A Framework for Salt/Nitrate Source Identification Studies

Prepared by: CV-SALTS Knowledge Gained Subcommittee for CV-SALTS Technical Advisory Committee

December 15, 2011

tomg 12/15/11 11:09 AM
Deleted: November 30

1. Introduction

At the April 22, 2011 Executive Committee Meeting, the Knowledge Gained Subcommittee presented a technical memorandum, dated April 15, 2011, to the Executive Committee outlining a framework for preparing salt/nitrate source identification studies. The Executive Committee approved the basic elements provided in the memorandum and directed the Knowledge Gained Subcommittee to complete a more detailed framework document. This document provides the more detailed framework for preparing regional-scale salt/nitrate source identification studies in the Central Valley, as requested by the Executive Committee. These studies would be completed as an element of salt and nutrient management plan development in the Central Valley. An overarching conceptual framework for preparation of salt and nitrate management plans in the Central Valley will be developed in the future by the CV-SALTS Technical Advisory Committee.

Our recommendation is that salt/nitrate source identification studies be conducted in a phased manner that utilizes best available information and tools to promote cost-effective and timely evaluations, and to provide an opportunity for on-going stakeholder input to that process. We have developed a suggested approach for preparing "Initial Studies" consisting primarily of initial data gathering and simplified conceptual modeling to establish preliminary water budgets and salt/nitrate balances for each identified Study Area.[1]

The Knowledge Gained Subcommittee recommends that the Initial Studies include basic information about known sources of salt and nitrate, land uses, areas of contamination and impairment, recycled

[1] We use the term "Study Area" throughout the document to define planning areas within the Central Valley. At this point we have not attempted to define Study Areas beyond thinking of them as small enough to be effectively managed and modeled. The framework described herein is intended to guide regional-scale salt/nitrate source identification studies and is not necessarily applicable to source identification studies that would be accomplished on a facility- or municipal-scale basis, although much of this framework is scalable for those applications. [Note: To complete the Initial Studies described in this memo, a delineation of Study areas must be completed]

tomg 12/15/11 11:19 AM
Deleted: 1

tomg 12/15/11 11:19 AM
Deleted: 30

water and groundwater recharge projects, regulatory constraints, and past or ongoing local planning programs and monitoring pertaining to the management of salt and nitrate within the Study Area. [2] Such basic information will be useful to Stakeholders for characterizing and categorizing identified Study Areas and evaluating the need and scope for subsequent "Follow-up Studies"[3] needed to support the development of Salt and Nitrate Management Plans.

2. Technical Study Goals

The goals, or general statements of intent, of the salt/nitrate source identification studies[4] , as an element of the overall Salt and Nutrient Management Plans, are to provide data and information that can contribute to:

- Characterization and categorization of identified Study Areas throughout the Central Valley;
- An understanding of the linkages between Study Areas;
- Prioritization of potential salt/nitrate management practices;
- Support for Salt and Nitrate Management Plans required by the Recycled Water Policy;
- Support for appropriate changes to beneficial use and water quality objective changes; and
- Support for proposed Basin Plan amendments.

3. Technical Study Objectives

Technical objectives define the strategies or steps to attain the identified goals. To provide flexibility to the parties performing the studies, these objectives are general in nature. Steps for performing studies that comply with these objectives are described in later sections of this document.

The key technical objectives for an Initial Study are:

1. Develop a conceptual model for the Study Area including identification of sources, sinks, and transformation processes necessary for the development of water budgets and salt/nitrate mass balances;

[2] Such information does not include detailed evaluations of the current management and policy issues in Study Areas. However, we recognize the value and need for such evaluations and recommend that they be completed simultaneously with, but separate from, the Initial Studies. Ultimately, salt/nitrate source identification studies must consider these topics/issues to be relevant.

[3] At this point, a detailed approach for preparing subsequent "Follow-up Studies" has not been developed because the specific scopes of such additional studies will depend on the Initial Study results and region-specific management and policy issues for the Study Area.

[4] The term "salt/nitrate source identification studies" is a general term, and refers to both the Initial Studies and Follow-up Studies.

tomg 12/15/11 11:19 AM
Deleted: 1

tomg 12/15/11 11:19 AM
Deleted: 30

2. Characterize the current understanding of the movement of water and salt/nitrate into and out of neighboring Study Areas;
3. Develop preliminary water budgets and salt/nitrate mass balances using available information;
4. Identify potential management strategies;
5. Make a preliminary estimate of the rate of salt/nitrate accumulation or reduction in the unsaturated zone, surface water, and groundwater within a Study Area;
6. Analyze historical and projected salt /nitrate loading rates and concentrations for surface water and groundwater within the Study Area in cases where these loads can be quantified; and
7. Identify and evaluate data gaps, data sensitivity, default assumptions, and data limitations for the Study Area.

Follow-up Studies will likely be needed for a Study Area based upon stakeholder review of Initial Study results and the region-specific management and policy issues for the Study Area[5]. Technical objectives for the Follow-up Studies include:

1. Delineate the lateral and vertical extents of regions within a Study Area where beneficial uses are being or have been impaired by salt/nitrate accumulation, or are vulnerable to such impairment;
2. Determine current and legacy salt/nitrate sources that may have contributed to beneficial use impairment and refine the estimates of the salt/nitrate load contribution of each source;
3. Assess the fate and transport of salt and nitrate in soil, surface water, and groundwater, including surface water mixing, denitrification and preferential migration pathways (e.g., presence or absence of low permeability strata, proximity of irrigation or potable supply wells);
4. Ensure compliance with the salt and nutrient management plan requirements of the Recycled Water Policy; and
5. Characterize temporal and spatial variations in salt/nitrate loads that may influence salt and nitrate management strategies and the implementation of new or improved management practices, e.g. the Real Time Management Program of discharges to the San Joaquin River.

4. Technical Study Approach

Studies should be conducted in a phased approach to promote cost-effective evaluations and provide an opportunity for stakeholder input at intermediate points in the technical study process.

Initial Studies should be completed for all Study Areas. They should consist of the initial data gathering and simplified conceptual modeling to determine preliminary water budgets and salt/nitrate balances. The Initial Studies should also include the collection of additional information about known contamination and impairments, recycled water and groundwater recharge projects, regulatory

[5] The study area for any Follow-up Study should be the same as the study area for the Initial Study.

tomg 12/15/11 11:19 AM
Deleted: 1

tomg 12/15/11 11:19 AM
Deleted: 30

constraints, and local planning, monitoring and management programs pertaining to salt and nitrate within the Study Area.

INITIAL STUDIES

Step 1: Study Area Delineation and Characteristics - The first step in an Initial Study is a clear delineation of the Study Area and a description of Study Area characteristics. All studies should pertain to a clearly defined Study Area, with horizontal and vertical boundaries that are consistently used as the frame of reference for all subsequent evaluations. Considerations in establishing boundaries should include natural hydrological boundaries (watersheds and groundwater basins), water supply and wastewater infrastructure, boundaries for application of existing salt/nitrate water quality objectives or TMDL wasteload/load allocations, land use characteristics, data availability and coverage in compatible GIS format, availability and extent of existing surface and groundwater modeling tools, and boundaries of existing planning entities such as counties, water districts, agricultural coalitions, and Integrated Regional Water Management (IRWM) planning areas. An advantage to selecting Study Areas based on natural hydrological boundaries may be a reduction in the cost and amount of time it takes to develop water budgets and salt/nitrate mass balances. On the other hand, use of political boundaries may better define a sustainable management area that engages appropriate stakeholders and capitalizes on existing planning efforts and tools. Study area characteristics that should be described include land use, surface and groundwater quality, climate, physiography, geology, hydrology, and hydrogeology. GIS should be used to delineate Study Areas and Study Area features to promote consistency between Study Areas and to incorporate geo-spatial information into the conceptual model.

Step 2: Screening Existing Analytical Tools – The second step consists of choosing the appropriate analytical tool(s) for the evaluation and should include screening publicly available analytical tools, including GIS-based inventories and mapping approaches, watershed models and surface and groundwater simulation models, which cover the region of interest. The tools should be evaluated to assess the appropriateness of their use, including the development of a strategy for using these analytical tools to meet the objectives of identifying the occurrence and movement of salt and nitrate into, within, and from the selected study area (including all components of the hydrologic system), to produce the desired water and salinity budgets within the chosen region, and to identify potential management strategies. Making use of existing models, in particular those that are calibrated and well-documented, can save considerable time and lend credibility to the water and salinity budget analysis. However, care should be taken to understand the conceptual basis of any model selected. Appendix A provides more detail on the types of models available and the issues that must be considered during the selection process.

Step 3: Preliminary Water Budgets - The third step in an Initial Study is the development of preliminary water budgets.[6] A water budget is the characterization and accounting of inputs (water sources),

[6] More than one water budget may need to be developed to capture variability in water volumes and management strategies attributable to different hydrologic conditions (e.g., wet, above normal, below normal, dry, and critical

tomg 12/15/11 11:11 AM
Deleted: is the

tomg 12/15/11 11:11 AM
Deleted: of

tomg 12/15/11 11:22 AM
Deleted: It also allows comparisons to previous studies, which helps to validate the analysis, especially if the previous studies were well accepted. Linkage or integration of surface, groundwater and water quality models is desirable if this linkage allows more thorough tracking of basin hydrology and if the models are capable of exchanging component hydrology and water quality information in a prescribed manner. For example, the WARMF model is designed for simulation of natural soil layers within a few meters of the surface, including the root zone. Tile drainage and percolation to the deeper groundwater system are important processes in the San Joaquin River watershed. Adaption of WARMF to simulate these processes requires careful application of the model by an advanced WARMF modeler. Care should be taken to understand the conceptual basis of these models to avoid attempting to link models that are fundamentally incompatible. Attempting to force information exchange between models with different temporal (e.g. models with daily versus monthly time steps) or spatial (e.g. model layering) conceptual frameworks requires substantial project resources. When inadequately planned or funded, or when time allotted for completion of calibration/verification and other aspects of checking the modeling work is insufficient, the success of the overall analysis can be compromised. There is no substitute for careful and informed planning at this stage of the process to determine how the models that have been selected will be used to achieve program objectives, to determine the datasets available as inputs to each model, and to decide how outputs from “upstream” models will be mapped to the inputs to “downstream” models in the study framework. ... [1]

tomg 12/15/11 11:19 AM
Deleted: 1

tomg 12/15/11 11:19 AM
Deleted: 30

outputs (water sinks), and changes in water volume (e.g., groundwater elevation changes) for a defined Study Area. Examples of water sources and sinks are provided in the attached Salt/Nitrate Balance Study Evaluation Checklist (Table 1). The study also may need to identify constraints to the water budget as applicable[7] (e.g. permit terms, environmental regulations, risk management). *The development of accurate water budgets is the foundation of the salt/nitrate mass balances.*

Step 4: Preliminary Loads and Mass Balances - The fourth step in an Initial Study is the development of preliminary salt/nitrate loads and mass balances using available information. All salt/nitrate sources, sinks, concentrators and transformation processes are identified with appropriate quantitative, location, and associated land use data. Examples of salt/nitrate sources, sinks, and concentrators are provided in the attached Salt/Nitrate Balance Study Evaluation Checklist (Table 1). This information is used in conjunction with the water budgets to estimate salt/nitrate loads and to complete accompanying mass balances. Salt/nitrate loads being discharged to a particular water body are estimated by multiplying the flow volume of each discharge by its total dissolved solids (TDS) (or other measurement of salt concentration) and nitrate concentrations. For groundwater it will be necessary to define an appropriate unit of the aquifer system for purposes of analyzing assimilative capacity and to establish that there is an equivalent analysis of the groundwater data that is representative of that unit (e.g., it should not be assumed that the entire volume of groundwater in a basin/sub-basin is instantaneously and uniformly mixed).

Rudimentary salinity and nitrate budgets can be developed from these water budgets by assigning salinity and nitrate concentration values to hydrologic components of the surface and groundwater budgets. It needs to be recognized that salinity and nitrate accounting in the groundwater system is complex and poorly handled by many groundwater solute transport models. If a less rigorous approach is taken, care should be taken to document all model assumptions and to provide relevant water quality data that are the basis for these assumptions. Salinity budgets are only as good as the water budgets underlying them.

Whatever the approach taken - all data and assumptions relied upon to conduct the salt/nitrate mass balances should be clearly identified, inventoried (e.g., in the recommended database and GIS-based approach), and documented.

Step 5: Budget and Mass Balance Graphics - The fifth step in an Initial Study is to synthesize and create visualizations of water budget and salt/nitrate mass balance information. Data visualization should be done in consideration of salt/nitrate issues and regulatory endpoints so that stakeholders can determine if the studies are sufficient to accomplish the goals of the study (i.e., the goals established in Section 2 of

water year classifications, dry vs. rainy seasons). For surface water evaluations, a minimum of a monthly temporal scale for water budgets and salt/nitrate mass balances should be used. For groundwater evaluations, an annual, or if justified, longer temporal scale for water budgets and salt/nitrate balances should be used.

[7] It is critical to identify the water that may be consumed in the Study Area and that which passes through or remains in place.

tomg 12/15/11 11:19 AM
Deleted: 1

tomg 12/15/11 11:19 AM
Deleted: 30

this document) and facilitate development of regional Salt and Nutrient Management Plans that act together to protect or restore surface water and groundwater beneficial uses ultimately adopted in the Basin Plan.

The Knowledge Gained Subcommittee recommends that water budget and mass balance results be presented in a consistent manner and that uniform data visualization templates be developed by CV SALTS such that results of studies from different Study Areas can be compared and integrated.

Examples of recommended data visualization tools are water budget diagrams, mass balance diagrams, bar charts, pie charts, histograms and time series graphs. For consistency, we recommend that such data visualizations use the following units:

- Loading rates: tons/day, tons/month, or tons/year (depending on temporal scale of interest)
- Concentrations: mg/L
- Flow rates: acre-feet/day, acre-feet/month, or acre-feet/year (depending on temporal scale of interest)

The salt/nitrate source identification studies should contribute to the “common language” between regional Salt and Nitrate Management Plans, so as to enable regional management practices to be coordinated and not acting at cross-purposes to one another.

Step 6: Data Gaps and Limitations – The sixth step in an Initial Study is the Identification and evaluation of data gaps, data sensitivity, default assumptions, and data limitations for the Study Area.

FOLLOW-UP STUDIES

The nature and complexity of the necessary Follow-up Studies will vary depending on the situation. Additional investigations or computer modeling will likely be needed to refine water budgets, more accurately characterize temporal salt/nitrate concentration trends, evaluate salt/nitrate fate and transport, and help prioritize and implement management practices needed to meet (or attempt to meet) regulatory requirements (e.g., attainment of water quality objectives in local and downstream water bodies).

Follow-up Studies may include the following:

- Surface and groundwater modeling[8] to develop more refined water budgets, salt/nitrate mass balances, and for other complex analytical needs;

[8] It is critical that the strengths and weaknesses of the existing models be evaluated, particularly with respect to the work completed prior to the groundwater model development to physically characterize the coupling of storm water and groundwater systems. To the extent that complex surface water and groundwater flow dynamics are recognized for a sub-basin or planning and analysis unit with identified salt and nitrate issues, a flow model would allow for greater spatial and temporal differentiation, which is critical for salt and nitrate management.

tomg 12/15/11 11:19 AM
Deleted: 1
tomg 12/15/11 11:19 AM
Deleted: 30

- Evaluation of surface water bodies carrying the largest loads and regions within groundwater basins with the highest salt/nitrate concentrations;
- Evaluation of drivers of surface water and groundwater management, including land cover and land use decisions in the Study Area;
- Evaluation of land cover at current development level and at estimated build out (or through end of existing general plan coverage);
- Evaluation of current best land use and water resources management practices in the region; and
- Evaluation of current monitoring gaps and funding/schedule to address such gaps.

DATA COMPLETENESS AND ACCURACY

All data relied upon to conduct the studies should be clearly documented.

The reliability of the water budgets and salt/nitrate mass balances largely depends upon data completeness and accuracy. Data completeness and accuracy varies broadly throughout the Central Valley. Incomplete or conflicting data should be described, and actions needed to address such problems (e.g., using other assumptions supported by references needed to develop salt/nitrate loads and mass balances) should be documented.

Only data that has undergone quality assurance/quality control review should be used to conduct salt/nitrate source identification studies. Other data, considered but not used, should be clearly documented as being of lower quality. Sensitivity analyses should be conducted to determine whether data variability affects water budgets and salt/nitrate mass balances.

Assumptions will need to be made in cases where no data exist. All assumptions should be clearly identified and, whenever, possible, supported by references. **The Knowledge Gained Subcommittee recommends that CV SALTS develop a set of suggested default assumptions for use when data are not available. Sensitivity analyses can be used to determine whether default assumptions are appropriate, or whether additional data collection or studies are needed.**

5. Suggested Initial Study Outline

A suggested general outline for the Initial Study report, along with a brief description of each report section, is provided below. In addition, the attached Salt/Nitrate Balance Study Evaluation Checklist (Appendix B) provides more detail and should be reviewed and used in conjunction with the outline below. The recommended outline for each Initial Study report includes:

- Description of the Study Area and Physical Description of Regions: This section should include an overview of the study goals and objectives, the constituents addressed in the study, and any stakeholders participating in study. In addition, both written and graphical descriptions should

tomg 12/15/11 5:28 PM
Deleted: ttachment

tomg 12/15/11 11:18 AM
Deleted: 1

tomg 12/15/11 11:19 AM
Deleted: 1

tomg 12/15/11 11:19 AM
Deleted: 30

be provided of regional, watershed, and groundwater basin boundaries; areal extent of the region; climate, water sources, hydrology, geology, hydrogeology, and land use of the region.

- Data: This section should identify data sources, discuss data quality, limitations and sensitivity, and describe any assumptions used and the basis for those assumptions. Input databases should be summarized, and made available in digital format for more detailed review.

- Tools: This section should identify the analytical tools selected for the initial study and the evaluations conducted to ensure the appropriateness of the tools selected to meet the initial program objectives and to create the foundational basis for follow-up studies.

- Water Budgets: This section should include one or more preliminary water budgets that characterize the water dynamics and use of the region, at spatial and temporal scales that are appropriate for salt/nitrate management. This section should include a conceptual model of the budgets; discuss factors influencing the budgets; identify and quantify the significant surface and groundwater sources entering and pathways leaving the region; and should develop and discuss the water balances. All assumptions upon which the water budgets were based should be clearly identified, and the bases for the assumptions should be explained and, where possible, supported by references.

- Salt/Nitrate Loads and Mass Balances: This section should include preliminary salt/nitrate loads and mass balances that correspond to each water budget developed. This section should identify all significant salt/nitrate sources and sinks; quantify salt/nitrate loads associated with each source and sink; prioritize sources to soil, surface water and groundwater, and estimate the rate of salt/nitrate accumulation or loss and project groundwater TDS/nitrate concentrations into the future. Representative TDS/nitrate concentrations used to calculate salt/nitrate loads should be identified. All assumptions upon which the mass balances were based should be clearly identified, and the bases for the assumptions should be explained and, where possible, supported by references. Data gaps and recommended areas of further study, if needed, should be discussed.

- Additional Basic information: For each Study Area, additional basic information should be collected that will be needed for the overall CV-SALTS effort. This additional information should include a summary of:
  - Known contamination/impairment in the Study Area – this information could be obtained from individuals, organizations, or agencies familiar with water quality issues in the Study Area (e.g. County Environmental Health Departments, Integrated Regional Water Management Groups, water purveyors. water users)
  - Recycled water and groundwater recharge projects in effect or planned in the Study Area
  - Water quality objectives, beneficial uses, local planning objectives, and existing management

tomg 12/15/11 11:19 AM
Deleted: 1
tomg 12/15/11 11:19 AM
Deleted: 30

programs and strategies pertaining to salt and nitrate loads and concentrations within the Study Area, and

- Surface water and groundwater monitoring programs collecting flow, groundwater level, and salt and nitrate-related water quality data.

- Recommendations: This section should discuss follow-up studies appropriate to the selected study area. For example, more populated areas and /or areas with intensive and diverse land and water use will likely require more comprehensive analyses and modeling efforts with sufficient spatial and temporal detail to achieve adequate understanding of salt and nitrate occurrence, loading and movement and to implement effective management strategies.

tomg 12/15/11 11:19 AM
Deleted: 1

tomg 12/15/11 11:19 AM
Deleted: 30

Appendix A
Additional Considerations in the Selection of Modeling Tools

In the performance of salt/nitrate source identification studies, a recommended early step is the screening and evaluation of existing analytical tools. This appendix provides additional information regarding issues that should be considered during the model screening and selection process, drawing from lessons learned in the Central Valley.

The use of existing modeling tools, in particular those that are calibrated and well-documented, can save considerable time and lend credibility to source identification and water and salinity budget analysis. Use of existing models also allows comparisons to previous studies, which helps to validate the analysis, especially if the previous studies were well accepted.

Linkage or integration of surface, groundwater and water quality models is desirable if this linkage allows more thorough tracking of basin hydrology and if the models are capable of exchanging component hydrology and water quality information in a prescribed manner. For example, the WARMF model is designed for simulation of natural soil layers within a few meters of the surface, including the root zone. Tile drainage and percolation to the deeper groundwater system are important processes in the San Joaquin River watershed. Adaption of WARMF to simulate these processes requires careful application of the model by an advanced WARMF modeler. Care should be taken to understand the conceptual basis of these models to avoid attempting to link models that are fundamentally incompatible. Attempting to force information exchange between models with different temporal (e.g. models with daily versus monthly time steps) or spatial (e.g. model layering) conceptual frameworks requires substantial project resources. When inadequately planned or funded, or when time allotted for completion of calibration/verification and other aspects of checking the modeling work is insufficient, the success of the overall analysis can be compromised. There is no substitute for careful and informed planning at this stage of the process to determine how the models that have been selected will be used to achieve program objectives, to determine the datasets available as inputs to each model, and to decide how outputs from "upstream" models will be mapped to the inputs to "downstream" models in the study framework.

Cogent examples of these issues relevant to CV-SALTS surfaced in the initial Salt and Nitrate source study performed for CV-SALTS, the, as yet unpublished, US Bureau of Reclamation-sponsored west-side study, and the Delta Drinking Water Policy Technical Working Group's study of source influences in the Sacramento and San Joaquin watersheds. It should be noted that along with these lessons learned about the inherently complex studies of detailed source-sink relationships in a vast watershed, the power and utility of the tools employed were also strongly recognized in project conclusions.

tomg 12/15/11 2:38 PM
Formatted: Title

tomg 12/15/11 2:35 PM
Deleted: It

tomg 12/15/11 5:24 PM
Deleted: led by LWA

tomg 12/15/11 5:25 PM
Deleted: i

The different evapotranspiration computation algorithms utilized in the WARMF model and used in groundwater models such as IWFM and MODFLOW, and the difficulty in determining a groundwater model component analogous to the WARMF deep recharge, present challenges in linking the models together. Where these sorts of data exchange problems arise, it should be incumbent on the modeling team to document these problems and the remedies adopted. The difficulties of linking models within a modeling framework are usually underestimated. Models such as MODFLOW and IWFM have built-in water budget subroutines – known as ZONEBUDGET, in the case of the finite difference MODFLOW model, and Z-Budget, in the case of the finite element IWFM model. These water budget outputs have been further manipulated into customized spreadsheets for model applications such as WESTSIM into terms that stakeholders may be more familiar with and therefore able to provide critical feedback. For example expressing recharge, evapotranspiration and seepage for a pre-defined three dimensional "zone" in units of acre-ft/acre (depth of water) makes sense to an irrigator who tends to think in these terms.

tomg 12/15/11 5:26 PM
Deleted: –

Appendix B – Suggested Components of a Central Valley Salt/Nitrate Balance

tomg 12/15/11 3:06 PM
Deleted: ttachment 1

tomg 12/15/11 3:06 PM
Deleted: Comparison

tomg 12/15/11 3:07 PM
Deleted: Studies

The following checklist was prepared by the CV-SALTS Knowledge Gained Subcommittee to provide guidance regarding the tasks involved in the preparation of salt and nitrate balances for selected areas. The goal of the list is twofold: (1) to aid parties during the planning stage of a project to determine the type of information that may be appropriate to consider during their study; and (2) to summarize what information was gathered at the end of the study.

This checklist has been used in part to summarize reviews of two pilot studies that have been performed in the Central Valley and have been reviewed by the committee. One of the studies utilized the WARMF analytical model and the other utilized a spread sheet model. The reader is referred to the results of the review (narrative and checklist) and to the studies in question, all of which are posted on the CV-SALTS website (www.cvsalinity.org).

tomg 12/15/11 3:10 PM
Deleted: e

tomg 12/15/11 3:10 PM
Deleted: also

tomg 12/15/11 3:11 PM
Deleted: provides an evaluation of

tomg 12/15/11 3:13 PM
Deleted: , to see examples of the approaches that have been used to address the listed tasks.

Suggested Components of a Central Valley Salt/Nitrate Balance

			Study Aspects	
1	**Description of the Study and Physical Description of Study Area**			
	Identifies Stakeholders Participating in the Study			←○
	Identifies Goals and Objectives of the Study			←○
	Physical Description of Study Area			
		Describes physical boundaries of the Study Area		←○
		Describes the rationale for the physical boundaries		←○
		Applies physical boundaries to water, salt, and nitrate balances		←○
		Provides the areal extent (acreage) of the Study Area		←○
		Identifies watershed boundaries within and near the Study Area		←○
		Identifies groundwater subbasin boundaries within and near the Study Area		←○
		Identifies hydrologic areas (surface and groundwater) tributary to and from the Study Area		←○
		Describes Study Area geology		←○
		Describes Study Area hydrogeology		←○
		Describes current Study Area land use		←○
		Describes the Study Area climate		←○
		Identifies Study Area water sources		←○
		Are GIS shapefiles and data sources available for the following:		
			Physical boundaries of Study Area	←○
			Boundaries of watershed(s)	←○
			Boundaries of groundwater subbasin(s)	←○
			Surface water bodies	←○
			Land use	←○
2	**Data**			
		Presents and references all flow data used for the study		←○
		Presents and references all salt data used for the study		←○
		Presents and references all nitrate data used for the study		←○
		Evaluates and discusses data sensitivity		←○
		Identifies and quantifies data limitations, including accessibility and availability in useful format		←○
3	**Water Budget(s)**			
		Provides a conceptual model of the water budget(s)		←○
		Identifies and describes the water uses associated with various land uses		←○
		Defines and discusses an appropriate physical scale based on available data		←○
		Defines and discusses an appropriate temporal scale based on available data		←○
		Develops water budget(s) for dry, wet, and average conditions		←○
		Identifies and discusses the applicability of the following factors in the water budget:		
			assumed water usage used for different land use categories	←○
			hydrology	←○
			residence time factors	←○
			regulatory demands	←○
			habitat considerations	←○
			flood control	←○
			water supply variability	←○
		Identifes and discusses the applicability of the following elements in the water budget(s):		
			imported surface water	←○
			precipitation	←○
			land application of wastewater	←○
			wastewater discharges to surface water	←○

Suggested Components of a Central Valley Salt/Nitrate Balance

Study Aspects				
			residential irrigation	←○
3	**Water Budget(s) (continued)**			
			irrigation subsurface drainage	←○
			agricultural runoff	←○
			stormwater runoff	←○
			groundwater extraction	←○
			groundwater recharge	←○
			groundwater seepage to surface water	←○
			groundwater inflow from outside the Study Area	←○
			groundwater outflow from the Study Area	←○
			surface water inflow from outside the Study Area	←○
			surface water outflow from the Study Area	←○
			infiltration	←○
			evaporation	←○
			evapotranspitration	←○
		Defines terminologies used in the water budget(s)		←○
		Provides a written explanation of the water budget(s)		←○
		Identifies data gaps in the water budget(s) and recommends areas for further study		←○
		Provides a graphical representation of the water budget(s)		←○
		--Graphic identifies and quantifies all significant sources of inflow to the Study Area		←○
		--Graphic identifies and quantifies all water leaving the study area		←○
4	**Salt Balance(s)**			
		Provides a conceptual model of salt movement from sources to sinks in the Study Area		←○
		Develops salt balance(s) for dry, wet, and average conditions		←○
		Identifies and discusses the applicability of the following sources and sinks in the salt balance(s):		
			imported surface water	←○
			agricultural runoff	←○
			irrigation subsurface drainage	←○
			soil amendments	←○
			fertilizer	←○
			CAFOs (e.g., dairies)	←○
			industries (e.g., food processors, wineries)	←○
			food and other products exported from the Study Area	←○
			land application of wastewater	
			-- CAFOs	←○
			-- municipalities	←○
			-- food processors and other industries	←○
			wastewater discharges to surface water	
			-- municipalities	←○
			-- food processors and other industries	←○
			residential irrigation	←○
			septic tank systems	←○
			stormwater runoff	←○
			water transfers	←○
			groundwater extraction	←○
			groundwater recharge	←○
			groundwater seepage to surface water	←○
			groundwater inflow from outside the Study Area	←○

Suggested Components of a Central Valley Salt/Nitrate Balance

Study Aspects				
			groundwater outflow from the Study Area	←○
			surface water inflow from outside the Study Area	←○
4	**Salt Balance(s) (continued)**			
			surface water outflow from the Study Area	←○
			mineral dissolution	←○
			atmospheric deposition and scour	←○
			upwelling of saline groundwater	←○
		Defines terminologies used in the salt balance(s)		←○
		Identifies, quantifies, and prioritizes salt sources to groundwater largest to smallest		←○
		Identifies, quantifies, and prioritizes salt sources to surface water largest to smallest		←○
		Provides concentrations and flow rates for each source		←○
		Provides loading rates for each source		
			lbs	←○
			tons	←○
			per day	←○
			per month	←○
			per year	←○
			per acre	←○
			per Study Area	←○
		Identifies and quantifies salt sinks		←○
		Provides loading rates to each sink		←○
		Provides a written explanation of the salt balance(s)		←○
		Provides a graphical representation of the salt balance(s)		←○
		--Graphic identifies and quantifies all significant salt sinks out of the Study Area		←○
		Identifies data gaps in the salt balance and recommends areas for further study		←○
		Quantifies the rate of salt accumulation or reduction in the Study Area assuming current conditions		←○
		Projects salinity concentrations into the future assuming current conditions		←○
5	**Nitrate Balance(s)**			
		Provides a conceptual model of nitrate movement from sources to sinks in the Study Area		←○
		Develops nitrate balance(s) for dry, wet, and average conditions		←○
		Identifies and discusses the applicability of the following sources and sinks in the nitrate balance(s):		
			imported surface water	←○
			agricultural runoff	←○
			irrigation subsurface drainage	←○
			soil amendments	←○
			fertilizer	←○
			CAFOs (e.g., dairies)	←○
			industries (e.g., food processors, wineries)	←○
			food and other products exported from the Study Area	←○
			land application of wastewater	
			-- dairies and other CAFOs	←○
			-- municipalities	←○
			-- food processors and other industries	←○
			wastewater discharges to surface water	
			-- municipalities	←○
			-- food processors and other industries	←○
			residential irrigation	←○
			septic tank systems	←○

Suggested Components of a Central Valley Salt/Nitrate Balance

Study Aspects				
			stormwater runoff	←○
			water transfers	←○
			groundwater extraction	←○
5	**Nitrate Balance(s) (continued)**			
			groundwater recharge	←○
			groundwater seepage to surface water	←○
			groundwater inflow from outside the Study Area	←○
			groundwater outflow from the Study Area	←○
			surface water inflow from outside the Study Area	←○
			surface water outflow from the Study Area	←○
			atmospheric deposition and scour	←○
			naturally occuring nitrate in groundwater	←○
			plant uptake and nutrient cycle	←○
			reaction decay	←○
			gaseous loss, volatilization	←○
		Defines terminologies used in the nitrate balance(s)		←○
		Identifies transformation of nitrate precurors into nitrates by discharge type		←○
		Identifies, quantifies, and prioritizes nitrate sources to groundwater largest to smallest		←○
		Identifies, quantifies, and prioritizes nitrate sources to surface water largest to smallest		←○
		Provides concentrations and flow rates for each source and pre-cursor		←○
		Provides loading rates for each source and pre-cursor		
			lbs	←○
			tons	←○
			per day	←○
			per month	←○
			per year	←○
			per acre	←○
			per Study Area	←○
		Identifies and quantifies nitrate and precursor sinks		←○
		Provides loading rates to each sink		←○
		Includes nitrogen losses in analysis		←○
		Provides a written explanation of the nitrate balance(s)		←○
		Provides a graphical representation of the nitrate balance(s)		←○
		--Graphic identifies and quantifies all significant nitrate sources into the Study Area		←○
		--Graphic identifies and quantifies all significant nitrate sinks out of the Study Area		←○
		Identifies data gaps in the nitrate balance and recommends areas for further study		←○
		Quantifies the rate of nitrate accumulation or reduction in the Study Area assuming current conditions		←○
		Projects nitrate concentrations into the future assuming current conditions		←○