A complete description of CRAM Attribute and Metrics is provided in Collins et al. (2008).

D. What criteria will be used to evaluate each of the measurements and observations?

A combination of several criteria will be used to screen and identify "minimally disturbed" sites. These include a lack of known anthropogenic stressors present at a site, previous condition assessments (e.g. CRAM) or site data that indicate high condition or function, and local knowledge of individuals familiar with the site. In addition, reference sites must be accessible in the long-term. Sites located on public lands and ecological reserves (identified from property boundary maps) will be prioritized for the network because these are most likely to be protected and accessible as reference sites in the long-term. Once sites have been selected, written permission that acknowledges the site's intended use and access procedures will be secured. Sites located on private lands will be used only if a written agreement from the landowner and an expectation of continued access if ownership changes can be obtained.

Sites that meet the above criteria will be considered eligible for inclusion of the network. Once a site has been targeted, it will be assessed with CRAM. The reference network will be constructed based on CRAM Attribute scores. This will provide a network where some reference sites will score high in some attributes and not in others. Reference standard sites will be defined as sites that score a minimum of 90 for all CRAM Attributes. However, it is recognized that such sites may not exist for a particular wetland type in all regions of the State. Existing CRAM data sources will be mined to analyze statistical distributions of CRAM attribute scores (e.g. perennial tidal estuaries, wadeable streams). These distributions will be used to assist in identifying cutoffs for what gets included in the reference network for each region For the CRAM wetland types that are currently not validated and/ or little data is available (i.e. perennial depresssional wetlands, vernal pools), the 90 score cutoff requirement will be relaxed or adjusted as these modules are refined over time.

This information will be used to create reference profiles for each region (e.g. urban streams in the SF Bay, high gradient ephemeral streams in the South Coast) based on CRAM Attribute and Metric scores for the specific CRAM wetland types.

2.2 Measurement Quality Objectives (MQOs) for Field Activities

This project subscribes to the general quality assurance procedures outlined in the CRAM User's Manual (Collins *et al*. 2008) and the CRAM Technical Bulletin (CWMW 2009). In addition, this project will follow the procedures and data quality objectives outlined in two existing Quality Assurance Project Plans (QAPPs) that were previously developed for CRAM. These include the QAPPs for the calibration of estuarine and riverine wetland types (Fetscher et al 2005) and the assessment of the status of California's estuarine wetlands with CRAM (Sutula et *al.* 2007). Both documents outline measurement quality objectives for all field activities as they relate to CRAM data collection relative to data representativeness, comparability, completeness, precision, accuracy, and sensitivity.

2.3 Data Review

This project subscribes to the general data review procedures outlined in Collins *et al.* 2008, Sutula et *al.* (2007), and Fetscher et al (2005). Field crews will complete the field data sheets for CRAM assessment in hardcopy form. 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, the site will need to be revisited so that the data may be collected again.

The CRAM field team leaders will be responsible for making sure that all data forms that are used in assessment are filled out completely. CRAM field teams will provide the project lead with completed forms for each site, which will be delivered to the Project Manager within three days after the site is visited. The project manager will check each form for completeness (i.e., all fields requiring information are completed). If a project manager 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 three days after the form is submitted to the project manager, and, if necessary, sites will be visited again to obtain or correct the data in question.

2.4 Data Management

This project subscribes to the general data management procedures outlined in Collins *et al.* 2008, Sutula et *al.* (2007), and Fetscher et al (2005). Data management for this assessment will involve maintaining CRAM data and site-specific information, including hardcopy and electronic imaging and other background information for selected sites, completed field data sheets and GIS data. eCRAM will be used by the assessment teams as the standardized database for CRAM data. Regional CRAM databases (as Microsoft Excel spreadsheets) will be maintained by each regional lead and the results batch loaded into a centralized database maintained at SCCWRP and into the CRAMwetlands.org public database. Various types of statistical software will be used to analyze the data.

Each region will be responsible for managing the data for their region. Routine backups of the computing systems and databases at these organizations are performed daily, and network and computer security are governed by the individual System Administrators. Backup tapes are stored in fireproof facilities off-site. Raw data collected for this project will be maintained for a minimum of 5 years.

2.5 Assessment Oversight

This project subscribes to the general assessment oversight procedures outlined in Collins *et al.* 2008, Sutula et *al.* (2007), and Fetscher et al (2005).

2.6 Acquired Data (Also Known As Secondary Data, Existing Data, Non-Direct Measurements)

An office-based assessment that includes a review of relevant background information for each candidate reference site will be conducted prior to any field work. This will site that include a review of relevant watershed reports, geologic, hydrologic, soils or environmental reports, published maps, and any literature on the site. All air photos and other imagery used will adhere to the quality assurance guidelines in outlined in Collins *et al.* 2008, Sutula et *al.* (2007), and Fetscher et al (2005).

2.7 Reports to Management

The status of data collection during this project will be reported to the USEPA Region 9 grant manager on a quarterly basis. A draft assessment report will be filed no later November 2011. If EPA requires or requests copies of these reports, they shall be submitted in a timely fashion. The final list of reference sites will be vetted with the California Wetland Monitoring Council (CWMW)

3.0 FIELD STUDY DESIGN/MEASUREMENT PROTOCOL(S)

(1) Descriptions of the locations where the measurements and observations will be made, and where samples will be collected for on-site or off-site analyses.

A total of 95 reference standard sites will be identified for this project based on the criteria described in Section 2.1. Sites will be distributed across wetland types and regions according to the table below. Note that the Central Valley (CV) includes two regions: the Sacramento Valley and the San Joaquin Valley)

Wetland Type	Number of Sites	Number of Regions	Total
Perennially Tidal Estuarine	8	4 (NC, CC, SF Bay, SC)	32
Seasonally Tidal Estuarine	3	3 (NC, CC, SC)	9
Vernal Pool	3	4 (SF Bay, CV, SC)	12
Riverine	3	7 (NC, CC, SF Bay, CV, SC, Sierra)	21
Depressional	3	7(NC, CC, SF Bay, CV, SC, Sierra)	21
Total			95

(2) Descriptions of the timing and/or frequency for each measurement, observation, and sampling activity that applies to your study.

A one-time CRAM assessment will be conducted at each site to establish a baseline CRAM score profile. Assessments will be conducted during the appropriate assessment window for each CRAM wetland type.

(3) Descriptions of the protocols to be used for all measurements, observations, and analyses required for the project and the rationale for their selection.

This project subscribes to the general protocols and procedures outlined in Collins *et al.* 2008, Sutula et *al.* (2007), and Fetscher et al (2005). CRAM is a qualitative assessment method and no sample collection (e.g. soils, sediment, and water quality measurements, etc.) is required.

3.2 Biological and Habitat Characteristics

3.2.1 Field Data

3.2.1.1 Vegetation

NA

3.2.1.2 Habitat Assessment

The California Rapid Assessment Methods (CRAM) will be used to assess wetland condition. The most current versions of the User's Manual (Collins *et al.* 2008) and field books can be viewed and downloaded at the CRAM website (www.cramwetlands.org).

3.2.1.3 Botanical Surveys

NA

3.2.1.4 Faunal Surveys

NA

3.2.2 Voucher Specimens for On or Off-Site Identification

In some cases, plant vouchers may be needed to identify plant species that cannot be determined in the field. Should this occur, photographs of the plant will be taken in addition to collecting a sample.

3.2.2.1 Botanical

Standardized techniques (e.g. CNPS) will be used for collecting, preserving, and archiving botanical specimens that could not be identified at a field site.

3.2.2.2 Faunal

NA

4.0 FIELD PREPARATION AND DOCUMENTATION

4.1 Field Preparation

Appropriate preparations will be made prior to going into the field and will follow the procedures described in Collins *et al.* 2008, Sutula et *al.* (2007), and Fetscher et al (2005).

4.2 Field Notes

4.2.1 Field Logbooks

During each field assessment, the following information will be recorded:

- Team members
- Time of arrival/entry on site and time of site departure
- Other personnel on site
- Summary of any meetings or discussions with land owners, agency personnel, contractors, etc.
- Deviations or variances from sampling plans, site safety plans, and QAPP procedures

4.2.2 Field Data Sheets and Forms

Example copies of all field books and data forms to be used for this project can be viewed and downloaded at: http://www.cramwetlands.org/documents.

4.2.3 Photographs

Photographs will be taken at the CRAM assessment locations following the standardized procedures described in the CRAM Technical Bulletin (CWMW 2009). They will serve to verify information entered in the field logbook. For each photograph taken, the following information will be recorded:

- Time, date, and location
- Description of the subject photographed
- Name of person taking the photograph

4.3 Documentation of Sample Collections

The following information will be provided for each CRAM assessment:

- Names and contact information for all individuals who conducted the CRAM assessment.

- Fully completed CRAM data sheet. All submetric, metric, and attribute scores will be provided as well as copies of the CRAM worksheets used to score metrics (where relevant).

- Brief rationale for assignment of each submetric and metric score (if needed).

- Completed Stressor Checklist.

- A map of the AA consisting of the boundary of the AA on the imagery provided by eCRAM or other imagery of comparable or better resolution and vintage. Submittal of maps with appropriate coordinates will follow the procedures described in the CRAM Technical Bulletin (CWMW 2009) and the California Wetlands Portal (www.californiawetlands.net/tracker)

- General site information, including any relevant information such as recent natural or anthropogenic disturbances, known presence of sensitive species, etc.

- Photographs of the site illustrating key aspects of the wetland being assessed. Photographs should be clearly associated with specific locations on the ground and should conform to the Standard Procedures for Stream Assessment provided by the State Water Resources Control Board (http://www.waterboards.ca.gov/water_issues/programs/swamp/cwt_guidance.shtml).

- The timing of the assessment relative to the Assessment Window for the type of wetland being assessed.

All CRAM assessments will be uploaded to the statewide database using eCRAM and the California wetlands web portal (www.CaliforniaWetlands.net). The California wetlands web portal a global point of entry for access to information and data on all aquatic resources in California (i.e. estuaries, depressional wetlands, lakes, streams/rivers, etc.). Documentation on reference sites on the Portal will consist of various type of spatial data (location, coordinates, surrounding land use), metadata (site history, access, ownership, etc.), and monitoring data (rapid assessment scores, water quality, biological monitoring, etc.).

4.4 Labeling of Sample Collections

NA

4.5 Field Variances

As condition in the field may vary, it may become necessary to implement minor modifications to sampling as presented in this plan. When appropriate and feasible, the EPA Project Officer will be notified before implementing the changes. Minor or temporary modifications should be documented in field logbooks or field data sheets and in the final report as appropriate. Significant or major changes to the approved plan may require prior approval by the EPA Project Officer and will need to be documented in the final report.

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Appendix B. Concept White Paper: Developing a Statewide Network of Reference Wetlands for California: Conceptual Approach and Process for Prioritizing and Selecting Reference Site (January 2010).

Produced by: Christopher W. Solek[1], Eric Stein[1], Joshua N. Collins[2], Letitia Grenier[2], J. Ross Clark[3], Kevin O'Connor[3], Cara Clark[3], and Chad Roberts[4]

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EXECUTIVE SUMMARY

California is in the process of developing a comprehensive and coordinated State wetland monitoring and assessment program. However, key components of the State's wetland monitoring toolkit are missing and/or require development. One such component is a statewide network of wetland reference sites. Recognizing this, the U.S.EPA awarded the Southern California Coastal Water Research Project (SCCWRP), on behalf of its project collaborators (the San Francisco Estuary Institute, Moss Landing Marine Laboratories, Humboldt Bay Harbor Recreation and Conservation District), a Region 9 Wetland Program Development Grant to develop Phase 1 of the State reference network. This includes drafting the conceptual approach, articulating a process for how wetland reference sites will be prioritized, selected, and monitored, and beginning the process of populating the State network with reference sites for targeted wetland types.

The statewide network of reference wetlands will be organized by region and by wetland type to support ambient assessments and project (restoration/mitigation) evaluations. The intent is for the regional networks to support the various State and Federal agencies developing agency-specific programs that require the use of reference wetland sites. Because the reference networks are intended for use across various State programs and agencies, they will require cooperative strategies for their support and maintenance. Therefore, phased development of the reference network is envisioned. The pooling of regional expertise, agreement on regional priorities, defining the most appropriate methodologies, data sharing, and cost sharing will be critical for all phases of the network's development. Over time, these networks will provide long-term data on condition across gradients of disturbance, anthropogenic stress, and over time scales that encompass climatic (and other temporal) patterns. Individual projects will be able to use the information from these reference networks to help establish project-specific targets and to interpret site-specific monitoring data.

The State reference wetland network is being developed under the following constructs:

1. The reference condition is defined as "minimally disturbed" (approximating natural or near-natural conditions). The minimally disturbed condition provides a definitive representation of biological integrity as well as an absolute standard against which to measure the condition of other wetland resources. For these regions of the State where an insufficient number of high quality sites will likely be found, efforts will be made to identify the least disturbed sites in these regions. The least-disturbed condition describes wetlands that exhibit the lowest signs of human disturbance in landscape that has been significantly altered by human activity (Brinson 1995).

2. Phase 1 of the network's development will focus on identifying reference standard sites, defined as "minimally disturbed" wetland sites (those most approximating natural or near-natural conditions). Over time, the State network will be comprised of sites that exhibit the range (or gradient) of variability exhibited by a regional wetland subclass, from relatively natural (e.g. undisturbed or minimally disturbed conditions) with highest levels of functioning (reference standard sites) to severely altered conditions.

3. Wetlands to comprise the State reference network will be classified according to a system that is being developed to support California's Wetland and Riparian Area Protection Policy (WRAPP). Because the State classification system is still under development, Phase 1 will classify wetlands using the typology of the California Rapid Assessment Method (CRAM).

4. The target population (reference domain) includes all wetland types in California from the border with Oregon at the north to the border with Mexico at the south. For Phase 1, 95 reference sites will be identified and the following wetland types targeted: perennial saline estuaries, seasonal saline estuaries, depressional wetlands (including vernal pools), and perennial, wadeable streams.

5. For Phase 1, reference sites will be distributed among seven broad regions of the State: 1) North Coast (as a subsection of Klamath), 2) Bay-Delta, 3) Central Coast, 4) South Coast, 5) Central Valley (San Joaquin and Sacramento Valleys), and 7) Sierras. These regions are based on a combination of Omernik ecoregions and RWQCB boundaries. Over time, the State reference network will be based on the Level 3 ecoregions of the DFG in order to fully partition the natural variability among the various regions of California

6. The criteria that will be used to determine reference stand sites for the state network will be determined using a combination of screening tools: 1) lack of anthropogenic stressors based on GIS and remote sensing screens; 2) existing wetland condition data to indicate high condition (e.g. ambient survey data); 3) local knowledge; and 4) long-term-site access. Current land use maps will be used to screen candidate reference sites for long-term accessibility. Sites located on public lands and ecological reserves will be prioritized because these are most likely to be protected and accessible in the long-term.

7. CRAM will be used to verify the local condition of candidate reference sites. These data will be used to create reference profiles for specific types of wetland classes based on regional expectations of the reference standard based on CRAM attribute and metric scores.

8. Reference site information and documentation will be made available via the State Wetland Web Portal *(www.CaliforniaWetlands.net).* This portal is supported by a wide variety of agencies as a means to both manage wetland data and provide a mechanism for disseminating data to the public, environmental organizations, and water quality professionals. Inclusion in the portal will ensure that information on the reference sites is broadly available.

9. Ongoing management of the State reference network will occur via the California Wetlands Monitoring Workgroup (CWMW), which is comprised of all major State and Federal agencies with wetland regulatory or management responsibilities.

FOREWARD

California (State) has embarked on the process of developing coordinated regional networks of reference wetland sites. Although the use of reference sites is not novel to the science of wetland monitoring in the State, the procedures for defining reference condition have been largely driven by project or program specific objectives and sites have not been selected using standardized criteria and methods. This allows for selection of reference sites that are closely related to the comparison site, but is an often difficult and costly approach to developing and managing a coordinated reference network over the long term. A reference network for wetlands based on standardized criteria and site screening procedures is particularly important for California, where natural variability among wetland types is compounded by a tremendous variability in topography, climate, and land use.

In 2008, the bioassessment committee of the State Water Board's Surface Water Ambient Monitoring Program (SWAMP) drafted the framework for a comprehensive reference condition management program (RCMP) for wadeable perennial streams in California (Ode and Schiff 2008). However, it was recognized that reference conditions must be established for all wetland and aquatic resource types in the State. Since that time, the California Wetland Monitoring Workgroup (CWMW) was endorsed as a subcommittee of the California Water Quality Monitoring Council (Senate Bill 1070; Kehoe 2006). The CWMW drafted a Wetlands and Riparian Assessment Monitoring Program (WRAMP) to coordinate all regional and statewide efforts in order to develop a set of standardized practices and methods for monitoring wetlands (CWMW 2009). The WRAMP highlights the importance of establishing a standardized network of reference wetland sites in order to calibrate its core assessment methodologies to reference conditions to account for the natural regional variations in wetland condition.

Recognizing that a network of wetland reference sites is a fundamental component of the State's wetland program and monitoring toolkit, the U.S. EPA awarded the Southern California Coastal

Water Research Project (SCCWRP), on behalf of its project collaborators (the San Francisco Estuary Institute, Moss Landing Marine Laboratories, Humboldt Bay Harbor Recreation and Conservation District), a Region 9 Wetland Program Development Grant to develop the conceptual framework for a regionally-based network of reference wetland sites and begin the first phase of populating the network with wetland reference sites.

Document Purpose and Organization

This document is presented in three sections. Section I discusses the intended uses of a State reference network and describes how such a network will help to develop capacity for the State to implement more effective wetland programs and policies. Section II outlines the overall conceptual approach for development of a network of regionally-based reference wetland sites in California. This includes the contextual framework for development and a recommended process (via a phased approach) for screening and selecting sites to comprise the networks over time. This section describes how the regional networks will initially be populated with reference sites for targeted wetland types, representing Phase 1 of the development for the State reference network. Appendix I provides general background and technical support material as it relates to reference network development. A glossary of terms and definitions is also included.

SECTION I: Why California Needs a Network of Reference Wetlands

Wetlands[1] in California (State) are regulated and managed by a variety of programs across multiple State and Federal agencies. Most of these programs and policies include a goal of maintaining or restoring wetland condition or function. The ability to determine proximity to this goal depends, in part, on having well defined assessment targets. In order to establish these targets, reference conditions must be clearly defined. Defining reference conditions (based on reference sites) provides a scientifically defensible basis upon which to define attainable biological expectations for natural, wetland ecosystems (Hughes *et al*. 1986, Kentula *et al*. 1992, Barbour *et al*. 1996, Reynoldson *et al*. 1997, Karr and Chu 1999, Bailey *et al.* 2005). Most commonly, these expectations are defined by a range of indicator or index scores, with the range of values a result of natural variability in time and in space (Stoddard *et al*. 2006). The various definitions of reference condition have been discussed extensively (Hughes and Larsen 1988, Hughes 1995, Rosenberg *et al.* 1999, Stoddard *et al*. 2006). The concept is flexible and can be approached in multiple ways depending on the management objectives, available resources, and accuracy required by a particular program. Regardless of definition, the reference condition provides the standard against which changes in current biological conditions are evaluated.

Intended Uses of the Regional Reference Wetland Networks

The State network of reference wetlands will be organized by region and by wetland type to support both ambient assessments and project evaluations of wetland condition. The regional reference networks are intended to support the efforts of various State and Federal agency-specific programs that require the use of reference wetland sites. It is expected that over time, various types of data will be collected at the wetland sites comprising the regional reference

[1] See Appendix II for an operative definition for wetlands in California as recommended by the Policy Development Team for the California Wetland and Riparian Area Protection Policy (WRAPP).

networks. The types of methods used and the indicators to be monitored at these sites will ultimately depend upon the nature of monitoring needed at the site in question and the resources available to carry out the monitoring.

Because the regional networks will be used by various agencies for a variety of programs, they will require cooperative strategies for their support and maintenance. Therefore, phased development and implementation of the reference networks are envisioned. Regional expertise, agreement on regional priorities, defining the most appropriate methodologies, data sharing, and cost sharing will be critical for all phases of the network's development.

Technical Framework for Development and Implementation

Development of the State reference network can be contextualized within a three tiered technical framework, modeled on the Level 1-2-3 approach (USEPA 2006), that integrates monitoring at varying spatial scales and levels of intensity. Under this framework, Level 1 tools (landscape assessment and mapping) can be used to develop the sample frames from which candidate reference sites can be selected and identified; Level-2 tools (rapid assessment) can be used to verify reference condition at wetland sites identified at Level-1; and Level 3 tools (intensive site assessment) can be used to fully characterize the reference condition, develop indices of biological integrity, and validate information gathered at the Levels 1 and 2. Stein *et al.* (2007a) provide a detailed examination of the Level 1-2-3 framework and discuss how it can be integrated in the context of state and federal wetland programs in California.

Using any combination of Level 1-2-3 data permits the development of landscape and/or watershed "profiles" that can be used to address management questions about landscape and/or watershed condition. A watershed profile is a particular type of landscape profile that covers an entire watershed. Landscape and/or watershed profiles allow a better understanding of the distribution of wetland types within a watershed and their relationship to landscape position. In this context, they provide a means to determine the location and type of wetlands found in unimpacted landscapes (i.e. the location potential reference wetland sites). There are three primary applications of the landscape/watershed profile concept. One is to assess the ambient overall condition (or "health") of a landscape, in which case the profile is usually restricted to Level 1 data plus ambient surveys of overall condition based on Level 2 data. Other applications include setting landscape-level performance standards and planning for mitigation (see following section on Applications).

Applications

A network of wetland reference sites is the cornerstone of comprehensive wetland monitoring and assessment program. The regional networks can be used for a wide range of applications to meet the needs of a variety of State monitoring programs and policies in several ways.

Support the Development and Implementation of Standardized Wetland Assessment Methods

To be most effective, monitoring at reference sites will utilize assessment methods and target indicators that compliment and/or enhance the efforts of developing and established monitoring programs, including the Wetlands and Riparian Assessment Monitoring Program (WRAMP) developed by the California Wetlands Monitoring Workgroup (CWMW) [2] and the State Water Board's Surface Water Ambient Monitoring Program (SWAMP).

The CWMW requires ongoing testing, review and refinement of the core wetland assessment methods of the WRAMP. This includes the use of Level 2 rapid assessment methods (RAMs) to assess ambient condition, as well as combining RAMS with more intensive measures (Level 3) when they are needed to design projects or assess particular aspects of condition or project performance. Most notably, the California Rapid Assessment Method for Wetlands (CRAM) has been developed as a cost-effective, standardized tool to assess wetland condition throughout California (Collins *et al.* 2008; CWMW 2010). The assessment methodologies of the WRAMP (such as CRAM) and the data collected need to be calibrated and validated to reference conditions (based on a network of reference sites) to account for the natural regional variations in wetlands and riparian areas in California.

The regional reference wetland networks will also be an important component in methodological training and other quality assurance and control (QA/QC) tasks related to method development, refinement, and implementation. For these purposes, reference sites for project specific applications and training/teaching purposes will also be needed.

Characterization of Wetland Beneficial Uses

A network of reference wetland sites would be the primary mechanism by which to characterize beneficial uses for wetlands in California. Wetlands provide multiple benefits to the people of California, depending on wetland type and location. These beneficial uses define the resources, services, and qualities of wetlands and other aquatic systems (Table 1). In this context, the reference condition can be viewed as the greatest potential for a wetland or aquatic resource to support all of its beneficial uses given the historical land use and be used to interpret numeric criteria that limit how much a parameter(s) can change from what would occur in a "natural" system (Apfelbeck 2008). The characterization of the ecological functions that are appropriate and attainable for wetlands in California would allow for the aggregation of ecological functions into a set of beneficial uses that can be attributed to wetlands in the State. Verification of these functions can be achieved based on a "weight of evidence" that is systematically gathered at wetland sites that are typical of the types of wetlands found in California. Wetland health may be evaluated either by similarity of "sampled" wetlands to reference condition or by numeric criteria based on data obtained from the reference wetland sites (see above).

Direct measures of wetland condition and aquatic health closely link to the beneficial uses or functions and serve as a basis for establishing water quality objectives, discharge prohibitions, and anti-degradation policies. From the perspective of the landscape profile concept and setting landscape-level performance standards, the ambient profile would become the baseline condition

[2] The California Wetland Monitoring Workgroup (CWMW) is a subcommittee of the California Water Quality Monitoring Council (Senate Bill 1070; Kehoe 2006). The CWMW has a mission to improve the monitoring and assessment of wetland and riparian resources by developing a comprehensive monitoring plan for wetlands in California through the review of technical and policy aspects related to wetland monitoring tool development, implementation and use of data to improve wetland management. One of the recommendations of the CWMW is the establishment of the California Wetlands and Riparian Assessment and Monitoring Program (WRAMP).

under California antidegradation policies (Resolution No. 68-16). This policy requires that existing high quality wetlands be maintained to the maximum extent possible extent. In order to determine “high quality”, reference conditions (based on a network of reference sites) must be defined. In this case, the profile is usually based on Level 1 and Level 2 data, plus any Level 3 data needed to address specific beneficial uses of concern.

Table 1. Examples of existing (E) and potential (P) beneficial uses of selected Cowardin wetlands (SWRCB 2007).

	Type of Wetland			
Beneficial Use	**Estuarine**	**Riverine**	**Lacustrine**	**Palustrine**
Agricultural supply	E	E	E	E
Cold, freshwater habitat		E	E	E
Ocean, commercial, and sport fishing	E			
Estuarine Habitat	E			
Freshwater replenishment		E	E	E
Groundwater recharge	E	E	E	E
Industrial service supply	E	P	P	
Fish migration	E	E	E	
Navigation	E	E	E	E
Water contact recreation	E	E	E	E
Noncontact water recreation	E	E	E	E
Shellfish harvesting	E	E		
Fish spawning	E	E	E	E
Warm freshwater habitat		E	E	E
Wildlife habitat	E	E	E	E
Preservation of rare and endangered species	E	E	E	E

Improve Decision Making for Wetland Restoration and Mitigation Projects

A network of reference wetlands is central to the planning, design, and evaluation of restoration and mitigation projects[3] (Brinson and Rheinhardt 1996). Wetland and riparian resources in California are regulated and managed by a variety of programs across multiple State and Federal agencies. A common element of every program is the need to identify reference sites that can be used to gauge success and/or compliance with wetland regulations and policies. In the past, reference sites have been identified on a case-by-case or project-specific basis. Although this allows for selection of reference sites that are closely related to the comparison site, it is a difficult and costly approach over the long term.

Individual projects will be able to use the information from the established reference networks to help establish realistic targets for wetland restoration and mitigation efforts (e.g. CWA 404 program), interpret site-specific monitoring data, compare impacted and degraded sites, and make cross-project comparisons. Landscape and/or watershed profiles of impact sites and ambient condition can be developed and used to assess the level of local impact, which would inform mitigation ratios. A subsequent profile of the proposed mitigation sites is then compared

[3] A project is defined as any human activity that results in a change in extent, form, structure, or condition of a wetland. Such activities often require a permit under Section 404 or 401 of the CWA, a Waste Discharge Requirement (WDR) by the State of California, a Streambed Alteration Agreement (Section 1600 of the Fish and Game Code), or a Federal or State funded or supported wetland restoration project.

to the ambient survey to assess the efficacy of the mitigation proposal. Subsequent monitoring is used to assess whether or not the mitigation is successful.

Reference sites can also provide context for tracking the progress of restoration and mitigation sites relative to natural variability and/or anthropogenic effects. Used in combination with ambient survey data, reference sites can be used to establish science-based performance criteria and trajectories (e.g. 401/ WDR program). A network of reference sites would directly assist agencies in meeting the requirements of the federal Mitigation Rule (Federal Register 40 CFR Part 230 and 33 CFR parts 325 and 332) that governs compensatory mitigation for activities authorized by permits issued by the US Army Corps of Engineers (Corps). This rule establishes performance standards and criteria for the use of permittee-responsible compensatory mitigation, mitigation banks, and in-lieu programs to improve the quality and success of compensatory mitigation projects for activities authorized by Corps permits. In cases where a condition or functional assessment method is not available (or not appropriate), reference sites can provide an anchor against which to compare qualitative assessments or evaluations based on best professional judgment.

Support the Development of Biological Objectives for all Wetland Types

Reference condition sites provide the foundation for developing biological objectives for all wetland and aquatic resource types. Biological objectives are derived from ecological assessments involving integrated measures (indices) of the composition, diversity, and functional organization of a biological community that are used to describe or measure the qualities in a wetland that must be present to support a desired biological condition (EPA 2008). Direct measures of ecological condition are increasingly preferred as assessment end-targets because they more closely link to the beneficial uses or functions that are the focus of protection and management. Ecological indicators have the added advantage of integrating condition over space and time, thus providing a more comprehensive assessment than other traditional indicators. In contrast, chemistry or toxicity based assessment endpoints require inferences about their relationship with the ultimate management objectives.

One of several challenges in developing to biological objectives is that ecological condition first needs to be documented at sites with minimal anthropogenic disturbance to serve as the standard (or benchmark) against which all assessment results are compared. A key step in the process of developing biological benchmarks is to define the reference condition through the establishment of a network of reference sites. Biological expectations will vary from wetland to wetland because aquatic biota differ in their preferences for specific environmental conditions (e.g., elevation, climate, geology, etc.). In order to accurately predict the biological assemblages expected to occur at a specific wetland site, it is essential to account for the major environmental factors responsible for natural variability in the biota. The development of a statistically valid reference wetland monitoring network would provide a means to quantify this inherent natural variability and define the appropriate regional expectations for observable differences in wetland condition in the State.

Assess the Effects of Climate Change and Other Long-term Changes

Reference sites can be used as a baseline for long-term trend monitoring of changes in wetland condition and function within the landscape over time. Although probabilistically selected sites can also be used to detect regional trends, the need for a large number of sites logistically precludes their use for this. Therefore, monitoring at fixed reference sites is a valuable complement to probabilistic sampling. Trend monitoring via repeated site visits is especially important in the context of global climate change on wetlands because this will affect the aquatic ecosystems of both reference and impaired wetland sites. Therefore, it will be necessary to distinguish the effects of climate change (e.g. changes in water temperature, timing of flows, sea level rise) from that of other disturbances and stressors by selecting the appropriate indicators (e.g. changing species composition, food web interactions, or emergence dates for aquatic macroinvertebrates) in order to appropriately control for these effects.

Data collected at reference wetland sites over time could also be used to evaluate how indicator species respond to climate change and develop databases on species traits related to climate sensitivity. In addition, historical data can be used to examine trends at reference sites linked to climate variables, to project potential effects from climate change, and examine the vulnerability of reference sites to various landscape and land use changes (e.g. long-term successional studies or impact analysis on a group of wetlands). Reference sites can also serve as alternatives to standard experimental controls that are seldom available (Tiner 2002).

Documentation of Reference Sites, Data Sharing, and Long-term Data Management

Because the regional reference sites will be used for a wide range of applications are intended to support the efforts of various State and Federal agency-specific programs that require the use of reference wetland sites, the data gathered at these sites needs to be made available to a wide range of users. The California wetlands web portal (www.CaliforniaWetlands.net) [4] provides a global point of entry for access to information and data on all aquatic resources in California (i.e. estuaries, depressional wetlands, lakes, streams/rivers, etc.). It includes interactive maps and monitoring data that focus on the location, extent and health of the state's wetlands. It is intended for use by the public, environmental organizations, water quality professionals, and State agencies with an interest in aquatic resource monitoring and assessment.

Documentation on reference sites on the Portal will consist of various type of spatial data (location, coordinates, surrounding land use), metadata (site history, access, ownership, etc.), and monitoring data (rapid assessment scores, water quality, biological monitoring, etc.). As the regional networks develop, additional data on existing reference sites, as well as yet-unidentified reference sites, can be added to the website over time. It is recommended that additional information be compiled on these sites to help with interpretation of assessment data. Such factors should include land use (using existing data layers), water sources, agency districts or

[4] Content for the California wetlands portal is coordinated through the California Wetland Monitoring Workgroup and can be accessed through the Monitoring Council's *My Water Quality* website under the "*Are Our Wetland Ecosystems Healthy?"* theme (http://www.waterboards.ca.gov/mywaterquality/aquatic_ecosystem_health/). The *My Water Quality* website manages all State water quality data and assessment products; it has been structured around a series of theme-based assessment questions that reflect key water quality information needs of managers, scientists, and the public.

regions that may influence how the wetlands are managed, and wildfires, floods, or other natural phenomena which may have affected the areas assessed. For example, it is important to understand flood history, as these episodic events can influence geomorphic and hydrologic aspects of the wetlands, and in turn, the habitat and species functions.

SECTION II: Conceptual approach to development

Reference Condition

Phase 1 of the network's development will focus on identifying reference standard sites, defined as "minimally disturbed" wetland sites (those most approximating natural or near-natural conditions) based on CRAM[5]. The minimally disturbed condition provides a definitive representation of biological integrity as well as an absolute standard against which to measure the condition of other wetland resources. Reference standard sites represent the conditions exhibited by a subset of reference wetlands that correspond to the highest condition or level of functioning across the suite of conditions or functions of a wetland subclass (Brinson 1995). It is acknowledged that there will be regions of the State where an insufficient number of high quality sites will likely be found (e.g. low elevation, urbanized portions of southern California, portions of the San Francisco Bay area). In these cases, efforts will be made to identify the least disturbed sites in these regions. The least-disturbed condition describes wetlands that exhibit the lowest signs of human disturbance in landscape that has been significantly altered by human activity (Brinson 1995).

Over time (as reference sites are added), the regional reference networks will encompass the range of aquatic resource condition present across a landscape and/or watershed, from relatively natural (e.g. undisturbed or minimally disturbed conditions) with highest levels of functioning (reference standard sites) to severely altered conditions. This will provide long-term data on wetland condition across gradients of disturbance, anthropogenic stress, and over time scales that encompass climatic and other temporal patterns.

Wetland Types and Subtypes (Classification)

The wetland types to comprise the reference network will be classified in accordance with a system being developed to support the State Wetland and Riparian Area Protection Policy (WRAPP). A State classification system is necessary because different types of wetlands have correspondingly different functions, services, and beneficial uses. This system must be standardized and robust to foster collaborations and coordination among the various wetland interests that require the use of reference wetlands. Because one of the intended uses of the reference network is to improve decision making for target wetland restoration and mitigation projects, wetland types and landscape settings that are most commonly impacted during the permitting process will be well represented in the network.

[5] The use of CRAM to define the reference standard for Phase 1 of the reference network's development is appropriate because efforts to build State capacity to assess wetlands have focused on CRAM as a standardized Level 2 wetland assessment method.

Because the State classification system is still in development, Phase 1 efforts will classify wetlands according to wetland typology developed for CRAM. CRAM wetland typology is based on a hybrid of National Wetland Inventory (NWI) classification (Cowardin *et al.* 1979), Hydrogeomorphic (HGM) classification (Brinson 1993), and operative State wetland nomenclature. This typology is currently developed for six types of wetlands in California, four of which have sub-types (Table 2). Although the need to be consistent with both the NWI and HGM typologies was important, there was also a need to recognize the kinds of wetlands named in California wetland protection policies. The hierarchical CRAM typology reflects all of these considerations, but it favors the HGM classification system overall, with sub-types that reflect State policy (Collins *et al*. 2008). It is expected that some level of sub-classification and regionalization of this typology will be necessary to develop effective metrics that can accurately characterize the ranges in integrity for these wetland types throughout California. A complete description of CRAM wetland types and subtypes is provided in Collins et al. (2008).

The use of CRAM wetland typology for Phase 1 of the reference network's development is appropriate because efforts to build State capacity to assess wetlands have focused on CRAM as a standardized wetland assessment method. Furthermore, crosswalks from the CRAM typology to other wetland classifications systems (e.g. NWI and HGM) are available.

Table 2. Current CRAM wetland typology (Collins *et al*. 2008)

CRAM Wetland Types	CRAM Sub-types
Riverine Ecosystems	Confined Riverine*
	Non-confined Riverine *
Depressional Wetlands	Individual Vernal Pools
	Vernal Pool Systems
	Other Depressional systems
Estuarine Wetlands	Perennial Saline Estuarine*
	Perennial Non-saline Estuarine
	Seasonal Estuarine
Playas	no sub-types
Slope Wetlands	Seeps and Springs
	Wet Meadows
Lacustrine Wetlands	no sub-types

*Verified and validated against Level 3 data (Stein *et al*. 2009)

Phase 1 begins the process of establishing regional networks of reference wetland sites. For this effort, 95 reference standard sites for targeted CRAM wetland types will be identified. Sites representing five CRAM wetland types will be distributed among seven major bioregions of California according to Table 3.

Table 3. Number of sites, regions, and wetland types targeted for Phase 1

Wetland Type	Number of Sites	Number of Regions	Total
Perennially Tidal Estuarine	8	4	32
Seasonally Tidal Estuarine	3	3	9
Vernal Pool	3	4	12
Riverine	3	7	21
Perennial Depressional	3	7	21
Total			95

These wetland types were targeted for Phase I development of the regional networks for several reasons. The CRAM methodology is most developed for these types, with the riverine and estuarine types validated against independent, more intensive measures of condition (Stein et al. 2009). This has resulted in refinement of the metrics for these wetland types and provides for a higher level of confidence in the ecological meaning of CRAM scores. In addition, several related efforts are underway to validate and refine the modules for the other targeted wetland types. The perennial depressional module and vernal pool submodule have been developed, with validation studies beginning. Efforts are also underway to refine and validate the existing module for seasonally tidal estuaries.

Reference Domain

Phase 1 efforts will begin to populate the regional networks with reference sites for six broad regions of California: 1) North Coast (as a subsection of Klamath), 2) Bay-Delta, 3) Central Coast, 4) South Coast, 5) Central Valley (San Joaquin and Sacramento Valleys), and 7) Sierras (Figure 2). These regions represent a combination of Omernik Level III ecoregions and Regional Water Quality Control Board (RWQCB) boundaries (Ode and Schiff 2008). Because these delineations include significant ecological gradients that could contribute to natural variability in wetland condition, they are appropriate to use as the initial boundaries for this first phase of the network's development.

Over time, to fully account for the natural regional variations in wetlands and riparian areas throughout California, and be consistent with SWAMP and the State WRAMP, the regional reference networks will be distributed according to the Level III ecoregions (Omernik and Griffith 2010; Table 3) as defined by the California Department of Fish and Game (DFG; Figure 3). The DFG Level III ecoregions denote areas of general similarity in ecosystems and in the type, quality, and quantity of environmental resources. They are designed to serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components. These general purpose regions are critical for structuring and implementing ecosystem management strategies across federal agencies, state agencies, and nongovernment organizations that are responsible for different types of resources within the same geographical areas. The approach used to compile these ecoregions is based on the premise that ecological regions can be identified through the analysis of patterns of biotic and abiotic phenomena, and both terrestrial and aquatic characteristics. These include geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology. The relative importance of each characteristic varies from one ecological region to another.

Table 3. Level III Ecoregions of California

- Coast Range
- Cascades
- Sierra Nevada
- Central California Mountains and Foothills
- Central California Valley
- Southern California Mountains
- Eastern Cascades Slopes and Foothills
- Central Basin and Range
- Mojave Basin and Range
- Klamath Mountains
- Northern Basin and Range
- Sonoran Basin and Range
- Southern California/Northern Baja Coast

Selecting Appropriate Wetland Maps

Reference sites will be identified and selected using existing wetland inventories and maps, including the USFWS National Wetland Inventory (NWI), the National Hydrography Dataset (NHD), and the California Statewide Wetlands Inventory. When available, updated and more detailed regional wetland maps, including the southern California wetlands mapping project (http://www.socalwetlands.com) and the Bay Area Aquatic Resource Inventory (http://www.sfei.org/BAARI), will also be used[6].

Reference Site Selection Criteria and Screening Methods

The following criteria will be used to identify sites that are most likely to be minimally or least disturbed by human activities and result is a set of regional candidate reference sites. It is recognized that the process of identifying reference condition sites for the regional networks based on these criteria (especially for Phase 1) will be iterative and require a combination of methods and data sources.

1. Lack of known anthropogenic stressors

[6]It is recognized that comprehensive wetland maps for the entire State currently do not exist. Because the NWI was established to assess decadal and longer-term changes in wetland acreage across the United States, it is not adequate to use as a sample frame for ambient surveys within states. Sample frames for ambient surveys generally require more detail and accuracy than NWI typically provides. For example, the existing State inventory for California (based on NWI) was found to be less accurate than required to serve as the sample frame for the recent statewide survey of perennially tidal estuarine wetland condition (see Sutula *et al*. 2008). In this case, the existing inventory had to be updated based on more recent imagery and local expertise

It is initially important to develop a comprehensive list of anthropogenic landscape stressor variables to determine their role in affecting or predicting condition for all wetland types to comprise the regional networks. 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, especially to riparian zones (Bryce et al. 1999). Ideally, abiotic factors should be the principal criteria used in selecting candidate reference sites. The use of non-biological factors is necessary to avoid circularity in defining the biological characteristics that become the basis of reference biological datasets.

Ode and Schiff (2008) outline a sequential process that employs a series of successive filters to screen and identify potential reference condition sites for wadeable perennial streams in California. The general approach, using a combination of landscape-scale and local condition information (based on aerial imagery and site visits), can be used to identify reference sites for other wetland types. This approach will apply to a large portion of the state where high quality sites are available (i.e. North Coast, Central Coast, Sierras). For regions where an insufficient quantity of high quality sites exist, such as the agriculturally dominated Central Valley or intensely urbanized areas of the southern California coastal plain, a modified version of this approach that employs lower thresholds and places more emphasis on local condition measures can be used.

All regions of the State will first need to be delineated using a geographic information systems (GIS) based method using a series of remote sensing data filters. Under this approach, candidate areas are identified for a region with GIS and then wetlands within these regions are targeted for reconnaissance to verify reference quality characteristics. Much spatial information already exists in the form of validated GIS layers for many candidate stressors that potentially impact wetlands, but there is a very large amount of variation in the degree to which datasets are accurate, current, and consistent across wide geographical ranges. Potential sources of data that will be used to identify candidate areas include coverages for road density, population, forest fragmentation/stand age, agricultural and urban land use, and grazing allotments (Vogelmann 2001; USGS TIGER files; Kagan and Caicco 1992). Other remote sources of information (e.g. air photos, Ortho Digital Quads, and thematic mapping) will also be used. The ArcView® extension, Analytical Tools Interface for Landscape Analysis (ATtILA; USEPA 2004) is one GIS-based tool that will be used to calculate landscape stressor metrics. Initially, a limited number of GIS coverages (e.g. road density, urban and agricultural land use, population density) will be used to establish landscape-level land use patterns.

Sites to comprise the network will be selected using this GIS database of point source stressors to determine their role in affecting or predicting wetland condition[7]. This information will be used to map potential wetland areas with minimal human activity. Once assembled, the GIS data can

[7] Biological objectives (a primary driver for the development of the reference network) must be based on an understanding of the relationship between ecosystem condition and anthropogenic stressors. Evaluation of condition alone can be useful in assessing wetland status and trends, but without an understanding of how condition is affected by stressors impacting the ecosystem, these evaluations are less useful for informing management decisions.

be incorporated into a landscape-based stressor model based on a suite of independent abiotic and landscape stressor criteria to provide an objective method for screening sites characterized by few or no known anthropogenic stressors (Ode and Schiff 2008). For the reference gradient approach, it has been recommended that both a stressor/abiotic approach and ground-based rapid assessment information be used to screen potential reference sites to ensure (1) that the full range of stressor levels are included in the reference gradient, and (2) the minimally disturbed reference sites (reference standards) are adequately represented in the reference gradient (Faber-Langendoen *et al*. 2009). This information can then be used to estimate and interpret the biological response of aquatic ecosystems to increasing effects of stressors (Davies and Jackson 2006; EPA 2005).

2. Previous condition assessments that indicate high condition or function

When available, existing data that indicate high condition or function for a site will be used to identify candidate reference sites. This can be based on Level 2 or-3 data collected as part of an ambient survey or targeted research study. Ambient distributions of data collected from randomly selected sites for a particular wetland type are especially valuable as they can be used to provide context for identifying reference sites. In California, baseline condition data for perennially tidal saline estuaries and wadeable perennial streams are available through a statewide ambient assessment with CRAM (Sutula *et al*. 2008) and the SWAMP Perennial Stream Assessment (PSA), respectively. These data can be correlated with landscape stressor data in order to be reasonably confident that the minimally disturbed end of the gradient (i.e. reference standard) has been accurately identified.

However, reliance on any type of biological data alone to establish reference also risks a degree of circularity. The best way to guard against this is to use independent filters (e.g. a landscape stressor screen as described above) to select the biotic response metrics. The circularity concern may be less of a problem in highly modified systems than more pristine systems because relationships between metrics and stressors are simpler (Karr and Chu 1999). While the extreme lack of reference sites in some regions of the State will require the acceptance of some circularity, adding additional steps to guard against the risks of circularity should be a consideration (Ode and Schiff 2008). Although field-verified sites will more likely identify sites across the entire reference gradient, this method is not as spatially systematic in its approach, and relies on a combination of expert judgment, narrative criteria, and descriptions of wetland condition.

3. Local knowledge

Local knowledge screens and regional expertise is a relatively inexpensive method to screen and select reference sites. The knowledge of local groups and resource managers from state and federal land management agencies will help to identify reference sites in their respective regions; however, the inconsistency and inherent bias of this technique suggests that it is best used in conjunction with other methods. Candidate reference sites identified by this means will be subject to the oversight of the California Wetland Monitoring Workgroup (CWMW).

4. Long-term Access

Reference sites must be accessible in the long-term. Sites located on public lands and ecological reserves (identified from property boundary maps) will be prioritized for the network because these are most likely to be protected and accessible as reference sites in the long-term. Once sites have been selected, written permission that acknowledges the site's intended use and access procedures will be secured. Sites located on private lands will be used only if a written agreement from the landowner and an expectation of continued access if ownership changes can be obtained.

Phase I Approach to Determining and Verifying Reference Sites based on CRAM

For Phase I, reference standard sites will initially be screened by identifying sites located in areas of relatively stable landuse (i.e. sites not likely to change over time) that experience relatively low levels of anthropogenic stress (based on aerial imagery, remote sensing , GIS, etc.). These sites will be considered for inclusion in the regional reference networks.

Once candidate reference sites for each targeted wetland type have been identified using these criteria, these sites will need to be visited to assess local condition. For Phase 1, CRAM will be used to assess the condition of the proposed reference sites. CRAM assesses wetland condition based on four overarching *attributes*: Buffer/Landscape Context, Hydrology, Physical Structure, and Biotic Structure. Within each of these attributes are a number of *metrics* that address more specific aspects of wetland condition. Because the goal of developing CRAM was to have a consistent method for all wetlands and riparian areas in California (a large, diverse geographic area), its assessment metrics were developed and scaled relative to theoretically optimum states that would have occurred in the absence of substantial human influence (Sutula et *al*. 2006).

To conduct a CRAM assessment, a series of metrics is evaluated in the field to for a pre-defined assessment area to yield a numeric score based either on narrative or schematic descriptions of condition or on thresholds across continuous values for a particular wetland type. Metric scores under each attribute are aggregated to yield scores at the level of attributes, and attribute scores are aggregated to yield a single overall index score via simple arithmetic formulas. Attribute and index scores are expressed as percent possible, ranging from 25 (lowest possible) to a maximum of 100. See Collins *et al*. (2008) for a complete description of the CRAM methodology and scoring framework.

Reference site condition will be verified by examining a site's overall index score as well as attribute scores for a particular wetland type. Two types of reference standard sites based on CRAM will identified: 1) sites where the overall index score indicate high condition (2) sites where one or one or more of the attribute scores indicate high condition. This will provide a network in which some reference sites will score high in some attributes and low in others. Because CRAM attribute scores are aggregated to yield a single overall index score, it is important to identify high condition sites based on individual attributes as well as overall index score.

Minimally disturbed sites (i.e. reference standard sites) will initially be defined sites that scored 90 or above in CRAM for overall index and for all attributes. However, it is recognized that such sites may not exist in all regions for all wetland types. In these cases, the reference standard (or least disturbed) sites will be defined as sites in the 90th-percentile of CRAM overall index and attribute scores based on the distribution of CRAM scores for the region (if data are available). Using these data, reference profiles for specific types of wetland classes in each region (based on CRAM attribute and metric scores) will be created For existing CRAM modules that are not currently validated (e.g. depressional, vernal pool) high quality sites will still be identified using the prescribed absolute or percentile cutoff. Where existing data is available (e.g. perennial saline estuaries, perennial streams), distributions of CRAM attribute scores will be analyzed to identify cutoffs based on CRAM scores to determine which sites get included in the network for each region. These data will be used to create reference profiles for specific types of wetland classes based on regional expectations of the reference standard based on CRAM attribute (and metric) scores. For example, urban streams in the San Francisco Bay region may have a reference profile that is different from a high gradient ephemeral streams in southern California.

Estuarine wetlands

Saline perennial estuarine wetland subclass: For Phase 1, 32 reference standard sites for the perennially tidal estuary class of wetlands will be identified in the four coastal regions of California: South Coast, Central Coast, San Francisco Bay, and North Coast. Reference standard sites will be screened by identifying sites in the 90th-percentile of CRAM scores based on data from a 2007 statewide ambient assessment using CRAM (Sutula *et al*. 2008a). The State ambient assessment was based on an unequal probability-based allocation of sites by percent of estuarine wetland acreage. This was used to select 150 sites among the four coastal regions of the state (South Coast, Central Coast, San Francisco Bay, and North Coast) employing generalized random tessellation stratified (GRTS) design (Stevens and Olsen 1999; 2004).

Seasonal tidal estuarine subclass: For Phase 1, 9 reference sites for the seasonally tidal estuary class of wetlands will be identified in three coastal regions of California: South Coast, Central Coast, and North Coast. Because ambient distributions of CRAM scores are not available for this wetland type, sites will be screened through a combination of existing Level-3 data and local knowledge. Local condition will be verified with CRAM. [8]

Depressional wetlands

Vernal Pools/Vernal Pool Systems: For Phase 1, 12 reference sites for the vernal pool subclass of depressional wetlands will be identified in four regions of California (Sacramento Valley, San Joaquin Valley, San Francisco Bay-Delta, and North Coast). Because ambient distributions of CRAM scores are not available for this wetland type, sites will be screened through a

[8] An ambient assessment of seasonal tidal estuaries (or lagoons) condition based on CRAM is planned for 30 sites along the California coast (Clark and O'Connor 2008). The goal is to calibrate and validate the seasonally tidal estuarine CRAM module for its responsiveness to "good" vs. "poor" wetland condition and its ability to represent a range of conditions. When available, these data can be used to screen and select reference sites for the seasonal tidal estuaries.

combination of existing Level-3 data and local knowledge. Selected candidate sites will be verified with CRAM.

Perennial Depressional: Because it is recognized that the current depressional module of CRAM does not adequately assess seasonal depressional systems, Phase 1 efforts will focus on screening and identifying reference standard sites for perennial depressional wetlands. For Phase 1, 21 reference standard sites for the perennial subclass of depressional wetlands will be identified in seven regions of California: South Coast, Central Coast, San Francisco Bay, North Coast, Sacramento Valley, San Joaquin Valley, and Sierra based on a combination of Level-3 data and local knowledge. Selected candidate sites will be verified with CRAM.

Perennial wadeable streams

For Phase 1, 21 reference sites for wadeable perennial stream will be identified in seven bioregions of California: South Coast, Central Coast, San Francisco Bay, North Coast, Sacramento Valley, San Joaquin Valley, and Sierra. CRAM data collected through SWAMP's Perennial Stream Assessment (PSA) and Reference Condition Management Program (RCMP) will be used to screen and identify reference standard sites for this wetland class based on the approach described above.

Phase 1 Reference Site Documentation

For Phase 1, documentation for the 95 identified reference sites on the California Wetland Portal will consist of:

- Site location and coordinates;
- Name of individuals who conducted the CRAM assessment;
- Characterization of land use in catchment or perimeter of the site;
- Site history with sufficient detail for conducting the office portion of the CRAM assessment;
- Information on site ownership and current management;
- CRAM condition scores with scoring justification and appropriate photo documentation;
- Stressor information as indicated in the CRAM stressor checklist;
- Anticipated future changes in adjacent land uses or other stressors.

Next Steps and Long-term Management of the State Wetland Reference Network

Phase 1 represents the first step in developing a comprehensive network of regionally based wetland reference sites in California. It is expected that the regional networks will be dynamic over time as new sites are added and reference sites for other wetland types are identified (e.g. wet meadows, lacustrine wetlands, aridland streams, etc.). Therefore, a governance process for funding and managing the regional reference networks in the long-term is needed. This process should be facilitated via the oversight of the California Wetland Monitoring Workgroup (CWMW) through the establishment of a reference site review panel. This panel will be the mechanism for moving sites into and/or out of the State network (e.g. vetting of new sites for inclusion in the network, removal of existing sites that no longer represent reference condition, etc.). The CWMW can also ensure the coordination of efforts with other state and federal water quality monitoring, including SWAMP (and its Reference Condition Management Program), as well as agencies that currently have reference programs (e.g. USFS, EPA, USGS). In addition, the CWMW can serve as the venue for other agencies and programs that do not have reference condition programs (e.g., Non-point Source Monitoring, State Parks, Irrigated Lands Program, Agricultural Coalitions, etc.) to engage in and participate in the process.

Appendix I (for concept paper): Background and technical material on developing reference wetland networks

Defining Reference Condition and Goals for Reference Wetland Networks

Because the concept of reference condition can be applied either very narrowly or more broadly, the use of consistent and specified definitions (see glossary) is important and can greatly enhance collaboration and the transfer of knowledge. The following terminology, as described in Ode and Schiff (2008), is adapted from Stoddard *et al*. (2006):

- Reference Condition (RC(BI)) is the natural biological condition of a wetland, undisturbed by human activity. It is considered the absolute "natural" or pristine condition that could exist in the absence of all historical and current human disturbances. Because this term has a wide range of meanings in the literature, some have suggested that the term should be restricted to meaning "reference condition for biological integrity in the absence of significant human disturbance or alteration". This definition recognizes the need for a reference condition term reserved for "naturalness" or "biological integrity" even though it will only be approximated it in most parts of the world.

- Historical Condition (HC) refers to the condition of a wetland at some specified point in time in the past as interpreted from historical records or from remains (e.g. pollen or diatoms in lake sediments). The data used to construct this condition are often difficult to obtain, highly variable, or static in the sense that it only provides a snapshot of wetland condition at that particular time in history.

- Minimally Disturbed Condition (MDC) is the biological condition of wetlands found in landscapes with minimum human disturbance. MDC provides a definitive representation of biological integrity and an absolute standard against which to measure the condition of other wetland resources. However, it is typically very difficult to locate a sufficient number of wetlands with minimally disturbed conditions, especially at larger spatial scales.

- Least Disturbed Condition (LDC) describes the condition of wetlands that exhibit the lowest signs of human disturbance in landscape that has been significantly altered by human activity. It is a popular choice for determining reference conditions because it is often representative of what exists on the landscape in relative abundance. However, it has been suggested that LDC not be used as a benchmark for biological integrity because it often underestimates the potential for restoration, especially over time, as the "best of what's left" in severely altered landscapes continues to decrease in biologic integrity.

- Best Attainable Condition (BAC) can be used to specify a condition that is better than any in existence in a heavily modified region. BAC is the highest possible biological condition deemed achievable through the implementation of best management practices and other rehabilitation activities that can be undertaken in a given landscape under certain social and economic considerations. BAC differs from either MDC or RC(BI) because those conditions may never be achievable in a particular region. BAC expectations can be used to set realistic goals for the most degraded wetlands because it is based more on management considerations rather than being inextricably tied to ecological integrity.

Once the desired endpoint has been established, reference conditions are determined through a network of wetland sites (*reference wetlands*) within a specified geographic region that have been selected for the purposes of condition and/or functional assessment (Hughes 1995, Bailey *et al*. 2004). Because it is impossible to determine ***a priori*** how much variation is typical of any given population of sites, the goal of the reference-site approach is to define and describe the amount of this variability (Stoddard *et al*. 2006; Brinson and Rheinhardt 1996; Smith 1995).

The term *reference wetlands* can have different meanings depending on the goals and objectives of a particular program. Many monitoring programs develop a network of reference sites based on the concept of the *reference standard.* Reference standards represent the conditions exhibited by a subset of reference wetlands that correspond to the highest condition or level of functioning (i.e. highest sustainable capacity) across the suite of condition states or functions of a wetland subclass (Brinson 1995). This standard is generally used to characterize the desired state of wetland biotic conditions expected for a range of sites in areas of minimal human disturbance (Meyer 1997); any deviation from this range used as evidence of site impairment. Temporal and spatial variability, due to the influences of climate and natural disturbance, are inherent in any measure chosen to represent the natural state of ecological systems. Therefore, it must be recognized that a set of sites at any point in time, even in undisturbed condition, will exhibit a range of biological attributes (Stoddard *et al*. 2006). Because the distribution of wetland condition or function is unlikely to be uniform throughout a region (i.e. a random sample may not include the extremes), reference standards provide the means to identify the "best" sites of a particular condition, function, or group of conditions/functions (Rheinhardt *et al*.1997). In regions where wetlands are distributed in a matrix of various land use types (e.g. urbanized regions), data collected through the process of defining the reference standard can be used to determine breakpoints that distinguish the condition thresholds (e.g. good, fair, poor).

In some instances, reference wetlands represent the entire range of variability exhibited by a regional wetland subclass as a result of both natural processes (e.g., succession, fire, erosion) as well as anthropogenic causes (e.g., clear-cutting, grazing, urban development; Smith 2001). In this case, a network of sites is selected to represent the *biological condition gradient* that encompasses the complete range of aquatic resource condition present across a landscape, from relatively natural (e.g. undisturbed or minimally disturbed conditions) with highest levels of functioning to severely altered conditions. This information can then be used to model and interpret the biological response of aquatic ecosystems to increasing effects of stressors (Davies and Jackson 2006; EPA 2005). If the reference gradient approach is used, it has been recommended that both a stressor/abiotic approach and ground-based rapid assessment information be used to screen potential reference sites to ensure (1) that the full range of stressor levels are included in the reference gradient, and (2) the minimally disturbed reference sites (reference standards) are adequately represented in the reference gradient (Faber-Langendoen *et al*. 2009).

Using Reference Conditions to Set Restoration Goals

Using the traditional concept of reference systems can give a false sense of predictability of ecological outcomes. Rather than selecting static reference 'endpoints', a desired trajectory should be defined that takes into account a range of values for key system attributes that are inherently variable; e.g. ranges of flow and sediment inputs, variability in the location and number of habitat types, and changes in the species composition of assemblages through time and space (Hughes *et al*. 2005). The concept of setting definitive standards originally arose in response to concerns over toxic materials that cause lethal conditions once they reach some simple threshold (Poole *et al*. 2004). However, nonpoint sources predominate today and these problems vary considerably over time and space. Setting a single threshold encourages "homogenization of naturally diverse and dynamic systems" (Poole *et al*. 2004). Furthermore, it assumes that systems are unresponsive to gradually increasing stressors until some break point is reached and that ecosystems cannot maintain their health when the threshold is temporarily exceeded or is exceeded in some patches but not others.

This concept is especially pertinent to the science of restoration ecology, monitoring, and project design. Instead of viewing restoration goals as static endpoints, stochastic events (such as disturbances) could be combined with deterministic processes to design restoration and monitoring programs if the focus is on variation in trajectories of recovery (Suding and Gross 2006). Likewise, managers should work toward defining "regime" standards, rather than setting single standards, which describe a distribution of desired conditions over space and time (Poole *et al*. 2004). In severely degraded ecosystems, for example, it may be particularly important to consider many possible pathways to restoration because assuming an ecosystem can be returned to some historical or reference condition may divert attention from the need to identify internal feedbacks that are operating to keep the system in a degraded state (Zedler 2000). Restoration may require novel pathways because the dynamics of the degraded system may be very different from the "desired state" and the recovery trajectory can be quite different from the collapse trajectory (Hobbs and Norton 1996; Suding *et al*. 2004; Chambers and Linnerooth 2001; Duarte and Conley 2008). Because multiple pathways to restoration planning are likely possible and may depend on restoration actions (Duarte and Conley 2008), it is important for restoration "targets" to be based on an array of possible outcomes or states. Therefore, identifying a suite of reference sites that span a range (or gradient) of stress can help to identify the suite of potential restoration trajectories (Palmer 2009).

Defining the Reference Domain

Ecoregions are recognized as a consistent and useful organizing template for initially defining the reference domain (Bryce et al. 1999; Hughes and Larsen 1988) and have been used to develop a network of reference wetlands for a number of state and federal wetland programs (Griffith 1999). Omernik's Level III ecoregions (Thorson *et al*. 2003; Omernik, 1986) are the most commonly used as they tend to provide an acceptable distribution of sites across both jurisdictional and watershed boundaries. Bailey's ecoregions (Bailey 1994) are based on a narrower range of geology, climate and zoogeography. However defined, stratification based on ecoregions does not always adequately capture the natural gradients that are key drivers of biological condition (e.g. Hawkins and Norris 2000), and the suitability of these boundaries must be occasionally reevaluated as more data is collected.

Wetland Types and Subtypes (Classification)

Different types of wetlands have correspondingly different functions, services, and beneficial uses, therefore, a classification system is needed to distinguish one type of wetland from another. This classification system should be standardized to foster collaborations and coordination among the various wetland interest, be robust, and have the following characteristics:

- Represents full range of California wetland types, forms and, functions;
- Can be accurately classified during mapping without field visits or site reports, assuming the appropriate scale and resolution of aerial imagery are used;
- Supports ambient assessment of wetland condition;
- Is consistent with nomenclature of California wetland policies and programs;
- Can be adequately cross-walked to other classification systems, especially the National Wetland Inventory (NWI);
- Complements VegCAMP, a statewide initiative to map vegetation (VegCAMP 2007);
- Aids identification of site-specific beneficial uses of wetlands;
- Be adjustable to accommodate changes in the scope and specific focus of wetland policies and programs without requiring new wetland inventories or maps;
- Should not be too elaborate or no more complicated than needed to meet the other criteria

Site Screening Procedures

Steps associated with the screening process for reference site selection typically include:

1. Selecting the crucial screens for identifying and verifying reference sites.

2. Determining the methods used to make decisions under each screen. For example, what will be the data source(s) for landscape screens (e.g. aerial photos, G.I.S. data)? What are the important observation metrics for the field reconnaissance and rapid assessment screens?

3. Determining the number of specific criteria for passing a potential site through a reference screen. For example, what is the threshold for "discernible negative impact?" What is the threshold number for the rapid assessment screen?

Existing reference criteria data can be used to identify and verify reference sites. This can be based on previous site visits or ambient distributions of data collected from sites that were randomly selected. This pool of sites will typically be limited, however, so it will likely be necessary to supplement the data collected from reference sites with existing reference data. The existing reference site data would supplement data from the pool of additional sites that will need to be sampled and would greatly increase the level of confidence that the reference conditions are indeed representative of the standard. The difficulty is to find existing reference databases that utilized the same or comparable methods to verify reference sites. In order to achieve a detailed characterization of a particular wetland type and to account for unforeseen site access issues.

GIS data layers can be used to pre-screen for indicators of human disturbance at the regional scale. Other remote sources of information like air photos (Ortho Digital Quads) and thematic mapping could also be used. Potential areas are mapped where one might expect to find wetlands with minimal human activity. Potential sources of data that can be used to identify candidate areas include coverages for road density, population, forest fragmentation/stand age, agricultural and urban land use, and grazing allotments (Vogelmann 2001; USGS TIGER files; Kagan and Caicco 1992). For example, the Human Disturbance Index Reach (HDI) method was developed as an objective procedure for scoring and ranking potential reference sites for Oregon rivers and streams (Drake 2003). This method consists of a site level assessment that is performed during a reconnaissance or sampling visit. The reach level checklist documents the significant human disturbance activities observed at a given stream reach and can be used to ground-truth watershed-scale GIS coverages.

Best Professional Judgment (BPJ) is a relatively inexpensive method that is frequently used to screen and select reference sites. The knowledge of local groups and resource managers from state and federal land management agencies can help to identify reference sites in their respective regions; however, the inconsistency and inherent bias of this technique suggests that it is best used in conjunction with other methods. For example, wetlands identified using GIS can be combined with the areas identified through a BPJ survey to produce a combined set of candidate areas. A comparison of the combined areas with identified natural gradients will show if there are a sufficient number of candidate sites for a given region.

Field Reconnaissance and Site Verification

Site visits during reconnaissance or sampling are used to ensure that sites represent "true" reference condition and identify site level human disturbance not detected through the office-based candidate area pre-screening. A site evaluation will require walking in the wetland, observing riparian vegetation, and the recording of any information that would remove the reference site from the list.

Site verification involves examining site results for any anomalies by reviewing the landscape and site-specific disturbance/stressor information, the site visit disturbance/stressor assessment, and any sampling data collected. If discrepancies between these data are observed, then further evaluation of the site will be necessary. Final verification will require an evaluation of the condition data (biological, physical habitat, and/or water quality) that might indicate unidentified problems. Data that indicate the presence of stressors (e.g., alien species, excessive nutrients) are carefully reviewed to insure that no sites are misclassified as reference. If a disagreement between the stressors and the subsequent data is identified, that site is “flagged” as needing further review. If flagged sites pass a final review, then a site is accepted as reference. If reference conditions were not met, then the candidate reference site is rejected.

Verification is completed with the assignment of a site classification “grade”. The grade reflects the combined information of pre-screening, site visit and verification evaluation. Sites can be graded as near natural, minimally disturbed, and best available (or marginal) reference sites, depending on the needs of the program. High quality sites will typically have good water quality, minimal degradation, and be located in areas with minimal logging, grazing, mining or recreational activity.

Stratification and Identifying Appropriate Natural Gradients

Classification of wetlands according to the primary natural gradients in a region can help partition natural sources of variation and improve the ability to detect deviation from reference condition (Hughes 1995). This insures that reference sites will be representative of both the region and the dominant natural gradients that exist throughout the state. Creating a stratification scheme based on defined criteria will enable groups of sites to be distinguished from one another. Because many regions will have few or no established reference sites, stratification must occur through an iterative process. An initial stratification scheme could be based on *a priori* natural gradients that are expected to influence reference condition.

The ability to precisely establish biological expectations within a region is a function of the number of sites that are sampled and natural variability within the region. Therefore, a reference network should contain enough sites to provide a robust characterization of the State’s natural variability. Tiner (2002) suggests that the pools of candidate sites be at least 2-3 times the desired number of reference sites that are targeted for the network. Reliance on a small number of reference sites is risky because it increases the consequences of failure and/or loss of individual sites. The size of the regional networks in each region will depend on the number of major environmental gradients in each region (e.g., elevation, temperature, etc.) and the strength of influence of these gradients on wetland condition and function. A random monitoring design of these reference site pools is suggested because it provides an unbiased method for defining natural variability while still optimizing large-scale trend detection.

Differentiating between Natural and Human-induced Sources of Disturbance

Ideally, a network of reference wetlands should include sites that are representative/characteristic of the region. If the primary goal of establishing wetland reference sites is to determine whether or not a site is impaired, the effects of natural disturbance events, such as flood, fire or mass wasting of hillslopes, must be differentiated from human caused stressors. Sites should, therefore, be spatially dispersed within a region and represent a range of conditions to account for site variability due to both these factors. Sites could range from those recently and obviously disturbed to those sites partially or completely recovered from a given event.

Number of Sites for the Reference Network

Tiner (2002) suggests three sites as the absolute minimum, and 30-50 as the maximum number of sites per wetland subclass. Smith *et al*. (1995) suggest a range of 15-20 sites per wetland subclass. The number of sites necessary for a particular region for each wetland class or subclass can also be guided by potential threats to a particular wetland class/subclass, wetland types of special concern, available regional expertise, or relative abundance (e.g. proportions of NWI types). The Ohio EPA demonstrated that ecoregions with homogeneous landscape require fewer reference sites than more heterogeneous regions (Yoder and Rankin 1995). Tiner (2002) suggests that a range of 8-12 sites begins to account for the variability within a wetland subclass.

The number of reference sites to comprise the regional reference networks that will ultimately depend on the natural variability of a region. It will be important to gather information from a large number of sites in order to capture the full range of natural variability in California. These sites should also be distributed appropriately to represent the extent and distribution of wetland types within the California landscape. For example, depressional (palustrine) wetlands comprise a large portion of wetland habitat acreage in California; therefore this wetland class may require more reference sites in order to accurately characterize subtypes and account for the natural variability that will be observed.

In order to identify the major sources of natural variability, reference sites should be distributed along natural gradients known to influence condition. However, the extent of variation related to natural gradients is currently unknown for most regions of California. In order to begin to understand the range and distribution of wetland conditions that exist throughout California, sites to comprise the State reference network should be distributed along *a priori* natural gradients, including geology, climate (temperature and precipitation), and elevation. Classification of sites according to these natural gradients can help partition natural sources of variation in wetland condition and thereby improve the ability to detect deviation from true reference condition. As more data are collected, they will be used to determine which of these gradients has the most influence on reference condition to ensure that the regional networks are representative of the most important natural gradients.

Frequency of Sampling

Related to the number of reference sites is the frequency at which these sites will be assessed. Reference sites will need to be re-sampled periodically long-term trend detection. Sampling frequency at fixed reference sites is a function of variability in the biological metrics, the amount of time required to detect a trend, and the amount of detectable change. If analysis shows a significant shift in reference site conditions from past site data, then a re-sampling of reference sites may be needed. As more data are collected, power analysis can be used to establish the optimal sampling frequency (Ode and Schiff 2008).

Considerations for Indicator Selection

The condition of wetlands is determined by interactions among internal and external hydrologic, biologic (biotic), and physical (abiotic) processes (Brinson 1993). The condition of a wetland is mainly determined by the quantities and qualities of water and sediment (both mineral and organic) that are either processed on-site or that are exchanged between the site and its immediate surroundings, but the supplies of water and sediment (ultimately controlled by climate, geology, and land use), govern natural disturbance anthropogenic stress, and biota (especially vegetation) are also important. Biota, in particular, tends to mediate the effects of climate, geology, and land use on the quantity and quality of water and sediment. For example, vegetation can stabilize stream banks and hillsides, entrap sediment, filter pollutants, provide shade that lowers temperatures, reduce winds, etc.

Level-3 indicators will be used to assess ecological integrity or reflect current wetland condition at reference sites. It is recognized that some indicators are more effective in describing the ecological condition of wetlands than others. There are "core" indicators that can be used to characterize wetland condition regardless of wetland type and geographic domain, and "supplemental" indicators that are more effective for specific wetland types or regions. The indicators used for stressor diagnosis may not be the same as those used for regulatory decision-making and effectiveness monitoring. Therefore, judicious selection of the indicator classes, indicator types, and the metrics used to measure those indicators are an important consideration in the development and monitoring of reference wetlands.

Multiple indicators will need to be developed to account for the different sensitivities each indicator has for different stressors. Although most biological indicators integrate impacts from multiple stressors, each indicator has its own strengths and weaknesses. For example, several studies have shown that benthic macroinvertebrates are particularly sensitive to hydrologic and habitat modification that accompanies watershed urbanization, whereas benthic algae are more sensitive to water quality impacts, such as changes in nutrients or specific conductance (Sonneman et al. 2001, Walsh *et al*. 2001, Hirst *et al*. 2002, Mazor *et al*. 2006). Using multiple indicators in tandem provides greater sensitivity to more types of impacts, and over a greater range of the disturbance gradient.

Glossary of Terms

Biological integrity: The ability of an aquatic ecosystem to support and maintain a balanced, adaptive community of organisms with a species composition, diversity, and functional organization comparable to that of natural habitats within a region (USEPA 2002). In this case, it is quantitatively defined by the condition of *reference standard* sites.

Reference condition: The range (or continuum) of physical, chemical, and biological conditions occurring at sites that can be correlated with a known set of stressors. The reference condition is basis of comparison that defines the highest and lowest levels of potential or expected condition. Sampling reference sites is a method for determining reference condition

Reference standard condition: The highest level of potential or expected condition on the reference continuum. The reference standard represents the least-disturbed physical, chemical, and biological conditions across a population of wetlands and includes an estimate of natural variability.

Reference standard wetlands: A subset of reference wetlands from a regional wetland hydrogeomorphic subclass that is used to establish the standard of comparison. Generally, these are the least altered wetland sites in the least altered landscapes and sustain the highest level of function (highest sustainable capacity) across the suite of functions. Reference standard values will exhibit variability based on the reference domain wetlands and will generally provide a range of values that represent the normal variation of reference wetlands.

Reference domain: The geographic area from which reference sites are surveyed and selected. The reference domain includes all wetlands within a defined geographic region that belong to a single hydrogeomorphic subclass. The reference domain may include all or part (e.g. within an ecoregion) of the full range extent of a type (Faber-Langendoen et al. 2009).

Reference wetland network: A group of wetland sites that encompass the reference condition (range of variability) exhibited by a regional wetland hydrogeomorphic subclass(s). Sometimes referred to as the reference set.

Reference wetland: A single wetland site (physical location) within a reference wetland network that represents a particular wetland hydrogeomorphic subclass(s) for a geographic region.

Reference gradient*:* The gradient of ecosystem condition across a region varying from least disturbed (i.e. the reference standard) to highly impaired.

Disturbance: Events or regimes that are natural processes of an ecosystem. Although disturbances are natural phenomena, they might have similar impacts as stressors.

Stress: The consequence of anthropogenic events or actions that measurably affect conditions in the field (Collins *et al*. 2008).
Stressor: Any abiotic or biotic entity resulting from human activities that can induce an adverse response in ecosystem condition.

Indicator Class: A major component of an ecosystem or a major stressor type used to assess biological integrity or reflect current condition. Examples of biotic indicator classes include benthic macroinvertebrates, vegetation, fish, amphibians, and birds.

Indicator: A major element of an indicator class that can be used to assess or reflect the biological condition of that indicator class. Examples indicators for vegetation indicator class include structure, composition, diversity, life history, tolerance, and alien taxa.

Metrics: Measurements of an indicator. Example metrics for alien plant taxa indicator include % alien species richness, relative alien cover, and the number of invasive alien species.

Assemblage – An association of organisms that belong to the same major taxonomic group. Examples of assemblages used for biological assessments include algae, amphibians, birds, fish, benthic macroinvertebrates, and vascular plants.

Community – A community consists of populations of different species, interacting with one another and may include all organisms or focus on particular groups (e.g. aquatic, terrestrial, plant, animal, or microbial).

Function: The rates of physical, chemical and biological processes over time that characterize wetland ecosystems.

Condition: The current state of a wetland assessment area's physical and biological structure, the hydrology, and its buffer and landscape context relative to the best achievable states for the same type of wetland. Condition is evaluated based on observations made at the time of the assessment.

Functional Capacity: The likelihood of occurrence of a specific wetland function.

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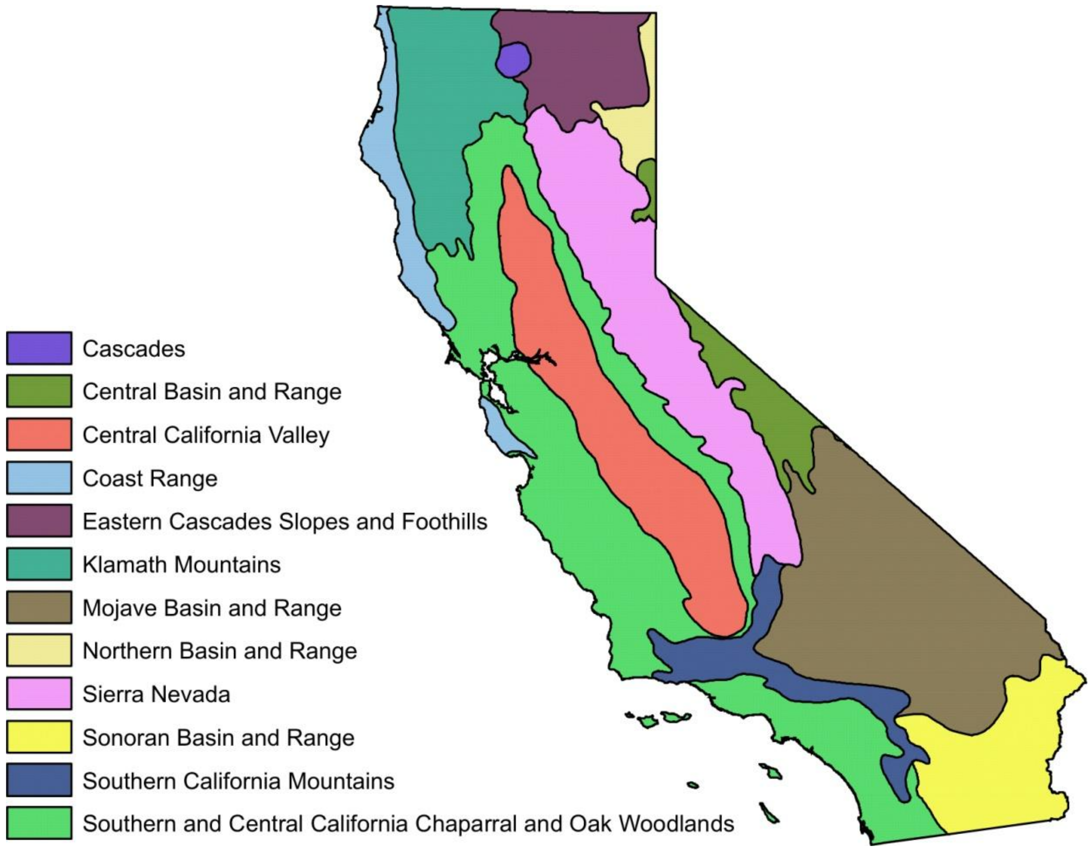
Figure 1. Bioregions identified for Phase I of the State reference wetland network's development.

Figure 2. Boundaries of 12 Level III Omernik ecoregions present in California (Ode and Schiff 2008).



Appendix C. List of Regional CRAM Assessment Team Members

Name	Organization	Region	Status
Alexis Kessans	ICF	South Coast	journeyman
April Robinson	San Francisco Estuary Institute	North Coast; SF Bay	trainer
Ayzik Solomesheh	University of California at Davis	Central Valley	journeyman
Betty Fetscher	Southern California Coastal Water Research Project	South Coast	trainer
Cara Clark	Central Coast Wetlands Group at Moss Landing Marine Labs	Central Coast	trainer
Carol Witham	Witham Consulting	Central Valley	trainer
Chad Roberts	Roberts Environmental and Conservation Planning LLC	North Coast; Central Valley	trainer
Christopher Solek	Southern California Coastal Water Research Project	South Coast	trainer
Eric Stein	Southern California Coastal Water Research Project	South Coast	trainer
Erik Larsen	AECOM	South Coast	trainer
Glenn Sybil	California Depratement of Fish and Game	Sierra	trainer
John Markham	USACE LA District	South Coast	journeyman
Josh Collins	San Francisco Estuary Institute	SF Bay	trainer
Kevin O'Connor	Central Coast Wetlands Group at Moss Landing Marine Labs	Central Coast	trainer
Lindsay Teunis	AECOM	South Coast	trainer
Martha Sutula	Southern California Coastal Water Research Project	South Coast	trainer
Melissa Scianni	US EPA Region 9	SF Bay	trainer
Mike Klinefelter	M.J. Klinefelter GIS & Environmental Consulting Services	South Coast	trainer
Paul Jones	US EPA Region 10	SF Bay	trainer
Ross Clark	Central Coast Wetlands Group at Moss Landing Marine Labs	Central Coast	trainer
Sarah Pearce	San Francisco Estuary Institute	North Coast; SF Bay	trainer
Wendy Renz	Vollmar Consulting	SF Bay; Central Valley	journeyman

Appendix D. List of Phase 1 Wetland Reference Sites.

Phase I Cal Reference Region	CRAM Wetland Class	CRAM Wetland Subclass	Site Name	Latitude	Longitude	County
Central Coast	Depressional	Perennial	Año Nuevo State Park	37.1188	-122.3119	San Mateo
Central Coast	Depressional	Perennial	Whitehouse Canyon Rd.	37.1592	-122.3269	San Mateo
Central Coast	Depressional	Perennial	Mud Hen Lake on Ft. Ord	36.6270	-121.7315	Monterrey
Central Coast	Estuarine	Bar Built	Pescadero	37.2616	-122.4061	San Mateo
Central Coast	Estuarine	Bar Built	Scott Creek Beach	37.0412	-122.2289	Santa Cruz
Central Coast	Estuarine	Bar Built	Arroyo de la Cruz	35.7101	-121.3101	San Luis Obispo
Central Coast	Estuarine	Perennial Tidal Saline	Bennett Slough	36.8173	-121.7892	Monterrey
Central Coast	Estuarine	Perennial Tidal Saline	Old Salinas Channel	36.7934	-121.7906	Monterrey
Central Coast	Estuarine	Perennial Tidal Saline	Morro Bay 1	35.3454	-120.8360	San Luis Obispo
Central Coast	Estuarine	Perennial Tidal Saline	Morro Bay 2	35.3473	-120.8297	San Luis Obispo
Central Coast	Riverine	Confined	Lower Wadell Creek	37.1177	-122.2677	Santa Cruz
Central Coast	Riverine	Non-confined	Upper Arroyo Seco Creek	36.1196	-121.4690	Monterey
Central Coast	Riverine	Non-confined	Upper Carmel River	36.3706	121.6624	Monterey
Klamath/North Coast	Depressional	Perennial	Tolowa Dune Swale Pond	41.8924	-124.1935	Del Norte
Klamath/North Coast	Depressional	Perennial	Espa Lagoon	41.3569	-124.0728	Humboldt
Klamath/North Coast	Depressional	Perennial	Elk Creek	41.7561	-124.1888	Del Norte
Klamath/North Coast	Estuarine	Perennial Tidal Saline	Mad River Slough - Central Island	40.8795	-124.1407	Humboldt
Klamath/North Coast	Estuarine	Perennial Tidal Saline	Remnant White Slough Marsh - HBNWR	40.7046	-124.2144	Humboldt
Klamath/North Coast	Estuarine	Perennial Tidal Saline	Jacoby Creek North	40.8443	-124.0830	Humboldt
Klamath/North Coast	Estuarine	Perennial Tidal Saline	Mad River Slough Pipeline Saltmarsh	40.8714	-124.1497	Humboldt
Klamath/North Coast	Estuarine	Perennial Tidal Saline	Jacoby Creek South	40.8427	-124.0830	Humboldt
Klamath/North Coast	Estuarine	Perennial Tidal Saline	South Bay - South Spit	40.7343	-124.2438	Humboldt
Klamath/North Coast	Estuarine	Perennial Tidal Saline	Big River Downstream	39.3034	-123.7806	Mendocino
Klamath/North Coast	Estuarine	Perennial Tidal Saline	Big River Upstream	39.3027	-123.7765	Mendocino
Klamath/North Coast	Estuarine	Perennial Tidal Saline	Arcata Bay Northeast	40.8480	-124.0841	Humboldt
Klamath/North Coast	Riverine	Confined	Cherry Creek	41.3650	-123.1890	Siskiyou
Klamath/North Coast	Riverine	Confined	Lost Man Creek	41.3247	-124.0084	Humboldt
Klamath/North Coast	Riverine	Confined	Monroe Creek	40.6725	-123.5232	Trinity
Klamath/North Coast	Riverine	Confined	Sugar Loaf	40.8615	-122.4638	Shasta
Klamath/North Coast	Riverine	Non-confined	Elk Creek	41.7399	-123.3562	Siskiyou
Klamath/North Coast	Riverine	Non-confined	Squaw Creek	40.3465	-123.9933	Humboldt
Modoc	Riverine	Confined	Indian Creek	40.2329	-121.8774	Tehama
Modoc	Riverine	Confined	South Fork Antelope Creek	40.2417	-121.8625	Tehama
Modoc	Riverine	Non-confined	Willow Creek	41.8957	-121.0231	Modoc
Modoc	Riverine	Non-confined	Rice Creek	40.3980	-121.4412	Plumas
Sacramento Valley	Depressional	Seasonal	Stone Lakes	38.4148	-121.4960	Sacramento
Sacramento Valley	Vernal Pool	Individual Vernal Pool	Vina Plains	39.9018	-121.9830	Tehama
Sacramento Valley	Vernal Pool	Individual Vernal Pool	Stillwater Plains	40.5067	-122.2613	Shasta
Sacramento Valley	Vernal Pool	Individual Vernal Pool	Stillwater Plains	40.5005	-122.2501	Shasta
Sacramento Valley	Vernal Pool	Individual Vernal Pool	Mariner Conservation Bank	38.9108	-121.3913	Placer
Sacramento Valley	Vernal Pool	Vernal Pool System	Vina Plains	39.8999	-121.9812	Tehama
Sacramento Valley	Vernal Pool	Vernal Pool System	Rancho Seco Preserve	38.3422	-121.0816	Sacramento
Sacramento Valley	Vernal Pool	Vernal Pool System	Rancho Seco Preserve	38.3418	-121.0782	Sacramento
Sacramento Valley	Vernal Pool	Vernal Pool System	Stillwater Plains	40.5072	-122.2589	Shasta
Sacramento Valley	Vernal Pool	Vernal Pool System	Stillwater Plains	40.5032	-122.2501	Shasta
Sacramento Valley	Vernal Pool	Vernal Pool System	Mariner Conservation Bank	38.9100	-121.3897	Placer
San Joaquin Valley	Depressional	Perennial	UC Merced Pond 1	37.3834	-120.3669	Merced
San Joaquin Valley	Vernal Pool	Vernal Pool System	UC Merced VSTP	37.3889	-120.3643	Merced
San Joaquin Valley	Vernal Pool	Vernal Pool System	Arena Plains	37.2556	-120.7102	Merced
San Joaquin Valley	Vernal Pool	Vernal Pool System	Stone Corral	36.4895	-119.2382	Tulare
San Joaquin Valley	Vernal Pool	Vernal Pool System	Great Valley Grasslands	37.2768	-120.8649	Merced
SF Bay Area	Depressional	Perennial	Dogtown Pond	37.9737	-122.7577	Marin
SF Bay Area	Depressional	Perennial	Lily Lake	37.9538	-122.6353	Marin
SF Bay Area	Depressional	Perennial	Hidden Lake	37.9405	-122.6158	Marin
SF Bay Area	Depressional	Perennial	Frog Pond	37.9731	-122.7572	Marin
SF Bay Area	Estuarine	Perennial Tidal Saline	Bolinas Bay 1	37.9148	-122.6866	Marin
SF Bay Area	Estuarine	Perennial Tidal Saline	Bolinas Bay 2	37.9174	-122.6810	Marin
SF Bay Area	Estuarine	Perennial Tidal Saline	Drake's Estero	38.0838	-122.9334	Marin
SF Bay Area	Estuarine	Perennial Tidal Saline	Limantour	38.0291	-122.8860	Marin
SF Bay Area	Estuarine	Perennial Tidal Saline	Suisun City	38.2297	-122.0395	Solano
SF Bay Area	Estuarine	Perennial Tidal Saline	Fagan Marsh	38.2197	-122.2962	Napa
SF Bay Area	Estuarine	Perennial Tidal Saline	Grey Goose	38.2048	-122.0690	Solano
SF Bay Area	Estuarine	Perennial Tidal Saline	Petaluma North	38.1972	-122.5694	Sonoma
SF Bay Area	Estuarine	Perennial Tidal Saline	Tomales Bay	38.1956	-122.9507	Marin
SF Bay Area	Estuarine	Perennial Tidal Saline	Rush Ranch	38.1909	-122.0130	Solano
SF Bay Area	Estuarine	Perennial Tidal Saline	Coon Island	38.1904	-122.3173	Napa
SF Bay Area	Estuarine	Perennial Tidal Saline	Shultz Slough	38.1656	-122.5502	Sonoma

Appendix E1. Intercalibration updates to CRAM SOPs (field books and CRAM User's Manual)

Summary of 3/6/2012 Changes to the CRAM Riverine Field Book (Version 5.0.2 to Version 6)

Entrenchment/Confinement Description:

- Updated language and added special note on relationship between the two concepts

Establish the Assessment Area:

- Highlighted special notes to consider
- Created new Figure 3 (formerly figure 3.4) describing the lateral extent of the AA
- Refined the description of lateral extent of AA

Attribute 1: Buffer and Landscape Context

Metric 1-Riparian Continuity

- Changed named of Landscape Connectivity to Riparian Continuity (Aquatic Area Abundance for all other wetland types)
- Refined description of Riparian Continuity metric
- Moved "special notes" earlier in the section
- Enlarged Figure 4 (formerly figure 4.1)

Metric 2- Buffer

- Added definition specific to the whole metric
- Highlighted "special notes"
- Added definition to % AA with buffer
- Added new figures (5, 6, and 7) to all three submetrics
- Changed some landcovers that are/are not considered buffer
- Added % AA with Buffer worksheet to allow practitioners to draw the AA and indicated where buffer does/does not exist and give a raw number for the %
- Added additional 'B' rating for Buffer condition and added additional language to the ratings to define what level of non-native species are in each rating level

Attribute 2: Hydrology

Metric 1- Water Source

- Added additional language to the definition
- Added new Figure 8 describing how to assess the metric
- Highlighted important words in rating table

Metric 2- Channel Stability

- Remove Hydroperiod from title
- Added additional language to the definition
- Removed references to other wetland types
- Removed table "field indicators of altered hydroperiod"
- Reworded the eighth indicator of equilibrium

- Split the second indicator of degradation in to two indicators
- Added “overall” condition boxes

Metric 3- Hydrological Connectivity
- Added additional language to the definition
- Added a description of how to assess this metric in a one-sided AA situation
- Added suggested locations of where to take measurements
- Added additional definitions of bankfull and floodplain
- Added additional tips of how to find bankfull
- Renumbered tables and figures

Attribute 3 Physical Structure:

Metric 1-Structural Patch Richness
- Revised several definitions of patch types, removed references to other wetland types
- Removed all other wetland types in worksheet
- Removed all other wetland types in Table 14 (formerly Table 4.16)

Metric 2- Topographic Complexity
- Renumbered Table 15 (formerly Table 4.17) and removed indicators of topographic complexity for other wetland types.
- Added paragraph on how to assess the metric
- Added worksheet to allow practitioners to draw three cross sections of the AA to assist in assigning a grade of condition
- Revised Figure 10 (formerly Figure 4.6)
- Revised language in rating Table 16 (formerly Table 4.18c) to be clearer of what is and is not considered a bench and what to include in the assessment of macro- and micro-topographic complexity.

Attribute 4 Biotic Structure:

Metric 1-Plant Community
- Revised definition of plant and invasive species
- Revised definition for submetric A- Number of Plant Layers
- Updated examples of plant species found in each layer
- Removed references to other wetland types in Table 17 (formerly Plant Community Metric Worksheet 1 of 8)
- Revised definition for submetric B- Number of Co-dominant Species
- Revised definition for submetric C- Percent Invasion
- Updated Plant Community Metric Worksheet with new layer and heights included in the table. Removed separate worksheet for confined and non-confined systems.
- Updated ‘A’ rating in Table 18 (formerly Table 4.19) to account for additional plat layer added to the Number of Plant Layers submetric

Metric 2-Horizontal Interspersion

- Changed name from Horizontal Interspersion and Zonation to just Horizontal Interspersion
- Made extensive additions and revisions to the definition
- Added Horizontal Interspersion Worksheet to allow practitioners to draw the AA and zones located within it to assist with grading the condition of this metric
- Revised Figure 12 (formerly Figure 4.9)
- Changed 'D' rating in Table 19 (formerly Table 4.20b) to read "AA has *minimal* plan-view interspersion" rather than "*essentially no* plan-view interspersion"

Metric 3-Vertical Biotic Structure

- Removed references to other wetland types in the definition
- Simplified Figure 13 (formerly Figure 4.11) to have just one example of each level of overlap
- Revised rating Table 20 (formerly Table 4.21) to include number of plant layers in the descriptions

Stressor Worksheet:

- Changed column headings to read "present" and "significant negative effect on AA" to add clarity to the role of these two columns

<u>Summary of Changes to the CRAM Estuarine Field Book (Version 5.0.2 to Version 6) 3/8/2012</u>

Establish the Assessment Area:

- Moved special considerations for estuarine systems to the beginning of the section
- Revised Figure 2 (formerly figure 3.5) describing the extent of the AA
- Removed all references to other wetlands from tables 1, 2, and 3 (formerly tables 3.5, 3.6 and 3.7)

Attribute 1: Buffer and Landscape Context

Metric 1-Aquatic Area Abundance

- Changed named of Landscape Connectivity to Aquatic Area Abundance
- Removed references to other wetlands in the definition
- Added "special notes" to this the section
- Added Figure 3
- Changed wording in rating table slightly to say "of the transects pass through anaquatic feature" rather than "of the transects is wetland habitat"

Metric 2- Buffer

- Added definition specific to the hole metric
- Highlighted "special notes"
- Added definition to % AA with buffer
- Added new figures (4, 5, and 6) to all three submetrics
- Changed some landcovers that are/are not considered buffer

- Added % AA with Buffer worksheet to allow practitioners to draw the AA and indicated where buffer does/does not exist and give a raw number for the %
- Added additional step to Table 7 (formerly Table 4.6)
- Added additional 'B' rating for Buffer condition and added additional language to the ratings to define what level of non-native species are in each rating level

Attribute 2: Hydrology

Metric 1- Water Source

- Added additional language to the definition, removed references to other wetland types
- Added new Figure 7 describing how to assess the metric
- Highlighted important words in rating table

Metric 2- Hydroperiod

- Added additional language to the definition
- Added additional language to the rating table
- Removed references to other wetland types
- Removed description and rating table for seasonal estuarine sub-type, these are now in a separate field book for Bar-built estuaries

Metric 3- Hydrological Connectivity

- Added additional language to the definition
- Added suggestion to indicate on aerial where restrictions to water movement occur
- Added limit to the distance from the AA a practitioner is supposed to consider when assessing this metric

Attribute 3 Physical Structure:

Metric 1-Structural Patch Richness

- Revised several definitions of patch types, removed references to other wetland types
- Removed all other wetland types in structural patch type worksheet
- Removed all other wetland types in Rating Table 14 (formerly Table 4.16)

Metric 2- Topographic Complexity

- Renumbered Table 15 (formerly Table 4.17) and removed indicators of topographic complexity for other wetland types.
- Added paragraph on how to assess the metric
- Added worksheet to allow practitioners to draw two cross sections of the AA to assist in assigning a grade of condition
- Revised Figure 8 (formerly Figure 4.6) to be more realistic looking
- Revised language in rating Table 16 (formerly Table 4.18c) to be clearer of what to include in the assessment of macro- and micro-topographic complexity.

Attribute 4 Biotic Structure:

- Added metric and submetric headings

Metric 1-Plant Community

- Revised definition of plant and invasive species
- Updated examples of plant species found in each layer
- Revised definition for submetric A- Number of Plant Layers
- Revised definition for submetric B- Number of Co-dominant Species
- Revised definition for submetric C- Percent Invasion
- Removed references to other wetland types in Table 17 (formerly Plant Community Metric Worksheet 1 of 8)
- Updated Plant Community Metric Worksheet to include heights in the table.

Metric 2-Horizontal Interspersion

- Changed name from "Horizontal Interspersion and Zonation" to "Horizontal Interspersion"
- Made extensive additions and revisions to the definition
- Added Horizontal Interspersion Worksheet to allow practitioners to draw the AA and zones located within it to assist with grading the condition of this metric
- Revised Figure 10 (formerly Figure 4.10) to be slightly less complex with only one example for each rating.
- Changed 'D' rating in Table 19 (formerly Table 4.20b) to read "AA has *minimal* plan-view interspersion" rather than "*essentially no* plan-view interspersion"

Metric 3-Vertical Biotic Structure

- Revised rating Table 20 (formerly Table 4.22) to highlight important words

Stressor Worksheet:

- Changed column headings to read "present" and "significant negative effect on AA" to add clarity to the role of these two columns

<u>Suggestions for revision to Depressional CRAM Field Book (from field exercise on 10/23/1)</u>

AA Establishment

1. From backshore, as indicated by high water marks or vegetation transition, including adjacent riparian that directly overhangs the backshore. Down to 10 m out into open water if present.
2. In large ponds with fringing wetlands, the AA boundary should be based on the rules in (1) above, and should extend along the shore to form an AA that is 1 ha in size.
3. In smaller ponds with less than 20 m of open water, if the pond is < 1ha the AA is the entire pond.
4. In wetlands that do not have distinct open water areas in the middle of the wetland, the AA can be a randomly placed 1 ha circle or encompass the entire wetland if it is smaller than 1 ha.

Landscape Connectivity

1. Should be called aquatic connectivity.

2. Considering the idea of measuring connectivity relative to the “wetland that contains the AA” rather than just the AA itself when that AA is part of a larger wetland. However, this would take the assessment away from the AA itself which is the unit being considered, so there was some pushback against this idea. The underlying assumption of CRAM that bigger wetlands are better does make this metric biased toward larger wetlands.

Buffer

1. For long linear wetlands or AAs, the buffer measurements should be drawn perpendicular to the edge of the AA, not radiating from a center point. This will be a more accurate estimation of the actual width of the buffer.
2. The list of buffer and non-buffer needs to be refined. What types of fences break a buffer? What about the concrete wall we encountered at the stormwater retention pond? What about a concrete spillway or other concrete structures that aren’t part of an actively used road or path? Should railroads be considered buffer? Links golf courses should not be buffer. More is needed to clarify.
3. Buffer Condition: we came up with the idea of developing a table where the 3 factors are evaluated separately and then summed to get a final grade for the metric. This would have to be refined. Or do we need to try to completely remove reference to stress/anthropogenic disturbance in this sub-metric?

Hydrology

1. The hydroperiod metric needs clarification and refinement, particularly for created wetlands. What is reference condition for these systems?

New Patch Types:

1. Open Water
    - Size requirements?
    - What functions does open water support: waterfowl, invertebrates, etc.
    - Conceptual model of functions
2. Large Woody Debris
    - Within AA, exposed above water or on marsh plain
3. Emergent Vegetation in water
    - Important for diversity of functions

Topographic Complexity

1. Is it reasonable to expect 2 benches in depressional systems? Is that reference? What is reference for these wetlands in terms of topographic structure?

Appendix E2. Results of the Regional Team Intercalibration for CRAM conducted in southern California from October 21-222, 2012.

	Site Number	Upper Newport Bay Site 2	Upper Newport Bay Site 2	Upper Newport Bay Site 2	Big Canyon Creek	Big Canyon Creek	Big Canyon Creek
	Date of Assessment	10/21/2011	10/21/2011	10/21/2011	10/22/2011	10/22/2011	
	Assessors	Central Coast	SF Bay-North	South Coast	Central Coast	SF Bay-North	South Coast
	Wetland Class	Estuarine	Estuarine	Estuarine	Riverine	Riverine	Riverine
	Wetland Subclass (conf/nonconf)	PSE	PSE	PSE	Unconfined	Unconfined	Unconfined
Attribute	**Buffer and Landscape Connectivity**	**19**	**21**	**19**	**19**	**19**	**21**
	Landscape Connectivity	9	9	9	12	12	12
	Buffer Metrics	10.39	12.00	10.39	7.14	7.14	8.74
	% of AA with Buffer	12	12	12	12	12	12
	Average Buffer Width	12	12	12	6	6	6
	Buffer Condition	9	12	9	6	6	9
Attribute	**Hydrology**	**27**	**27**	**27**	**27**	**30**	**27**
	Water Source	6	6	6	6	6	6
	Hydroperiod	12	12	12	9	12	9
	Hydrologic Connectivity	9	9	9	12	12	12
Attribute	**Physical Structure**	**18**	**18**	**18**	**12**	**18**	**12**
	Structural Patch Richnes	9	6	9	6	9	6
	Topographic Complexity	9	12	9	6	9	6
Attribute	**Biotic Structure**	**33**	**32**	**32**	**10**	**10**	**14**
	PC: No. of plant layers	12	9	9	6	6	6
	PC: No. of codominants	12	12	12	3	3	3
	PC: Percent Invasion	12	12	12	3	3	6
	Plant Community Metrics	12	11	11	4	4	5
	Interspersion	9	12	9	3	3	6
	Vertical Biotic Structure	12	9	12	3	3	3
	Overall AA Score	**81**	**82**	**80**	**58**	**66**	**63**

Appendix F. Recommendations for CRAM Audits: Auditing CRAM Scores as Part of the QA/QC Program for the Wetland and Riparian Area Monitoring Plan (WRAMP)

Recommendations For CRAM Audits

Auditing CRAM Scores as Part of the QA/QC Program for the Wetland and Riparian Area Monitoring Plan (WRAMP)

A TECHNICAL MEMORANDUM PREPARED BY:

LEVEL 2 COMMITTEE OF THE
CALIFORNIA WETLANDS MONITORING WORKGROUP

Draft Version 1 – March 2012

Executive Summary

A CRAM audit is a comparison between a CRAM assessment of unknown quality and a CRAM assessment of certified high quality for the same Assessment Area and time period. Each audit is the evaluation of the quality of one set of CRAM scores for a single CRAM Assessment Area and a single date. The basic goal of an audit is to determine the quality of the assessment being audited. Every CRAM audit addresses the following four topics:

1. Qualification of the CRAM practitioner(s) responsible for the audited assessment;
2. Level of preparedness of the practitioner(s);
3. Completeness of the assessment;
4. Accuracy of the assessment.

The L2 Committee submits the following recommendations for a program to audit CRAM scores, with the expectation that the recommendations will be revised based on input from the CWMW and thereafter incorporated into the quality control and quality assurance (QAQC) document for the Wetland and Riparian Area Monitoring Plan (WRAMP).

- Audits should be conducted in three regards: (1) ambient monitoring programs that employ CRAM; (2) routine assessments of CRAM reference sites; and (3) restoration or mitigation plans and projects for which CRAM results are incorporated into performance standards.

- CRAM audits should be conducted by two or more independent CRAM experts who do not have any financial or political interests in the outcome of the audits.

- The success of an audit depends on the competency of the auditors. Auditors must be proficient in CRAM. The minimum training that must be successfully completed to qualify a CRAM auditor is the same training required to qualify a CRAM trainer. It is recommended that CRAM practitioners who are recognized as trainers by the L2 Committee should be considered as candidate auditors.

- The roles and responsibilities of the audit team leader and other team members must be clearly identified;

- The CWMW should consider the establishment of regional teams to audit CRAM scores used in regulatory decisions; the formation of a regional audit team is likely to occur in phases;

- The L2 Committee is responsible for transmitting audit scores or final audit reports to the sources or sponsors of the scores that are audited. However, the audit team leader will represent the audit team in any discussions with the L2 Committee and other interests about the conduct or meaning of audit scores;

- The target precision values of CRAM metrics, attribute, or overall index should be determined by the L2 Committee based on the calibration and validation steps in the development of CRAM modules;

- All CRAM practitioners must adhere to the minimum requirements for assessment team composition as described in the CRAM SOPs, technical bulletins, and Quality Assurance Plan.

- A standardized procedure for on-site audit activities that includes a site walk-through should be adhered to by the audit team;

- The CWMW should determine the quality of a CRAM assessment as either: (1) good; (2) fair; or (3) poor, based on the audit report and advice from the L2 Committee;

- Efforts will be made to minimize poor CRAM assessments by continuing to improve training, encouraging the use of expert practitioners who have completed certified training programs, encouraging the use of the statewide CRAM database by all practitioners, and by using the database to assess and improve the performance of CRAM practitioners, trainers, and modules.

Document Purpose and Intended Audience

Having adequate quality assurances and quality control (QAQC) for CRAM data is vital to produce reliable information that meets the needs of all wetland and riparian regulators and managers. This document addresses the role of regional audit teams in providing adequate CRAM QAQC. It is intended for use by Federal, State, and local agencies that employ CRAM in regulatory or management decisions about wetlands It's purposes are to:

1) Describe the process for the development of regional CRAM audit teams;

2) Define the composition, role, and responsibilities of a regional CRAM audit team and its relationship with aquatic resource regulatory and management agencies;

3) Articulate the audit process for CRAM and describe the outcome of the process;

4) Describe the likely annual costs to utilize regional audit teams.

I. Background

In California, the coordination of all aspects related to wetland monitoring and assessment, including data quality assurance and control, occurs through the State's Wetland and Riparian Area Monitoring Plan (WRAMP; CWMW 2010; Figure 1). The WRAMP was drafted by the California Wetland Monitoring Workgroup (CWMW) and incorporates USEPA's Level 1-2-3 data classification system and general framework for monitoring and assessment of wetland resources (USEPA 2006). The WRAMP is intended to serve all State agencies and support the State Water Resources Control Board's Wetland and Riparian Area Protection Policy (WRAPP). The CWMW facilitates communication and coordination among the regional programs, subcommittees, and partner agencies that participate in the WRAMP. All activities of the CWMW (including implementation of the WRAMP) are subject to the overall guidance and approval of the California Water Quality Monitoring Council (Kehoe 2006).

The CWMW recognizes the need to develop a coordinated quality assurance and quality control (QAQC) plan that includes audits of selected monitoring data and reports. Audits are expected to be a key component of the QAQC program for each of the core methodologies of the WRAMP. The primary goal of these audits is to help maintain the highest possible standards of accuracy and precision of WRAMP output by helping to: (1) evaluate the efficacy of the WRAMP methodologies and (2) evaluate how well CRAM practitioners follow the instructions and guidance documents for the methodologies.

The CWMW recommends using cost-effective rapid assessment methods (RAMs) when appropriate to assess the overall condition or health of wetlands and streams. For this purpose, the CWMW has developed a California Rapid Assessment Method for wetlands and streams (CRAM) (http://www.cramwetlands.org). CRAM can be used to infer the ability of the assessed areas to provide the functions or services to which the areas are most suited (Collins *et al.* 2008). CRAM is being used by a variety of local, state and federal interests to assess the ambient condition of wetlands and steams and is likely to be used by state and federal regulatory and management agencies to help plan, design, and assess wetland and stream restoration and mitigation projects (CWMW 2010).

In 2010, the Monitoring Council directed the CWMW to create a Level 2 (L2) Committee to coordinate the review, development and implementation of rapid assessment tools including CRAM for all state agencies. One of the functions of the L2 Committee is to oversee various aspects of CRAM methodological training and QAQC.

Goals and Objectives of CRAM Audits

A CRAM audit is a comparison between a CRAM assessment of unknown quality and a CRAM assessment of certified high quality for the same Assessment Area and time period. Each audit is the evaluation of the quality of one set of CRAM scores for a single Assessment Area and a single date. The basic goal of an audit is to determine the quality of the assessment being audited. The definition of the Assessment Area is provided in the CRAM manual (Collins et al. 2008). Two or more assessments are assumed to represent the same period if they occurred during the same two-year time span. The period might be longer or shorter depending on case-specific circumstances, as explained below in Section V. The high quality assessment is certified by having been produced by an independent audit team that includes at least two experts in CRAM for the kind of wetland for which the audit is being conducted. The expertise of the members is assured by the level and timeliness of their CRAM training, as documented by the L2 Committee. The audit team is "independent" because none of its members who contribute to the audit score has any direct responsibility for the score being audited, nor has a financial or political interest in the outcome of the audit. Further information about the composition of an audit team is provided below in the section titled Audit Team Composition.

The L2 Committee recommends that audits should be conducted in three regards: (1) ambient monitoring programs that employ CRAM; (2) routine assessments of CRAM reference sites; and (3) restoration or mitigation plans and projects for which CRAM results are incorporated into performance standards. The audit process for ambient monitoring programs and reference site monitoring that incorporates CRAM is important because these programs provide the baseline measures of condition that are likely to inform project designs and performance standards. Auditing CRAM assessments of projects is important to help assure the correctness of decisions about project performance and compliance. The L2 Committee encourages discussion about how to improve CRAM for all of its applications. As a result, CRAM will continue to evolve in response to new data and changing needs of the user community. The audit process can help facilitate this discussion about CRAM and its continued improvement.

The specific objectives of CRAM audits may vary from agency to agency, depending on the differences in their missions and responsibilities. However, all organization using CRAM are expected to need CRAM audits to assure the integrity of their CRAM data. The recommended standardized audit process should be complementary across the CRAM user community.

II. Audit Team Composition

As stated above, CRAM audits should be conducted by two or more CRAM experts who do not have any financial or political interests in the outcome of the audits. These are the primary criteria for selecting auditors. An auditor can be anyone who meets the criteria for independence and expertise. Observers who do not meet these criteria can accompany auditors but should not have any influence on the audit scores. A given practitioner who meets the expertise criterion might also meet the independence criterion in some cases but not in others. In each case, each auditor will need to declare their independence as defined above.

The success of an audit depends on the competency of the auditors. They must be proficient in CRAM. This means that an auditor must be able to correctly identify any difference between an audit score and its corresponding audited score that is due to error in the latter. The minimum training that must be successfully completed to qualify a CRAM auditor is the same training required to qualify a CRAM trainer, and is described in the CRAM Quality Assurance Plan. It is recommended that CRAM practitioners who are recognized as trainers by the L2 Committee should be considered as candidate auditors. In addition, it is helpful but not mandatory that auditors have general familiarity with the CRAM audit process and procedures, and have a working understanding of the purposes of the CRAM scores that are being audited.

The roles and responsibilities of the audit team leader and other team members must be clearly identified. The responsibilities of the team leader are outlined below. The team leader:

- Is responsible for the overall conduct of the audit team, including but not limited to scheduling audits, selecting team members for specific audits, managing changes in membership, and holding and managing team meetings;
- Serves as the liaison between the audit team and the L2 Committee;
- Leads the technical interpretation of audit scores, especially with regard to the assessment of score accuracy and the identification of bias;
- Transmits the audit results and accompanying report to the L2 Committee.

As explained below in the section on reporting, the audit team leader and the audit team are not responsible for transmitting audit scores or final audit reports to the sources or sponsors of the scores that are audited. The L2 Committee is responsible for such transmittals, even if the source or sponsor is the Regional Water Board. However, the team leader will represent the audit team in any discussions with the L2 Committee and other interests about the conduct or meaning of audit scores.

III. Regional Audit Teams

The L2 Committee recommends that the CWMW consider the establishment of regional teams to audit CRAM scores used in regulatory decisions. This would include scores used in alternatives analyses and project feasibility studies, scores used in mitigation planning, scores used to establish performance standards for projects or used to define baseline conditions against which project performance is assessed. Each team would service one or more Regional Water Quality Control Boards (RBs). Reasons for the regional approach, and for using the RBs to define the regions, are given below.

1. Scores used in regulatory decisions will need the highest level of QAQCA. The continuity and consistency of a single audit team will help meet that need. The use of different teams to audit scores for any state program administered regionally would tend to introduce statistical variability and therefore uncertainty into the audits. This could be avoided by frequent inter-team calibration, bit with significant additional costs.
2. A single statewide team would have to either focus on regions sequentially over years and thus not be able provide timely audits in all regions every year, or would have to be divided into sub-teams, which would effectively be the same as regional teams.
3. The Regional Water Boards (RBs) have been identified by the CWMW as the administrative regions for the WRAMP.
4. There are ecological, climatological, and political/sociological differences among the regions as generally defined by the boundaries of the RBs that need to be reflected in the applications and interpretations of CRAM scores.
5. The RB boundaries are generally consistent with watershed boundaries and thus support the watershed approach to aquatic resource protection that is gaining prominence through state and federal policies and programs including 404, 401/WDR, and many TMDLs.
6. It is expected that most of the CRAM audits will pertain to regulatory decisions involving the RBs.
7. The audit scores will be stored with other CRAM data in the Regional Data Centers that service one or more RBs.

Regional teams are not necessarily the only source of CRAM audits. As explained below, audits might be done by the same or other auditors working apart from the regional teams for non-regulatory purposes.

The L2 Committee recognizes that the formation of a regional audit team is likely to happen in phases, as describe below.

<u>Phase I: Development Team.</u> At this phase, some regional and local regulatory and management agencies have some experience with CRAM but none are using it as a regular part of wetland or stream assessment. The pertinent Regional Water Board has recognized the need for a regional audit team, however, and has asked the CWMW to assist with its formation. On behalf this Regional Water Board, the CWMW instructs the L2 Committee to assist in team formation. The L2 Committee proceeds by forming a development team. Members of the development team must include at least one membersof the L2 Committee and should also include CRAM trainers with enough expert understanding of the particular nature of wetlands within the region to discern how the regional nature of wetlands might influence CRAM scores. The development team can also include representative staff from agencies that will be using CRAM scores. The development team coordinates the regional roll out of CRAM.

Phase II: Regional CRAM Roll Out. At this phase, the Regional Water Board has begun to explore the use of CRAM for ambient surveys or other applications, and/or recognizes the benefits of CRAM to other agencies within the region. The development team is led by a member of the L2 Committee, is recognized by the CWMW as a growing concern, and is working with the L2 Committee to develop CRAM trainers who mainly operate within the region and who qualify as candidate auditors.

Phase III: Advanced Training. At this phase, the Regional Water Board has decided to proceed with the establishment of a regional audit team, based in part on the outcomes of Phases 1 and 2. The development team now transitions into the audit team. A pool of 5-10 qualified candidate auditors is created based on the training that happened in Phase 2 plus additional training. All candidates will have accomplished the training for CRAM trainers as implemented through the L2 Committee. Candidates can be recruited from neighboring regions as appropriate.

Phase IV: Audit Team. At this phase, CRAM is an integral part of project assessment and/or ambient surveys of wetland and stream condition. There is a regional pool of 5-10 auditors who work through the L2 Committee to maintain their qualifications by being re-trained on new or revised CRAM modules and by serving as trainers. Ideally, the Regional Water Board has one or more staff serving on the audit team, and at least one person serving as a liaison between the audit team and the Regional Water Board.

Table 1. Status of CRAM audit teams for the Regional Water Boards and corresponding USACE Districts. See Appendix 1 for a current list of regional personnel.

Regional Water Board	**Corresponding USACE District**	**Phase I: Development Team**	**Phase II: Regional Assessment Team**	**Phase III: Qualified Training Team**	**Phase IV: Formal Audit Team**
North Coast (Region 1)	San Francisco	Y	Y	Y	N
SF Bay (Region 2)	San Francisco	Y	Y	Y	N
Central Coast (Region 3)	San Francisco	Y	Y	Y	N
Los Angeles (Region 4)	Los Angeles	Y	Y	Y	N
Central Valley (Region 5)	Sacramento	Y	Y	Y	N
Lahontan (Region 6)	Los Angeles	N	N	N	N

Colorado River (Region 7)	Los Angeles	N	N	N	N
Santa Ana (Region 8)	Los Angeles	Y	Y	Y	N
San Diego (Region 9)	Los Angeles	Y	Y	Y	N

IV. Scope and Content of an Audit

A CRAM audit is a comparison between a CRAM assessment of unknown quality and a CRAM assessment of certified high quality for the same Assessment Area and time period. The high-quality assessment is certified by having an audit team as its source, where the audit team is established through the L2 Committee.

Every CRAM audit addresses the following four topics, each of which is discussed below:

1. Qualification of the CRAM practitioner(s) responsible for the audited assessment;
2. Level of preparedness of the practitioner(s);
3. Completeness of the assessment; and
4. Accuracy of the assessment.

See Appendix 1 for an example of the CRAM audit field form and associated worksheets.

Qualification of the CRAM practitioner(s)

The L2 Committee recommends that all CRAM practitioners adhere to the minimum requirements for assessment team composition as described in the CRAM User's Manual (Collins *et al*. 2008), the technical bulletin on using CRAM in the context of regulatory and management programs (CWMW 2009), and the CRAM Data Quality Assurance Plan (in preparation). In brief, each CRAM assessment should be the product of a field team that meets the following requirements:

- The assessment team includes at least two practitioners working together in the field at the same time;
- At least one member of the assessment team has completed a 3-day CRAM training course within the past 5 years for the module being used in the assessment;
- The assessment team leader is registered as CRAM practitioner in the CRAM database (registration as a trainer suffices as registration as a practitioner).

The audit team will use the CRAM database and interviews with the assessment team leader to ascertain whether or not the assessment team has met each of these three minimum requirements for practitioner qualification. The evaluation can have a numeric value of 0 (no requirements have been met); 1 (one requirement has been met); 2 (two requirements have been met); or 3 (all three requirements have been met).

Level of Practitioner Preparedness

Practitioner preparedness refers to the degree to which the assessment team undertook the background check of site-specific existing information that is often (but not always) needed for an accurate assessment. This evaluation requires the audit team to conduct its own background check, and to determine to what degree the audited scores are consistent with the background information. The evaluation can have a numeric score of 0 (not consistent); 1 (partially consistent); or 3 (entirely consistent, which can mean that no existing data are available).

Assessment Completeness

An assessment is complete is it meets the following five requirements:

- There is map of the Assessment Area that follows the guidance for such maps in the CRAM manual and on the CRAM website;
- All worksheets in the CRAM field book are completed such that they provide adequate justification for the related metric scores;
- All data fields in the CRAM field book have all the entries needed to compute the scores for each CRAM metric;
- The stressor checklist is completed for each CRAM attribute;
- Appropriate explanations, site photographs, and supporting materials, including any voucher specimens used to verify plant species, are readily available and/or the correct contact person for them is clearly identified.

The CRAM data base will automatically report whether or not the first four requirements listed above have been met. To determine compliance with the last requirement listed, the audit team will need to search the database and may also need to try to contact the person(s) identified in the assessment as responsible for supporting materials that are not included in the database. The evaluation can have a numeric value of 0 (no requirements have been met or there is no suitable map of the assessment area); 1 (in addition to providing a suitable map, one requirement has been met); 2 (in addition to providing a suitable map, two to three requirements have been met); or 3 (all five requirements have been met).

Assessment Accuracy. The accuracy of an assessment will be determined by comparing the metric scores, attribute scores, and overall score of the assessment to the metric scores, attribute scores, and the overall score produced by the audit team. In each case, the assessment score should not differ from the audit score by more than the target precision of the metric, attribute, or overall index, as determined by the L2 Committee. The target precision values are determined by the L2 Committee based on the calibration and validation steps in the development of CRAM modules. At this time, the precision of CRAM Attribute scores and AA scores for riverine systems and estuarine wetlands is known to be 10%, or about 10 CRAM points for the AA score (i.e., 10% of the possible 100 points for an AA), and 3 - 5 points for the Attribute scores. This precision only pertains to riverine systems and estuarine wetlands, and can only be expected if practitioners have been adequately trained[9].

The L2 Committee expects that most audits will require a site visit by an audit team to determine the accuracy of field-based metric scores and submetric scores. The practitioners responsible for the audited assessment can accompany the audit team on the site visit to help explain the assessment and to receive technical advice from the auditors. However, the audit must proceed to its independent conclusion based on the assessment being audited, without any modifications to the assessment during the audit. CRAM scores that are based on aerial imagery or other remote sensing data can be audited apart from the site visit (see Table 2 in Appendix 2).

If a site visit by audit teams is not feasible, the competency of CRAM practitioners can be verified remotely through practitioner "self-audits" at field sites that have been previously assessed with CRAM by at least two independent practitioner teams that are fully trained and proficient in CRAM (e.g. CRAM trainers, PIs, audits teams, etc). Self-audit sites will be identified in all regions of the state and will demonstrate a range of CRAM condition scores, be accessible to the general public, and have the ability to reasonably withstand periodic degradation by repeated visitations without affecting CRAM condition scores.

The practitioners being audited would be required to conduct CRAM at least two of these locations and generate scores that are within the known precision of CRAM for the type of wetland being assessed, as well as meet the minimum data quality objectives for CRAM for practitioner preparedness and data completeness. Self-audit site information (site location, coordinates, site contact, and access instructions) will be made available off the Wetland Portal. The practitioners will submit their CRAM results to their Regional Data Center via paper field forms or through eCRAM and these scores will be verified by the responsible audit team.

The L2 Committee expects that the CRAM database will enable the L2 committee to identify systematic error suggesting bias among CRAM scores for any project, registered practitioner, trainer, or CRAM module. The intent is to enable the L2 Committee or other entities selected by the CWMW to test for systematic bias so that it can be remedied through improvements in CRAM modules or in CRAM training. The indicators of bias will vary depending on the purpose of the CRAM scores. The following scenarios are presented to illustrate how the database might be used to explore possible bias due to the selection of assessment areas, the CRAM module, or the practitioners.

- Reference sites are elected to represent very high-quality condition. There should not be low scores for reference sites.
- Scores for ambient surveys involving large areas should be broadly distributed around relatively abundant mid-range scores. The distribution of scores should not be positively or negatively skewed due to a preponderance of low scores or of high scores.
- In mitigation planning, impact sites tend to have low scores relative to reference sites due to efforts to avoid or minimize impacts to high-quality areas. There should not usually be a preponderance of high scores for impact sites.

[9] The precision of CRAM will be determined for additional wetland types as CRAM is calibrated and validated for them, continuing with depressional wetlands in 2012.

- Newly created mitigation sites and newly restored sites tend to have low or moderate initial scores because their conditions have not yet fully developed. There should not usually be a preponderance of high initial scores for newly restored sites or for newly created or purchased mitigation sites.

V. Timing, Frequency, and Number of Audits

The L2 Committee recommends that CRAM audits should be conducted as an integral part of regulatory or management agency efforts to use CRAM to assess impacts, plan mitigation, assess mitigation or restoration projects, or to assess ambient or baseline conditions. The number of individual assessments to audit will vary with the number of possible assessments and available funding, and will need to be determined together by the L2 Committee and the agencies responsible for any decisions that will be based on the assessments. The following scenarios are presented to help guide the audit planning.

- In general, audits should be conducted concurrent with, or soon after, the assessments that will be audited. Shortening the time between assessments and their audits will minimize the cost of redoing assessments.
- For any project having thirty or more CRAM assessments for any wetlands class, at least 10% of those assessments should be audited. For example, if an impact analysis, mitigation plan, or ambient survey involves 30 or more CRAM assessments for three wetland classes, then at least 10% of the assessments for each wetland class should be audited. In such cases, assessments will be randomly selected for auditing.
- If the L2 Committee determines from the CRAM database that a practitioner or trainer may be biased in their assessments or training, then the database will be used to select possibly biased assessments for auditing. At least five assessments should be audited in each case. The audited cases must not be more than two years old.

VI. On-Site Activities (Field Portion of Audits)

The L2 Committee recommends the following standardized procedure for on-site audit activities. All results must be recorded in the standardized audit form. A detailed discussion of the procedures for conducting CRAM Audits and training audit team members is found in Appendix 2.

Site Walk-through. The audit team should reconnoiter the entire, exact same Assessment Area that was subject to the assessment being audited. The Assessment Area map will guide this reconnaissance, and it can be further assisted by the practitioners who conducted the assessment, if they are available. This walk-though should precede the evaluation of any CRAM metrics. Its purpose is to for the audit team to gain a basic understanding of the form and structure of the Assessment Area.

Field-based Audit. The audit team will proceed as trained to conduct the field-based portion of the CRAM assessment as usual. All data fields will be completed for the Assessment Area defined for the audited assessment. However, the audit team should assess the accuracy and suitability of the Assessment Area map. The team will have in hand the results of the audited assessment, and will compare the audit scores to the audited scores for each metric and submetric as the audit proceeds. Auditors should document in writing any explanations for differences in audit scores and audited scores that exceed the target score precision, as defined by the L2 Committee. These explanations should be recorded while on-site (i.e. auditors should not wait to return to the office to record their explanations). The audit team should also take any photographs needed to support the audit.

The audit team leader should conduct a brief exit briefing with the audit team members before leaving the Assessment Area. The purpose of the briefing is to ensure that the field-based portion of the audit is complete, or to identify and assign any follow-up actions necessary to complete this part of the audit. The Auditors should revise and complete any preliminary explanations for observed discrepancies between the audit scores and the audited scores. In some cases, it may be necessary for audit findings to be kept confidential until the responsible agency has an opportunity to address any problems revealed by the audit. It is important that the audit team confine its scope of discussion to technical issues and concerns relating to the quality of the assessment being audited. The audit results should be treated as preliminary and not public until they are transmitted to the L2 Committee as a final audit report.

VII. Reporting

Each audit is the evaluation of the quality of a CRAM assessment. There is one audit per assessment, which is the set of CRAM scores for a single Assessment Area and a single date. The report will follow a standard template developed by the L2 Committee.

An audit report can cover one or more audits. The scope of the report will depend on the purpose of the audit. Reports for ambient surveys and large projects involving many individual Assessment Areas (and therefore many CRAM assessments), or that pertain to tests of practitioner or trainer bias, will include the results of multiple audits.

An audit report should highlight any evidence of systematic error among CRAM assessments. For example, a set of audits for a single ambient survey or large mitigation plan might reveal a preponderance of unacceptable low or high scores for particular metrics, perhaps in the context of a particular time-of-year, wetland class, or practitioner. Such findings can be helpful for identifying problems with a module, with training, or possible bias. The audit report should also highlight any clear and obvious explanations for discrepancies between audit scores and audited scores that can be used to guide corrective actions by the L2 Committee or the CWMW.

The L2 Committee recommends that the CWMW should determine the quality of a CRAM assessment as either: (1) good; (2) fair; or (3) poor, based on the audit report and advice from the L2 Committee. It is also recommended that, in general, an assessment should be categorized as good if it meets all of the on-site and off-site procedural requirements, and meets the accuracy requirements for all attribute scores and the overall index score. An assessment should be categorized as poor if it does not meet the accuracy requirements for one or more attributes or for the overall index score. An assessment should be categorized as fair if it meets the accuracy requirements but do not meet all of the on-site or off-site procedural requirements.

VIII. Corrective Actions:

Assessments that are categorized by the CWMW as either fair or poor may warrant corrective actions. The appropriate actions will vary depending on the cause of the categorizations.

In general, the differences between good and fair assessments are the consequence of minor practitioner error, miscalculations, and transcription errors. These problems can usually be remedied by minimal additional training of the responsible practitioners. The L2 Committee expects that fair assessments will not usually warrant any replacement assessments, although the assessment team leader might be contacted for targeted retraining.

Poor assessments can indicate pervasive and persistent errors, including systematic bias, that might require extensive retraining. They can raise serious questions about the quality of other assessments conducted by the same practitioners. A preponderance of poor assessments for ambient surveys or projects can warrant replacement assessments by more qualified practitioners. This is an extreme remedy that can incur considerable costs. The L2 Committee should strive to minimize poor assessments by continuing to improve training, encouraging the use of expert practitioners who have completed certified training programs, encouraging the use of the statewide CRAM database by all practitioners, and by using the database to assess and improve the performance of CRAM practitioners, trainers, and modules.

IX. Recommendations for Funding CRAM Audits as Part of the QA/QC Program for the Wetland and Riparian Area Monitoring Plan (WRAMP)

Introduction

An audit program for CRAM is subject to the same financial constraints that apply to other agency-based audit programs. The resources needed to effectively operate such a program include items such as labor, travel to/from field sites, and supplies, with labor and travel-related expenses comprising the majority of resources. In considering costs, an individual agency must clearly evaluate the scope and need for the audit and determine how much auditing it can afford. In addition, individual agencies must consider if it is necessary to plan their audit activities to coincide with fiscal budget cycles in order to provide for growth or reductions in work load from year to year.

It will be necessary for agency staff to ensure that projects are audited and budget requests for corrective action measures are submitted in a timely manner. Therefore, scheduling of audits and development of budget needs in response to audit findings should take into consideration the priority of the problems identified in the audit and the budget year cycle. This is critical because a costly corrective action identified after submittal of an agency's budget could lead to significant problems for the agency.

Agency management must develop a process for communicating the needs identified in the audit process into a report. Identification of problems and development of budget needs based on audit findings will be meaningless if this is not translated into a request for funds to conduct needed corrective actions. As with the budget process, in scheduling field audits, management should consider the timing of audits within the calendar year. This will allow sufficient time to address corrective action plans for serious deficiencies within the budget process.

Ideally, all aspects of QA/QC for CRAM (and other WRAMP core methodologies) would be integrated into existing agency programs and be included as line-items in annual budgets. These agency-based audit teams are fundamentally the regulatory gatekeepers, thus CRAM QA/QC should ultimately be funded by the regulatory programs. If agencies (like the Regional Water Boards) want CRAM audit teams, then each will have to internally devise a funding mechanism to support them, such as collecting fees from each permit recipient to pay for the teams.

Table 2: Components of a CRAM audit and projected cost estimates (as applicable). Cost estimates assume a flat rate of $125/hr. per audit team member. Labor costs will vary.

Task	labor cost/hr.	Minimum projected time/task	Maximum projected time/task	Minimum Per site cost ($)	Maximum Per site cost ($)
Pre-audit-planning[1]					
assemble aerial imagery and other assessment materials	125	1	2	$125	$250
conduct office portion of CRAM assessment	125	2	3	$250	$375
subtotal pre-planning				$375	$625
On-site audit activities[2]:					
initial site walk-through	125	0.5	1	$63	$125
field-based audit	125	3	4	$375	500
exit briefing with audit team	125	0.5	1	$63	$125
subtotal on-site activities				$500	$750
Reporting:					
Draft final audit report	125	2	5	$250	625
Post-audit activities:					
Follow-up on corrective actions (with L2 committee, etc.) as required[3]		2	5	$250	$625
Total hours		11	21		
Total per site labor cost				$1,375	$2,625
Travel-associated costs:[4]					
	Unit cost or rate	**Projected minimum cost**	**Projected maximum cost**	**Total minimum cost**	**Total maximum cost**
mileage (State rate)	0.55	75	200	41.25	110
airfare (round trip)		300	400	300	400
vehicle rental/day	$75	1	3	75	225
Other transport (tolls, etc.)		10	30	10	30
lodging	$125	1	3	125	375
Total travel costs				551	1140
GRAND TOTAL (range)				**$1,926**	**$3,765**

[1] task can be performed by a single audit team member
[2] Estimates for on-site labor are per individual (two audit team members are the recommended minimum)
[3] May be required for only select situations
[4] Travel costs will vary by site and situation

There are a number of options for funding an audit program for CRAM:

- The new federal mitigation guidelines require the use of wetland reference sites in evaluating success of wetland mitigation projects. Project permittees would "buy" into the developing regional reference network and have access to these sites for mitigation purposes. The money from this could be used to fund CRAM QA/QC (including audits). In this case, larger projects would buy more sites (and pay more into the fund), and smaller projects would buy fewer sites (and pay less).

- Identify at least 20 agencies in California that are actively using (or could potentially use) CRAM and have each one commit to donating an annual amount (e.g. 20K per year) to fund CRAM QA/QC for the State. These agencies could include project proponents, NPS grantees, 401 program (Water Boards), 404 program (Corps), 1600 Program (DFG), BLM, USFS, California Energy Commission, etc. All agencies that buy into such a program would receive the benefits of a standardized and validated wetland assessment method.

- Permittees pay as part of application fee and pays consultant to do CRAM QA/QC (includes audits). Part of the consultant contract with an agency for any major project is an independent audit by a QA team composed of people from the same consultant group who were not involved in the original work. In the case of CRAM, the consulting firm that is conducting the CRAM assessments for a project sets aside money to pay an auditor to come once a year at the start of the field season. As alternatives, consultants pay into a pot of money to fund a more independent auditor or the regulating agencies put money in the pot to do audits to ensure the most independent audit.

- The University Extension (the continuing education arm of the University of California) can be a way to reach the consultant community as the agencies start to require CRAM as part of project permits and a sustainable market for the method has developed. With SWAMP sponsorship, the University Extension could be utilized as a mechanism to "sell" CRAM audits to the State Waterboard Training Academy as a "training". This would be a way to integrate SWAMP into the process as the independent party to handle CRAM QA/QC.

  However, it would have to be determined if the University Extension program would collect funds from course clients to fund programs in non-University agencies. If the programs were located within University Extension, it could collect the funds, but it's unclear how the Water Boards would be able to exercise any control over how the University Extension mages the program.

- Fees for WRAMP training (L1, L2, IBI, Tracker, riparian buffer width, mitigation planning, etc) can cover operation and maintenance (OM) costs, including audits. This is a potential revenue train because it's new, needs-based, and self-contained (costs and coverage occur within WRAMP). It would mean that the RDC's perform the training and use that revenue to help cover their OM costs.

A well-designed audit process for CRAM would improve its efficiency across all agency programs that use or require the method. Successful implementation of such a program would improve efficiency across programs, allow the use of audit findings to help California evaluate progress toward reaching its wetland program goals, and assess the overall effectiveness of the WRAMP. However, success of this process requires a level of commitment from agency management to support the development, performance, and follow-up of audit findings and recommendations. Senior agency staff commitment to the process helps to ensure the availability of resources, staff time, and a willingness to follow-up on corrective measures in a timely manner. Upper management commitment can be expressed by buying into a formal audit policy for CRAM, holding briefings with organizational directors and other stakeholders, and publishing articles in Agency newsletters. Agency support should include commitments to support the following areas:

Adequate resources and staffing: Technical training of audit staff in regulatory matters, proper interview techniques, and providing staff with appropriate materials so that the audits are properly conducted is foundational to a successful audit program for CRAM. Upper management support is irrelevant without properly trained and equipped audit teams.

Budget for program development and performance: Sufficient staff time is needed to plan and develop audit program objectives and overall goal. This would go beyond training and staffing issues and focus on the planning process such that audit program objectives are anticipated and provided for in future years. This might include a commitment to bring more costly audit program activities (but no corrective actions) on-line in a phased approach or expanding beyond compliance audits to programmatic audits. This element is necessary in order for the audit program to develop and be successful over time. It is also evidence of management's commitment to an audit process rather than a one-shot audit effort.

Follow-up with corrective action measures in both a budgetary and programmatic fashion: There must be a commitment to fund and support the actions necessary to correct deficiencies identified by the two prior activities. This includes a commitment to systematic, permanent, or long-term corrective action measures as appropriate. Without a commitment to correct the deficiencies uncovered by the audit findings, the audit program becomes an added liability to the agency as opposed to reducing its overall risk profile.

Appendix 1. Example Audit Report Form and Worksheets

CRAM Quality Control/Quality Assurance
AUDIT FORM AND WORKSHEETS FOR ASSESSMENTS
USING THE CALIFORNIA RAPID ASSESSMENT METHOD (CRAM)

The California Rapid Assessment Method (CRAM) is a standardized, rapid, and repeatable assessment method that can be used routinely for wetland monitoring and assessment throughout the State of California. CRAM assesses the overall condition of wetlands, the results of which can be used to infer the ability to provide various functions or services to which a wetland is most suited. CRAM has a number of potential applications for regulatory and management uses in California, including the evaluation of pre-project conditions at potential mitigation or restoration sites; assessment of performance/success of mitigation/restoration sites; assessment of mitigation compliance; and comparison of proposed alternatives for regulatory or restoration planning purposes.

Purpose of CRAM Audits: On element of CRAM quality assurance/quality control (QA/QC) includes the review of CRAM assessments by an independent audit team. Audit teams can consist of trained CRAM instructors, CRAM development team (PI) members, and/or staff of responsible agencies. High value, high profile, or controversial sites may need review by an audit team at the request of an agency. It is recommended that audit teams independently review approximately 10-15% of all submitted CRAM assessments for a particular project. Ideally, site revisits by independent audit teams will be conducted in conjunction with on-going assessments to ensure completeness and that corrective action can be taken before the fieldwork for the project is completed. The audit process has a larger role in the QA/QC of CRAM application to large-scale project evaluation and will contribute to its verification, validation, and improve upon the technical adequacy of the method. As with any assessment method, discussion and debate on some elements of CRAM and its application are ongoing. As a result, it is expected that CRAM will continue to evolve in response to new data and changing needs of the user community. The audit process will permit this ongoing dialogue on differing viewpoints and perspectives with a goal of continuing to improve the utility of CRAM for project assessment.

Evaluation: For all submitted CRAM assessments, it is expected that field crews will adhere to the general QA/QC measures for as outlined in the CRAM Technical Bulletin (CWMW 2009). CRAM assessments will be evaluated in three main areas: 1) practitioner qualifications and preparedness to conduct the assessment (includes the office assessment portion of CRAM); 2) completeness of the assessment (all required data fields were completed and associated information was provided); and 3) practitioner accuracy. Practitioner preparedness refers to the degree to which the assessment team undertook the background check of site-specific existing information that is often (but not always) needed for an accurate assessment. This evaluation requires the audit team to conduct its own background check, and to determine to what degree the audited scores are consistent with the background information. The accuracy of practitioners will be assessed by comparing by comparing the metric scores, attribute scores, and overall score of the assessment to the metric scores, attribute scores, and the overall score produced by the audit team. In general, practitioners are expected to produce CRAM scores that are equal to the auditor scores for the same site, plus or minus the target precision of the metric, attribute, or overall index for the type of wetland being assessed (the precision of CRAM has been determined during the calibration/validation steps in CRAM development for each wetland module).

Corrective Actions: Assessments must meet the minimum QA requirements. Assessments failing to meet the basic quality standards may be rejected and returned to the author for correction, additional information may be requested, or a reassessment may be requested by the designated Quality Assurance officer(s). Discrepancies in scores between the field crews and audit teams can typically be addressed through corrective actions to improve inter-team consistency. Sources of error and suggested corrective actions may include the following:

- Mis-interpreted manual: corrective actions include re-reading the CRAM User's Manual, identifying specific sections to review, and/or additional CRAM training;
- Observer error (on-site evidence missed): Corrective actions include spending more time at the field site and additional CRAM training;
- Observed error (mis-estimation/mis-identification): corrective actions include more field experience, use of reference materials, and estimation and/or inter-calibration exercises;

- <u>Miscalculation/mis-recording</u>; corrective actions addressed through quality assurance practices.

Extensive, persistent, or pervasive errors by the assessment teams could result in additional fieldwork and may delay the anticipated end date of a project.

<u>Worksheet I. Basic Audit Information</u>

1. **Date of Audit/Site Visit(s):____**
2. **Audit Team Leader and Affiliation:**
   ____
3. **Additional Audit Team Members and Affiliations:____**
4. **Agency(s) Requesting Audit:____**
5. **Date(s) of Original CRAM Assessment(s) ______________________________**
6. **Project Name/Geographic Location**: __________________________________
7. **Individual(s) being evaluated (list all names and affiliations)**:
   ____
8. **List all site(s) that were audited as part of the project (if applicable). Provide the site name, unique site IDs, the type of wetland assessed, and GPS coordinates for each audit site. The CRAM AA code (from eCRAM) can be used as the unique site ID. <u>Use a separate audit form for each site audited.</u>**

	Site Name/ID No.	Wetland Type/ Subtype	Latitude	Longitude	Special Notes
1					
2					
3					

<u>Worksheet II. Practitioner Qualifications and Preparedness</u>

Answer the following questions below to determine if the assessment team was sufficiently prepared to conduct the CRAM assessment(s). Use space below each question for any explanation/special circumstances.

a. At least two practitioners conducted the CRAM assessment □ yes □ no
b. At least one assessment team member completed a 3-day training within the past five years for the wetland type being assessed □ yes □ no
c. The assessment team leader is registered as a CRAM practitioner (or trainer) in the CRAM database □ yes □ no
d. Most recent CRAM User's Manual, field book, and field forms were used □ yes □ no

Score _______

0 (no requirements have been met); 1 (one requirement has been met); 2 (two requirements have been met); 3 (three requirements have been met); or 4 (all three requirements have been met).

Worksheet III: Assessment Completeness

Evaluate the following aspects of the CRAM assessment(s) for completeness and correctness for all sites audited to determine if the meet the minimum QA/QC requirements were achieved? *Use space below for any explanation or special circumstances.*

Was the correct wetland class and subclass identified? □ yes □ no
Were CRAM assessment window considerations properly noted and guidelines adhered to? □ yes □ no
Was the CRAM Assessment Area properly identified? □ yes □ no
Was the boundary between the CRAM Assessment Area and the buffer properly demarcated? □ yes □ no
Was the CRAM stressor checklist completed for each CRAM attribute? □ yes □ no
Were the CRAM basic information form, score sheets, and worksheets properly completed? □ yes □ no
Appropriate explanations, photographs, and any supporting materials were provided □ yes □ no
If applicable, a relationship to similar or nearby sites with similar conditions (e.g. reference sites) was established. □ yes □ no □ NA
Special Notes:

Score _________

0 (no requirements have been met or there is no suitable map of the assessment area); 1 (in addition to providing a suitable map, one requirement has been met); 2 (in addition to providing a suitable map, two to three requirements have been met); 3 (in addition to providing a suitable map, three to four requirements have been met); 4 (in addition to providing a suitable map, four to five requirements have been met); or 5 (**all** requirements have been met).

Worksheet IV: Suggested Corrective Actions

Practitioner Preparedness	
Final Score	
Corrective Action or Additional Information Requested	□ yes □ no
Corrective Action(s) requested (list)	
Completeness of Assessment	
Final Score	
Corrective Action or Additional Information Requested	□ yes □ no
Corrective Action(s) requested (list)	

Worksheet V: Assessment Accuracy.

Index Scores			
Assessment	Audit	Difference	Target Precision

Landscape/Buffer Attribute Scores			
Assessment	Audit	Difference	Target Precision

Hydrology Attribute Scores			
Assessment	Audit	Difference	Target Precision

Physical Structure Attribute Scores			
Assessment	Audit	Difference	Target Precision

Biological Structure Attribute Scores			
Assessment	Audit	Difference	Target Precision

Metric Scores				
Metric (replace numbers with metric names)	Assessment	Audit	Difference	Target Precision
1				
2				
3				
4				
5				
6				
7				

Notes for any problematic metrics and/or sites:____

Overall Assessment Quality. Check best fit description.

- Good (meets all of the on-site and off-site procedural requirements, and meets the accuracy requirements for all attribute scores and the overall index score)
- Fair (meets the accuracy requirements but does not meet all of the on-site or off-site procedural requirements).
- Poor (does not meet the accuracy requirements for one or more attributes or for the overall index score)

Audit Lead Signature____ Date_________________

Audit Member Signature______________________________________ Date__________________

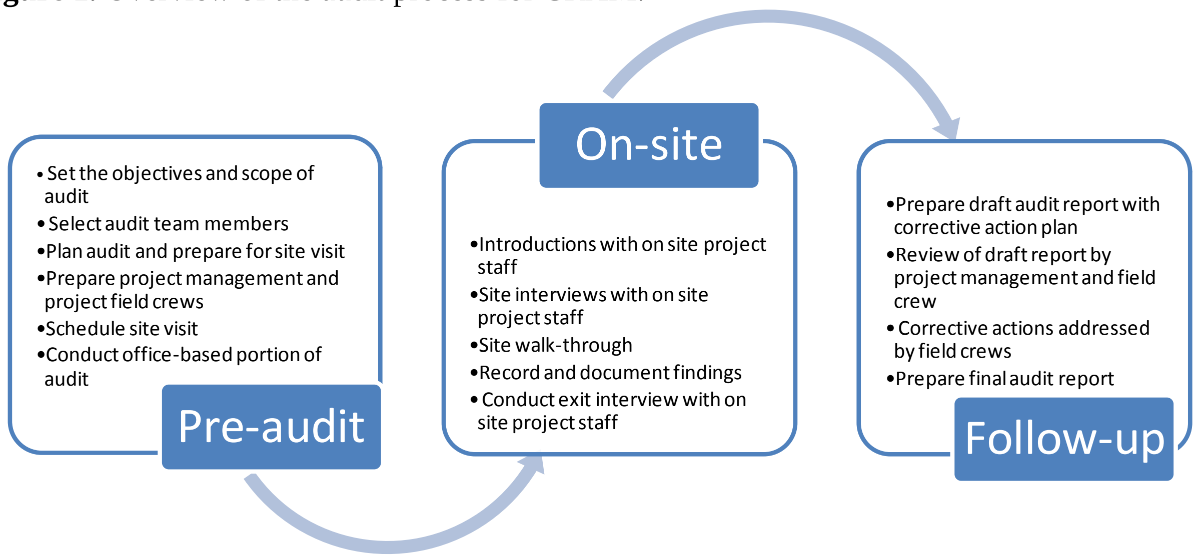
Final Audit Checklist (check if attached)

- Audit team members' statements of independence and qualification (required)
- Completed audit report and worksheets (required)
- Audit site visit photos (optional)
- Records of contacts with non-team experts or sources of supporting materials, including location of voucher specimens used to verify plant species and/or the correct contact person for them is clearly identified. (optional)
- Additional supporting materials (optional)
- Suggested causes for inaccurate scores or other shortcomings of the assessment (optional)

Appendix 2. Procedures for Conducting CRAM Audits and Training Audit Team Members.

Each CRAM audit should be conducted following four sequential steps: (1) pre-audit activities and planning; (2) preliminary office-based audit using information in the CRAM database, CRAM website, and other supporting materials; (3) on-site activities (including a field-based audit based on a site visit); and (4) post-audit activities (including an audit report with any recommended corrective actions). Figure 1 provides a schematic overview of the audit process.

Figure 1. Overview of the audit process for CRAM.



Pre-Audit Activities

Careful preparation helps to ensure that the audit team accomplishes its goals while using the least possible resources and labor time. Pre-audit preparation involves activities.

Setting the objectives and scope of the audit. The objectives define the purpose of the audit and establish performance criteria for the audit team. For CRAM audits, the overall objective is to evaluate how effectively CRAM practitioners comply with the QAQC specifications for CRAM. However, specific objectives may vary from audit to audit depending on the purposes of the CRAM assessments.

After the audit objectives are determined, it is necessary to define the scope of the audit. The scope of an audit includes its geographic extent, the particular classes of wetlands that will be covered, and the number of assessments that will be audited.

Planning and preparing the audit team for the site visit. Careful planning is crucial to ensuring that the limited time typically available for the site visit is used most effectively. Careful planning also minimizes the time necessary for follow-up activities after the site visit. Some of the factors to consider when planning a site visit are:

- Goals and scope of the audit;

- The audit team's familiarity with the assessment sites (site background);
- Resources available for conducting the audit;
- Site accessibility and security.

As part of audit planning, the audit team leader should ensure that all members of the audit team understand:

- The goals and scope of the audit;
- The audit team’s roles and responsibilities;
- The purposes of the CRAM assessments being audited;
- Signed statements of independence and technical qualifications as an auditor;
- Any potential health and safety risk and how to minimize them;
- Correct CRAM modules and other supporting materials; and
- The audit process and schedule.

In addition, each member of the audit team will provide a signed statement that they are technically qualified to conduct the audit and that they have no political or financial interest in its outcome.

Communication with parties responsible for the audited assessments In the case of an audit pertaining to a regulatory or management agency’s action or plan, the L2 Committee should communicate with the responsible agency to explain the reasons for the audit and how the audit will proceed. The agency will decide whether or not he practitioners who conducted the assessments should be contacted about the audit and whether or not they should accompany the audit team. A positive relationship with the responsible agency is vital to the success of these kinds of audits. To ensure their success, the L2 Committee should communicate the following to the agency:

- How the audit will proceed and how the results will be used by the L2 Committee and the CWMW;
- The names of persons who will be interviewed, including perhaps the practitioners responsible for the assessments being audited and any persons identified in the assessments as having pertinent information or supporting materials;
- A list of information needed for the audit that is not available in the CRAM database, including perhaps aerial imagery, on-site photographs, and other supporting information (as described in the CRAM QAQC Plan; and A detailed agenda and schedule for the audit.

Office-based Audit

Each CRAM audit will require a site visit by an audit team to determine the accuracy of the assessment being audited. However, practitioner preparedness, data completeness, and some of the CRAM metric and submetric scores can be audited apart from the field. to determine if some of the minimum reporting requirements were met. Information that can be gleaned from the CRAM database includes:

- The number of practitioners who conducted the assessment;
- Whether or not at least one member of the assessment team completed a formal CRAM training course within the past 5 years for the wetland type being assessed;
- There is map of the Assessment Area that follows the guidance for such maps in the CRAM manual and on the CRAM website;
- All worksheets in the CRAM field book are completed such that they provide adequate justification for the related metric scores;
- All data fields in the CRAM field book have all the entries needed to compute the scores for each CRAM metric;
- The stressor checklist is completed for each CRAM attribute; and
- Appropriate explanations, site photographs, and supporting materials, including any voucher specimens used to verify plant species, are readily available and/or the correct contact person for them is clearly identified.

Table 2 . List of CRAM attributes, metrics, and submetrics. Metrics or submetrics suitable for an office-based audit are highlighted in yellow.

Attribute	Metric and Submetrics	Office or Field Audit	Information Source
Buffer and Landscape Context	Landscape Connectivity (m)	Office	Aerial imagery and NWI
	Buffer (m):		
	Percent of AA with Buffer (s)	Office	
	Average Buffer Width (s)	Office	Aerial imagery
	Buffer Condition (s)	Field only	
Hydrology	Water Source (m)	Office	Watershed reports; aerial imagery
	Channel Stability(m)	Field only	
	Hydrologic Connectivity (m)	Office (for non-riverine wetlands only)	Aerial imagery
Physical Structure	Structural Patch Richness (m)	Field only	
	Topographic Complexity (m)	Field only	
Biological Structure	Plant Community (m):		
	Number of Plant Layers Present (s)	Field only	
	Number of Co-dominants Plant Species (s)	Field only	
	Percent Invasion (s)	Office	Cal-IPC
	Horizontal Interspersion and Zonation (m)	Field only	
	Vertical Biotic Structure (m)	Field only	

The audit team should use the guideline presented below to assess the quality of the assessment based on information apart from the field site visit. All results must be recorded in the standardized audit form.

Qualification of the CRAM practitioner(s). The requirements are as follows:

- The assessment team includes at least two practitioners working together in the field at the same time;
  - At least one member of the assessment team has completed a 3-day CRAM training course within the past 5 years for the module being used in the assessment;
  - The assessment team leader is registered as CRAM practitioner in the CRAM database (registration as a trainer suffices as registration as a practitioner).

The audit team will use the CRAM database and interviews with the assessment team leader to ascertain whether or not the assessment team has met each of these three minimum requirements for practitioner qualification. The evaluation can have a numeric value of 0 (no requirements have been met); 1 (one requirement has been met); 2 (two requirements have been met); or 3 (all three requirements have been met).

Level of Practitioner Preparedness. Practitioner preparedness refers to the degree to which the assessment team undertook the background check of site-specific existing information that is often (but not always) needed for an accurate assessment. This evaluation requires the audit team to conduct its own background check, and to determine to what degree the audited scores are consistent with the background information. The evaluation can have a numeric score of 0 (not consistent); 1 (partially consistent); or 3 (entirely consistent, which can mean that no existing data are available).

Assessment Completeness. An assessment is complete is it meets the following five requirements:

- There is map of the Assessment Area that follows the guidance for such maps in the CRAM manual and on the CRAM website;
- All worksheets in the CRAM field book are completed such that they provide adequate justification for the related metric scores;
- All data fields in the CRAM field book have all the entries needed to compute the scores for each CRAM metric;
- The stressor checklist is completed for each CRAM attribute;
- Appropriate explanations, site photographs, and supporting materials, including any voucher specimens used to verify plant species, are readily available and/or the correct contact person for them is clearly identified.

The CRAM data base will automatically report whether or not the first four requirements listed above have been met. To determine compliance with the last requirement listed, the audit team will need to search the database and may also need to try to contact the person(s) identified in the assessment as responsible for supporting materials that are not included in the database. The evaluation can have a numeric value of 0 (no requirements have been met or there is no suitable map of the assessment area); 1 (in addition to providing a suitable map, one requirement has been met); 2 (in addition to providing a suitable map, two to three requirements have been met); or 3 (all five requirements have been met).