California Rapid Assessment Method for Wetlands

User's Manual

Version 6.1

California Wetland Monitoring Workgroup

April 2013

CRAM California Rapid Assessment Method

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California Rapid Assessment Method (CRAM) For Wetlands

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Version 6.1
April 2013

A Product of the

Level 2-Rapid Assessment Committee

of the

California Wetlands Monitoring Workgroup

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Version History of CRAM Methodology

Version 6.1 released April 2013
Changes in this version:

- Changed Manual cover image and layout
- Updated list of Level 2 Committee member names
- Updated Chapter 3: Procedures for using CRAM, Step 2: Classify the Wetland According to the CRAM typology. The definitions and references were updated to reflect more current information.
- Updated Figure 3.2 with revised wetland names
- Re-inserted Chapter 4: Definition and Rationale for CRAM Attributes and Metrics. This chapter contains general information about each metric and submetric. All rating tables are still maintained in the individual field books.
- Re-inserted Chapter 5: Guidelines to Complete Stressor Checklists.
- Updated the Acronym List
- Removed Appendix I: Protocol for Project Assessment Based on CRAM. This information is now maintained in the CRAM Technical Bulletin (CWMW, 2009).
- Removed Appendix II: Flow Chart to determine plant dominance. This information is maintained in all of the individual field books.
- Removed Appendix 5: Invasive Plant Species List. Please refer to the California Invasive Plant Council website for this information.
- Fixed typos, website addresses, and table of contents

Version 6.0 released March 2012
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- Removed all of the tables and worksheets from Chapter 4: Guidelines for Scoring CRAM Metrics. This information is now maintained in individual field books.
- Removed some text from Chapter 3: Procedures for Using CRAM. This information is now maintained in individual field books.
- Removed Appendix VI. This information is now maintained in the Vernal Pools field books.
- Updated Appendix III with additional definitions
- Updated References section with additional citations
- Changed authorship, removed original Core and Regional Team information, added L2 Committee members
- Revised several figures and tables
- Replaced Seasonal Estuarine wetland sub-type with Bar-built estuarine wetland sub-type
- Revised wording through out the document to be consistent with recent developments in CRAM and wetland assessment in California.
- Fixed typos; updated heading and table of contents

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- Added section on version history of CRAM methodology and fixed typos

- Added paragraph in Section 2.3.1 to explain separation of assessments of condition and stress
- Added note to Section 3.2.2.2 that the depressional module was primarily based on perennial depressional wetlands and caution should be applied in the interpretation of scores in seasonal depressional wetlands
- Corrected text in various Sections to eliminate inconsistencies in terminology
- Updated figures in Chapter 3
- Revised the ratings for scoring Structural Patch Richness for Estuarine wetlands

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  - Revised the "C" and "D" ratings for scoring Number of Plant Layers Present for Slope and Confined Riverine wetlands

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- Vol 1, p. 36: Added language prescribing the calculation of mean submetric score in order to arrive at Plant Community metric value; in Table 3.8, changed expected maximum value of Biotic Structure attribute from 84 to 36 for Playas and Vernal Pools and 48 for all other wetland classes

- Vol 1, pp. 68-71: Changed "metric" to "submetric" for discussion of the four submetrics of the Plant Community metric
- Vol 2, pp.145-6: removed wrackline or organic debris in channel or on floodplain from worksheet 2 since this patch type is not expected in playas
- Vol 2, p. 55: Revised "D" narrative for number of plants layers present from "No layers are present" to "0-1 layer is present"
- Vol 2, pp. 133, 149, 166: Removed shading from scoring sheet for Interspersion and Zonation since this metric is assessed for vernal pools and playas
- Vol 2: Revised scoring forms to incorporate Plant Community metric

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Changes in this version:
- Split into two volumes: main manual and assessment forms
- Created separate volume for assessment forms - all supporting documents included with each class
- Updated entrenchment ratio and hydrologic connectivity metric bins
- Revised bins for percent co-dominant species that are non-native
- Added confined v. unconfined diagram
- Revised scoring to a 1-12 scale for all metrics

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Changes in this version:
- Separated estuarine class into two sub-classes: saline and non-saline

Version 4.0 released 5/25/06

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EXECUTIVE SUMMARY

Large amounts of public funds and human resources are being invested in the protection, restoration, creation, and enhancement of wetlands in California. The State needs to be able to track the extent and condition of these habitats to evaluate the investments in them now and into the future. The community of wetland scientists, managers, and regulators needs to be able to answer the questions: where are the wetland areas and how are they doing? This need is clearly indicated by the California State Wetlands Conservation Policy.

A consortium of local, state and federal authorities has been developing tools to increase the State's capacity to monitor its wetlands. The effort is guided by the three-level framework for surface water monitoring and assessment issued to the state by the USEPA (USEPA 2006). Level 1 consists of habitat inventories and landscape profiles based on the statewide wetland inventory as mandated by California Assembly Bill 2286, the California Aquatic Resources Inventory, the statewide riparian inventory as planned by the Riparian Habitat Joint Venture, and EcoAtlas of the Regional Data Centers (RDC) being developed by the State Water Resources Control Board and others as part of the California Environmental Data Exchange Network (CEDEN). Level 2 consists of rapid assessment of wetland condition in relation to the broadest suite possible of ecological and social services and beneficial uses. Level 3 consists of standardized protocols for intensive-quantitative assessment of selected services and to validate and explain Level 1 and Level 2 methods and results. All three levels are to be supported by data management systems that enable the State to compile local and regional Level 1-3 data into statewide summary reports. Level 1 and Level 2 methods are supported by open-source, web-based information systems (www.ecoatlas.org and www.cramwetlands.org) that are consistent with existing state and federal environmental databases. Level 3 protocols and results will be added to these information systems as they are developed.

This manual focuses on the California Rapid Assessment Method. CRAM has beendeveloped as a cost-effective and scientifically defensible Level 2 method for monitoring the conditions of wetlands throughout California. The CRAM web site (www.cramwetlands.org) provides access to an electronic version of this manual, training materials, eCRAM and the CRAM database. CRAM results can be uploaded to the database, viewed, and retrieved via the CRAM website using eCRAM. CRAM, eCRAM, and the supporting web sites are public and non-proprietary.

Initial CRAM development had focused on the wetlands of coastal watersheds from Mexico to Oregon. These watersheds in aggregate encompass almost as much variation in climate, geology, and land use as the State as a whole. A special effort was made, however, to involve environmental scientists and managers who are familiar with inland arid montane environments that are not well represented in the coastal watersheds. Seasoned staff from natural resource management and regulatory agencies, NGO science institutions, the private sector, and academia worked together through four coastal Regional Teams and a statewide Core Team to provide the breadth and depth of technical and administrative experience necessary to help assure statewide applicability of CRAM. Since then the ongoing development process has moved inland to include the Central Valley, Inland Empire and Tahoe regions.

CRAM development has incorporated aspects of other approaches to habitat assessment used in California and elsewhere, including the Washington State Wetland Rating System (WADOE

1993), MRAM (Burglund 1999), and ORAM (Mack 2001). CRAM also draws on concepts from stream bio-assessment and wildlife assessment procedures of the California Department of Fish and Wildlife, the different wetland compliance assessment methods of the San Francisco Bay Regional Water Quality Control Board and the Los Angeles Regional Water Quality Control Board, the Releve Method of the California Native Plant Society, and various HGM guidebooks that have been developed in California.

In essence, CRAM enables two or more trained practitioners working together in the field for one half day or less to assess the overall health of a wetland by choosing the best-fit set of narrative descriptions of observable conditions ranging from the worst commonly observed to the best achievable for the type of wetland being assessed. There are four alternative descriptions of condition for each metric of condition. Metrics are organized into four main attributes: (landscape context and buffer, hydrology, physical structure, and biotic structure) for each of six major types of wetlands recognized by CRAM (riverine wetlands, lacustrine wetlands, depressional wetlands, slope wetlands, playas, and estuarine wetlands). To the extent possible, CRAM has been standardized across all these wetland types, and the differences in metrics and narrative descriptions between wetland types have been minimized.

CRAM yields an overall score for each assessed area based on the component scores for the attributes and their metrics. The alternative narrative description for each metric has a fixed numerical value. An attribute score is calculated by combining (methods vary by attribute type) the values of the chosen narrative descriptions for the attribute's component metrics, and then converting the result into a percentage of the maximum possible score for the attribute. The overall score for an area is calculated by averaging the four final attribute scores . The maximum possible score represents the best condition that is likely to be achieved for the type of wetland being assessed. The overall score for a wetland therefore indicates how it is doing relative to the best achievable conditions for that wetland type in the state. Local conditions can be constrained by unavoidable land uses that should be considered when comparing wetlands from different land use settings.

CRAM also provides guidelines for identifying stressors that might account for low scores. Evident stressors are characterized as present or present and having a significant negative effect on an attribute score. The stressor checklist allows researchers and managers to explore possible relationships between condition and stress, and to identify actions to counter stressor effects.

CRAM is a cost-effective ambient monitoring and assessment tool that can be used to assess condition on a variety of scales, ranging from individual wetlands to watersheds and larger regions. Applications could include preliminary assessments to determine the need for more intensive analysis; supplementing information during the evaluation of wetland condition to aid in regulatory review under Section 401 and 404 of the Clean Water Act or other wetland regulations; and assisting in the assessment of restoration or mitigation projects by providing a rapid means of checking progress along a particular restoration trajectory. CRAM is not intended to replace any existing tools or approaches to monitoring or assessment, and will be used at the discretion of each individual agency to complement preferred approaches. Quality assurance and control practices have been developed to ensure that CRAM is appropriately applied in ambient and regulatory applications (California Wetland Monitoring Workgroup 2009).

CHAPTER 1: NEED, GOAL, STRATEGIC CONTEXT, INTENDED USES, AND GEOGRAPHIC SCOPE

1.0 Introduction

This document is the User's Manual for the California Rapid Assessment Method (CRAM) for Wetlands and Riparian Areas. Chapter 1 presents the rationale for CRAM, including why it's needed, its primary goal, its strategic context, intended uses, and the geographic scope of its applicability. Chapter 2 covers key terms, the conceptual framework for CRAM, and its development process. Chapter 3 describes the basic steps of the methodology. Chapter 4 provides background information and rationale for each of the metrics and attributes. Chapter 5 describes the guidelines to completing the stressor checklist.

1.1 Statement of Need

Large amounts of public and private funds are being invested in policies, programs, and projects to protect, restore, and manage wetlands in California. Most of these investments cannot be evaluated, however, because the ambient conditions of wetlands are not being monitored, the methods to monitor individual wetland areas are inconsistent, and there is little assurance of data quality. Furthermore, the results of monitoring are not readily available to analysts and decision makers. CRAM is a new approach that can provide consistent, scientifically defensible, affordable information about wetland conditions throughout California.

1.2 Justification for Rapid Assessment

The three most significant obstacles to developing adequate information about the conditions of California wetlands are (1) the lack of regional or statewide inventories of wetlands and related projects; (2) the high costs of conventional assessment methods; and (3) the lack of an information management system to support regional or statewide wetland assessments. The USEPA has developed a 3-tiered framework for comprehensive assessment and monitoring of surface waters that can guide efforts to overcome these obstacles (USEPA 2006).

> Level 1. Level 1 is a series of tools for landscape-level analysis of the State's aquatic resources. The toolbox consists of a Geographic Information System (GIS)-based inventory of aquatic resources (streams, wetlands, and riparian areas), data visualization, and landscape summary tools. The California Aquatic Resource Inventory, or CARI, is a standardized and comprehensive map of the State's aquatic resources and is essential for identifying their absence or presence and describing their geographic distribution and abundance. While there are various efforts to map wetlands on regional, county, and local levels, CARI is the primary wetland inventory for the State [http://www.sfei.org/it/gis/cari]. CARI is compatible with the National Wetlands Inventory (NWI) of the USFWS and the National Hydrography Dataset (NHD) of the USGS and also meets the needs of regional scientists, managers, and regulators. In addition to CARI, the State is continuing to track wetland restoration, enhancement, and mitigation projects that can be used to assess the cumulative effect of these projects on the extent and overall ambient condition of wetlands. EcoAtlas, an on-line visualization tool, houses these important aquatic resource inventories and allows

for dynamic querying and summarizing of information (www.ecoatlas.org). The landscape profile tool within EcoAtlas allows users to select a geographic area of interest and summarize various data layers within that area to produce a report of the following information: acreage of aquatic resources (existing and historical), CRAM scores, wetland projects, land cover, and census.

The Level 1 toolbox, aquatic resource inventory, project tracking, data visualization, and data analysis tools will aid wetland conservation planning by displaying aquatic resources in the context of other data layers. They will also serve as sample frames for objective, probabilistic surveys of the ambient condition of wetlands and for assessing the effects of projects and other management actions on the ambient wetland condition at various scales ranging from local watersheds to the State as a whole. Through CARI and EcoAtlas, the State can overcome the obstacle of not having an adequate inventory of wetlands and related projects to track changes in their extent and condition or the ability to holistically show and dynamically analyze information that contribute to the health and condition of wetlands.

Level 2. Level 2 methods assess the existing condition of a wetland relative to its broadest suite of suitable functions, services, and beneficial uses, such as flood control, groundwater recharge, pollution control, and wildlife support, based on the consensus of best professional judgment. In this regard, a level 2 assessment represents the overall functional capacity of a wetland. To be valid, rapid assessments must be strongly correlated to Level 3 measures of actual functions or services. Once validated, Level 2 assessments can be used where Level 3 data are lacking or too expensive to collect. Level 2 assessments can thus lessen the amount and kinds of data needed to monitor wetlands across large areas over long periods. CRAM is the most completely developed and tested Level 2 method for California at this time.

Level 3. Level 3 provides quantitative data about selected functions, services, or beneficial uses of wetlands. Such data are needed to develop indicators, to develop standard techniques of data collection and analysis, to explore mechanisms that account for observed conditions, to validate Level 1 and 2 methods, and to assess conditions when the results of Level 1 and Level 2 efforts are too general to meet the needs of wetland planners, managers, or regulators.

CRAM is based on a growing body of scientific literature and practical experience in the rapid assessment of environmental conditions. Several authors have reviewed methods of wetland assessment (Margules and Usher 1981, Westman 1985, Lonard and Clairain 1986, Jain *et al*. 1993, Stein and Ambrose 1998, Bartoldus 1999, Carletti *et al*. 2004, Fennessy *et al*. 2004). Most methods differ more in the details of data collection than in overall approach. In general, the most useful approaches focus on the visible, physical and/or biological structure of wetlands, and they rank or categorize wetlands along one or more stressor gradients (Stevenson and Hauer 2002). The indicators of condition are derived from intensive Level 3 studies that show relationships between the indicators, high-priority functions or ecological services of wetlands, and anthropogenic stress, such that the indicators can be used to assess the effects of management actions on wetland condition.

Existing methods have been used to assess wetlands at a variety of spatial scales, from habitat patches within local projects, to watersheds and regions of various sizes. Methods that are designed to assess large areas, such as the Synoptic Approach (Leibowitz *et al.* 1992), typically produce coarser and more general results than site-specific methods, such as the Hydrogeomorphic Method (HGM; Smith *et al.* 1995, Smith 2000) or the Index of Biotic Integrity (IBI; Karr 1981). Each scale of wetland assessment provides different information. Furthermore, assessments at different scales can be used for cross-validation, thereby increasing confidence in the approach being used. A comprehensive wetland monitoring program might include a variety of methods for assessing wetlands at different scales.

Existing methods also differ in the amount of effort and expertise they require. Methods such as the Wetland Rapid Assessment Procedure (WRAP; Miller and Gunsalus 1997) and the Descriptive Approach (USACOE 1995), are extremely rapid, whereas the Habitat Evaluation Procedure (HEP; USFWS 1980), the New Jersey Watershed Method (Zampella *et al.* 1994), and the Bay Area Watersheds Science Approach (WSA version 3.0, Collins *et al.* 1998), are much more demanding of time and expertise.

None of the existing methods other than CRAM can be applied equally well to all kinds of wetlands in California. The HGM and the IBI are the most widely applied approaches in the U.S. While they are intended to be rapid, they require more time and resources than are usually available, and both have a somewhat limited range of applicability. For example, IBIs are developed separately for different ecological components of wetland ecosystems, such as vegetation and fish, and for different types of wetlands, such as wadeable streams and lakes. HGM guidebooks are similarly restricted to one type of habitat, such as vernal pools or riverine wetlands, and they are typically restricted to a narrowly defined bioregion. Some guidebooks are restricted to individual watersheds. Trial applications of rapid assessment methods developed for other states, including the Florida WRAP and the Ohio Rapid Assessment Method (ORAM; Mack 2001) in California coastal watersheds indicated that significant modifications of these methods would be required for their use in California, and lead to developing CRAM.

1.3 Goal and Intended Use

The overall goal of CRAM is to:

> *Provide rapid, scientifically defensible, standardized, cost-effective assessments of the status and trends in the condition of wetlands and the performance of related policies, programs and projects throughout California.*

CRAM has beendeveloped as a rapid assessment tool to provide information about the condition of a wetland and the stressors that affect that wetland. CRAM is intended for cost-effective ambient monitoring and assessment that can be performed on different scales, ranging from an individual wetland, to a watershed or a larger region. It can be used to develop a picture of reference condition for a particular wetland type or to create a landscape-level profile of the conditions of different wetlands within a region of interest. This information can then be used in planning wetland protection and restoration activities. Additional applications could include:

- *preliminary* assessments to determine the need for more traditional intensive analysis or monitoring;

- providing *supplemental* information during the evaluation of wetland condition to aid in regulatory review under Section 401 and 404 of the Clean Water Act, the Coastal Zone Management Act, Section 1600 of the Fish and Game code, or local government wetland regulations; and
- *assisting* in the monitoring and assessment of restoration or mitigation projects by providing a rapid means of checking progress along restoration trajectories.

CRAM is *not* intended to replace any existing tools or approaches to monitoring or assessment, and will be used at the discretion of each individual agency to complement preferred approaches. Wetland impact analysis and compensatory mitigation planning and monitoring for larger wetland areas that exhibit more complex physical and biological functions will typically require more information than CRAM will be able to provide.

1.4 Related Rapid Assessment Efforts in California and Other States

Development of CRAM has incorporated concepts and methods from other wetland assessment programs in California and elsewhere, including the Washington State Wetland Rating System (WADOE 1993), MRAM (Burglund 1999), and ORAM (Mack 2001). CRAM also draws on concepts from stream bio-assessment and wildlife assessment procedures of the California Department of Fish and Wildlife, the different wetland compliance assessment methods of the San Francisco Bay Regional Water Quality Control Board and the Los Angeles Regional Water Quality Control Board, the Releve Method of the California Native Plant Society, and various HGM guidebooks that are being used in California.

1.5 Geographic Scope

CRAM is intended for application to all kinds of wetlands throughout California. Although centered on coastal watersheds through much of the initial development process, it has now spread inland to the Central Valley, Inland Empire and Tahoe regions. CRAM development to date has involved scientists and managers from other regions to account for the variability in wetland type, form, and function that occurs with physiographic setting, latitude, altitude, and distance inland from the coast. Validation efforts have indicated that CRAM is broadly applicable throughout the range of conditions commonly encountered. However, since CRAM emphasizes the functional benefits of structural complexity, it may yield artificially low scores for wetlands that do not naturally appear to be structurally complex. CRAM should therefore be used with caution in such wetlands. This can include riverine wetlands in the headwater reaches of very arid watersheds, montane depressional wetlands above timberline, and vernal pools on exposed bedrock. Future refinements of CRAM will be used to adjust CRAM metrics as needed to remove any systematic bias against any particular kinds of wetlands or their settings[1].

1.6 Supporting Information Systems

Information management is an essential part of a successful program of environmental monitoring and assessment. CRAM is supported by a public web site (www.cramwetlands.org) that provides downloadable versions of this User's Manual, training materials, and access to an

[1] The riverine and module of CRAM will be revised based on additional field work during FY 2012-14 to better accommodate assessment of arid headwater and other types of aridland streams.

open-source database that allows registered CRAM practitioners to upload, view, and download CRAM results (eCRAM). The CRAM website and database are being developed in the context of a broad initiative in California to improve data and information sharing throughout the community of environmental scientists, managers, and the concerned public. The California Wetlands Monitoring Workgroup (CWMW) has developed the California Wetlands Portal (waterboards.ca.gov/mywaterquality/eco_health/wetlands/) as a mechanism to improve communication with the public about the extent and condition of California's wetland resources.

1.7 Organization and Coordination to Develop CRAM

An organization was created to foster collaboration and coordination among the regional CRAM developers. USEPA awarded Wetland Program Development Grants through Section 104b(3) of the US Clean Water Act to the Southern California Coastal Water Research Project (SCCWRP), to a partnership of the Association of Bay Area Governments (ABAG) and the San Francisco Estuary Institute (SFEI), to a partnership of the Central Coast District of the California Coastal Commission (CCC) and the Moss Landing Marine Laboratories (MLML), and to the North Coast Region of the California Department of Fish and Wildlife (CDFW) to develop and begin implementing Level 1-3 methods, with an emphasis on Level 2 (CRAM) and information management. The Principal Investigators (PIs) worked with sponsoring agencies to form a statewide Core Team and Regional Teams that have provided the breadth and depth of technical and administrative experience necessary to develop and begin implementing CRAM.

1.7.1 Core Team

The Core Team fostered collaboration and coordination among the regions to produce a rapid assessment method that is consistent for all kinds of wetlands throughout California. The Core Team consists of the PIs plus technical experts in government agencies, non-governmental organizations, and academia. Core Team members are listed in the acknowledgments at the front of this document. The Core Team set the direction for the PIs and the Regional Teams, reviewed their products, and promoted CRAM to potential user groups.

1.7.2 Regional Teams

The Regional Teams advised and reviewed the work of the PIs to ensure that CRAM addressed regional differences in wetland form, structure, and ecological service. Members of the Regional Teams assisted in the verification and validation of CRAM, and provided feedback through the PIs to the Core Team about the utility of CRAM in the context of regional wetland regulation and management. Each Regional Team consisted of the PIs, local and regional wetland experts having experience with assessment methodologies, Core Team members who work within the region, and technical representatives from potential user groups.

1.7.3 Institutional Support

In 2010, the California Water Quality Monitoring Council (Kehoe 2006) directed the California Wetland Monitoring Workgroup (CWMW) to create a Level 2 Committee to coordinate the review, development and implementation of CRAM and other rapid assessment methods for all state agencies. CRAM is a core methodology of the Wetland and Riparian Area Monitoirng Plan (WRAMP), a statewide strategy developed by the CWMW to coordinate ongoing wetland monitoring and assessment efforts that consists of standardized methods to monitor the distribution, abundance, and condition of wetlands and riparian areas throughout California.

CRAM is also proposed as a key element of the State Water Board's emerging Wetland and Riparian Area Protection Policy (State Water Board Resolution No. 2008-0026) and is currently being tested by many other state and federal agencies for application to various regulatory and non-regulatory programs.

CHAPTER 2: KEY TERMS, CONCEPTS, ASSUMPTIONS, AND DEVELOPMENTAL PROCESS

2.0 Overview

CRAM uses standardized definitions for key terms, including "wetland," "disturbance," "stress," and "condition." CRAM is based on basic assumptions about functional relationships between condition and function or ecological service, and about the spatial relationships between stress and condition, as explained below. Please see Appendix I for a complete Glossary of terms.

2.1 Key Terms

Assessment Area (AA). An AA is the portion of a wetland that is the subject of a CRAM assessment. Multiple AAs might be needed to assess large wetlands. Rules for delineating an AA are presented in Section 3.5.

Stress. Stress is the consequence of anthropogenic events or actions that measurably affect conditions in the field. The key stressors tend to reduce the amount of wetlands, or they significantly decrease the quantity and/or quality of sediment supplies and/or water supplies upon which the wetlands depend. Gradients of stress result from spatial variations in the magnitude, intensity, or frequency of the stressors.

Disturbance. Disturbance is the consequence of natural phenomena, such as landslides, droughts, floods, wildfires, and endemic diseases that measurably affect conditions in the field.

Condition. The condition of a wetland is the state of its physical and biological structure and form relative to their best achievable states.

Buffer. For the purposes of CRAM, the buffer is the area outside the assessment area, including adjoining uplands and other wetland areas that can reduce the effects of stressors on the wetland's condition.

Landscape Context. The landscape context of a wetland consists of the lands, waters, and associated natural processes and human uses that directly affect the condition of the wetland or its buffer.

Ecological Services or Beneficial Uses. These are the benefits to society that are afforded by the conditions and functions of a wetland. Key ecological services for many types of wetlands in California include flood control, shoreline and stream bank protection, groundwater recharge, water filtration, conservation of cultural and aesthetic values, and support of endemic biological diversity.

Attribute. Attributes are categories of metrics used to assess condition of the wetland as well as its buffer and landscape context. There are four CRAM attributes: Buffer and Landscape Context, Hydrology, Physical Structure, and Biotic Structure.

Metric. A metric is a measurable component of an attribute. Each metric should be field-based (Fennessy *et al.* 2004), ecologically meaningful, and have a dose-dependent response to stress that can be distinguished from natural variation across a stressor gradient (Barbour *et al.* 1995).

Narrative Descriptions of Alternative States. For each type of wetland, the narrative descriptions of alternative states represent the full range of possible condition from the worst conditions that are commonly observed to the best achievable conditions, for each metric of each attribute in CRAM.

Indicators. These are visible clues or evidence about field conditions used to select the best-fit narrative description of alternative states for CRAM metrics.

Metric Score. The score for a CRAM metric is the numerical value associated with the narrative description of an alternative state that is chosen because it best-fits the condition observed at the time of the assessment.

Attribute Score. An attribute score is the percent of the maximum possible combination of the metric scores for the attribute.

CRAM Index Score or Overall Score. A CRAM Indx score or Overall score indicates the overall condition of an Assessment Area. It is calculated as the average of the four final attribute scores for the Assessment Area.

2.2 Conceptual Framework

CRAM was developed according to a set of underlying conceptual models and assumptions about the meaning and utility of rapid assessment, the best framework for managing wetlands, the driving forces that account for their condition, and the spatial relationships among the driving forces. These models and assumptions are explicitly stated in this section to help guide the interpretation of CRAM scores.

2.2.1 Management Framework

The management framework for CRAM is the Pressure-State-Response model (PSR) of adaptive management (Holling 1978, Bormann *et al.* 1994, Pinter *et al.* 1999). The PSR model states that human operations, such as agriculture, urbanization, recreation, and the commercial harvest of natural resources can be sources of stress or *pressure* affecting the condition or *state* of natural resources. The human *responses* to these changes include any organized behavior that aims to reduce, prevent or mitigate undesirable stresses or state changes. Natural resource protection depends on monitoring and assessment to understand the relationships between stress, state, and management responses. The managers' concerns guide the monitoring efforts, and the results of the monitoring should influence the managers' actions and concerns.

Assessment approaches vary in that they may evaluate any or all aspects of the pressure-state-response model. Pressure indicators describe the variables that directly cause (or may cause) wetland problems, such as discharges of fill or urban encroachment. State indicators evaluate the current condition of the wetland, such as plant diversity or concentration of a particular contaminant in the water. Response indicators demonstrate the efforts of managers to address the wetland problem, such as the implementation of best management practices. The approach used by CRAM is to focus on *condition* or *state*. A separate stressor checklist is then used to note which, if any, stressors appear to be exerting *pressure* affecting condition. It is assumed that managers with knowledge of pressures and states will exact more effective *responses*.

The PSR framework is a simple construct that can help organize the monitoring components of adaptive management. It can be elaborated to better represent complex systems involving interactions and nonlinear relations among stressors, states and management responses (e.g., Rissik *et al*. 2005) For the purposes of CRAM, the PSR model is simply used to clarify that CRAM is mainly intended to described state conditions of wetlands.

2.2.2 Rapid Assessment

CRAM embodies the basic assumption of most other rapid assessment methods that ecological conditions vary predictably along gradients of stress, and that the conditions can be evaluated based on a fixed set of observable indicators. CRAM metrics were built on this basic assumption according to the following three criteria common to most wetland rapid assessment methods (Fennessy *et al*. 2004):

1. *the method should assess existing conditions* (see Section 2.1 above), without regard for past, planned, or anticipated future conditions;
2. *the method should be truly rapid,* meaning that it requires two people no more than one half day of fieldwork plus one half day of subsequent data analysis to complete; and
3. *the method is a site assessment* based on field conditions and does not depend largely on inference from Level 1 data, existing reports, opinions of site managers, etc.

2.2.3 Forcing Functions, Stress, Buffer, and Condition

The condition of a wetland is determined by interactions among internal and external hydrologic, biologic (biotic), and physical (abiotic) processes (Brinson, 1993). CRAM is based on a series of assumptions about how these processes interact through space and over time. First, CRAM assumes that 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. Second, the supplies of water and sediment are ultimately controlled by climate, geology, and land use. Third, geology and climate govern natural disturbance, whereas land use accounts for anthropogenic stress. Fourth, biota (especially vegetation) tend to mediate the effects of climate, geology, and land use on the quantity and quality of water and sediment (Figure 2.1). For example, vegetation can stabilize stream banks and hillsides, entrap sediment, filter pollutants, provide shade that lowers temperatures, reduce winds, etc. Fifth, stress usually originates outside the wetland, in the surrounding landscape or encompassing watershed. Sixth, buffers around the wetland can intercept and otherwise mediate stress (Figure 2.2).

2.2.4 Condition, Ecological Service, and CRAM Scores

Three major assumptions govern how wetlands are scored using CRAM. First, it is assumed that the societal value of a wetland (i.e., its ecological services) matters more than whatever intrinsic value it might have in the absence of people. This assumption does not preclude the fact that the support of biological diversity is a service to society. Second, it is assumed that the value depends more on the diversity of services than the level of any one service. Third, it is assumed that the diversity of services increases with structural complexity and size. CRAM therefore favors large, structurally complex examples of each type of wetland.

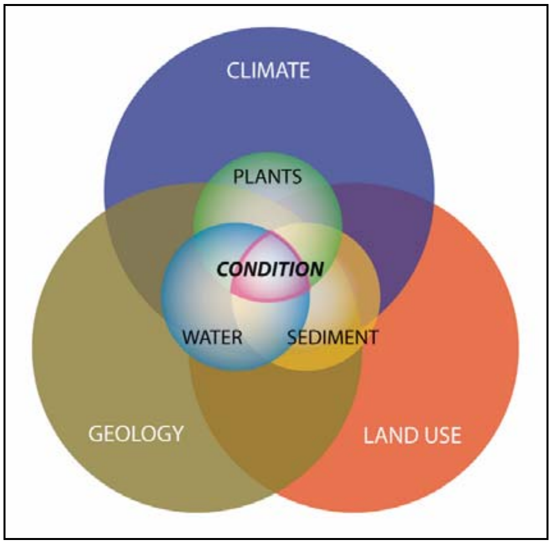


Figure 2.1: Spatial hierarchy of factors that control wetland conditions, which are ultimately controlled by climate, geology, and land use.

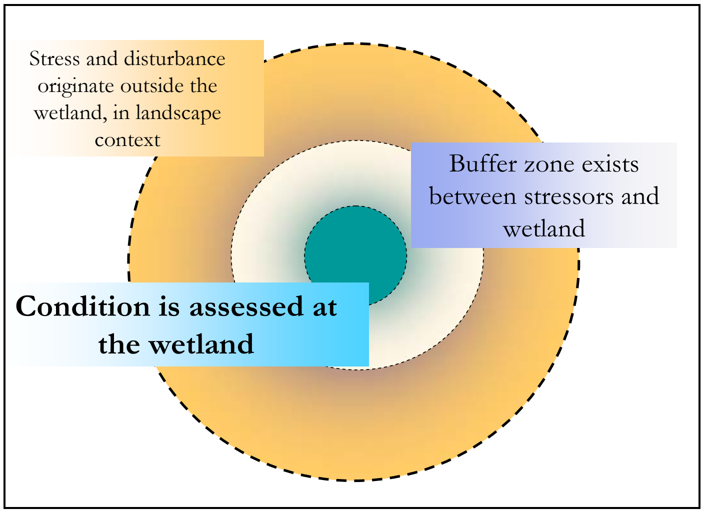


Figure 2.2: Spatial hierarchy of stressors, buffers, and wetland condition. Most stressors originate outside the wetland. The buffer exists between the wetland and the sources of stress, and serves to mediate the stress

2.3 Developmental Framework

The CRAM developmental process consisted of nine steps with distinct products organized into three phases: basic design, calibration, and validation (Table 2.1).

Table 2.1: Basic outline of CRAM development.

Core Team	Basic Design Phase	Develop conceptual models of wetland form and function
		Identify universal Attributes of wetland condition
		Nominate Metrics of the Attributes
		Nominate descriptions of alternative states for each Metric
Core and Regional Teams	Calibration Phase	Clarify and revise the Metrics and narrative descriptions of alternative states based on regional team input and inter- and intra-team comparisons
		Develop a checklist to identify stressors
		Test and select methods of scaling and weighting Attributes and Metrics
		Test and select formulas for calculating Attribute scores and AA scores
	Validation Phase	Validate Metrics and Attributes using Level 3 data
		Conduct independent peer review
		Provide outreach and training

2.3.1 Basic Design

This phase of CRAM development involved creating conceptual models of wetland form and function, defining key terms, developing the wetland typology, identifying the attributes, and formulating metrics that describe each attribute. The basic design work was done primarily through initial field-testing and feedback by Regional Teams and the Core Team. Version 2.0 of CRAM marked the completion of the basic design phase.

Each CRAM attribute is represented by a set of metrics (Table 2.2 below), and each metric is represented by a set of mutually exclusive narrative descriptions of alternative states. In aggregate, the alternative states of all the metrics for any type of wetland represent its full range of visible form and structure.

An effort was made to separate assessments of condition from assessments of stress. This was done to explore correlations between stress and condition. For example, CRAM AAs can be grouped according to their associated stressors, and the groups can be compared based on their CRAM scores. The separation has been difficult to achieve, however. For example, the Plant Community metric of the Biotic Structure attribute includes a sub-metric about the relative abundance of non-native plant species, although biological invasion is usually considered a significant stressor. Some autocorrelation can therefore be expected between stress and condition as assessed using the current version of CRAM

2.3.2 Verification

The verification phase was used to determine if the draft wetland classification scheme, the attributes, the metrics, and the narrative descriptions of alternative states were (1) clear and understandable; (2) comprehensive and appropriate; (3) sensitive to obvious variations in condition; (4) able to produce similar scores for areas subject to similar levels of the same kinds of stress; and (5) tended to foster repeatable results among different practitioners. The verification phase was also used to test and select methods of calculating, scaling, and weighting scores for metrics, attributes, and AAs.

Verification involved iterative adjustments to the classification system and the metrics during multiple field tests by each Regional Team. The amount of revision has declined steadily, but minor changes are expected to continue as the number of CRAM users and the amount of its use increases. For the CRAM version used in the Validation Phase, all the regional teams were able to meet the targeted within-team and between-team QAQC standards of 10% and 20%, respectively, for each metric.

Table 2.2: CRAM Attributes, Metrics, and submetrics

Attributes		Metrics and Submetrics
Buffer and Landscape Context		Aquatic Area Abundance or Steam Corridor Continuity
		Stream Corridor Continuity (Bar-built estuaries only)
		Aquatic Area in Adjacent Landscape (Bar-built estuaries only)
		Marine Connectivity (Bar-built estuaries only)
		Buffer:
		Percent of AA with Buffer
		Average Buffer Width
		Buffer Condition
Hydrology		Water Source
		Hydroperiod or Channel Stability
		Hydrologic Connectivity
Structure	Physical	Structural Patch Richness
		Topographic Complexity
	Biotic	Plant Community:
		Number of Plant Layers Present or Endemic Species Richness (vernal pools only)
		Number of Co-dominant Species
		Percent Invasion
		Horizontal Interspersion
		Vertical Biotic Structure

2.3.3 Validation

The purpose of the validation phase was to assess the overall performance of CRAM by regressing metric scores and attribute scores on Level 3 data representing expected relationships between condition and function or service (Table 2.3). The same models were used to guide alternative approaches for weighting and combining scores. CRAM performed best using the simplest combination rules without any weighting. The level of performance was adequate for the functions and services represented by the selected Level 3 data. The validation phase for estuarine wetlands and riverine/riparian systems was completed with CRAM version 4.0. The other types of wetlands will be validated as CRAM is implemented. The current status of development of each of the CRAM wetland modules is available on the CRAM website (www.cramwetlands.org).

Table 2.3: Expected relationships among CRAM attributes, metrics, and key services.

KEY SERVICES	Buffer and Landscape Context	Hydrology			Physical Structure		Biotic Structure				
	Buffer and Landscape Connectivity Metrics	Water Source	Hydroperiod or Channel Stability	Hydrologic Connectivity	Structural Patch Richness	Topographic Complexity	Number of Plant Layers	Number of Co-dominant Species and Endemic Species Richness	Percent Invasion	Horizontal Interspersion and Zonation	Vertical Biotic Structure
Short- or long-term surface water storage	X		X	X	X	X				X	X
Subsurface water storage		X	X	X		X					
Moderation of groundwater flow or discharge	X	X									
Dissipation of energy					X	X	X			X	X
Cycling of nutrients	X		X	X	X	X	X	X	X		X
Removal of elements and compounds	X		X	X		X	X			X	
Retention of particulates			X	X	X	X	X	X		X	
Export of organic carbon			X	X			X		X	X	X
Maintenance of plant and animal communities	X		X	X	X	X	X	X	X	X	X

CHAPTER 3: PROCEDURES FOR USING CRAM

3.0 Summary

The general procedure for using CRAM consists of eight (8) steps (Table 3.1).

Table 3.1: Steps for using CRAM.

Step 1	Assemble background information about the management of the wetland.
Step 2	Classify the wetland using the CRAM typology and this manual (see Section 3.2 and Figure 3.2).
Step 3	Verify the appropriate season and other timing aspects of the field assessment.
Step 4	Estimate the boundary of the AA in the office (subject to field verification).
Step 5	Conduct the office assessment of stressors and on-site conditions of the AA.
Step 6	Conduct the field assessment of stressors and on-site conditions of the AA.
Step 7	Complete CRAM assessment scores and QA/QC Procedures.
Step 8	Upload CRAM results into statewide information data management system.

3.1 Step 1: Assemble Background Information

CRAM assessments are aided by background information about the management objectives, history, known or expected stressors, and general ecological character of the wetland to be assessed. Background materials may include the following (Table 3.2).

Table 3.2: Example of background materials.

- USGS topographic quadrangles, National Wetlands Inventory (NWI), State Wetlands Inventory, road maps, and other maps of geology, soils, vegetation, land uses, etc.
- Air photos and other imagery, preferably geo-rectified with 1-3 m. pixel resolution.
- California Natural Diversity Database (CNDDB) search results.
- Relevant reports on geology, geotechnical conditions, hydrology, soils, environmental impacts, cultural history, land use, restoration and mitigation projects, management plans, etc., from water districts, flood control districts, open space districts, state and federal agencies, etc.

3.2 Step 2: Classify the Wetland according to the CRAM typology

Wetland classification requires the application of a standard wetland definition followed by the application of a standard typology or classification system.

3.2.1 General Definitions of Wetlands and Riparian Areas

CRAM employs the following wetland definition recommended by the Technical Advisory Team (TAT) to the SWRCB Policy Development Team for the California Wetland and Riparian Area Protection Policy (WRAPP):

> *An area is **wetland** if, under normal circumstances, (1) the area has continuous or recurrent saturation of the upper substrate caused by groundwater or shallow surface water or both; (2) the duration of such saturation is sufficient to cause anaerobic conditions in the upper substrate; and; (3) the area either lacks vegetation or the vegetation is dominated by hydrophytes (SFEI-ASC 2009).*

This definition reflects current scientific understanding of the formation and functioning of wetlands (Lewis *et al.* 1995, Mitsch and Gosselink 2007) and uses field indicators of hydrology, substrate condition, and plant community composition to distinguish wetland areas from other areas of a landscape. This is commonly regarded as the "three-criterion approach" to defining, identifying, and delineating wetland areas in the field (Tiner 1999). Hydrology is the dominant factor in wetland formation because it controls the development of anaerobic chemical conditions, and thus strongly influences the abundance of plant species tolerant of such conditions (Voesenek *et al.* 2003) or indicative of them (Reed 1988).

This wetland definition recognizes that all three criteria might not be evident or present in some areas that provide wetland functions, beneficial uses, or ecological services at some times of the year or in some years (especially during prolonged dry periods), and that some of these areas lack vegetation and therefore may satisfy only two criteria (i.e., wetland hydrology and hydric substrates). The vegetation criterion in this definition requires dominance by hydrophytes only when the wetland is vegetated. That is, non-vegetated areas that satisfy the hydrology and substrate criteria, such as some tidal flats, playas, and shallow non-vegetated ponds, are still considered wetlands. The definition also includes wetland creation, restoration, enhancement, and mitigation sites that have not yet been colonized by vegetation.

CRAM is intended to assess "condition" in wetland areas that satisfy the criteria according to the above definition. However, because CRAM was originally designed to assess vegetated wetlands, meaning wetlands that support at least 5% cover of vegetation during the peak growing season, CRAM may have limited applicability in non-vegetated wetlands (e.g. tidal flats, mudflats) or any wetlands with less than 5% cover of vegetation. While the current version of CRAM can be used in these systems, this must be appropriately annotated in the comments section of the CRAM Basic Information page and the Plant Community metric so that the results of these assessments can be tracked and, if necessary, additional metrics or modules can be proposed.

For the purposes of CRAM, an assessable wetland is further defined as the portion of a discrete area of wetland habitat (as defined by the Draft SWRCB Policy) that is large enough to contain one or more CRAM Assessment Areas (AAs). An assessable wetland may be the same size as an AA or larger than multiple AAs, but it is never smaller than an AA (see AA delineation guidelines in Section 3.5 and AA size recommendations in Table 3.7 below). This modification is necessary to convert a Level 1 wetland inventory based on the TAT definition into a sample frame for ambient surveys of wetland condition using CRAM. A sample frame is a list or map of every wetland or potential CRAM AA within the population of wetlands to be surveyed (Särndal *et al.* 1992).

CRAM recognizes that all wetlands have some amount of adjacent riparian area that reflect various ecological and/or physical processes and local management. For this reason, CRAM employs the riparian definition provided by the US National Research Council (NRC):

> *"**Riparian Areas** are transitional between terrestrial and aquatic ecosystems and are distinguished by gradients in biophysical conditions, ecological processes and biota. They are areas through which surface and subsurface hydrology connect water bodies with their adjacent uplands. They include those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems. Riparian areas are adjacent to perennial, intermittent, and ephemeral streams, lakes and estuarine-marine shorelines" (National Research Council 2002).*

The same functions typically associated with wetlands are, to varying degree, also associated with its accompanying riparian areas (National Research Council 2002). The riparian areas adjacent to rivers and stream corridors are particularly connected through various ecological and hydrological processes. Although the term "riparian" has traditionally been synonymous with "woody" vegetation occurring at the edge or margin of a wetland, many wetlands often contain a woody riparian vegetation component within the boundary of the wetland itself. In other instances, riparian areas only occur outside the wetland boundary, where they may function at various distances from the wetland edges to "buffer" wetland conditions. Some wetlands may lack a woody vegetation component entirely. Individual CRAM AAs for some wetland types (such as riverine) may always include the portions of the adjacent riparian area. For other types of wetlands (such as depressional or estuarine), AAs may occur near the edge of the wetland and include riparian areas, or in the interior of a wetland and lack riparian areas.

The boundaries of a wetland can be determined on the basis of a jurisdictional delineation (JD; this requires compliance with established standards in approved regulatory reference documents; e.g., the 1987 USACE Manual and the two Regional Supplements, pursuant to the federal Clean Water Act), and may be approximated from mapping such as the National Wetland Inventory (NWI). A JD is especially useful for determining the boundaries of a wetland when assessing impacted sites or mitigation sites as defined under Section 404 of the Clean Water Act (CWA). Identifying wetlands under the Draft SWRCB Wetland Policy (2013) is based on similar wetland identification criteria to those used by the US Army Corps of Engineers (USACE) and US Environmental Protection Agency (USEPA) under Section 404 of the CWA, and delineation is proposed to be based on the same references as for the federal program.

If the wetland cannot be identified from an existing inventory or a JD, then its boundaries should be sketched on the base imagery for the CRAM assessment, using Best Professional Judgement and the general guidelines in Table 3.3 and Figure 3.1 below. A sketch map based on these guidelines cannot replace results from a JD,or the NWI. Although a JD is helpful in identifying the boundaries of a wetland where a CRAM assessment is to be conducted, it is NOT a prerequisite for conducting CRAM. CRAM can still be conducted on wetlands that do not have an associated JD. In most cases, however, wetland and "riparian" boundaries are based on features that can only be identified with certainty during field evaluations

Table 3.3: Guidelines to delineate a wetland for the purpose of CRAM.

Delineating Feature	Description of Features
Backshore	The backshore of a wetland is the boundary between the wetland and the adjoining upland, where the upland is at least 5m wide. The high-water contour of the wetland is a good proxy for its backshore boundary.
Foreshore	The foreshore of a wetland is the boundary between the vegetated wetland and any adjoining semi-aquatic, non-wetland area, such as an intertidal flat or a non-vegetated riverine channel bar, or a fully aquatic area such as the open water area of a lake or estuary that is at least 30m wide.
Adjoining Wetland	Any wetland that is mostly less than 5m distant from the wetland being assessed is an adjoining wetland.

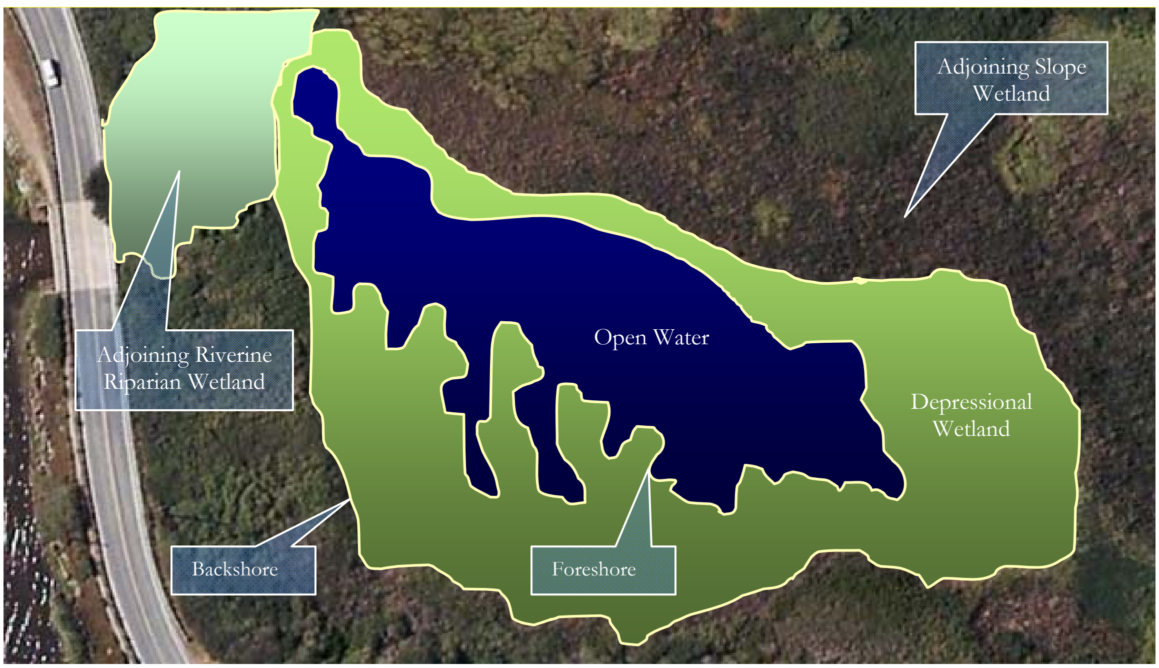


Figure 3.1: Using the backshores, foreshores, and the boundaries between wetland types to delineate a wetland.

3.2.2 Wetland Typology

CRAM provides excellent support for aquatic resource condition assessment in California. Its typology is based on a functional classification approach similar to HGM (Brinson 1993) that uses geomorphic setting, water source, and hydrology to infer function and ecology. CRAM "modules" were developed in direct response to California's assessment and policy needs, and includes many rare wetland types for California, such as vernal pools. CRAM typology supports the Wetland and Riparian Area Monitoring Plan (WRAMP) of the California Wetlands Monitoring Workgroup (CWMW; CWMW 2010). Furthermore, CRAM typology can be cross-walked to other classification systems as needed and allows for seamless integration between Level 1 mapping and Level 2 condition assessment in California.

At this time, CRAM modules have been developed for six major aquatic resource types, four of which have sub-types (Table 3.4 and Figure 3.2). These modules are not comprehensive, modification and refinement are ongoing, and new modules will be created with time.

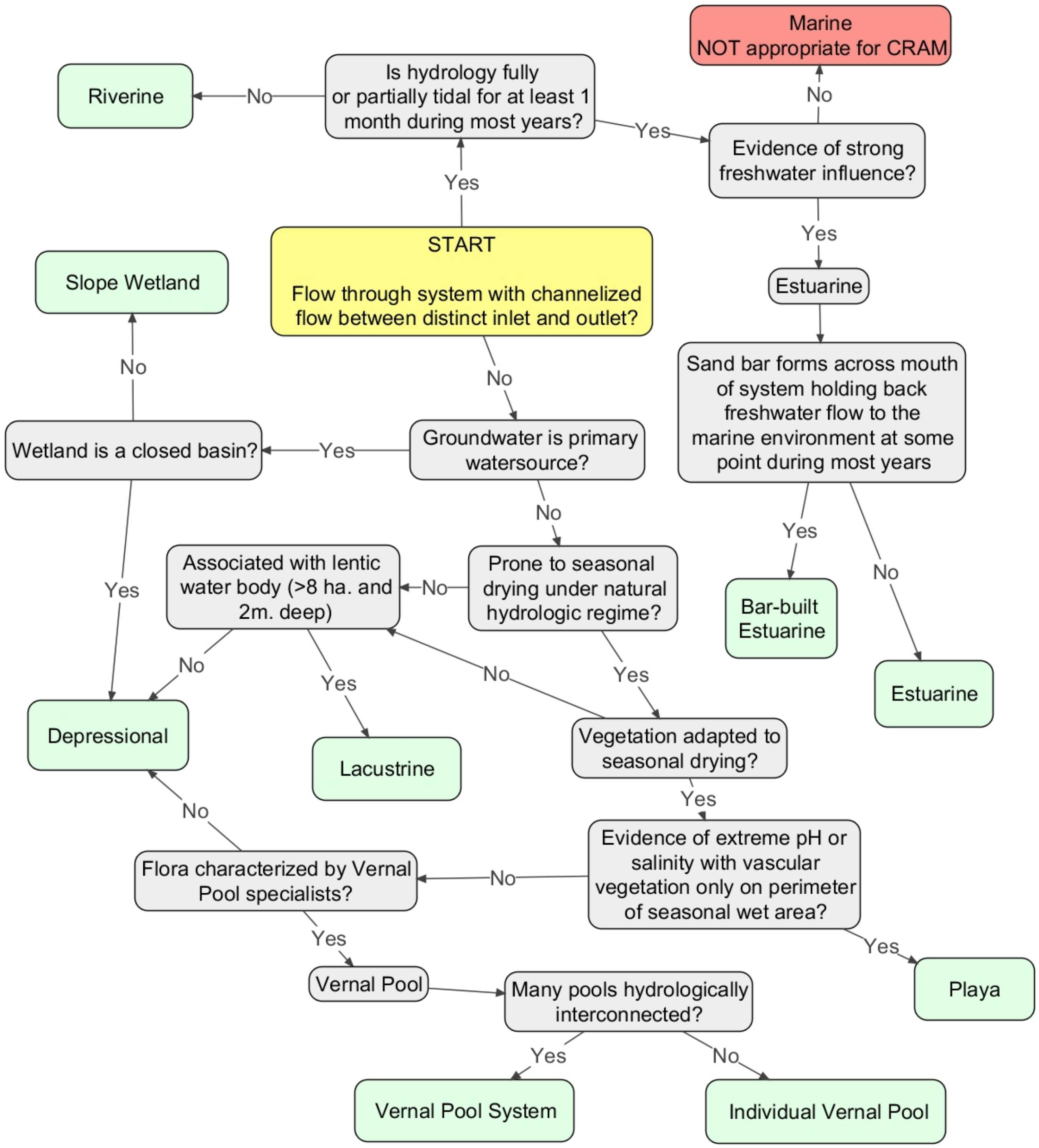
Table 3.4: The CRAM Wetland Typology.

CRAM Wetland Types	**CRAM Sub-types**
Riverine	Confined Riverine
	Non-confined Riverine
Depressional	Individual Vernal Pools
	Vernal Pool Systems
	Depressional
Playas	no sub-types
Estuarine	Perennial Saline Estuarine
	Perennial Non-saline Estuarine
	Bar-Built Estuarine
Lacustrine	no sub-types
Slope	Seeps and Springs
	Forested Slope
	Wet Meadows

Some wetlands will have undergone a conversion from one type to another due to either natural or anthropogenic events. For example, a channel avulsion may capture a depressional wetland and convert it to a riverine system, or construction of a dam may impound a stream and convert it to a lacustrine system. In any case, the wetland should be evaluated according to its current type and condition. Metric scores should be assigned using the ratings for the current state of the wetland, without regard for what the wetland might have been in the past, or what it might become in the future.

However, for converted wetlands, the historical type (if identifiable) as well as the existing type should be noted. The stressor checklist enables the user to document whether the wetland is currently being stressed by the conversion (i.e., if the process of conversion is continuing and a significant source of stress).

Figure 3.2: Flowchart to determine wetland type and sub-type.



3.2.2.1 Riverine (Including Closely Associated Riparian Areas)

A riverine wetland consists of the riverine channel and its active floodplain, plus any portions of the adjacent riparian areas that are likely to be strongly linked to the channel and immediate floodplain through bank stabilization and allochthonous organic material (productivity) inputs. An active floodplain is defined as the relatively level area that is periodically flooded, as evidenced by deposits of fine sediment, wrack lines, vertical zonation of plant communities, etc. The water level that corresponds to incipient flooding can vary depending on flow regulation and whether the channel is in equilibrium with water and sediment supplies. Under equilibrium conditions, the usual high water contour that marks the inboard margin of the floodplain (i.e., the margin nearest the center of the channel) corresponds to the height of bankfull flow, which typically has a recurrence interval of about 1.5 to 2.0 years under mesic climate conditions (see Special Notes below for a definition of bankfull). The active floodplain can include broad areas of vegetated and non-vegetated bars and low benches among the distributaries of deltas and braided channel systems. The active floodplain does not include terraces that are geomorphically disconnected from channel-forming processes, although riparian areas along sloping terrace margins may be included as part of the AA since they can affect the floodplain by contributing material and providing shading. Vegetated wetlands can develop along the channel bottoms of intermittent and ephemeral streams during the dry season. Dry season assessment in these systems therefore includes the channel beds. However, the channel bed is excluded from the assessment when it contains non-wadeable flow. To help standardize the assessment of riverine wetlands, the assessments should be restricted to the dry season. Based on the proposed California state wetland definition, vegetated and non-vegetated wetlands can develop within riverine channels and their associated riparian areas. Unless otherwise determined, CRAM assumes that all riverine channels satisfy the proposed state wetland definition.

There may be a limit to the applicability of this module in low order (i.e., headwater) streams, in very arid environments, and in desert streams that tend not to support species-rich plant communities with complex horizontal and vertical structure. CRAM may be systematically biased against such naturally simple riverine systems. In addition, this module has limited application in river reaches with extremely broad floodplains, such as those which occur where large rivers occupy valleys with very low channel slopes, or near coastal embayments or the ocean, unless the extent of the floodplain included in the Assessment Area is limited to an area less than about two times bankfull width on each side of the channel (see below). There is ongoing research and development of CRAM modules for both arid streams and large rivers, which will be made available as they are completed. In the interim, caution should be used when interpreting results from these types of streams.

Riverine wetlands are further classified as confined or non-confined, based on the ratio of valley width to channel bankfull width (see Figure 3.3 below). A channel can be considered confined by artificial levees and urban development if the average distance across the channel at bankfull stage is more than half the distance between the levees or more than half the width of the non-urbanized lands that border the stream course. This assumes that the channel would not be allowed to migrate past the levees or into the urban development, or that levee breaches will be promptly repaired. Confined or non-confined channels can also be entrenched, based on the ratio of flood prone width to bankfull width (Figure 3.3 below). Entrenchment is separate from channel confinement, and strongly affects the hydrologic connectivity between riverine wetlands and their surrounding landscapes.

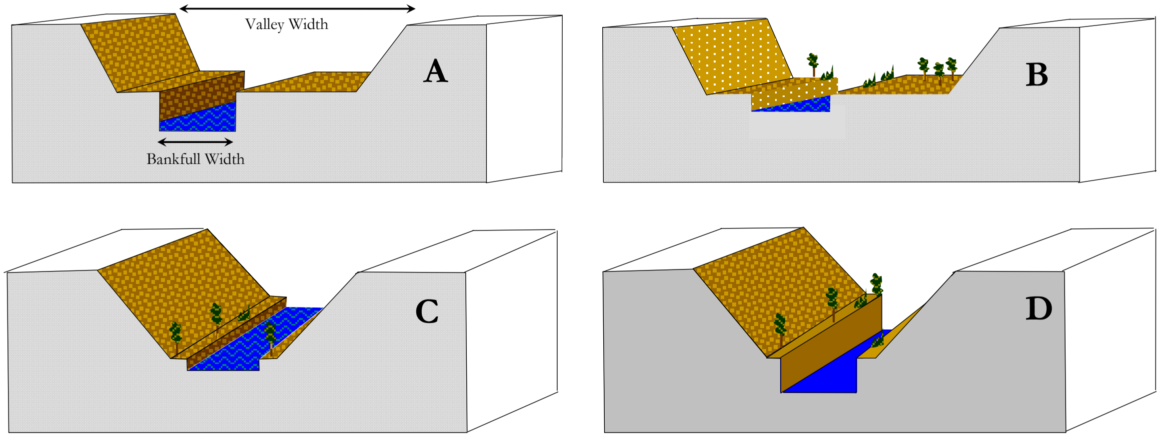


Figure 3.3: Illustrations of riverine confinement and entrenchment. (A) non-confined entrenched, (B) non-confined not entrenched, (C) confined not entrenched, and (D) confined entrenched riverine sub-types.

3.2.2.1.1 Non-confined Riverine Sub-type

In non-confined riverine systems, the width of the valley across which the system can migrate without encountering a hillside, terrace, or other feature that is likely to prevent further migration **is at least twice** the average bankfull width of the channel. Non-confined riverine systems typically occur on alluvial fans and plains, in low gradient landscapes, and along broad valleys.

3.2.2.1.2 Confined Riverine Sub-type

In confined riverine systems, the width of the valley across which the system can migrate without encountering a hillside, terrace, man-made levee, or urban development **is less than twice** the average bankfull width of the channel. Confined riverine systems are typically found in the lower order, higher gradient upper reaches of watersheds, or in constrained urban systems.

3.2.2.2 Depressional Wetlands

Depressional wetlands occur in topographic lows (i.e., closed elevation contours) that allow the accumulation of surface water and, in some cases, groundwater. These systems can be natural or artificial in origin and can occur on the landscape as isolated basins with distinct boundaries, or as a complex of shallows and seasonally wet depressions created by the slight topographic relief with indistinct boundaries, or as a large complex of interconnected basins. The margins of distinct depressional wetlands are relatively easy to discern in aerial photos and in the field. Ponds on fault traces (e.g. sag ponds, snow melt ponds), valley bottoms (e.g. cutoff ox-bows on floodplains), landslide impoundments, and on broad saddles along ridges (e.g. kettle-holes in moraines) are examples of naturally occurring depressional wetlands. Stormwater treatment ponds, wildlife habitat enhancements (e.g., duck ponds), stock ponds, and water hazards on golf courses are examples of artificially constructed depressional wetlands.

Depressional wetlands often lack a direct hydrologic connection to surface waters, and their hydrologic regime may be determined by groundwater discharge, overland runoff, and precipitation. However, many depressional wetlands (e.g., stockponds, constructed wetlands, or oxbows) are directly connected to surface waters and. Depressional wetlands can be perennial (perennially/permanently flooded) or seasonal (seasonally or temporarily flooded), and may lack surface ponding or saturated conditions during dry years[1]. As defined by CRAM, perennially flooded depressional wetlands have some amount of surface ponding for at least 9 months during most years (i.e. in greater than 5 out of 10 years). Seasonally flooded depressional wetlands are defined as supporting surface ponding for between 4 and 9 months of the year, and temporarily flooded depressional wetlands possess surface water between 2 weeks and 4 months of the year.

CRAM recognizes that all wetlands have some amount of adjacent riparian area, as defined by the US National Research Council (see glossary). For the purposes of CRAM, the riparian areas adjacent to depressional wetlands are considered part of the wetland and are included in the Assessment Area.

3.2.2.2.1 Artificial Depressional Wetlands

A large variety of types and configurations exist for artificially constructed depressional wetlands. In the more urbanized areas of California, many depressional wetlands have been constructed and/or engineered primarily to treat urban runoff for water quality improvement or to store flood flows. In some areas of the state, such as the Central Valley, the majority of depressional wetlands are intensively managed and artificially flooded to promote a variety of benefits to many species of wildlife, especially waterfowl (vegetation for food and cover, adequate water quality, breeding and resting sites).

3.2.2.2.2 Vernal Pool Wetlands

Vernal pools are ephemeral wetlands that form in shallow depressions underlain by bedrock or by an impervious, near-surface soil horizon. These depressions fill with rainwater and runoff during the winter and may remain inundated until spring or early summer, sometimes filling and emptying repeatedly during the wet season. Vernal pools undergo four distinct annual phases: (1) the wetting phase with the onset of the first rains; (2) the aquatic phase when the peak rainfall and inundation occurs; (3) the drying phase when many plants flower and produce seed and many animals disperse; and finally (4) the drought phase when the soil dries and cracks, and the plants succumb to extreme dry conditions. Vernal pools typically support a minimum of 30% cover of native plant species during the aquatic or drying phase. Vernal pools in disturbed areas or subjected to abnormal rainfall patterns might not meet this criterion due to invasion by non-native plants. If the wetland is mostly characteristic of a vernal pool but also has characteristics of other kinds of wetlands, such that its classification as a vernal pool is not completely certain, then it should be considered a vernal pool.

3.2.2.2.3 Vernal Pool Systems

Vernal pools often occur together and with vernal swales as vernal pool systems. These can have many pools of various sizes and shapes, varying floral and faunal composition, and various hydroperiods. Water can move between adjacent pools and swales through the thin soils above

[1] There may be a limit to the applicability of CRAM in extremely seasonal depressional wetlands (inundated less than 1-2 months/year) that tend not to support species-rich plant communities with complex horizontal and vertical structure. CRAM may be systematically biased against such naturally simple depressional systems. Therefore, while the current version of the CRAM depressional module can be used in these systems, the results are being tracked carefully.

the underlying impervious substrate. The lack of surface flow between pools does not necessarily indicate that they are not hydrologically inter-connected.

3.2.2.2.4 Other Depressional Systems

Depressional wetlands other than vernal pools can be seasonal[1] or perennial, but their flora and fauna are mostly not characteristic of vernal pools, and they lack the impervious substrate that controls vernal pool hydrology. They differ from lacustrine wetlands by lacking an adjacent area of open water (at least 2 m deep and 8 ha total area). They differ from playas by lacking an adjacent area larger than the wetland of either alkaline or saline open water less than 2 m deep or non-vegetated, fine-grain sediments. Unlike slope wetlands (i.e., springs and seeps), depressional wetlands depend more on precipitation than groundwater as their water source.

3.2.2.3 Playa Wetlands

The central feature of a playa is a seasonal or perennial body of very sodic (i.e., strongly alkaline) or saline water less than 2m deep that is larger than the adjacent, fringing wetland. The benthic sediments of a playa are mostly very fine-grain clays and silts. The fringing wetlands are characterized by grasses and herbaceous plants tolerant of the soluble salts that accumulate along the margins of the playas (Gustavson *et al.* 1994, Rocchio 2006). Playas differ from vernal pools by having little or no vascular vegetation within the area that is seasonally saturated or inundated. Vernal pools are generally much smaller than playas. And, unlike vernal pools, playas are more dependent on runoff than direct precipitation. The condition of a playa can be strongly influenced by the condition of its watershed (Keate 2005). The shallowness of playas and their high salinity or alkalinity distinguishes them from lacustrine systems.

3.2.2.4 Estuarine Wetlands

An estuary consists of aquatic (i.e., sub-tidal) and semi-aquatic (i.e., intertidal) environments that are strongly influenced by mixtures of ocean water and upland runoff due to tidal processes operating through an ocean inlet. Estuaries are mostly enclosed by land. Their inlets may be natural or unnatural. Typical sources of freshwater include rivers, streams, lakes and reservoirs, point discharges (e.g., effluent from sewage treatment facilities), and storm drains.

An estuarine wetland consists of the vegetated marsh plain, its pannes, potholes, hummocks, and other habitat elements of the plain, as well as the natural levees, shell beds, submerged plant beds, and other habitat elements created or supported by tidal processes and associated with tidal channels that tend to dewater at low tide or that are less than 30m wide. Tidal channels that do not tend to dewater at low tide or that are wider than 30m are not considered to be part of the wetland and can serve to separate one estuarine wetland from another.

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[1] There may be a limit to the applicability of CRAM in seasonal depressional wetlands that tend not to support species-rich plant communities with complex horizontal and vertical structure. CRAM may be systematically biased against such naturally simple depressional systems. Therefore, while the current version of CRAM depressional module can be used in these systems, the results are being tracked carefully. The depressional wetlands CRAM module will be revised based on additional field work during FY 2012-03.

3.2.2.4.1 Perennial Saline Estuarine Wetland Sub-type

For the purposes of CRAM, saline estuarine wetlands are distinguished from non-saline estuarine wetlands by the obvious dominance of salt-tolerant species of emergent vascular vegetation, such as cordgrass (*Spartina* spp.), pickleweed (*Salicornia* spp.), and salt grass (*Distichlis* spp.) along the foreshore of the wetland and along the immediate banks of the larger tidal channels that tend to dewater at low tide.

3.2.2.4.2 Perennial Non-saline Estuarine Wetland Sub-type

In non-saline wetlands (i.e., brackish or freshwater estuarine wetlands), the plant community along the foreshore of the wetland and along the immediate banks of the larger tidal channels that tend to dewater at low tide is dominated by species that don't tolerate high salinities, such as cattails (*Typha* spp.), rushes (*Scirpus species),* and willows (*Salix* spp.).

3.2.2.4.3 Bar-Built Esturaine Sub-type

Bar-built estuaries are the reaches of coastal rivers and streams that are ecologically influenced by seasonal closures of their tidal inlets. The frequency and duration of inlet closure can be natural or managed. The tidal regime can be muted or not (i.e., the tidal range can be the same or less than that of the adjacent marine or estuarine system when the tidal inlet is open). The salinity regime of a bar-built estuary can be highly variable. It can be fresh throughout very wet years or hypersaline during extended droughts. Bar-built estuaries are often referred to as "lagoons;" geomorphologically this term refers to any coastal water feature behind a bay-mouth bar.

This module is not used for large coastal lagoons, such as Big Lagoon and Stone Lagoon in Humboldt County and Lake Earl/Tolowa in Del Norte County, even though these lagoons are intermittently tidal. These lagoons are not associated with significant fluvial sediment sources from streams or rivers, and their hydrodynamics differ from the bar-built estuaries covered by this module. These large lagoons are covered, in part, by the Lacustrine Module, and additional development work in appropriate elements of other modules is in progress.

It should be noted that tidal influences on streamflow dynamics may extend many meters above the upstream limit of estuarine mixing when estuaries are open to full tidal exchanges, but this module does not apply to tidal but non-estuarine reaches of rivers or streams. Additionally, if a system has been altered such that hardened structures at its mouth prevent the formation of a sand bar that would close off the system to marine influence, this is considered a type change to a perennially saline estuary and is not covered by this module.

3.2.2.5 Lacustrine Wetlands

Lacustrine systems are lentic water bodies that usually exceed 8 hectares in total area during the dry season and that usually have a maximum dry season depth of at least 2m. They are deeper and larger than depressional wetlands or vernal pools or playas. Some lacustrine systems are separated from estuarine or marine systems by barrier beaches, dunes, or other natural or artificial barriers that are occasionally but irregularly breached. Some of these coastal lacustrine systems are locally referred to as lagoons. Here they are regarded as lacustrine systems because they resemble other lacustrine systems based on CRAM attributes and metrics.

3.2.2.6 Slope Wetlands

Slope Wetland is a broad category of groundwater-dominated wetlands inclusive of wet meadows, forested slopes, seeps and springs sub-types. In these wetlands groundwater may emerge into the root zone or across the ground surface seasonally or perennially, but mainly has unidirectional flow. The term "slope" refers to the uni-directional flow of ground and surface water within the wetland, rather than to a geomorphic feature (e.g. hillslope, toe-slope).

3.2.2.6.1 Seeps and Springs

These wetlands occur on hillsides or at the base of dunes, hills, alluvial fans, levees, etc. Springs are indicated by groundwater emerging and flowing across the ground surface and sometimes through indistinct or very small rivulets, runnels, and other features that are too small to be called a creek or riverine system. They often lack the features of riverine channels, such as a thalweg or floodplain. Seeps are similar to springs but lack a single-dominant origin of surface flow. Most of the flow is confined to the root zone and is not evident on the ground surface. Seeps and Springs may have, or may lack woody vegetation; no distinction is made in CRAM.

3.2.2.6.2 Wet Meadows

Wet meadows include bogs, fens, and alpine meadows where the hydrology is controlled mainly by fluctuations in ground water levels. They are associated with broad, gentle topographic gradients along which the near-surface ground water moves advectively, albeit slowly, in one dominant direction. If the hydroperiod of a wetland that looks like a wet meadow mainly depends on direct precipitation, then it is a depressional wetland (see Sections 3.2.2.2 and 3.2.2.3 above). Some wet meadows are associated with fluvial riverine channels, while others do not contain any distinct channel and have only sub-surface flow or surface sheet flow. Because the meadows with channels often have unique features that are not found in those without channels, this classification splits wet meadows into two types: Channeled Meadows and Non-channeled Meadows.

3.2.2.6.3 Forested Slopes

Forested slope wetlands are separated from wet meadows, by the percent coverage of trees. Forested Slope Wetlands are slope wetlands larger than 0.5 acres (0.2 ha) that form due to a seasonal or perennial emergence of groundwater into the root zone and in some cases onto the ground surface, and that support more than 30% cover of tall woody vegetation, as evidenced in aerial imagery, a LiDAR-derived tree height hillshade, or other sources of plant height information (Cayce et al., 2012). These wetlands can adjoin non-forested slope wetlands (i.e., wet meadows). They can include wetland areas with less than 30% woody cover (i.e., non-forested slope wetlands) that are not larger than 0.5 acres (0.2 ha).

3.4 Step 4: Verify the Appropriate Assessment Window

The Assessment Window is the period of time each year when assessments of wetland condition based on CRAM should be conducted. One Assessment Window exists for all attributes and metrics of each wetland type, but different types of wetlands can have different Assessment Windows. For example, the window is not the same for vernal pools and estuarine wetlands.

In general, the CRAM Assessment Window falls within the *growing season for the characteristic plant community of the wetland type to be assessed*. For wetlands that are not subject to snowfall and that are non-tidal, the main growing season usually extends from March through September, although it may begin earlier at lower latitudes and altitudes. The growing season tends to start earlier and last longer in tidal wetlands than adjoining non-tidal wetlands due to the seasonal variations in tidal inundation. For wetlands subject to snowfall, the start of the growing season is retarded by the spring thaw, which at very high elevations may not happen until late May or early June, depending on the depth of the snow pack. For seasonal wetlands (e.g., vernal pools, playas, and some seeps), the growing season will generally be March through June, although it can be much shorter for vernal pools.

Since the timing of the growing season varies with altitude and latitude, the Assessment Window might vary within and between regions, and local or regional cues may be needed to determine when the window opens and closes each year. The best cues will be the early evidence of new growth of plants, and the subsequent senescence of the plants, for any given wetland types. For example, the assessment of seasonal depressional wetlands might begin after the start of the growing season (the window is opening) but before summertime desiccation of the wetland soils (the window is closing). Some experts can reconstruct conditions for the Assessment Window after it closes based on forensic botany and other field techniques. <u>It should be clearly noted on the CRAM data sheets, however, if an assessment is being done outside the designated Assessment Window.</u>

Note that the assessment of estuarine wetlands should occur at low tide, when most of the smaller intertidal channels of the wetland are dewatered and associated benthic indicators of conditions are visible.

Also note that riverine wetlands should not be assessed during high water, not only because some important indicators of channel condition might be concealed, but also because of the dangers presented by high flows. Riverine wetlands should be assessed late in the growing season, near the onset of base flow.

3.5 Step 5: Establish the Assessment Area (AA)

The Assessment Area (AA) is the portion of the Wetland that is assessed using CRAM. An AA might include a small wetland in its entirety. But, in most cases the wetland will be larger than the AA. Rules are therefore needed to delineate the AA.

Establishing a proper AA is a critical step in correctly performing a rapid assessment using CRAM. As explained below, the use of an incorrect AA can yield results that are not reproducible, and that are not likely to relate to stressors or management actions. The delineation of the boundary of an AA must adhere to the following guidelines.

It is assumed that different wetlands, even neighboring wetlands of the same type, can be managed differently, or for different purposes, and can be subject to different stressors. Therefore, each AA must not encompass or involve more than one wetland, as defined in the Level 1 inventory.

Since CRAM metrics vary between wetland types, each AA must only represent one type of wetland. Different types of wetlands can be contiguous with each other, or even nested one within the other, but each AA must only represent one wetland type.

The wetland AA must be classified using the typology provided in Section 3.2.2 and it must be assessed using the metrics designed for its wetland type. Misclassification of wetlands can lead to using the wrong CRAM module, which in turn will lead to spurious assessments.

Each of the additional considerations outlined below, if applied alone, could lead to defining a different AA for the same wetland. The delineation of an AA is therefore an optimization among these considerations. Experience has shown, however, that for the purpose of standardizing the AAs for any wetland type, the overriding considerations are hydro-geomorphic integrity and size.

3.5.1 Hydro-geomorphic Integrity

Wetland managers need to be able to distinguish between the effects of management actions and the natural variability within and among wetlands of any given type based on CRAM scores. In effect, the AA should help maximize the CRAM signal-to-noise ratio.

Each AA must therefore encompass most if not all of the natural spatial variability in the visible form and structure of its encompassing wetland, and the AA should also encompass most of the internal workings of the wetland that account for its homeostasis – its tendency to maintain a certain overall condition or return to it during or after significant stress or disturbance.

For an AA to have this desired level of integrity, it should be bounded by obvious physical changes in topography, hydrology, or infrastructure that significantly control the sources, volumes, rates, or general composition of sediment supplies or water supplies within the AA at the time of the field assessment. In essence, the boundaries of an AA should not extend beyond any features that represent or cause a major spatial change in water source or sediment source.

One way to visualize the AA is to identify the spatial scale at which the structure and form of the wetland seem to repeat themselves (i.e., the scale at which self-similarity becomes evident). This is assumed to be the scale at which the internal workings of the wetland yield the least variability in form and structure. For example, the s-shaped curve created by two consecutive river bends tends to have a wave length equal to 10x the average width of the river through the bends (Leopold 1994). Also, large estuarine wetlands tend to consist of a number of drainage networks of very similar length and drainage area for any given drainage order (Collins *et al.* 1987, Collins and Grossinger 2004). Shorelines can be characterized by alternating reaches of erosion and deposition that repeat themselves at certain spatial scales relating to wave fetch and shoreline geology (e.g., Philips 1986). Observing the patterns of self-similarity for a given wetland type can help identify the dimensions of the appropriate AA.

3.5.2 AA Size

For any given wetland type, larger AAs might tend to yield higher CRAM scores. This is because CRAM is especially sensitive to wetland structural complexity, and larger AAs can afford more opportunity to encounter variability in structure. For any given wetland type, having AAs of very different sizes can introduce variability into CRAM scores.

As stated above, one of the primary considerations for delineating an AA is its hydro-geomorphic integrity. The boundaries of the AA should be established based on clear breaks in surface hydrology, sediment supply, or geomorphology (see Tables 3.5 and 3.6 below). Experience has shown, however, that most of the AAs of each wetland type that are delineated according to indicators of hydro-geomorphic integrity fall within a narrow range of size, although their shapes are more variable. This suggests that size guidelines can be applied to the process of establishing an AA without necessarily violating the criterion for the hydro-geomorphic integrity of the AA.

Furthermore, in some cases the self-similar, self-organizing, integral area of a wetland is not clearly evident. For example, some wet meadows, brackish estuarine wetlands, large riverine systems, and fringing wetlands of playas and lacustrine systems lack obvious hydrological breaks or other features that clearly demarcate changes in water supplies or sediment supplies. In these cases, overall size may be the dominant criterion for delineating the AA.

The preferred AA size is generally greater for types of wetlands that tend to have broad, level planes than for wetlands fringing steep terrain. The size-frequency distribution of wetlands for each wetland type (a Level 1 analysis) was also considered when the recommendations for AA sizes were being developed.

Examples of features that should be used to delineate an AA, and other features that should not be used, are listed in Tables 3.5 and 3.6 below. The preferred and minimum AA sizes for each wetland type are presented below in Table 3.7.

To the degree possible, the delineation of an AA should first be based on the hydro-geomorphic considerations presented in Tables 3.5 and 3.6. But, if these considerations are not applicable, or if the resulting AA is more than about 25% larger than the preferred size presented in Table 3.7, then the AA delineation should rely only on the size guidelines. The number of AAs per wetland will depend on the purpose of the assessment, as outlined in Table 3.8.

In addition to the guidance below, there are special considerations for establishing a AA for each wetland type located in the field books of each CRAM module.

Table 3.5: Examples of features that should be used to delineate AA boundaries. A more complete list is presented in the field books for each wetland type.

Flow-Through Wetlands	**Non Flow-Though Wetlands**	
Riverine, Estuarine and Slope Wetlands	**Lacustrine, Wet Meadows, Depressional, and Playa Wetlands**	**Vernal Pools and Vernal Pool Systems**
• diversion ditches • end-of-pipe large discharges • grade control or water height control structures • major changes in riverine entrenchment, confinement, degradation, aggradation, slope, or bed form • major channel confluences • water falls • open water areas more than 30 m wide on average or broader than the wetland • transitions between wetland types • foreshores, backshores and uplands at least 5 m wide • weirs, culverts, dams, levees, and other flow control structures	• above-grade roads and fills • berms and levees • jetties and wave deflectors • major point sources or outflows of water • open water areas more than 30 m wide on average or broader than the wetland • foreshores, backshores and uplands at least 5 m wide • weirs and other flow control structures	• above-grade roads and fills • major point sources of water inflows or outflows • weirs, berms, levees and other flow control structures

Table 3.6: Examples of features that should not be used to delineate any AAs. A more complete list is presented in the field books for each wetland type.

- at-grade, unpaved, single-lane, infrequently used roadways or crossings
- bike paths and jogging trails at grade
- bare ground within what would otherwise be the AA boundary
- equestrian trails
- fences (unless designed to obstruct the movement of wildlife)
- property boundaries
- riffle (or rapid) – glide – pool transitions in a riverine wetland
- spatial changes in land cover or land use along the wetland border
- state and federal jurisdictional boundaries

Table 3.7: Preferred and minimum AA sizes for each wetland type. Wetlands smaller than the preferred AA sizes can be assessed in their entirety.

Wetland Type	Recommended AA Size
Slope	
Spring or Seep	Preferred size is 0.50 ha (about 75m x 75m, but shape can vary); there is no minimum size (least examples can be mapped as dots).
Wet Meadow	Preferred size is 1.0 ha (about 140m x 140m, but shape can vary); Maximum size is 2.0 ha; minimum size is 0.1 ha (about 30m x 30m).
Depressional	
Vernal Pool	There are no size limits.
Vernal Pool System	Preferred size is <10 ha (about 300m x 300m; shape can vary); there is no minimum size so long as there are between 3 and 6 pools. If the system has between 3 and 6 pools, assess all of them. If there are more than 6 pools, select 6 that represent the range in size of pools present on the site.
Other Depressional	Preferred size is 1.0 ha (a 56 m radius circle or about 100m x 100m, but shape can vary); Maximum size is 2.0 ha (an 80 m radius circle or about 140m x 140m, but shape can vary); There is no minimum size.
Riverine	
Confined and Non-confined	Recommended length is 10x average bankfull channel width; maximum length is 200 m; minimum length is 100 m. AA should extend laterally (landward) from the bankfull contour to encompass all the vegetation (trees, shrubs vines, etc.) that probably provide woody debris, leaves, insects, etc. to the channel and its immediate floodplain; minimum width is 2 m.
Lacustrine	Preferred size is 2.0 ha (about 140m x 140m, but shape can vary); Minimum size is 0.5 ha (about 75m x 75m).
Playa	Preferred size is 2.0 ha (about 140m x 140m, but shape can vary); Minimum size is 0.5 ha (about 75m x 75m).
Estuarine	
Perennial Saline	Preferred size and shape for estuarine wetlands is a 1.0 ha circle (radius about 55m), but the shape can be non-circular if necessary to fit the wetland and to meet hydro-geomorphic and other criteria. The minimum size is 0.1 ha (about 30m x 30m).
Perennial Non-saline	
Bar-Built	Maximum size is 2.25 ha (about 150 m x 150 m, but shape can vary), The minimum size is 0.1 ha (about 30m x 30m).

3.5.3 Assessment Purpose

There are two primary purposes for using CRAM. It is used to assess the ambient condition of a population of wetlands or to assess the condition of an individual wetland or wetland project. The same guidelines for delineating AAs (see Tables 3.5 through 3.7 above) pertain to project assessments and ambient assessments using CRAM.

However, the number of AAs per wetland can vary between ambient surveys and individual wetland assessments. Multiple AAs might be required to assess the average condition of a wetland project that is many times larger than one AA, whereas just one AA would be required in the same wetland if it were only being assessed as part of an ambient survey (see Table 3.8).

Table 3.8: Guidelines for determining the number of AAs per wetland.

	Assessment Scenario
Single AA	If the size of the wetland is within the size limits given in Table 3.7, then the entire wetland constitutes the AA, regardless of the purpose of the assessment. Or If the wetland is one in a population of wetlands to be assessed as part of an ambient survey, then delineate one AA around each point randomly selected within the wetland as part of the sample draw from the ambient sample frame. For more information about ambient sampling design go to http://epa.gov/nheerl/arm/designing/design_intro.htm.
Multiple AAs	If the wetland is about twice as large as the preferred size AA from Table 3.7, and if the purpose is to assess the average condition of the wetland, then assess the second AA and report the results for both AAs. Or If the wetland is at least thrice as large as the preferred size AA from Table 3.7, and if the purpose is to assess the average condition of the wetland, then randomly select and assess three AAs from the array of all possible AAs for the wetland. If the overall score for the third AA differs from the average of the first two scores by more than 15%, then assess a randomly selected fourth AA; if its score differs from the average of the first three by more than 15%, then assess a randomly selected fifth AA. Repeat this procedure until the overall score for the latest AA is no more than 15% different than the average of all previous scores, or until the array of possible AAs is exhausted. For more detailed instructions on assessing multiple AAs per wetland, see the CRAM Technical Bulletin).
Reporting	The final boundaries of all the AAs of a wetland should be mapped using either the eCRAM software mapping tool or by drawing a heavy pencil line on a hardcopy of the site imagery. Hardcopy maps will need to be digitized using the online version of eCRAM as part of the process of entering CRAM results into the online CRAM database.

3.5.3 Special Considerations for Post-assessment Analysis

For CRAM scores to be comparable they must be standardized in terms of time (i.e., scores should represent comparable amounts of assessment effort during comparable years and times of year), and in terms of space (i.e., for any given wetland type, the scores should represent comparable amounts of wetlands, and these should have hydrological and ecological integrity; see Section 3.5.2 above).

For a variety of reasons, scores that do not meet these standards cannot be compared and cannot be combined into datasets. For example, assessments that take longer or that involve larger areas are likely to encounter more structural complexity and therefore yield higher scores.

The use of Assessment Windows (see Section 3.4 above), fixed assessment times (i.e., no assessment should take longer than one half day in the field), recommended AA sizes, and guidelines for assembling data of varying vintage will achieve more consistent assessment results.

To achieve the spatial standards, each AA for each wetland type should fall within a standard size range that is large enough to incorporate the natural processes of homeostasis that characterize the wetland (see discussion of AA integrity in Section 3.5.2), but small enough to meet the time constraints (see Table 3.7).

An additional spatial consideration for ambient surveys is that the probability of any wetland within a given area being selected for assessment increases with its size, and weighting CRAM scores for the inclusion probabilities of their associated AAs depends on having a standard AA size range for each wetland type. For more information about ambient sampling design go to http://epa.gov/nheerl/arm/designing/design_intro.htm.

Standardizing the shape of AAs (e.g., having all AAs be circles or squares of fixed size) may increase the ease with which they are delineated, but may also lead to a disregard of features such as water control structures that affect AA integrity. Standardizing the shapes of AAs is less important than standardizing their sizes.

3.5.4 Special Considerations for Assessing Projects

For the purposes of CRAM, a "project" includes any on-the-ground activity which results in a physical change in the area or condition of an aquatic resource[1]. Projects can be associated with a regulatory or funding decision. Such projects are often at least partly delimited by property lines or other administrative or legal boundaries. Wetland restoration projects, mitigation projects, mitigation banks, and wetlands that are targeted for development (i.e., impacted wetlands) are often delimited by property lines. However, for the purposes of CRAM, the definition of *project* is independent of any regulatory or administrative definition under the Clean Water Act, Porter Cologne, Section 1600 of the State's Fish and Game Code, Coastal Zone Management Act, CEQA, or NEPA.

Property lines, jurisdictional limits, and other administrative or legal boundaries should not automatically be used to delineate AAs, except for the assessment of a project, in which case the

[1] Projects can include the acquisition or placement of a wetland, riparian area, or other aquatic habitat in a conservation easement (or other permanent protection).

wetland and its AA(s) are confined to the project boundaries. A formal wetland Jurisdictional Delineations (JD) in good standing for a project can be used in the absence of any other wetland map to define the wetland and to help delimit the AA(s). If the project is much larger than one AA, then the process outlined in the CRAM Technical Bulletin should be used to assess multiple AAs.

The best achievable condition of a project might be unavoidably constrained by adjacent or nearby land uses. In these situations, the expected or target level of performance of a project might be adjusted for the land use constraints. In other words, although a project is assessed relative to the best achievable conditions for its wetland type throughout the State, what is expected or deemed acceptable for any particular project might reflect its land use setting. For example, stream restoration projects in urban landscapes need not be held to the same standards of high performance as projects in rural or non-developed landscapes. As CRAM scores accumulate throughout the State, their relationship to land use setting can be analyzed to guide local adjustments in project performance criteria that are based on CRAM.

3.6 Step 6: Conduct Initial Office Assessment of Condition Metrics and Stressors

For each CRAM assessment, there is initial office work to acquire the site imagery, plan logistics for the site visit, and to assemble information about the management of the site and its possible stressors. Preliminary scores can be developed for some metrics, based on existing documentation (e.g., aerial photography, reports, etc.), prior to conducting any fieldwork. Such preliminary scoring is not necessary, however, and any preliminary scores must be verified during the site visit. The initial office work is itemized in Table 3.10 below.

Table 3.10: CRAM metrics suitable for pre-site visit draft assessment.

Background Information to Assemble Prior to the Site Visit
• 1m-3m pixel resolution digital geo-rectified site imagery • Site-specific and neighboring reports on hydrology, ecology, chemistry, etc. • Access permission if needed • Preliminary map of the Assessment Area • Maps to the site, access points, and other logistical information

Metrics/Submetrics Suitable for Preliminary Scoring Prior to Site Visit			
Attributes		Metrics/Submetrics	Suitable?
Buffer and Landscape Context		Aquatic Area Abundance	Yes
		Stream Corridor Continuity(riverine, BBE)	Yes
		Aquatic Area in Adjacent Landscape (BBE)	Yes
		Marine Connectivity (BBE)	Yes
		Percent of AA with Buffer	Yes
		Average Buffer Width	Yes
		Buffer Condition	No
Hydrology		Water Source	Yes
		Hydroperiod or Channel Stability	No
		Hydrologic Connectivity	No
Structure	Physical	Structural Patch Richness	No
		Topographic Complexity	No
	Biotic	Number of Plant Layers Present	No
		Number of Co-dominant Species	No
		Endemic Plant Species Richness (vernal pools)	No
		Percent Invasion	No
		Horizontal Interspersion and Zonation	No
		Vertical Biotic Structure	No

For air photos and other imagery, the minimum pixel resolution is 3m (i.e., each pixel in the digital image of a site should represent no more than about $9m^2$ of area). National Agriculture Imagery Program (NAIP; http://www.fsa.usda.gov) aerial imagery with a spatial resolution of 1m is available for the entire state (years 2005, 2009, and 2010) as either Digital Orthogonal Quarterly Quadrangle (DOQQ) tiles or as compressed county mosaics (CCMs) from the Cal-Atlas website (atlas.ca.gov). Older, lower resolution (3m) imagery in DOQQ format is also available.

3.7 Step 7: Conduct Field Assessment of Condition Metrics and Stressors

After assembling the background information about the wetland to be assessed, the next step is to conduct an assessment of the wetland in the field. A complete description of CRAM metrics and the Stressor Checklist is provided in the individual field books for each CRAM module. Fieldwork for CRAM consists of finding and confirming the boundaries of the AA, and scoring the AA based on the condition metrics and stressor checklist. Any field-based modifications of the preliminary AA boundary must be recorded on the site imagery.

3.8 Step 8: Complete CRAM Scores and Basic QA/QC Procedures

3.8.1 Calculating CRAM Scores

Scores for CRAM are easily calculated. There is no weighting of any metrics or attributes. Weightings are not supported by theory or the validation exercises. Letter scores for each metric (A, B, C, D) are simply converted into whole integer scores (12, 9, 6, 3, respectively; see Step 1 in Table 3.11).

For the Hydrology and Physical Structure attributes, the attribute scores are simply calculated as the sum of the component metric scores (see Step 2 in Table 3.11).

For the Buffer and Landscape Context attribute, the submetric scores relating to buffer are combined into an overall buffer score that is added to the score for the Landscape Connectivity metric, using the formula in Step 2 in Table 3.11.

For the Biotic Structure attribute, the Plant Community metric consists of three submetrics (Number of Plant Layers Present; Number of Co-dominant Species; and Percent Invasion). Prior to calculating the Biotic Structure attribute score, the values for these submetrics must be averaged. Then the Biotic Structure attribute score can be calculated as described in Table 3.11.

Each raw attribute score is then converted into a percentage of the maximum possible score (see Step 3 in Table 3.11). This eliminates any weighting of one attribute relative to another due to their differences in numbers of component metrics and numbers of alternative states of the metrics.

An overall AA score is calculated by averaging the attribute scores. All scores are rounded to the nearest whole percentage value (see Step 4 in Table 3.11).

Different wetlands are likely to have different functions and ecological services due to differences in wetland form, structure, geomorphic setting, climatic regime, evolutionary stage, stressor regime, etc. It is therefore unlikely that the same CRAM score represents the same level of function or even the same set of functions for different wetlands. CRAM scores cannot be used to infer wetland function except in the context of correlations between CRAM scores and actual functional levels, as measured using Level 3 methods. Validation efforts to date indicate that CRAM scores are strongly correlated to a variety of wetland functions and services.

It is expected that the same scores for different wetlands of the same type probably represent the same overall condition and functional capacity. CRAM can therefore be used to track the progress of restoration efforts over time, to compare impacted sites to their in-kind mitigation sites, or to compare an individual wetland to the status and trends in ambient condition of its wetland type.

CRAM scores can also be used to compare the status and trends of different types of wetlands. This is because all wetlands are assessed relative to their best achievable condition. For example, separate ambient surveys of lacustrine and estuarine wetlands might reveal that one type is doing better than the other, relative to their particular overall best achievable conditions.

Table 3.11: Steps to calculate attribute scores and AA scores for most wetland types.

Step 1: Calculate Metric Score	For each Metric, convert the letter score into the corresponding numeric score: A=12, B=9, C=6 and D=3.
Step 2: Calculate raw Attribute Score	For each Attribute, calculate the Raw Attribute Score as the sum of the numeric scores of the component Metrics, except in the following cases: • For Attribute 1 (Buffer and Landscape Context), the submetric scores relating to buffer are combined into an overall buffer score that is added to the score for the Aquatic Area Abundance, using the following formula: $\left(\text{Buffer Condition} \times \left(\text{\% AA with Buffer} \times \text{Average Buffer Width} \right)^{½} \right)^{½} + \text{Aquatic Area Abundance}$ • For Attribute 4 (Biotic Structure) Prior to calculating the Raw Attribute Score, average the three Plant Community sub-metrics. Then sum this result with the other two Biotic Structure metrics. • Do not round the Raw Attribute scores to the nearest integer.
Step 3: Calculate final Attribute Score	For each Attribute, divide its Raw Attribute Score by its maximum possible score, which is 24 for Buffer and Landscape Context, 36 for Hydrology, 24 for Physical Structure, and 36 for Biotic Structure. Do not round the final Attribute scores to the nearest integer before calculating the AA Index Score. You may round the final Attribute score to the nearest integer for reporting purposes.
Step 4: Calculate the AA Index Score	Calculate the AA Index Score by averaging the Final Attribute Scores. Round this average to the nearest whole number (integer) to get the AA Index Score (0.5 or greater rounds up, less than 0.5 rounds down).

There are many possible ways to graphically present CRAM scores. The choice should depend on the information to be conveyed and the intended audience. It will not usually be necessary to present metric scores except in the context of validation efforts and to explain attribute scores. The metric scores can be presented effectively, however, as a circular graph that depicts the contribution of each metric to the overall score (e.g., Figure 3.4A). Site-specific and ambient scores can be compared in bar charts (Figure 3.4B). The progress of a restoration or mitigation project can be shown as the change in average overall score relative to performance standards (Figure 3.4C). The ambient conditions of two different types of wetlands can be compared based on the frequency distributions of the overall scores (Figure 3.4D). The ambient condition of any given wetland type can be displayed as the cumulative frequency of overall scores (Figure 3.4E). The graphs pertaining to ambient condition or to any population of wetlands can be produced for a variety of spatial scales, from watersheds or regions to the State as a whole.

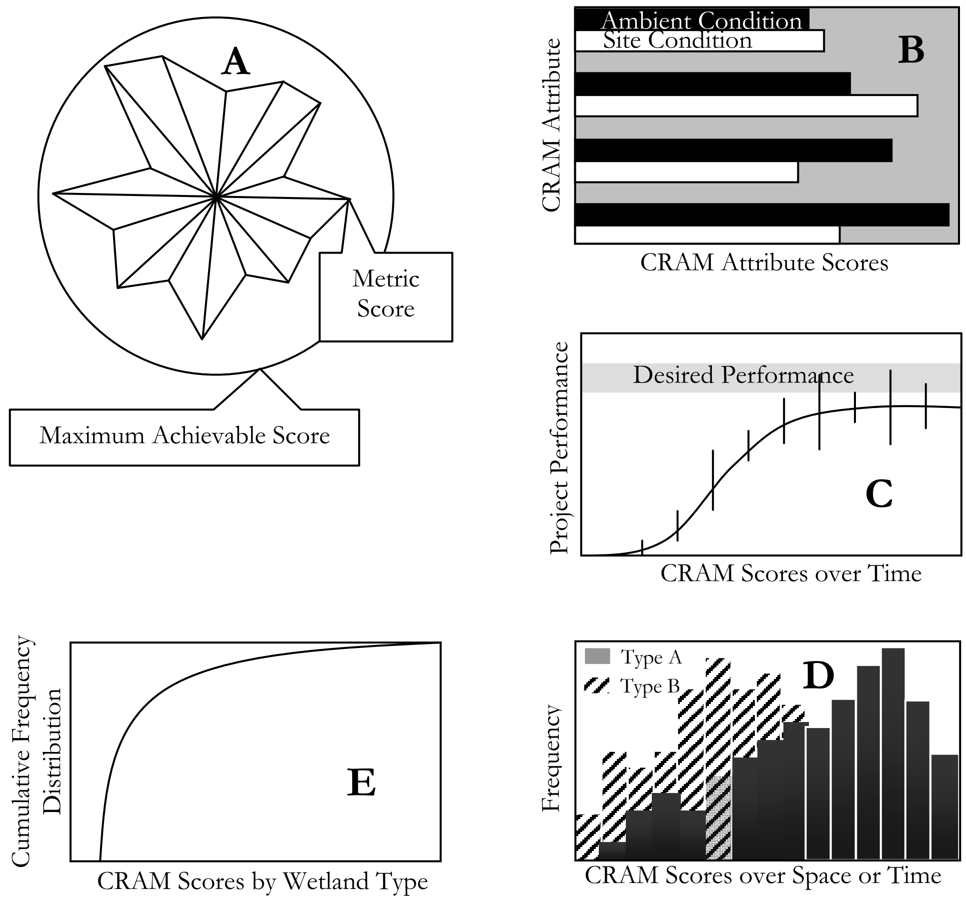

Figure 3.4: Example graphs for displaying CRAM results.

Figure shows (A) "spider plot" of metric scores for one or more AAs (multiple areas would be represented by average scores) (see Ambrose *et al.* 2006); (B) site-specific attribute scores compared to ambinet conditions or reference conditions; (C) changes in AA scores over time for a wetland an project; (D) comparison of two different populations of wetlands based on the frequency distribution of their AA scores; and (E) cummulative frequency distribution of scores for one population of wetlands.

3.8.2 Initial QA/QC Procedures for Data Collectors

Part of the value of CRAM is its ability to yield reproducible results for wetlands of similar condition, regardless of the data collector. Quality control procedures should be employed to assure that the data collectors or assessors are using the same approach and are obtaining information accurately when conducting CRAM assessments. For large wetland projects having numerous AAs and for ambient assessments involving multiple wetlands, it is recommended that at least 10% of the AAs be revisited by an independent CRAM assessment team and compared to the original assessments for the same AAs. The replicate scores should be within 10% of the original scores for each attribute.

In addition to taking on or more CRAM training courses, all CRAM practitioners are advised to carefully read and understand the most recent version of the CRAM User's Manual before they begin conducting assessments. The User's Manual and CRAM training materials are available at the CRAM web site (www.cramwetlands.org). Supporting materials include a photo-glossary with picture examples of many of the terms and wetland characteristics described or referenced in the User's Manual. These materials are intended to help users develop an understanding of the complete range of conditions for each metric, and arrive at consistent conclusions about wetland condition.

The initial quality control procedures for any assessment involve a basic review of the AA map and the summary scoring sheet. The recommended topics for the initial quality control are listed in Table 3.12 below.

Table 3.12: Recommended topics of initial QA/QC.

Recommended Topics of Initial QA/QC for CRAM Results
• *AA map quality:* hardcopy maps must be clear enough to be readily digitized. AA maps must be on geo-rectified imagery with minimum pixel resolution of 3 m (i.e., each pixel should represent no more than 9 m^2). • *Summary data sheet:* make sure all fields of information for site name, wetland type, date of assessment, personnel making the assessment, etc. are complete and legible. • *Summary score sheet*: make sure that every metric and attribute has a correct score, and that the overall site score is also correct. • *Summary stressor sheet:* make sure the stressor checklist has been completed.

3.8.3 Initial Quality Control Procedures for Data Managers

The main objective of data management is to assure that the data are accurately collected and verified for analysis and interpretation by CRAM practitioners and resource managers. Procedures described in this User's Manual are designed to help assure the accuracy and consistency of data collection and processing. Since metric scores are combined into more complex attribute and overall CRAM site scores, any errors in data collection can be compounded if quality control measures are not followed.

Data management involves maintaining various types of data and information, including hardcopy and electronic imaging and other background information for sites to be assessed using CRAM, as well as completed field data sheets. Routine backups of the computing systems and databases should be performed daily, along with measures to assure network and computer security. Backup files containing CRAM data should be stored in fireproof facilities. In addition, hardcopies of the data should be maintained and, if the data are only in electronic form, printouts of these data should be stored separately from the electronic versions.

These basic criteria for secure data management are currently met through administration of the CRAM web site and supporting database at the San Francisco Estuary Institute as a regional Information Center of CEDEN. The eCRAM interface, the CRAM database, and its supporting web sites are open source. No aspect of CRAM programming is proprietary. The CRAM database incorporates numerous measures to assure accurate data entry and processing, including the following.

- Each database field that requires a value is checked for null or missing values.
- Standard codes are provided in look-up lists for populating the data table fields.
- The entry of duplicate records is prevented, based on a unique combination of fields that define the primary key.
- If one record set is related to another, it is checked for orphan records (parent records have child records and child records have parent records).
- Users are prompted to complete data fields as data are being uploaded into the database via the CRAM web site.
- Data entry and editing are password-protected; data authors can only access and edit their own data.
- All data are time-stamped and automatically assigned to a unique site code.
- Database users are automatically prompted to download new versions of CRAM if the version they have is outdated.

3.9 Step 9: Upload Assessment Data and Results

No CRAM assessment is complete until the results are uploaded into the CRAM database. The database is accessible at www.cramwetlands.org/dataentry. Anyone who wants to enter data into the database must register on the CRAM website to obtain a database log-in name and password. Results for hardcopy versions of CRAM must be transcribed into the electronic version on the web site. The database is only accessible to registered users, and they can only access and edit their own data. All results marked as "public" when entered into eCRAM can be viewed by the public through interactive maps at the CRAM web site.

CHAPTER 4: DEFINITION AND RATIONALE FOR CRAM ATTRIBUTES AND METRICS

4.0 Summary

This chapter contains background information for each metric of CRAM. Each metric is supported by a definition, rationale, and an indication of the metric's sensitivity to seasonal variability in wetland condition.

A field book describing the standard operating procedures for each wetland type is provided on the CRAM website (www.cramwetlands.org) along with datasheets for conducting CRAM assessments.

4.1 Attribute 1: Buffer and Landscape Context

For the purposes of CRAM, a buffer is a zone of transition between the immediate margins of a wetland and its surrounding environment that is likely to help protect the wetland from anthropogenic stress (see Figure 2.2). Areas adjoining wetlands that probably do not provide protection are not considered buffers.

Buffers can protect wetlands by filtering pollutants, providing refuge for wetland wildlife during times of high water levels, acting as barriers to disruptive incursions by people and pets into wetlands, and moderating predation by ground-dwelling terrestrial predators. Buffers can also reduce the risk of invasion by non-native plants and animals, by either obstructing terrestrial corridors of invasion or by helping to maintain the integrity and therefore the resistance of wetland communities to invasions.

Because regulation and protection of wetlands historically did not extend to adjacent uplands, these areas in some cases have been converted to recreational, agricultural, or other human land uses and might no longer provide their critical buffer functions for wetlands.

CRAM includes two metrics to assess the Buffer and Landscape Context attribute of wetlands: the Aquatic Area Abundance metric and the Buffer metric. The buffer metric is composed of three submetrics: (1) percentage of the AA perimeter that has a buffer; (2) the average buffer width; and (3) the condition or quality of the buffer.

4.1.1 Metric 1: Aquatic Area Abundance (Stream Corridor Continuity)

A. Definition: The aquatic area abundance of an Assessment Area is assessed in terms of its spatial association with other areas of aquatic resources, such as other wetlands, lakes, streams, etc. It is assumed that wetlands close to each other have a greater potential to interact ecologically and hydrologically, and that such interactions are generally beneficial.

B. Rationale: Wetlands are often important components of local mosaics of multiple types of habitat. The components of such mosaics tend to be inter-connected by the flow of water and movements of wildlife, such that they have additive influences on the timing and extent of many landscape-level processes, including flooding, filtration of pesticides and other contaminants, and wildlife support. In turn, these processes can strongly influence the form and function of wetlands. The functional capacity of a wetland is therefore determined not only by its intrinsic properties, but by its relationship to other habitats across the landscape. For example, Frissell *et al*. (1986) concluded that the structure and dynamics of stream habitats are determined by the surrounding watershed. Several researchers have concluded that landscape-scale variables are often better predictors of stream and wetland integrity than localized variables (Roth *et al*. 1996; Scott *et al*. 2002). Wetlands that are close together without hydrological or ecological barriers between them are better able to provide refuge and alternative habitat patches for meta-populations of wildlife, to support transient or migratory wildlife species, and to function as sources of colonists for primary or secondary succession of newly created or restored wetlands. In general, good landscape connectivity exists only where neighboring wetlands or other habitats do not have intervening obstructions that could inhibit the movements of wildlife.

For the purposes of CRAM, 500 m has been surmised as the maximum distance between wetlands and other water-dependent habitats that does not by itself function as a barrier to the easy regular movements of small mammals, birds, amphibians, or reptiles. Greater distances between the wetland of interest and neighboring habitats are considered breaks in landscape connectivity.

C. Seasonality: This metric is not sensitive to seasonality.

4.1.2 Metric 2: Buffer

The buffer is the area adjoining the AA that is in a natural or semi-natural state and currently not dedicated to anthropogenic uses that would severely detract from its ability to entrap contaminants, discourage visitation into the AA by people and non-native predators, or otherwise protect the AA from stress and disturbance.

4.1.2.1 Submetric A: Percent of AA with Buffer

A. Definition: This submetric is based on the relationship between the extent of buffer and the functions provided by aquatic areas. Areas with more buffer typically provide more habitat values, better water quality and other valuable functions.

B. Rationale: The ability of buffers to protect a wetland increases with buffer extent along the wetland perimeter. For some kinds of stress, such as predation by feral pets or disruption of plant communities by cattle, small breaks in buffers may be adequate to nullify the benefits of an existing buffer. However, for most stressors, small breaks in buffers caused by such features as trails and small, unpaved roadways probably do not significantly disrupt the buffer functions.

C. Seasonality: This metric is not sensitive to seasonality.

4.1.1.2 Submetric B: Average Buffer Width

A. Definition: The average width of the buffer adjoining the AA is estimated by averaging the lengths of straight lines drawn at regular intervals around the AA from its perimeter outward to the nearest non-buffer land cover, or to a maximum distance of 250 m, whichever is first encountered. The maximum buffer width is 250 m. The minimum buffer width is 5 m, and the minimum buffer length along the AA perimeter is also 5 m. Any area that is less than 5 m wide and 5 m long is assumed to be too small to provide buffer functions.

B. Rationale: A wider buffer has a greater capacity to serve as habitat for wetland edge-dependent species, to reduce the inputs of non-point source contaminants, to control erosion, and to generally protect the wetland from human activities.

C. Seasonality: This metric is not sensitive to seasonality.

4.1.1.3 Submetric C: Buffer Condition

A. Definition: The condition of a buffer is assessed according to the extent and quality of its vegetation cover, the overall condition of its substrate, and the amount of human visitation. Buffer conditions are assessed only for the portion of the wetland border that has already been identified as buffer. Thus, evidence of direct impacts (parking lots, buildings, etc.) by people are excluded from this metric, because these features are not included as buffer land covers; instead these impacts are included in the Stressor Checklist.

B. Rationale: The condition or composition of the buffer, in addition to its width and extent around a wetland, determines the overall capacity of the buffer to perform its critical functions.

C. Seasonality: This metric is not sensitive to seasonality.

4.2 Attribute 2: Hydrology

Hydrology includes the sources, quantities, and movements of water, plus the quantities, transport, and fates of water-borne materials, particularly sediment as bed load and suspended load. Hydrology is the most important direct determinant of wetland functions (Mitsch and Gosselink 2007). The physical structure of a wetland is largely determined by the magnitude, duration, and intensity of water movement. For example, substrate grain size, depth of wetland sediments, and total organic carbon in sediments tend to be inversely correlated to duration of inundation in a lacustrine wetland. The hydrology of a wetland directly affects many physical processes, including nutrient cycling, sediment entrapment, and pollution filtration. For example, Odum and Heywood (1978) found that leaves in freshwater depressional wetlands decomposed more rapidly when submerged. The hydrology of a wetland constitutes a dynamic habitat template for wetland plants and animals. For example, Richards *et al.* 2002 concluded that meandering and braiding in riverine systems control habitat patch dynamics and ecosystem turnover. Additionally, the spatial distribution of plants and animals in a tidal marsh closely correspond to patterns of tidal inundation or exposure (Sanderson *et al.* 2000).

4.2.1 Metric 1: Water Source

A. Definition: Water Sources directly affect the extent, duration, and frequency of saturated or ponded conditions within an Assessment Area. Water Sources include direct inputs of water into the AA as well as any diversions of water from the AA. Diversions are considered a water source because they affect the ability of the AA to function as a source of water for other habitats while also directly affecting the hydrology of the AA. Direct inputs of water affecting conditions during the dry season are especially important because they strongly influence the structure and composition of wetland plant and animal communities. The Water Source metric therefore focuses on conditions that affect dry season hydrology.

Direct, natural water sources include precipitation, ground water discharge, and flooding of the AA due to high tides or naturally high riverine flows. Examples of direct, unnatural sources include stormdrains that empty into the AA or into an immediately adjacent area. For seeps and springs that occur at the toes of earthen dams, the reservoirs behind the dams are water sources. Indirect sources that should not be considered in this metric include large regional dams that have ubiquitous effects on broad geographic areas of which the AA is a small part. For example, although the salinity regimes of some estuarine wetlands in San Francisco Bay are indirectly affected by dams in the Sierra Nevada, others are directly affected by nearby discharges from sewage treatment facilities. However, the effects of urbanization on hydrological dynamics in the immediate watershed containing the AA ("hydromodification") are considered in this metric; because hydromodification both increases the volume and intensity of runoff during and immediately after rain events and reduces infiltration that supports base flow discharges during the drier seasons later in the year. Engineered hydrological controls, such as pumps, weirs, and tide gates can serve to demarcate the boundary of an AA, but they are not considered water sources.

B. Rationale: Wetlands depend on constant or recurrent, shallow inundation or saturation at or near the surface of the substrate (National Research Council 2001). Consistent, natural inflows of water to a wetland are important to their ability to perform and maintain most of their intrinsic ecological, hydrological, and societal functions and services. The flow of water into a wetland also affects its sedimentary processes, geo-chemistry, and basic physical structure. Sudol and Ambrose (2002) found that one of the greatest causes of failed wetland mitigation or restoration projects is inadequate or inappropriate hydrology.

C. Seasonality: Water source should be evaluated during the dry season.

4.2.2 Metric 2: Hydroperiod or Channel Stability

A. Definition: Hydroperiod is the characteristic frequency and duration of inundation or saturation of a wetland during a typical year. The natural hydroperiod for estuarine wetlands is governed by the tides, and includes predictable variations in inundation regimes over days, weeks, months, and seasons. Depressional, lacustrine, playas, and riverine wetlands typically have daily variations in water height that are governed by diurnal increases in evapotranspiration and seasonal cycles that are governed by rainfall and runoff. Seeps and springs that depend on groundwater may have relatively slight seasonal variations in hydroperiod.

Channel stability only pertains to riverine wetlands. It is assessed as the degree of channel aggradation (i.e., net accumulation of sediment on the channel bed causing it to rise over time), or degradation (i.e., net loss of sediment from the bed causing it to be lower over time). There is much interest in channel entrenchment (i.e., the inability of flows in a channel to exceed the channel banks) and this is addressed in the Hydrologic Connectivity metric.

B. Rationale: For all wetlands except riverine wetlands, hydroperiod is the dominant aspect of hydrology. The pattern and balance of inflows and outflows is a major determinant of wetland functions Mitch and Gosselink (1993). The patterns of import, storage, and export of sediment and other water-borne materials are functions of the hydroperiod. In most wetlands, plant recruitment and maintenance are dependent on hydroperiod. The interactions of hydroperiod and topography are major determinants of the distribution and abundance of native wetland plants and animals. Natural hydroperiods are key attributes of successful wetland projects (National Research Council 2001).

For riverine systems, the patterns of increasing and decreasing flows that are associated with storms, releases of water from dams, seasonal variations in rainfall, or longer term trends in peak flow, base flow, and average flow are more important than hydroperiod. The patterns of flow, in conjunction with the kinds and amounts of sediment that the flow carries or deposits, largely determine the form of riverine systems, including their floodplains, and thus also control their ecological functions. Under natural conditions, the opposing tendencies for sediment to stop moving and for flow to move the sediment tend toward a dynamic equilibrium, such that the form of the channel in cross-section, plan view, and longitudinal profile remains relatively constant over time (Leopold 1994). Large and persistent changes in either the flow regime or the sediment regime tend to destabilize the channel and cause it to change form. Such regime changes are associated with upstream land use changes, alterations of the drainage network, and climatic changes. A riverine channel is an almost infinitely adjustable complex of interrelations between flow, width, depth, bed resistance, sediment transport, and riparian vegetation. Change in any of these factors will be countered by adjustments in the others. The degree of channel stability can be assessed based on field indicators.

This metric evaluates recent changes in the hydroperiod, flow regime, or sediment regime of a wetland and the degree to which these changes affect the structure and composition of the wetland plant community or, in the case of riverine wetlands, the stability of the riverine channel.

C. Seasonality: For all wetland types other than depressional wetlands, vernal pools, and playas, hydroperiod should be evaluated during the dry season. For depressional wetlands and playas, hydroperiod should be assessed during the latter part of the wet season (i.e., June and July, in most years). The assessment window for vernal pools can be relatively short, and varies from one year to the next. As a general rule, however, hydroperiod for vernal pools should be assessed near the end of their growing season, when botanical indicators of successional change in hydroperiod are evident (i.e., April or May in most years).

4.2.3 Metric 3: Hydrologic Connectivity

A. Definition: Hydrologic Connectivity describes the ability of water to flow into or out of the wetland, or to accommodate rising flood waters without persistent changes in water level that can result in stress to wetland plants and animals.

B. Rationale: Hydrologic connectivity between wetlands and adjacent uplands promotes the exchange of water, sediment, nutrients, and organic carbon. Inputs of organic carbon are of great importance to ecosystem function. Litter and allochthanous input from adjacent uplands provides energy that subsidizes the aquatic food web (Roth *et al.* 1996). Connection with adjacent water bodies promotes the import and export of water-borne materials, including nutrients. Hydrologic connections with shallow aquifers and hyporheic zones influence most wetland functions. Plant diversity tends to be positively correlated with connectivity between wetlands and natural uplands, and negatively correlated with increasing inter-wetland distances (Lopez *et al.* 2002). Amphibian diversity is directly correlated with connectivity between streams and their floodplains (Amoros and Bornette 2002). Linkages between aquatic and terrestrial habitats allow wetland-dependent species to move between habitats to complete life cycle requirements. For estuarine wetlands, the function of upland transitions as refuge for intertidal wildlife during extreme high tides is especially important

For all wetland types except riverine, this metric is scored by assessing the degree to which the lateral movement of rising tides or flood waters are restricted by features such as levees, dikes, sea walls, or road grades in the AA, its encompassing wetland and the associated upland transition zone.

For riverine wetlands, Hydrologic Connectivity is assessed based on the degree of channel entrenchment (Leopold *et al.* 1964, Rosgen 1996, Montgomery and MacDonald 2002). Entrenchment is calculated as the flood-prone width divided by the bankfull width. The flood-prone width is measured at the elevation equal to twice the maximum bankfull depth; maximum bankfull depth is the height of bankfull flow above the thalweg.

C. Seasonality: This metric is not sensitive to seasonality.

4.3 Attribute 3: Physical Structure

Physical structure is defined as the spatial organization of living and non-living surfaces that provide habitat for biota (Maddock 1999). For example, the distribution and abundance of organisms in riverine systems are largely controlled by physical processes and the resulting physical characteristics of habitats (e.g., Frissell *et al.* 1986). Metrics of the Physical Structure attribute in CRAM therefore focus on physical conditions that are indicative of the capacity of a wetland to support characteristic flora and fauna.

4.3.1 Metric 1: Structural Patch Richness

A. Definition: Patch richness is the number of different obvious types of physical surfaces or features that may provide habitat for aquatic, wetland, or riparian species. This metric is different from topographic complexity in that it addresses the number of different patch types, whereas topographic complexity evaluates the spatial arrangement and interspersion of the types. Physical patches can be natural or unnatural.

B. Rationale: The richness of physical, structural surfaces and features in a wetland reflects the diversity of physical processes, such as energy dissipation, water storage, and groundwater exchange, which strongly affect the potential ecological complexity of the wetland. The basic assumption is that natural physical complexity promotes natural ecological complexity, which in turn generally increases ecological functions, beneficial uses, and the overall condition of a wetland. For each wetland type, there are visible patches of physical structure that typically occur at multiple points along the hydrologic/moisture gradient. But not all patch types will occur in all wetland types. Therefore, the rating is based on the total number of expected patch types present in an AA for a given type of wetland.

C. Seasonality: This metric is not sensitive to seasonality.

4.3.2 Metric 2: Topographic Complexity

A. Definition: Topographic complexity refers to the micro- and macro-topographic relief within a wetland due to abiotic features and elevations gradients.

B. Rationale: Topographic complexity promotes variable hydroperiods and concomitant moisture gradients that, in turn, promote ecological complexity by increasing the spatial and temporal variability in energy dissipation, surface water storage, groundwater recharge, particulate matter detention, cycling of elements and compounds, and habitat dynamics. Areas that are aerated due to flow across complex surfaces may promote volatilization of compounds, or re-suspension and export of water-borne material.

Topographic complexity is assessed by noting the overall variability in physical patches and topographic features. Care must be taken to distinguish indicators of topographic complexity or habitat features within a wetland. For each type of wetland, topographic complexity can be evaluated by observing the number of elevational features that affect moisture gradients or that influence the path of water flow along a transect across the AA, and the amount of micro-topographic relief along the gradients or flow paths. Topographic gradients may be indicated by plant assemblages with different inundation/saturation or salinity tolerances.

C. Seasonality: This metric is not sensitive to seasonality.

4.4 Attribute 4: Biotic Structure

The biotic structure of a wetland includes all of its organic matter that contributes to its material structure and architecture. Living vegetation and coarse detritus are examples of biotic structure. Plants strongly influence the quantity, quality, and spatial distribution of water and sediment within wetlands. For example, in many wetlands, including bogs and tidal marshes, much of the sediment pile is organic. Vascular plants in estuarine and riverine wetlands entrap suspended sediment. Plants reduce wave energies and decrease the velocity of water flowing through wetlands. Plant detritus is a main source of essential nutrients, while vascular plants and large patches of macroalgae function as habitat for wetland wildlife.

4.4.1 Metric 1: Plant Community

A. Definition: The Plant Community Metric is composed of three submetrics for each wetland type. Two of these sub-metrics, Number of Co-dominant Plants and Percent Invasion, are common to all wetland types. For all wetlands except Vernal Pools and Vernal Pool Systems, the Number of Plant Layers as defined for CRAM is also assessed. For Vernal Pools and Pool Systems, the Number of Plant layers submetric is replaced by the Endemic Species Richness submetric. A thorough reconnaissance of an AA is required to assess its condition using these submetrics. The assessment for each submetric is guided by a set of a set of rules (Figure 4.1) and the Plant Community Worksheets. The Plant Community metric is calculated based on these worksheets.

A "plant" is defined as an individual of any vascular macrophyte species of tree, shrub, herb/forb, or fern, whether submerged, floating, emergent, prostrate, decumbent, or erect, including non-native (exotic) plant species. Mosses and algae are not included among the species identified in the assessment of the plant community. For the purposes of CRAM, a plant "layer" is a stratum of vegetation indicated by a discreet canopy at a specified height that comprises at least 5% of the area of the AA *where the layer is expected.*

Non-native species owe their occurrence in California to the actions of people since shortly before Euroamerican contact. Many non-native species are now *naturalized* in California, and may be widespread in occurrence. "Invasive" species are non-native species that "(1) are not native to, yet can spread into, wildland ecosystems, and that also (2) displace native species, hybridize with native species, alter biological communities, or alter ecosystem processes" (CalIPC 2012). CRAM uses the California Invasive Plant Council (CalIPC) list to determine the invasive status of plants, *with augmentation by regional experts.*

B. Rationale: The functions of whole-wetland systems are optimized when a rich native flora dominates the plant community, and when the botanical structure of the wetland is complex in 3-dimensional space, due to species diversity and recruitment, and resulting in suitable habitat for multiple animal species. Much of the natural microbial, invertebrate, and vertebrate communities of wetlands are adjusted to the architectural forms, phenologies, detrital materials, and chemistry of the native vegetation. Furthermore, the physical form of wetlands is partly the result of interactions between plants and physical processes, especially hydrology. A sudden change in the dominant species, such as results from plant invasions, can have cascading effects on whole-system form, structure, and function.

The Plant Community Metric is assessed in terms of the similarity between the dominant species composition of the plant community and what is expected based on CRAM verification and validation studies, regional botanical surveys, and historical resources. This metric requires the ability to recognize the most common and abundant plants species of wetlands. When a CRAM field team lacks the necessary botanical expertise, photographs and/or voucher specimens will need to be collected using standard plant presses and site documentation. This can greatly increase the time required to complete a CRAM assessment.

C. Seasonality: This suite of metrics is ideally assessed during the latter third of the growing season, when all plant layers have developed to their full extent.

4.4.1.1 Submetric A: Number of Plant Layers Present

The first submetric of the Plant Community Metric is the Number of Plant Layers Present in the AA. This submetric does not pertain to Vernal Pools or Playas. Plant layers play a large role in the assessment of the biotic structure attribute. They are distinguished from one another by the differences in average maximum heights of their co-dominant plant species. To be counted in CRAM, a layer must cover at least 5% of *the portion of the AA that is suitable for the layer*. This would be the littoral zone of lakes and depressional wetlands for the one aquatic layer, called “floating.” The “short,” “medium,” and “tall” layers might be found throughout the non-aquatic areas of each wetland class, except in areas of exposed bedrock, mudflat, beaches, active point bars, etc. The “very tall” layer is usually expected to occur along the backshore, except in forested wetlands.

It is essential that the layers be identified by the actual plant heights (i.e., the approximate maximum heights) of plant species in the AA, regardless of the growth potential of the species. For example, in a riverine system a young sapling redwood between 0.5 m and 1.5 m tall would belong to the “medium” layer, even though in the future the same individual redwood might belong to the “very tall” layer. Some species might belong to multiple plant layers. For example, groves of red alders of all different ages and heights might collectively represent all four non-aquatic layers in a riverine AA. Riparian vines, such as wild grape, might also dominate all of the non-aquatic layers.

Standing (upright) dead or senescent vegetation from the previous growing season can be used in addition to live vegetation to assess the number of plant layers present. However, the lengths of prostrate stems or shoots are disregarded. In other words, fallen vegetation should not be “held up” to determine the plant layer to which it belongs. The number of plant layers must be determined based on the way the vegetation presents itself in the field.

4.4.1.2 Submetric B: Number of Co-dominant Species

The second submetric, Number of Co-dominant Species, deals directly with dominant plant species richness in each plant layer and for the AA as a whole. For each plant layer in the AA, all species represented by living vegetation that comprises at least 10% relative cover within the layer are considered to be dominant. Only living vegetation in growth position is considered in this metric. Dead or senescent vegetation is disregarded.

The investigator lists the names of all co-dominant plant species in each layer. The list is used to determine the total number of co-dominant species for all the layers that are represented in the AA. Some species, such as wild grapes and poison oak, can dominate multiple layers. Even though such plants provide have functional differences between layers, they should only be counted once when calculating the Number of Co-dominant Species for the AA. No matter how many layers a given species dominates, it should only be counted once as a co-dominant.

4.4.1.3 Submetric C: Percent Invasion

For the third submetric, Percent Invasion, the number of invasive co-dominant species for all plant layers combined is assessed as a percentage of the total number of co-dominants, based on the results of the Number of Co-dominant Species sub-metric. The invasive status for many California wetland and riparian plant species is based on the Cal-IPC list. However, the best professional judgment of local experts may be used instead to determine whether or not a co-dominant species is invasive. If the status cannot be determined in the field, then a voucher specimen and field photographs of the plants in question should be used in conjunction with the Jepson Manual (Baldwin, et al. 2012) or in consultation with appropriate experts to determine invasive status.

4.4.1.4 Submetric C (vernal pools): Endemic Species Richness

This submetric only applies to Vernal Pools and Vernal Pool Systems. These wetlands are distinguished from all other wetland types by a unique endemic flora. This submetric is based on the total number of endemic plant species that appear in the AA as listed in the CRAM Vernal Pools Plant List.

4.4.2 Metric 2: Horizontal Interspersion

A. Definition: Horizontal biotic structure refers to the variety and interspersion of plant "zones." Plant zones are plant monocultures or obvious multi-species associations that are arrayed along gradients of elevation, moisture, or other environmental factors that seem to affect the plant community organization in plan view. Interspersion is essentially a measure of the number of distinct plant zones and the amount of edge between them.

B. Rationale: The existence of multiple horizontal plant zones indicates a well-developed plant community and predictable sedimentary and bio-chemical processes. The amount of interspersion among these plant zones is indicative of the spatial heterogeneity of these processes. Richer native communities of plants and animals tend to be associated with greater zonation and more interspersion of the plant zones.

C. Seasonality: This metric is not sensitive to seasonality.

4.4.3 Metric 3: Vertical Biotic Structure

A. Definition: The vertical component of biotic structure assesses the degree of overlap among plant layers. The same plant layers used to assess the Plant Community Composition metrics are used to assess Vertical Biotic Structure. To be counted in CRAM, a layer must cover at least 5% of the portion of the AA that is suitable for the layer. This metric does not pertain to Vernal Pools, Vernal Pool Systems, or Playas.

B. Rationale: The overall ecological diversity of a wetland tends to correlate with the vertical complexity of the wetland's vegetation. For many types of wetlands in California, overlapping layers of vegetation above or below the water surface contribute to vertical gradients in light and temperature that result in greater species diversity of macroinvertebrates, fishes, amphibians, and birds. In riparian areas, the species richness of birds and small mammals tends to increase with the density and number of well-developed, overlapping plant layers. Many species of birds that nest near the ground or water surface in wetlands commonly require a cover of vegetation at their nest sites. Multiple layers of vegetation also enhance hydrological functions, including rainfall interception, reduced evaporation from soils, and enhanced filtration of floodwaters.

In many depressional wetlands and some wet meadows, the detritus of above-ground growth of low and medium layers of herbaceous plants and emergent monocots tends to get entrained within the layers as an internal canopy below the maximum height of the upper plant layer. These "entrained canopies" serve as cover for many wildlife species.

In estuarine wetlands, the entrained canopies entrap debris including coarse plant litter that is lifted into the canopies by rising tides. As the tide goes out, the material is left hanging in the plant cover. Over time, these entrained canopies can gain enough density and thickness to provide important shelter for many species of birds and small mammals that inhabit estuarine wetlands. Most passerine birds and rails that nest in estuarine wetlands choose to nest below an entrained canopy because it protects them from avian predators, including owls and harriers.

C. Seasonality: This metric should be assessed late during the growing season.

CHAPTER 5:
GUIDELINES TO COMPLETE STRESSOR CHECKLISTS

A. Definition: For the purposes of CRAM, a stressor is an anthropogenic perturbation within a wetland or its setting that is likely to negatively impact the functional capacity of a CRAM Assessment Area (AA). In contrast, disturbances are distinctly defined as natural phenomena, although they might have similar impacts as stressors.

B. Rationale: Physical and biological processes connect wetlands to their environmental settings and thus help shape wetland conditions, which are therefore influenced by land use practices within the settings (Frissell *et al.* 1986, Roth *et al.* 1996, Scott *et al.* 2002). Wetland conditions can also be affected by stressors operating directly within the wetlands, although these tend to be less abundant than stressors originating in the surrounding landscape.

The purpose of the Stressor Checklist is to identify stressors within a CRAM Assessment Area (AA) or its immediate vicinity that might help account for any low CRAM scores. In some cases, a single stressor might be the primary cause for low-scoring conditions, but conditions are usually due to interactions among multiple stressors (USEPA 2002).

There are four underlying assumptions of the Stressor Checklist: (1) stressors can help explain CRAM scores; (2) wetland condition declines as the number of stressors acting on the wetland increases (there is no assumption that the decline is additive (linear), non-linear, or multiplicative); (3) increasing the intensity or the proximity of the stressor results in a greater decline in condition; and (4) continuous or chronic stress increases the decline in condition.

C. Seasonality: The Stressor Checklist is not sensitive to seasonality.

D. Office and Field Indicators: The process to identify stressors is the same for all wetland types. For each CRAM attribute, a variety of possible stressors are listed. Their presence and likelihood of significantly affecting the AA are recorded in the Stressor Checklist Worksheet. For the Hydrology, Physical Structure, and Biotic Structure attributes, the focus is on stressors operating within the AA or within 50 m of the AA. For the Buffer and Landscape Context attribute, the focus is on stressors operating within 500 m of the AA. More distant stressors that have obvious, direct, controlling influences on the AA can also be noted.

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APPENDIX I: GLOSSARY

aggradation – filling and raising of the level of the bed of a stream by deposition of sediment; the opposite of degradation

algal mat- macroalgae occurring on the water surface of a wetland.

allochthonous – external source of energy (carbon) for a stream (e.g., dead leaves, branches, and dead trees that fall into the river)

alluvial – refers to natural, channelized runoff from terrestrial terrain and the material borne or deposited by such runoff

anthropogenic – arising from human activity

aquatic area abundance- for the purposes of CRAM, a measure an aquatic area's spatial association with other areas of aquatic resources, such as other wetlands, lakes, streams, etc. For riverine systems, this metric is scored as the continuity of the riparian corridor over a prescribed distance upstream and downstream of the CRAM Assessment Area (AA).

arcuate- shaped or bent like an arc or bow (i.e. broadly curving)

assessment area – the portion of a wetland or riverine system that is the subject of the CRAM evaluation

assessment window – the period of time when assessments of wetland condition should be conducted. In general, it is during the growing season for the characteristic plant community of the wetland type to be assessed.

attribute – attributes constitute the obvious, universal aspects of wetland condition; CRAM recognizes a total of four attributes of condition within a wetland: (1) buffer and landscape context; (2) hydrology; (3) physical structure; and (4) biotic structure.

avulsion – sudden shift or movement of fluvial flow entirely or in part from one channel to another, less sinuous and steeper channel. Avulsions are typically formed during large storm events when high discharge erodes a new channel in the floodplain. Avulsions are more common in braided or aggrading stream channels.

backshore- the boundary between the wetland and the adjoining upland, where the upland is at least 5m wide. The high-water contour of the wetland is a good proxy for its backshore boundary.

bankfull – height of fluvial flow corresponding to the floodplain. This is the stage when water in the channel just begins to flow onto the floodplain.

bank slump- a portion of a bank that has broken free from the rest of the bank but has not eroded away

bar – a transient sedimentary feature within an intertidal and fluvial channel that is often exposed during low-water periods. Bars direct flows and form along the inside of a meander bend (point-bar) or in the middle of straight channel reach (in-channel bar). They are convex in profile and are comprised of alluvial or tidal deposits of sand, gravel, cobble, or other material. Their surface material varies in size from small on top to larger along their lower margins and they sometimes support vegetation.

barrier beach – a natural area of sand or gravel along a lacustrine, marine or estuarine shore that blocks the landward action of tides or waves

benthic – pertaining to the sea bed, river bed, or lake floor

berm- A flat strip of land, raised bank, or terrace bordering a wetland. Berms can be natural or artificial in origin.

borrow ditch-a ditch dug along a roadway to furnish fill and provide drainage

boulder- a size category of rock having a long axis greater than 25 cm

braided – a stream that forms an interlacing network of branching and recombining channels separated by floodplains, channel bars, or islands

buffer – for the purposes of CRAM, the area extending from the immediate edge of the AA that is in a natural, or semi-natural, state and protects the AA from stressors

catchment – synonymous with watershed. An area of land, bounded by a drainage divide, which drains to a fluvial channel or water body.

channel- a feature in tidal and fluvial systems consisting of a bed, its opposing banks, plus its floodplain, that confines and conveys surface water flow. The system of diverging and converging channels that characterize braided and anastomosing fluvial systems usually consist of one or more main (primary) channels plus secondary channels.

channel stability- a measure of the degree of channel aggradation (i.e. net accumulation of sediment on the channel bed causing it to rise over time) or degradation (i.e. net loss of sediment from the bed causing it to be lower over time).

coarse woody debris- a single piece of woody material, greater than 30 cm in diameter and greater than 3 m long

cobble-a size category of rock having a long axis from about 6 cm to about 25 cm

condition – condition is defined as the ability of a wetland to maintain its complexity and capacity for self-organization with respect to species composition, physio-chemical characteristics, and functional processes, relative to healthy wetlands of the same type. There are three primary aspects of condition: location, form, and structure.

confinement – the degree to which levee, terraces, or hillsides prevent the lateral migration of a fluvial channel

crenulated- having a margin that is very finely indented, notched, or with rounded (scalloped), projections, as in a crenulated foreshore of a wetland.

culvert- a drain or covered channel that crosses under a road, railway, etc.

debris jam – an accumulation of material, organic or inorganic, floating or submerged, that has been lodged into place by the action of a flowing water. Debris jams partially or completely obstruct surface water flow and sediment causing a change in the course of flow.

deciduous – plants (trees and shrubs) that shed all of their leaves annually, such that there is a time each year at which individuals of the species are essentially devoid of leaves

deposition – the settlement of materials out of moving water and onto the bed, banks, or floodplain of a wetland or riverine channel.

degradation – the long-term lowering of a fluvial channel due to erosion of its bed

detritus – deposition of newly dead or decaying organic matter

disturbance – the consequence of natural changes in forcing functions, or controlling factors, through space and over time; disturbance is natural, regardless of its frequency, persistence, or magnitude

drop structure- an artificial structure, typically small and built on streams with steep gradients, to pass water to a lower elevation while controlling the energy and velocity of the water as it passes over.

dryland farming-a system of growing crops in arid or semiarid regions without artificial irrigation, by reducing evaporation and by special methods of tillage.

duff – a spongy layer of decaying leaves, branches, and other organic materials along a wetland shore or in a riverine riparian area

ecological services – the services, or beneficial uses, for which a wetland can be managed; key ecological services for many types of wetland include flood control, groundwater recharge, water filtration, conservation of cultural values, aesthetics, and the support of special-status species.

emergent vegetation - plant species typically growing on saturated soils or on soils covered with water for most of the growing season; the leaves of emergent aquatic species are partly or entirely borne above the water surface; examples of such species include *Rorippa nasturtium-aquaticum* (watercress) and *Schoeneoplectus californicus* (tule, bulrush).

entrenchment – the inability of flows in a channel to exceed the channel banks (i.e. the vertical containment of stream); a measure of the degree to which fluvial flood flows are contained within channel banks without access to the effective valley. Entrenchment as a field measurement is calculated as the flood-prone width divided by the bankfull width.

effective valley width – the portion of a valley within which its fluvial channel is able to migrate without cutting into hill slopes, terraces, man-made levees, etc.

floodplain – the bench or broader flat area of a fluvial channel that corresponds to the height of the bankfull flow. It is a relatively flat depositional area that is periodically flooded, as evidenced by deposits of fine sediment, wrack lines, vertical zonation of plant communities, etc.

flood prone - land susceptible to inundation by extreme flood events. The height of the flood prone area approximately corresponds to twice bankfull height.

fluvial – of, relating to, or happening in, a river or stream

forb – a plant with a soft, rather than permanent, woody stem that is not a grass or grass-like

foreshore- the boundary between the vegetated wetland and any adjoining semi-aquatic, non-wetland area, such as an intertidal flat or a non-vegetated riverine channel bar, or a fully aquatic area such as the open water area of a lake or estuary that is at least 30m wide.

free-floating – plants that float at or just beneath the water surface without attachment to the substrate; free-floating aquatic species are transported freely by wind and water currents

function – for the purposes of Level 2 assessment, a function is something that a wetland stream or riparian area does. For example, groundwater recharge, flood-stage desynchronization, pollution filtration, wildlife support, and recreation are wetland functions. In this context, functions are identified separately from the processes that cause them to happen. In most cases, Level 3 tools are needed to assess the processes that account for functions.

herbaceous – a plant having stems that are not secondarily thickened and that die down annually

headcut- an erosional feature of some streams where an abrupt vertical drop in the stream bed occurs. The process of headcutting involves the initiation of channel incision at a nick point as the stream channel bed elevation adjusts to a natural or human induced disturbance. In flowing streams, head cuts resemble a small waterfall. A small plunge pool may be present at the base of the head cut due to the high energy of falling water. When not flowing, the head cut will resemble a very short cliff or bluff in the stream channel.

hummock – a mound composed of organic materials (typically less than 1m high) along the banks and floodplains of fluvial systems created by the collection of sediment and biotic material around wetland plants such as sedges.

hydrologic connectivity- a measure of the ability of water to flow into or out of the wetland, or to accommodate rising flood waters without persistent changes in water level that can result in stress to wetland plants and animals

hydroperiod- the characteristic frequency and duration of inundation or saturation of a wetland during a typical year

hyporheic – saturated zone under a river or stream, comprising substrate with the interstices filled with water

knick point – an abrupt change of gradient in the profile of a stream or river, typically due to a change in the rate of erosion. This is the point where the stream is actively eroding the streambed to a new base level; nick points tend to migrate upstream. See definition for *headcut.*

in-channel bar- a transient sedimentary feature within an intertidal or fluvial channel that forms in the middle of straight channel reach.

interfluve – the region of higher land between two fluvial channels or swales on a floodplain or in a braided channel system

interspersion-a measure of the number of distinct patches (as in plant zones) and the amount of edge between them.

invasive – species that have been introduced from other regions by the actions of people and that exhibit a tendency to significantly displace native species, hybridize with native species, alter biological communities, or alter ecosystem processes.

litter- a layer of organic matter (partly decomposed leaves, twigs, etc) on the ground.

littoral zone – the nearshore area of a water body, where it is sufficiently shallow to allow light to penetrate to the bottom and reach rooted vegetation; corresponds with the limit of submerged aquatic vegetation

meander – the curves of a fluvial or tidal channel as viewed from above; a meander cutoff is a new, shorter channel across the narrow neck of a meander

metric – a measurable component of a CRAM attribute

muted- pertaining to an estuarine tidal regime in which the fluctuation of the water level is lower in amplitude than would be expected due to levees, culverts, tide gates, or other artificial devices which inhibit the exchange of water between the site and the tidal body. These obstructions reduce the range of tides but still allow frequent inundation and exposure.

natural levee – a low ridge landward of the active floodplain of a channel that forms by deposition during flood events.

nonpoint source discharge- any discharge to a wetland resulting from diffuse sources (e.g. land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification). Includes any type of discharge that does not meet the legal definition of "point source" (see definition below)

organic – pertaining to, or derived from, living organisms, or to compounds containing carbon as an essential component

panne – a shallow topographic basin that forms on a fluvial floodplain or tidal marsh plain. Pannes lack vegetation but exist on a well-vegetated wetland plain and fill with water at least seasonally due to overland flow.

patch – a spatially distinct structural element of a wetland system large enough to serve as habitat for wildlife, or to serve as an indicator of spatial variations in hydrological or edaphic (soil) conditions within a wetland

planar bed- a reach of a stream characterized by long, relatively straight channel of uniform depth

periphyton – benthic algae that grow attached to surfaces such as rocks or larger plants

point-bar- a transient sedimentary feature within an intertidal and fluvial channel that form along the inside of a meander bend

point-source discharge- any discernible confined and discrete conveyance (e.g. a pipe, ditch, channel, or conduit) from which pollutants are or may be discharged into a waterway. This term does not include agricultural storm water discharges and return flows from irrigated agriculture.

pool (on floodplain)- a shallow topographic basin on a fluvial floodplain or tidal marsh plain that has been inundated by water.

pool (in channel)- a depression within a fluvial or tidal channel that is much deeper than the average depth of the channel. Pools tend to retain water longer than other areas of the channel during periods of low or no surface flow.

POTW-publicly-owned treatment work; a term used in the United States for a sewage treatment plant that is owned, and usually operated, by a local government agency. They are usually designed to treat domestic sewage and not industrial wastewater.

primary channel-a channel in fluvial and tidal systems that conveys the majority of the surface water flow

rating – for a CRAM metric, a rating represents its state relative to the full range of possible states, from worst possible state to best

reach – a length of stream, lacustrine shore, or estuarine shore that has generally consistent physical and biological characteristics

riffle or rapid – a submerged, topographical high area in a fluvial channel created by the accumulation of relatively coarse-grained sediment (gravel, cobble, or boulders) causing turbulent surface flow and indicated by standing waves

riparian – a transitional area between terrestrial and aquatic ecosystems, distinguished by gradients in biophysical conditions, ecological processes and biota; areas through which surface and subsurface hydrology connect water bodies with their adjacent uplands, including those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems; riparian areas are adjacent to perennial, intermittent, and ephemeral streams, lakes and estuarine-marine shorelines (National Research Council 2002).

riprap- broken stones loosely deposited in water or on a soft bottom to provide a foundation and protect a riverbed or river banks from scour: used for revetments, embankments, breakwaters, etc.

run – a reach of straight, smooth, fast-moving fluvial flow between riffles; also called a glide

scour – concentrated erosive action of flowing water in streams that removes and carries away material from the bed and banks

secondary channel-a channel in fluvial and tidal systems that conveys flood flows, but not the majority of the flow

sediment – organic or inorganic material that has been transported and/or deposited by wind or water action. Sediment can be coarse (i.e., gravel or larger) or fine (i.e. clay, silt, sand). A fresh splay of sediment is one that has been deposited during the current or previous season's runoff event.

sediment mound- a depositional feature (typically less than 1m high) along the banks and floodplains of fluvial systems formed from repeated flood flows depositing sediment on the floodplain. Sediment mounds lack plant cover.

slough – a large tidal channel, or a large fluvial channel lacking an obvious terminal water body, can also refer to an abandoned fluvial channel within the effective valley

snag – a standing, dead tree or shrub at least 3 m (10 feet) tall

sorting-a measure of the spread of particle size in the substrate. Well-sorted particles are made up of similarly sized particles. Poorly sorted particles are made up of a wide variety of different particle sizes.

stress – the consequence of unnatural, anthropogenic changes in forcing functions or controlling factors; key stressors are anthropogenic actions that tend to modify the quantity and/or quality of physical or biological habitat, sediment supplies, and/or water supplies upon which the desired functions of the wetland depend

stressor – an agent that inflicts stress on a wetland

submerged or submergent vegetation - plant species that are adapted to spending their lifespan, from germination to fruiting, completely or nearly completely under water. Submerged vegetation consists of aquatic macrophytes such as *Elodea canadensis* (common elodea), *Ruppia cirrhosa* (ditchgrass), and *Zannichellia palustris* (horned pondweed) that are rooted in the sub-aqueous substrate but do not usually grow high enough in the overlying water column to intercept the water surface.

swale –broad, elongated, vegetated, shallow depressions that can sometimes help to convey flood flows to and from vegetated marsh plains or floodplains. However, they lack obvious banks, regularly spaced deeps and shallows, or other characteristics of channels. Swales can entrap water after flood flows recede. They can act as localized recharge zones and they can sometimes receive emergent groundwater.

thalweg – the line connecting the lowest or deepest points along the riverbed

thatch- a matted layer of partly decayed leaves, stems, etc. between growing vegetation and the soil.

tide gate- an opening through which water may flow freely when the tide sets in one direction, but which closes automatically and prevents the water from flowing in the other direction.

transportation corridor- a linear pathway for a particular mode of transportation (highway, road, rail, canal, etc.)

tributary- a type of secondary channel that originates in the wetland and only conveys flow between the wetland and the primary channel. Short tributaries that are entirely contained within the CRAM Assessment Area (AA) are regarded as secondary channels.

undercutting- the removal of material at the base of a streambank or shoreline of a wetland by the erosive action of flowing water

unnatural levee- an artificially raised embankment along a wetland that constrains water flows. Their primary purpose is to provide hurricane, storm, and flood protection relating to seasonal high water, storm surges, precipitation, and other weather events.

variegated- having variety in form. As viewed from above, a variegated shoreline resembles a meandering pathway. Variegated shorelines provide greater contact between water and land.

island- an area of land above the usual high water level and, at least at times, surrounded by water. Islands differ from hummocks and other mounds by being large enough to support trees or large shrubs.

vegetation management-the practice of manipulating vegetation within a prescribed management area. Includes prescribed burning, grazing, chemical applications, timber harvesting, and any other economically feasible methods of enhancing, retarding, or removing the above-ground parts of plants.

wetlands – lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water; wetlands must have one or more of the following attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is saturated with water or covered by shallow water at some time during the growing season of each year (Cowardin *et al.* 1979).

wier- a small overflow barrier used to alter the flow characteristics of a river or stream. Weirs are commonly used to prevent flooding, measure discharge, and to help render a river navigable.

wrack or wrackline – an accumulation of natural floating debris (kelp, plastic debris, wood, and similar material) left along the shore of a river, lake, tidal marsh, or other water body by high water levels

xeric – characterized by an extremely dry habitat

zonation – distribution of plants or animals arranged in zones or bands, caused by gradations of abiotic and/or biotic factors

APPENDIX II: ACRONYM LIST

AA	Assessment Area
Cal-IPC	California Invasive Plant Council
CDFW	California Department of Fish and Wildlife
CEDEN	California Environmental Data Exchange Network
CNDDB	California Natural Diversity Database
CRAM	California Rapid Assessment Method for Wetlands
CWMW	California Wetland Monitoring Workgroup
DOQQ	Digital Orthogonal Quarterly Quadrangles
eCRAM	A web-based data submission tool for CRAM
GIS	Geographic Information System
HEP	Habitat Evaluation Procedure
HGM	Hydrogeomorphic Functional Assessment Method
IBI	Index of Biotic Integrity
JD	Jurisdictional Delineation
NAIP	National Agriculture Imagery Program
NGO	Non-governmental Organization
NHD	National Hydrography Dataset
NRC	National Research Council
NWI	National Wetlands Inventory
ORAM	Ohio Rapid Assessment Method
PI	Principal Investigator
PSR	Pressure-State-Response Model
QA/QC	Quality Assurance/Quality Control
RDC	Regional Data Center
SWAMP	Surface Water Ambient Monitoring Program
SWRCB	State Water Resources Control Board
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
WADOE	Washington State Department of Ecology

WRAMP	Wetland and Riparian Area Monitoring Plan
WRAP	Wetland Rapid Assessment Procedure
WRAPP	Wetland and Riparian Area Protection Policy