CV-SALTS Geographic Information Systems Basin Planning Technical Services

Task 5 Scope of Work

The following is a detailed description of the scope of work and corresponding budget of Task 5 of the Geographic Information System (GIS) Technical Services that will be completed over the next seven (7) months in conjunction with CV-SALTS. This scope of work addresses Task 5 of the GIS Technical Services, as requested in the CV-SALTS Request for Qualification (RFQ). The LWA Team responded to the RFQ on May 30, 2012 and was authorized to provide additional GIS Technical Services on August 6, 2012 for Tasks 1 through 4 included in the RFQ[1]. This scope of work was prepared by the LWA Team pursuant to the approval of the Task 5 Work Plan by the Executive Committee on January 11, 2013. Any changes to the scope of work will require Executive Committee approval and adjustments to the project budget. The scope of work will be initiated after a notice to proceed has been received from the CV-SALTS Executive Director and/or Technical Program Manager. The elements that are included in the approved Task 5 Work Plan are outlined below in this scope of work and discussed with details in the following sections.

BACKGROUND

This section describes the status of ongoing CV-SALTS deliberations on technical and policy questions related to this scope, and the technical approach taken in this scope.

Status of CV-SALTS Deliberations on AGR Thresholds

At the time of the development of this scope of work, the policy and technical discussions related to protection of AGR beneficial uses is ongoing (Quinn and Klassen, 2011; Dickey, 2011), partly in response to questions in the literature about the accuracy and potential conservatism of simplistic quantitative approaches (Letey et al., 2011; vanGenuchten and Gupta, 1993). At the time of the preparation of this scope, it is therefore premature describe a tool set that, when applied, will provide analyses required by an unknown future policy. Fortunately, CV-SALTS is undertaking technical and policy deliberations to answer some of the outstanding questions regarding appropriate selection and use of quantitative tools to develop thresholds that will be useful as part of AGR definitions. The approach in this scope is to proceed with data gathering and initial zoning work that is least dependent on the outcome of this concurrent process, and that provides foundational data and preliminary results that will be necessary, regardless of the specific outcome of the deliberative process.

Further, a final step in which these tools are applied is described in this scope of work, assuming a specific outcome. ***This step (Subtask 5.3) and related scope will need to be re-examined once the deliberative process is completed, unless it is resolved that the process described in the scope is appropriate.***

Technical Approach Taken in this Scope

Existing models relate crop, climate, soils, management, and irrigation water quality in a quantitative way. Crop, soil, and to a lesser extent ambient water quality data are available for most irrigated zones. Were the means to apply these models over irrigated areas of Region 5 available, they could inform the process of protecting AGR beneficial uses. Exactly how this information will be employed depends heavily on the outcome of ongoing policy discussions.

[1] The detailed Work Plan for Tasks 1, 3, and 4 of the GIS Services was submitted to CV-SALTS in August and approved by the CV-SALTS Executive Committee on September 10, 2012.

The purpose of Task 5 is to develop a GIS-based Crop Sensitivity (to salinity) Tool Set (CST). That is, spatial data (cropping patterns, climate, soils, and management) will be analyzed to identify the most sensitive crops grown, and the irrigation water quality required to produce that crop. Available water supply quality can be compared to what crops require. The intention is that these tools would help to establish a technical (not policy) linkage between agricultural water quality needs on one hand, and actual water quality on the other, identifying areas where use and quality would be most likely to conflict.

It is recognized that conditions (such as cropping patterns) and data sets to characterize those conditions (e.g., GIS layers) are evolving. To be useful, tools will need to be modular so that data or assumptions could be updated and new results generated with minimum effort. To allow the work to progress, readily available data sets will be employed to produce results that are as comprehensive in geographic scope as practicable. It will be important for collaborators, reviewers, and users to bear in mind that some analyses may be preliminary pending finalization of policy decisions, and to focus on the nature of the tools as the main concern within this scope. Definitive applications and results will need to await finalization of policy decisions and alignment with a final technical approach.

It is also possible that more in-depth analysis will be needed even to determine the technical relationships among these several factors and crop production. One way to evaluate the performance of the CST is to compare results to those of more detailed studies of specific areas. Three such comparisons are mentioned in this scope of work.

Throughout this document, work items that *will* happen are described as part of this scope of work, and items that *could* happen that are of interest and made possible by this work, are either omitted or their exclusion from this scope is explicit.

A schematic flow chart (**Figure 1**) illustrates the process that will be followed to develop an abbreviated Hoffman-type result for irrigated agricultural lands in the Central Valley. Also illustrated is the more rigorous and detailed, iterative analysis actually employed in Hoffman's method (Hoffman, 2010). Although technically feasible at the whole-valley scale, this detailed approach is recommended after an initial application of the abbreviated approach. This will allow CV-SALTS and stakeholders to identify areas where the detailed approach would be most helpful in making decisions. For example, where water quality is reliably adequate to irrigate the most sensitive major crops, a detailed analysis may not be necessary. **Figure 1** will be a useful reference to the reader attempting to understand exactly what work is being proposed, as well as relationships to outside data sources, among data generated, as well as how these data underpin specific results.

The following three tasks are a technical approach applying the principles described above, to achieve the stated purpose of Task 5:

- **Task 5.1 - Research and Develop Map Layers** – This is a large-scale data gathering effort for the Central Valley to generate the map layers that will form the basis for analysis under Tasks 5.2 and 5.3. An irrigation water quality data request will be generated and responses tabulated (see below the Subtask "Irrigation Supply Water Sources and Quality" for details). Although salinity is the main focus of analysis under these tasks, other water supply quality data (for other constituents) will be captured and available for later use. In addition, basic definitions (e.g., minor crops that can be ignored, tolerable levels of yield reduction, and what constitutes a dry year) will need to be procured or developed (see **Figure 1**). Crop sensitivity thresholds to soil water salinity, and irrigation and drainage district boundaries, as well as the study area boundaries for Hoffman (2010), Grattan and Isidoro (2006), and Montgomery et al. (2010) will

also be procured for later use. Agroclimatic data for the Central Valley, available in summary fashion by Detailed Analysis Units (DAUs) from DWR, along with more detailed climate records (primarily to ensure variability is properly accounted for) will be added to the database. Soils data from the NRCS will also be included. *Mapping and data products that will be produced include all the major factors (climate, soils, crop coverage, and water supply quality) that determine CSZs, throughout most irrigated areas of the Central Valley.*

- **Task 5.2 - Identify Crop Sensitivity Zones (CSZs)** – Task 5.2 will develop CSZs based on data from Task 5.1. The goal will be to segregate areas with markedly different applied (surface and ground) water quality, cropping patterns, climate, and/or soils. Irrigation and drainage district, Initial Analysis Zone (IAZ) boundaries (as part of the ICM project), and drainage basins (CVRWQCB Staff, 1991) will be used as preliminary guides. Study areas employed in Hoffman (2010), Grattan and Isidoro (2006), and Montgomery et al. (2010) will also be matched as closely as practicable. Up to 25 CSZs will be identified. Crop mixture summaries will be developed, and major crops identified within each CSZ. CSZs will be reviewed and refined with CV-SALTS. *Mapping and data products produced will include most sensitive crops, and their levels of sensitivity to soil salinity, throughout most irrigated areas of the Central Valley.*

- **Task 5.3 - Determine Applied Water Sensitivity Thresholds** – Task 5.3 will employ data from Task 5.1, along with the CSZs and major crop mixtures from Task 5.2. Crops will be screened based on soil water salinity thresholds to identify the most Sensitive Major Crop (SMC). Estimated dry-year agroclimatic and irrigation management parameters will be used to develop approximate soil irrigation water salinity relationships for the SMC in each CSZ. Based on these, tolerable maximum irrigation water salinity for each CSZ will be estimated. This abbreviated method will again be as similar to those employed in the Hoffmann (2010) study as practicable, but is primarily streamlined by employing previously summarized agroclimatic data from DWR, and less iteration in selection of the SMC and maximum irrigation water salinity.

  Detailed analyses have been completed for three areas: Yolo County around Woodland (Grattan and Isidoro, 2006), the South Delta (Hoffman, 2010), and along the Lower San Joaquin River (Montgomery, 2010). The results of one of these studies will be compared to results of analyses in this and the preceding task as first orders of business, before work on other areas proceeds. The LWA Team will consult with CV-SALTS regarding the study area to be used for comparison before the analysis. In addition, where (surface and/or ground) water supply salinity data are available, they will be compared to sensitivity thresholds for the same areas. Areas where water supply salinity exceeds sensitivity thresholds may warrant future investigation with regard to actual influence of salinity on crop production. Existing AGR beneficial use designations will also be compared with CSZ results. *Mapping and data products that will be produced throughout most irrigated areas of the Central Valley include a) a map of CSZ applied water crop sensitivity thresholds, and comparisons of these with b) available applied water quality, as well as with c) existing AGR beneficial use designations.*

PHASED APPROACH

The LWA Team proposes a two phased approach for Task 5 for the development of the CST for irrigated areas in the Central Valley. The overall effort is proposed to delineate up to 25 crop sensitivity zones (CSZs) within the Central Valley.

- Phase 1 effort will entirely complete Task 5.1 data gathering, and Task 5.2 Crop Sensitivity Zones (CSZs) delineations. This initial phase of work will also include the determination of crop sensitivity thresholds for one CSZ, and comparison to results of an existing, detailed study. Several alternative detailed studies exist, for Yolo County, the South Delta, and the Lower San Joaquin River areas. The work will be done over four months.

- Phase 1 will include consultation with CV-SALTS regarding the appropriate methodology to be used for Phase 2. The methodology that has been scoped here (application of the Hoffman Model) is one possible approach. However, given the sensitivity of results to the quantitative tools and assumptions, it will be important to ensure that Phase 2 work is aligned with CV-SALTS technical and policy choices.

- Phase 2 effort will be the continuation of threshold determinations for up to 24 CSZs. The work will be completed over a two-month period. This Phase of work will be further discussed in CV-SALTS committee meetings in the course of completing Phase 1; hence, it is not part of this authorization. The schedule in **Attachment A** has a tentatively start date for Phase 2 on 28 June 2013 (pending approval of the Phase 2 budget by the Executive Committee).

The budget breakdown for Phase 1 and Phase 2 efforts is presented in **Table 1**. The detailed schedule for the two phases is shown in **Attachment A**.

Following is a detailed description of the Task 5 approach, work to be completed, schedule (**Attachment A**) and corresponding budget (**Table 1**).

TASK 5.1 RESEARCH AND DEVELOP MAP LAYERS

The objective of Task 5.1 is to develop GIS map layers for irrigated agricultural areas of the Central Valley as a foundation for the identification of CSZs (Task 5.2), and for calculation of crop sensitivity thresholds (Task 5.3). Recent land cover mapping from DWR, and from derivations and syntheses of DWR data (in WARMF and CVHM, for example) will serve as the default for this work. The most recent, readily available land cover data will be employed, and the CST will allow for update of these data as more recent data become available.

When the multiple data sets from different sources are consolidated in the same GIS layer, the accuracy of the data sets will be assessed. Compiled data from the different sources will be cross checked in the geodatabase for discrepancies through cascading queries and data record filters to identify duplicate, missing, or conflicting data. Without trying to perfect these data, major problems that could affect this tool development task will be identified and addressed.

A Technical Memorandum (TM) 5.1 will summarize the dataset, sources, and issues and limitations that are identified in the data sets. It should be noted that data gaps and/or out-of–date data are likely to be a common occurrence given the 13 million acres that are included in the study area. These will be noted in TM 5.1.

Data sets listed in the Data Source Matrix table (provided as Attachment C in the Task 5 Work Plan) cover most of the Central Valley. In addition, as noted below, GIS layers developed under Tasks 3 and 4 of the GIS project will be incorporated into Task 5 to provide the Central Valley data coverage. Task 4 GIS layers with water quality data will feed into GIS layers for Subtasks 5.1.3.

Tasks 5.1.1 through 5.1.8 will be performed to create the GIS data layers from the identified data sources. While Task 5 will start after GIS Tasks 3 and 4, the Task 5.1 schedule is aggressive to expedite the work and provide better alignment with the Task 3 and 4 schedules (**Attachment A**).

Subtask 5.1.1: Political or Other Boundaries and Base Map Information, and Preliminary Policy Recommendations

The LWA Team will build off of the Task 3 baseline map layers (updated from the Phase 1 BUOS GIS) and add boundaries that are geographically pertinent to the delineation of CSZs (see **Figure 1**). These boundaries will include the following:

- Political boundaries (counties, cities);
- Other jurisdictional boundaries such as irrigation districts, drainage districts, and water districts, and Regional Board boundaries;
- Initial Analysis Zone (IAZ) boundaries;

In addition to these geographic data, **Figure 1** shows how certain policy recommendations will be required from CV-SALTS, or will need to be anticipated by the LWA Team, to complete this work, including:

- Definition of a minor crop, or one that is sufficiently rare to be ignored in assessing the sensitivity of crops in a CSZ.
- Definition of a tolerable level of yield reduction, so that the productivity level of sensitive crops that should be employed in the analysis can be known.
- Definition of a dry year, for the purposes of selecting the climatic conditions under which the root zone salinity levels should be estimated.

With respect to the use of estimated dry-year agro-climatic data, yield reductions in sensitive crops due to salinity will be felt most acutely during dry years (i.e., when crop evapotranspiration (ET) is greater than precipitation). This is true for two reasons. First, there is less precipitation to help leach salt downward and through the root zone. Second, the climatic (temperature, ET) stress on the crop may be greater, so that osmotic stresses imposed by salinity can become more harmful. It should be noted that, should these definitions evolve, or be set at site-specific levels, the CST could be employed to update results to reflect new definitions.

Subtask 5.1.2: General (Statsgo2) and Order 2 (SSURGO) Soil Mapping

Soils database for the Central Valley will be acquired from the Natural Resources Conservation Services (NRCS) Soil Data Mart - Statsgo2 (U.S. General Soil Map). Soils data are available publicly and they can best be analyzed in ArcGIS with the NRCS' extension – the SSURGO the Soil Survey Geographic Database online viewer. Additional soil data are available from United States Forest and Park Service databases, but is generally less critical since little of this area is irrigated cropland. Information collected in the geodatabase will include soil classification, as well as physical and chemical properties, drainage conditions, and productive capacity.

Subtasks 5.1.3 and 5.1.4: Irrigation Supply Water Sources and Quality

As shown on **Figure 1**, irrigation water quality will be examined when developing CSZs, and will be compared to results for CSZs. The original Subtask 5.1.4 of the RFP (Average Groundwater Quality Available for Agriculture) will be covered under this Subtask.

Where available, irrigation supply water quality data will be compiled from irrigation and groundwater management districts for service areas. Other sources of available data include data sources that are currently being compiled in the ICM and GIS projects, including WARMF and CVHM databases, UC Davis SBX2 databases, the SWRCB GAMA Program, California Department of Public Health (CDPH), USGS, DWR, and Department of Pesticide Regulation (DPR). Ambient groundwater quality data (for

agricultural wells), to the extent that they are available, are already being developed by the LWA Team under GIS Subtasks 4.5 and 4.8.

Water quality data gathering will focus on total dissolved solids (TDS) and electrical conductivity (EC) since the Task 5 focuses on salinity effects on irrigated agriculture. However, where available, concentrations of specific ions affecting agriculture (e.g., boron, sodium, calcium, magnesium, nitrate, chloride) will also be incorporated into the database. For some sources, water quality data are already organized in databases by CDPH, DPR, etc.

While the data from the current GIS project (Subtasks 4.5 and 4.8) will be used to supplement Task 5 effort, representative irrigation water quality data is currently lacking for many geographies. Yet it is critical to know the quality of applied water for many purposes, including the proposed comparisons to thresholds generated during Phase 2 of this work. Therefore, a focused data request will be generated to facilitate compilation of readily available irrigation water quality data from stakeholders. The data request will be prepared at the beginning of Task 5 and will request at least three data items: 1) TDS of applied surface water, 2) TDS of applied groundwater, and 3) the proportion of applied water supplied from groundwater. The LWA Team will compile data provided by June 2013 in the requested format to perform the comparison analysis.

Subtask 5.1.5: Agriculture Beneficial Use Listings

This data layer will be completed under Task 3 of the GIS Technical Services. Under Task 3, beneficial uses and water quality objectives for the existing waters, including AGR, will be linked to the updated NHD 2012 dataset. This data layer will be compared with results for CSZs in Task 5.3.

Subtask 5.1.6: Current Crops Grown

Cropping pattern data also form part of the basis development of the CSZs (see **Figure 1**). WARMF input data include data from DWR, the Dairy General Permit, and USGS on land cover for the WARMF areas. However, additional geographic coverage will be needed for areas without WARMF coverage. CVHM crop classes will be investigated, since they too are based on DWR data. However, CVHM crop classes are based on predominant crops on each CVHM model grid area (as mapped by DWR), and may ignore sensitive crops that do not dominate areas within the size of these grids. Current and historic crop pattern data directly from DWR (to individual field level of resolution) may therefore be a better source for these areas. This mapping is only at intervals of seven or more years. Nevertheless, the most recent and readily available land cover data will be adequate for CST development, and can be refined for later analyses in areas where this appears necessary.

Land cover in some areas of the Central Valley (e.g., surrounding Modesto) has evolved greatly, for example through the planting of microspray-irrigated permanent crops (e.g. almonds). These shifts, though they may be quite significant to future salt and nutrient transport from root zones (and thus cropping system sensitivity), are not fully reflected in DWR land cover mapping that is sometimes years old. Based on discussions with a vendor of updated data, we anticipate that they will provide mapping and summary tables illustrative of these shifts free of charge. These will be incorporated into TM 5.1 to shed light on this issue so that it can be properly understood for future refined analyses in areas, where justified.

Subtask 5.1.7: Current and Historic Value of the Crops Grown

The CV-SALTS Executive Committee policy discussion around the use of crop value in the AGR beneficial use determinations remains dynamic. We recommend no effort on this topic at this time. If this becomes a greater focus at a later date, crop value data from the USDA, California Department of Food and Agriculture (CDFA), or Ag Commissioners can be compiled later.

Subtask 5.1.8: Other Constraints Limiting Growth of Crops

Climate data are available from the California Irrigation Management Information System (CIMIS) and National Climatic Data Center (NCDC), and have been summarized for several years for DAUs by DWR, including monthly evapotranspiration (ETo), precipitation, as well as applied water, and ET of applied water (for 21 crop classes, including the relatively sensitive alfalfa, dry beans, almonds, and rice) for the years 1998 through 2001. CIMIS data records will be employed to statistically characterize average and dry water years. **Figure 1** shows how crop ET and precipitation during the growing season for a dry year (which can be calculated from these data) can be employed in later subtasks to support a Hoffman-like screening analysis.

The impact of salinity on crops in terms of yield reduction is summarized in many studies (e.g., Maas and Grattan, 1999; Hoffman 2010). The recent CV-SALTS white paper "Salinity Effects on Crop Yields" (CDM Smith Memorandum, 30 July 2012) summarized the current state of knowledge regarding the effects of elevated salinity on crop yields with specific attention to seasonal tolerances. Crop sensitivity data will be compiled from these sources and the US Salinity Laboratory. **Figure 1** shows how these will feed into screening CSZ data to identify the most sensitive crops, and then employed to set thresholds for maximum root zone salinity.

Deliverables:

- *One set of "Foundation" GIS shape files associated with Subtasks 5.1.1 and 5.1.8 layers with geodatabase and metadata*
- *Presentation of Draft Maps for Crop Sensitivity Tool*
- *One (1) Draft Technical Memorandum 5.1 summarizing GIS data layers 5.1.1 to 5.1.8, including data sources, data structure, QA/QC process, data gaps and limitations. The Draft TM will be submitted electronically both in Microsoft Word and Adobe Acrobat (PDF) format.*
- *One (1) Final Technical Memorandum 5.1 summarizing GIS data layers 5.1.1 to 5.1.8. The Final TM will be submitted electronically both in Microsoft Word and Adobe Acrobat (PDF) format. The Final TM will be submitted after responding to comments by the Project Committee and TAC as directed by the TPM. The LWA Team will work with the TPM to provide a tracking table for responses to general and specific comments and submit the table with the Final TM. The LWA Team will respond to one (1) set of comments compiled by the TPM.*

TASK 5.2 IDENTIFY CROP SENSITIVITY ZONES

The purpose of Task 5.2 is to develop up to 25 CSZs for irrigated agricultural portions of the Central Valley that, to the extent practicable, subdivide areas with distinctly different cropping patterns, climatic conditions, and water supply. Given the expanse and great diversity encompassed by this region, some of the CSZs may still be relatively diverse, but for an initial, screening-level, Hoffman-like analysis, this number of units should provide a sufficient foundation. This initial, comprehensive analysis will provide a basis for selecting areas that warrant more thorough, detailed analysis.

After CSZs are developed, their cropping patterns, range of likely irrigation water qualities, and leaching fractions (LFs) will be estimated. **Figure 1** shows how these parameters will either be employed in developing irrigation water salinity thresholds, or will be compared to those thresholds.

Subtask 5.2.1: Define CSZs Based on Irrigation Water Quality and Cropping Patterns

The Draft CSZs and corresponding threshold development will be driven by four major factors:

1. Cropping patterns - where crops are grown (which is an indication of what can or will be grown);
2. Irrigation water management and water quality of surface and ground waters, including where water quality is impaired relative to existing crop tolerances;
3. Soils; and
4. Climatic conditions.

GIS data layers of these four major factors (much of it compiled in Subtask 5.1) will be "stacked" in the ESRI™ ArcMap® Spatial Analyst® to identify apparent similarities in spatial trends and to select the most useful CSZ delineations.

Cropping Patterns - Salt tolerance of crops will be mapped based on data compiled in Task 5.1. The density of sensitive crops in areas will be quantified and mapped, along with the density of specific, sensitive crops. The results of these analyses will be referenced when developing CSZs, and to the extent practicable, CSZs will encompass areas in which these frequencies are relatively consistent.

Source and Water Quality of Irrigation Water - The reasons for employing irrigation source water quality in developing CSZs are the following:

1. Within localized areas with similar water supply, the frequency of sensitive crops can also be similar.
2. Results of this analysis will be of interest to groups who provide or manage water supplies. To the extent that CSZs conform to some of their boundaries, this will make results more meaningful.
3. In Task 5.3, resulting maximum tolerable irrigation water salinity will be compared to actual irrigation water salinity (where these data are available), to provide a sense of where there is potential for sensitive crops to be affected by irrigation water salinity. Again, this comparison will be easier and perhaps more useful if boundaries align generally with recognized water supply boundaries.
4. In Task 5.3, resulting maximum tolerable irrigation water salinity will be compared to results in Hoffman (2010), Montgomery et al. (2010), and Grattan and Isidoro (2006). This comparison will be easier and perhaps more useful if boundaries align generally with boundaries of these studies.

Actual irrigation water quality can be employed where available (see above the Subtask "Irrigation Supply Water Sources and Quality"). Polygons representing districts supplying or managing water, and IAZs, will be helpful as proxies for water quality where there is reason to believe irrigators within an area have access to similar water quality.

Soils - Soils data will also be reviewed when delineating CSZs, with an emphasis on soil texture, drainage class, depth to groundwater, and water holding capacity, properties that most strongly influence soil-plant-water relationships. A similar approach was taken by Hoffman (2010) for mapping soil data in the South Delta area. Locations of saline and sodic soils will be considered.

Climate Conditions - Climate factors (average monthly ET and an estimate of effective precipitation) for DAUs will be used to characterize climate, and referred to in delineating CSZs.

Subtask 5.2.2: Summaries and Presentation of CSZ Properties

Summary tables and maps illustrating the distribution of the major factors (sensitive crops, irrigation water quality and sources, soils, and climate) among the CSZs will be developed, so that the characteristics of these areas can be reviewed and understood.

The LWA Team will present CSZ delineations and summaries of properties to CV-SALTS and allow for comments and refinements (see **Table 1** or **Attachment A** schedule for Subtask 5.2.2) before commencing Task 5.3. The presentation will be documented in PowerPoint slides made available for comments.

The finalized CSZ delineations and summaries of their properties will be included in TM 5.2.

Deliverables for Phase 1 effort only:

- *GIS layer of draft CSZs*
- *Presentation of draft CSZs along with summary maps and tables illustrating their properties*
- *One (1) Draft Technical Memorandum 5.2 identifying CSZs selection criteria and limitations*
- *Note: Response to comments and CSZ finalization will be documented in TM 5.2.*

Note on Phase 1: The Final TM and GIS layers for the CSZ delineation will be part of Phase 2 deliverables. This will allow for coordination on final CSZ maps and the remaining water sensitivity threshold calculations (Task 5.3) to be performed during Phase 2.

TASK 5.3 DETERMINE APPLIED WATER SENSITIVITY THRESHOLDS

The objective of Task 5.3 is to develop the maximum irrigation water salinity concentration tolerable by the SMC in each CSZ. The planned steps to determine this value are illustrated in **Figure 1**. They parallel the approach taken by Hoffman (2010). However, monthly climatic data for each CSZ (see Subtask 5.1.8), and an estimate of the ratio of soil to irrigation water salinity are employed, each providing some simplification that will facilitate completion of the work for a large geographic area on a restricted budget and schedule, while retaining the main inputs and logic of Hoffman (2010).

These steps for each CSZ (please refer to **Figure 1** for logical relationships) include the following:

- Procure working definitions of the following, supplied by CV-SALTS, or created as interim placeholders while awaiting later decisions on definitions, of the following:
  - Minor crops that can be ignored when selecting SMCs
  - The tolerable level of yield reduction for the SMC
  - A dry year during which the tolerable level of yield reduction would occur
  - Select SMCs based on crop patterns and soil water salinity thresholds for each CSZ
- Determine the maximum soil salinity level (ECsw) that is tolerated by the SMC without intolerable yield reduction
- Estimate the ratio between soil and irrigation water salinity that occurs during a dry year
- Estimate the dry-year maximum tolerable irrigation water salinity (MTIS)

The MTIS will be spatially compared to the following (see **Figure 1**):

1. Findings of detailed studies of areas in the South Delta (Hoffman, 2010), Yolo County around

Woodland and Davis (Grattan and Isidoro, 2006), and along the Lower San Joaquin River (Montgomery et al., 2010). The value of this comparison is to evaluate whether the CST is providing results that are generally consistent with more detailed work, and if not, to begin to understand why.

2. Actual irrigation water salinity, where this is known. Where irrigation water is sufficiently dilute to avoid unacceptable yield reductions in SMC yield, further evaluation may be less pressing.
3. Existing beneficial use salinity criteria. It will be interesting to see how these criteria align with CST results for the Central Valley region.

The results of these comparisons will be summarized in draft and final versions of TM 5.3. Included will be map and tabular summaries of SMCs, of ratios between soil and irrigation water salinity, of MTIS, and of the three listed comparisons of other data sets with MTIS.

Deliverables for Phase 1 Effort only:

- *GIS layers and other calculations (databases, workbooks) associated with analysis inputs and outputs for one of the three CSZs (Yolo County, the Lower San Joaquin River, and South Delta areas).*
- *One (1) Draft Technical Memorandum 5.3 for methods of applied water sensitivity threshold development*
- *One (1) Final Technical Memorandum 5.3 for methods of applied water sensitivity threshold development.*

REFERENCES

Central Valley Regional Water Quality Control Board (CVRWQCB) Staff. 1991. Inland Surface Waters Plan (sections pertaining to delineation of drainage basins).

Dickey, J. 2012. Potential influence of crop sensitivity and leaching tools and assumptions on target salinity levels. Memo to CV SALTS Coalition, dated December 6, 2012.

Grattan, S.R. and D. Isidoro-Ramirez. 2006. An Approach to Develop Site-Specific Criteria for Electrical Conductivity, Boron and Fluoride to Protect Agricultural Beneficial Uses.

Hoffman, G.J. 2005. Salt Tolerance of Crops in the Southern Sacramento-San Joaquin Delta. A report for the California Environmental Protection Agency, the State Water Resources Control Board, and the Division of Water Rights.

Letey, J., G.J. Hoffman, J.W. Hopmans, S.R. Grattan, D. Suarez, D.L. Corwin, J.D. Oster, L. Wu, C. Amrhein. 2011. Evaluation of soil salinity leaching requirement guidelines. Agricultural Water Management, 98:502-506.

Maas, E.V., and S.R. Grattan. 1999. Crop yields as affected by salinity. In R.W. Skaggs and J. van Shilfgaarde, eds., Agricultural Drainage. Agron. Monograph 38. ASA, CSSA, SSSA, Madison, WI.

Montgomery, A., F. Kizito, J. Simi, C. Cheng. June, 2010. Salt Tolerance of Crops in the Lower San Joaquin River (Merced to Stanislaus River reaches) – Draft. Central Valley Regional Water Quality Control Board.

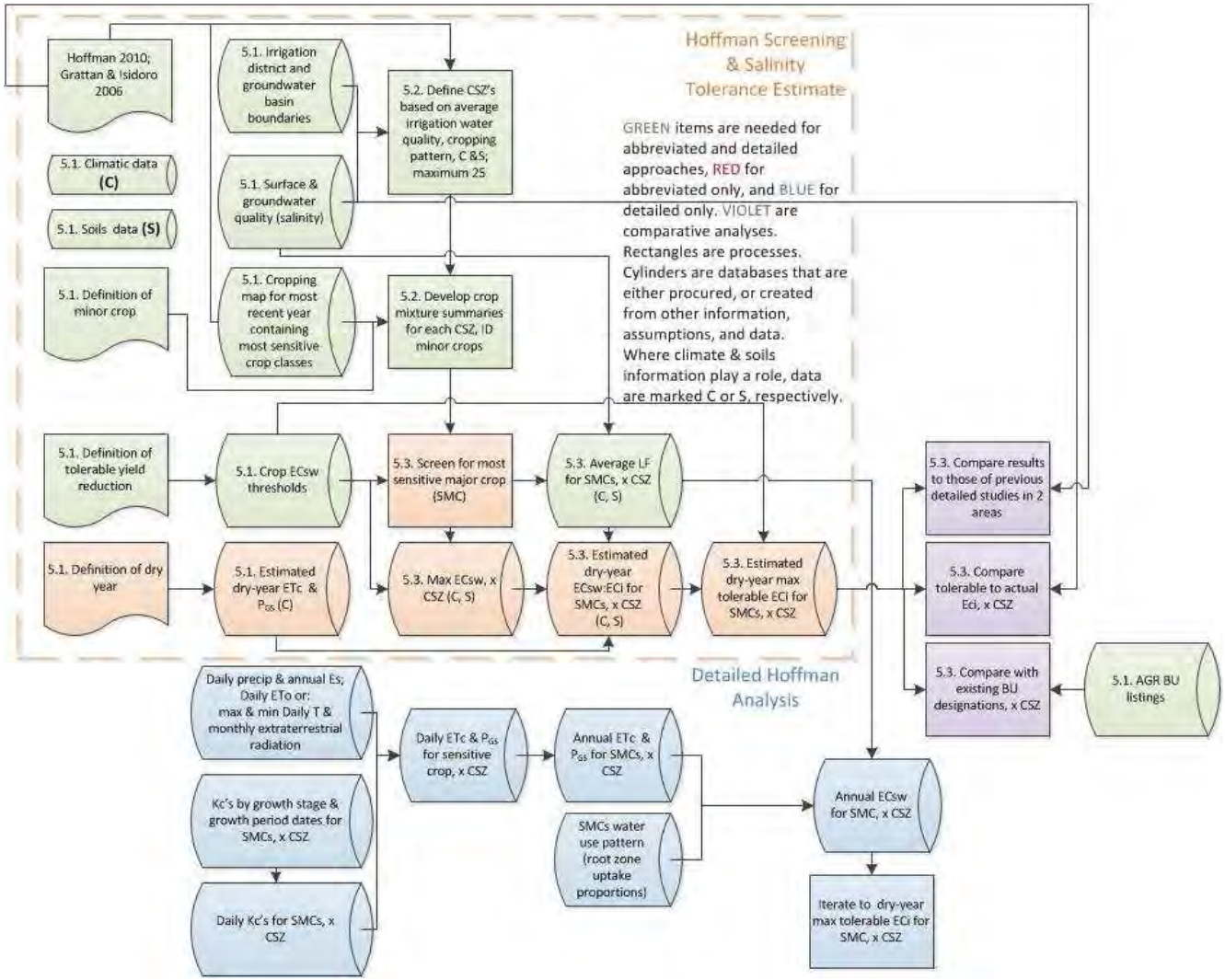
Quinn, N. and P. Klassen. 2011. Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) Technical Advisory Committee Recommendations Regarding City of Davis Salinity Study Draft Workplan. Letter to Diana Messina, NPDES Program Manager at the CVRWQCB, dated October 4, 2011.

VanGenuchten, M. Th., S.K. Gupta. 1993. A Reassessment of the Crop Tolerance Response Function. Journal of the Indian Society of Soil Science, 41:730-737.

Table 1 Task 5 Deliverables Schedule and Budget Summary

Phase 1 tasks authorized on 1/11/2013	Start	Finish	Budget	Comment	Phase
5.1 Data Research and GIS setup for CSZ delineations	1 March	1 July	$32,046	Data compilation for all layers. One-time budget authorization.	1
5.2.1 Define CSZs based in water quality and crop patterns for 25 CSZs for CV-SALTS checkpoint review	15 March	1 July	$27,360		1
5.3 Determine Applied Water Sensitivity Thresholds for one (1) CSZ	19 April	15 July	$5,677	Develop and compare results for one CSZ to results of a detailed study (to check against accepted results)	1
5.2.2 Checkpoint presentation to CV-SALTS	15 May		$15,580	This will be a MS PowerPoint and On-line web demonstration of CSZ mapping. Modifications will be made to CSZs based on input received.	1
Deliverables: • Draft & Final Geodatabase and TM for Task 5.1. • Draft only TMs and geodatabase for Tasks 5.2 & 5.3.	15 July		$40,395	Final maps and TM for Task 5.1 will be completed under this Phase 1 effort. Only the draft maps and TM for CSZ delineation are part of Phase 1 effort. The Final TM and GIS layers for Task 5.2 are intended to be part of Phase 2 deliverables. This will allow for coordination on final CSZ maps and the remaining water sensitivity threshold calculations (Task 5.3) to be performed in the Phase 2 efforts.	1
Requested Budget for Phase 1			$121,060	Budget includes LWA team project coordination	1
Phase II tasks to be authorized. Schedule shown assumes timely deliberations and authorization. Budget & task definitions assume no change to proposed scope. If either of these assumptions prove to be untrue, then schedule and/or scope (including associated budget) may need to be revised. This work is shown as part of the Phase 1 effort, but are not budgeted.					1
5.3 Determine Applied Water Sensitivity Thresholds for 24 CSZs	10 July	13 Sept	$65,292	Continuation of threshold determinations – 24 zones	2
5.2.2 & 5.3 Deliverables: Final Geodatabase, technical memo, and final presentation to CV-SALTS	6 August	30 Sept	$46,842	Time table includes final approval of CSZs by CV-SALTS	2
As-needed A/QC			$6,800		2
Requested Budget for Phase 2			$118,935	Budget includes LWA team project coordination	2

Figure 1 Schematic of Task 5 Work Approach for Developing Crop Sensitivity Tool[a]

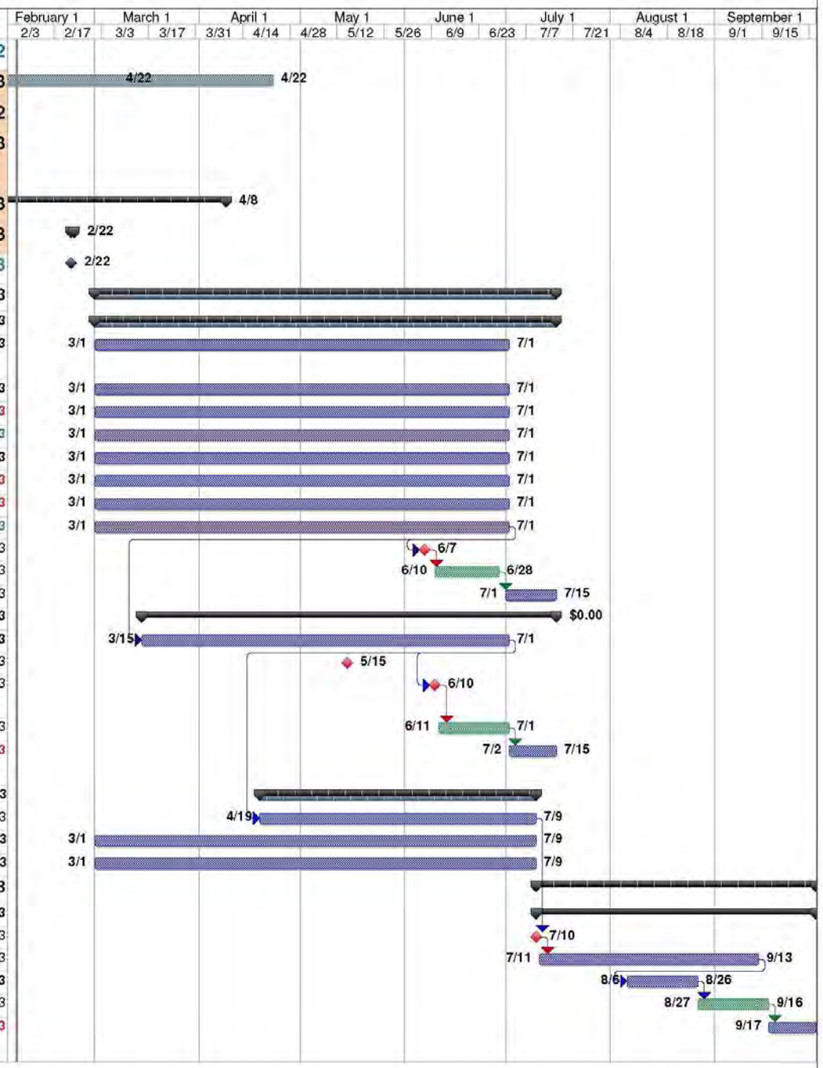


[a]In developing a process diagram, items were placed in the most logical locations practicable, and redundancy was avoided. This creates some difficulty when aligning the diagram with the scope. For example, data and policy decisions compiled under Subtask 5.1 (and so numbered) are employed for the accomplishment of later subtasks. Nevertheless, they are numbered here for the Subtask in which they are first dealt with (i.e., 5.1). If the data are employed in later analysis steps, the arrows in the flow chart so indicate. The same holds for CSZs developed under 5.2, which are also employed in subsequent tasks.

Attachment A - GIS Technical Services Detailed Schedule CV-SALTS

Wed 2/6/13 Update

ID	Task Name	Duration	Start	Finish
1	**Execution of Contract with SJCDA / Notice to Proceed**	1 day	Mon 8/6/12	Mon 8/6/12
2	**Task 1: Project Management & Coordination & QA/QC**	186 days	Mon 8/6/12	Mon 4/22/13
46	**Task 2: Work plan Development**	106 days	Mon 8/6/12	Mon 12/31/12
59	**Task 3: Address identified data gaps in the Phase 1 Geodatabase and update GIS**	79 days	Wed 9/19/12	Mon 1/7/13
67	**Task 4: Incorporate Additional GIS Layers into Existing System**	1338 days	Mon 2/25/08	Mon 4/8/13
229	**Task 5: Develop Crop Sensitivity Tools**	1 day	Fri 2/22/13	Fri 2/22/13
230	**Approval of Workplan**	1 day	Fri 2/22/13	Fri 2/22/13
231	**Phase 1 (budget authorized 1/11/2013)**	97 days	Fri 3/1/13	Mon 7/15/13
232	**Task 5.1 Research and Develop Map Layers**	97 days	Fri 3/1/13	Mon 7/15/13
233	Subtask 5.1.1 – Political or Other Boundaries and Base Map Information, and Preliminary Policy Recommendations	87 days	Fri 3/1/13	Mon 7/1/13
234	Subtask 5.1.2 – General (Statsgo2) and Order 2 (SSURGO) Soil Mapping	87 days	Fri 3/1/13	Mon 7/1/13
235	Subtask 5.1.3 – Irrigation Supply Water Sources and Quality (contributing effort from Task 4.5)	87 days	Fri 3/1/13	Mon 7/1/13
236	Subtask 5.1.4 – Average Groundwater Quality Data Available for Agriculture (included in Task 5.1.3)	87 days	Fri 3/1/13	Mon 7/1/13
237	Subtask 5.1.5 – Agriculture Beneficial Use Listings (data will mostly come from Task 3)	87 days	Fri 3/1/13	Mon 7/1/13
238	Subtask 5.1.6 – Current Crops Grown	87 days	Fri 3/1/13	Mon 7/1/13
239	Subtask 5.1.7 – Current and Historic Value of the Crops Grown (no effort)	87 days	Fri 3/1/13	Mon 7/1/13
240	Subtask 5.1.8 – Other Constraints Limiting Growth of Crops	87 days	Fri 3/1/13	Mon 7/1/13
241	Deliverable 5.1 Draft GIS layers and TM Summary of GIS Data Layers	1 day	Fri 6/7/13	Fri 6/7/13
242	CV-SALTS Committee approval period of GIS map layers 5.1.1 to 5.1.8	15 days	Mon 6/10/13	Fri 6/28/13
243	Deliverable 5.1 Final GIS layers and TM Summary of GIS Data Layers	11 days	Mon 7/1/13	Mon 7/15/13
244	**Task 5.2 Identify Crop Sensitivity Zones**	87 days	Fri 3/15/13	Mon 7/15/13
245	Subtask 5.2.1 – Define CSZs based on Irrigation Water Quality and Cropping Patterns for 25 CSZs	77 days	Fri 3/15/13	Mon 7/1/13
246	Checkpoint Presentation to CV SALTS	1 day	Wed 5/15/13	Wed 5/15/13
247	Deliverable 5.2 Draft GIS layers of proposed CSZs and Draft Technical Memorandum identifying CSZ selection criteria, properties, and limitations	1 day	Mon 6/10/13	Mon 6/10/13
248	CV-SALTS Committee approval period of GIS and TM	15 days	Tue 6/11/13	Mon 7/1/13
249	Deliverable 5.2 Final GIS and Technical Memorandum identifying CSZ selection criteria, properties, and limitations	10 days	Tue 7/2/13	Mon 7/15/13
250	**Tas 5.3 Identify Crop Sensitivity Zones (One CSZ)**	58 days	Fri 4/19/13	Tue 7/9/13
251	Determine Applied Sensitivty Thresholds (One CSZ)	58 days	Fri 4/19/13	Tue 7/9/13
252	**Ongoing Review of Policy and Technical Issues with CV-SALTS**	93 days	Fri 3/1/13	Tue 7/9/13
253	**Finalization of Methodology for Subtask 5.3**	93 days	Fri 3/1/13	Tue 7/9/13
254	**Phase 2 (bugdet not authorized; schedule pending approval of Phase 2 budget)**	59 days	Wed 7/10/13	Mon 9/30/13
255	**Task 5.3 Applied Water Sensitivity Thresholds (24 CSZs)**	59 days	Wed 7/10/13	Mon 9/30/13
256	Checkpoint Presentation to CV-SALTS	1 day	Wed 7/10/13	Wed 7/10/13
257	Determine Applied Water Sensitivity Thresholds (24 CSZs)	47 days	Thu 7/11/13	Fri 9/13/13
258	Deliverable 5.3 Draft Map layers and TM of applied water crop sensitivity thresholds (25 zones)	15 days	Tue 8/6/13	Mon 8/26/13
259	CV-SALTS Committee approval period of GIS map layers 5.1.1 to 5.1.8	15 days	Tue 8/27/13	Mon 9/16/13
260	Deliverable 5.3 Final Map Layers and TM for methods of applied water sensitivity threshold development	10 days	Tue 9/17/13	Mon 9/30/13



Page 1

Note that timing of approval for Phase 2 will determine the actual schedule, and changes to methodology may require revision to the Phase 2 scope and budget.