1. INTRODUCTION

This report provides descriptive information on the various major sources of water quality data pertinent to the pressing salinity impairment issues in the Central Valley of California. It is not intended to be a comprehensive collection of all the metadata descriptions; it however contains the descriptions of the available and publicly accessible major water quality databases and data sources. Therefore, this report can serve as a general guide for hydrology and hydrogeochemistry modelers who seek actual field data inputs for initial and boundary conditions and for the purpose of model calibrations and validations. In addition, this guide provides examples of water quality trends in both spatial and temporal dimensions, which can help decision makers to identify and address potential problems as well as to design and prioritize remedial actions.

1.1 Background of Salinity Impairment

Salts are naturally occurring chemicals in the environment. They form common minerals that constitute many common rock types in the earth's crust, including carbonate rocks, such as limestone and marble, and evaporite sedimentary rocks that are composed of common soluble salts, including halite (sodium chloride or rock salt), gypsum (calcium sulfate), and sylvite (potassium chloride). Common soluble salts – chloride, sulfate, carbonate and bicarbonate – are major dissolved components of natural waters. Nutrients such as nitrate and phosphate are also present naturally in minor amounts. However, water contaminated by wastewater or agricultural drainage may contain excess amounts of nitrate and chloride which exacerbate the problem of soil salination.

Salination of soils has always been the most important issue concerning the sustainability of irrigated farmlands in arid areas. Ancient civilizations, such as those in Mesopotamia, rose and then declined because their agricultural economies were ruined by salt accumulation on their lands, while other civilizations, such as ancient Egypt, survived because the natural hydrologic conditions of their lands helped drain away the salt and prevent waterlogging.

The Central Valley of California is currently facing similar salinity impairment issues. Intense irrigation coupled with the arid climate upsets the natural salt balance of the region. Water import to the southern portion of the Central Valley through the federal Central Valley Project and State Water Project also inadvertently bring in tons of salt each year without any means of flushing the salt to the ocean. This results in an annual salt import of 995 kilotons for the San Joaquin hydrologic basin and 1,208 kilotons for the Tulare hydrologic basin, according to an estimate by the California Department of Water Resources.

In addition to the salt imported through the water conveyance projects, salt is also produced from various anthropogenic sources, including agricultural activities, industrial operations, and waste disposal.

Natural runoffs also contain salt from the dissolution of natural occurring minerals in common rocks and soils. This problem is more pronounced in the west side of the Central Valley because of its geological history. The Coastal Range bordering the west side of the Valley is made up of metamorphic and sedimentary rocks of marine origins. Thus runoffs from the west naturally have higher salt contents in terms of their total dissolved solids (TDS) concentrations, because the soil in the west side naturally contains higher amounts of soluble minerals than the soil in the east side of the Valley.

1.2 Imports, Exports, and Storage of Salt in the Central Valley

The accumulation and movement of salt in the Central Valley are governed by the principle of the conservation of mass based on which a general mass balance equation for salt in the Central Valley can be written as follows:

$$\sum I_i + \sum E_j = \sum \Delta S_k - \sum s_l \qquad (1\text{-}1)$$

where

I_i is the mass of import from the *i-th* source,

E_j is the mass of export from the *j-th* source,

ΔS_k is the change in mass storage of the *k-th* salt storage reservoir, and

s_l represents other possible salt sinks not included as salt exports, such as natural decomposition and degradation (e.g. bacterial denitrification, assimilation, etc).

In practice, not all the masses of salt imports and exports can be easily identified or accurately measured. However, for the purpose of salinity management and policy development, accounting for the major contributions to each term of the above equation with reasonable estimates would likely to suffice. For the delta storage term ΔS_k, the estimate on the changes of mass storage is more important than the absolute mass in each storage component, although the amount of salt accumulation does control the absolute water quality and affect the productivity in the soil.

The following tables (Tables 1-1, 1-2, 1-3, and 1-4) summarize the main components for each of the three terms of the mass balance equation. These tables are not meant to be comprehensive. Rather, it serves as a preliminary guide to identifying areas for further investigations and to focusing on the type of data that are needed for developing salinity management models and formulating regulatory policy.

Table 1-1: Sources of Salt Import *(I_i)*			
	Import Source	**Form of Salt**	**Information needed**
1	Central Valley Project (USBR)	Dissolved minerals	Total Dissolved Solids (TDS), Electrical Conductivity (EC), analytical concentrations of dissolved ions (major minerals), flow rate, integrated flow volume.
2	State Water Project (DWR)	Same as above	Same as above.
3	Other water conveyance projects	Same as above	Same as above.
4	Fertilizer application	Fertilizer minerals	Percent salt components, types and amounts of fertilizer usage per acre of crops. Crop distribution.
5	Human waste - municipal	Dissolved minerals in waste water effluent	Volume of discharge, major chemical analyses of effluent, TDS, electrical conductivity, groundwater quality monitoring information.
6	Human waste – septic systems	Same as above	Estimate of numbers of septic system, average discharge volume, density and distribution pattern.
7	Industrial waste discharge, e.g. food processing	Dissolved salt in waste discharge and in leachate from disposal facilities	Discharge volume and water quality control and monitoring data
8	Animal waste – confined animal facilities, such as dairies, etc	Dissolved minerals in wastewater, and in animal feeds	Water quality control and monitoring data
9	Biosolid disposal	Soluble Salt in biosolids	Disposal tonnage, chemical analyses of sewage sludge
10	Natural runoffs	Dissolved minerals in surface water channels and storage	Total Dissolved Solids (TDS), Electrical Conductivity (EC), analytical concentrations of dissolved ions, stream gauging data, hydrograph records
11	Natural deposition of salt	Salt in precipitation and dry deposition	Climate records, concentration estimates.
12	Food imports	Salt contents in food	Salt estimates in municipal waste steam
13	Smog	NO_x from vehicle and industrial emissions	Air quality estimates from Air Board

Table 1-2: Sources of Salt Exports *(E_j)*			
	Export Source	**Form of salt**	**Information needed**
1	State Water Project	Dissolved minerals	Total Dissolved Solids (TDS), Electrical Conductivity (EC), analytical concentrations of dissolved ions (major minerals), flow rate, integrated flow volume.
2	Other water conveyance projects	Same as above	Same as above
3	River runoffs to the Delta and San Francisco Bay	Dissolved minerals and minerals in suspended solids	Total Dissolved Solids (TDS), Electrical Conductivity (EC), analytical concentrations of dissolved ions (major minerals), flow rate, integrated flow volume. hydrograph records, turbidity, sediment analyses.
4	Food exports	Assimilated food produce, proteins	Salt contents in produce, food export tonnage

Table 1-3: Salt Storage Reservoirs *(S_k)*			
	Storage	**Form**	**Information needed**
1	Ground water	Dissolved minerals	Total Dissolved Solids (TDS), Electrical Conductivity (EC), analytical concentrations of dissolved ions (major minerals),water table level changes, specific yields, porosity.
2	Surface water channels – rivers and streams	Dissolved minerals and minerals in suspended solids	Total Dissolved Solids (TDS), Electrical Conductivity (EC), analytical concentrations of dissolved ions (major minerals), flow rate, hydrograph records, turbidity data, sediment analyses, sediment load.
3	Reservoirs and lakes	Dissolved salt	Changes in water storage. Water quality data, including Total Dissolved Solids (TDS), Electrical Conductivity (EC), analytical concentrations of dissolved ions (major minerals)
4	Vadose zone	Dissolved salt in soil water and soil minerals	Water quality analyses of soil water, and soil minerals.
5	Solid waste disposal facilities	Mineral solids and dissolved minerals in leachate	Waste tonnage, waste composition.

Table 1-4: Sinks of Salt *(s_l)*			
1	Natural degradation	Atmospheric emission	For example, denitrification rate, nitrogen oxide and ammonia emissions

The transfer pathways of salt among the different reservoirs in the valley is depicted in a figure in the preliminary report on salinity in the Central Valley by the Central Valley Regional Water Quality Control Board (CVWQCB, 2006) and is reproduced below (Figure 1.1).

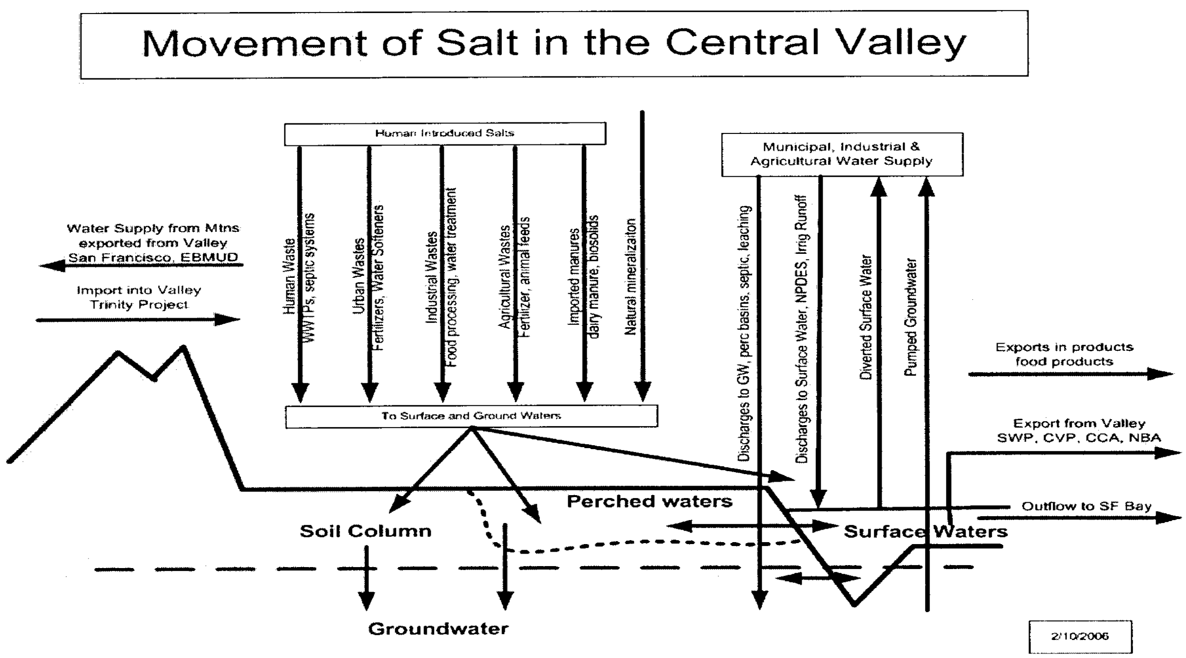

Figure 1.1 Conceptual movement of salt in the Central Valley among various sources and storage reservoirs (from CVWQCB, 2006).

1.3 Purpose of the Report

To provide an access to the necessary technical data for management decisions and policy formulation, a centralized data repository for all salt related data ideally should be developed. However, due to the huge volume of data available and the mixed nature of data that were collected by different agencies at different times, the development of an integrated centralized database is presently beyond the scope of this work.

The purpose of this report is to identify major data sources of salt imports, exports, storage reservoirs, and sinks in the Central Valley, and to provide data descriptions and metadata information on these data sources. This report can be used as a resource guide by managers and scientists to assemble the necessary information and technical data for further analyses or to obtain input data for modeling applications. From these data sources, the needed data can be assembled, integrated, and applied. Examples of applications of the assembled data may include:

- Estimating net gain/loss of salt in the Valley
- Tracing salt pathways among salt reservoirs using hydrologic models
- Scenario analyses applying stochastic methods
- Optimization using management models
- Economic impact analysis
- Farm management and business development, such as making decisions on crops, agricultural practices, and fertilizer application.

This work represents an initial step to examine the sources, availability, spatial, and temporal distributions of salinity related data. Based on the spatial and temporal data distributions, data gaps can be identified. It will help us to focus future efforts in collecting additional data to fill the data needs.

1.4 Overview of the Document

This data source guide is divided into seven chapters. Chapter 1 presents the background information, provides a list of major import and export sources and sinks, and salt reservoirs in the Central Valley of California. It also described the general organization of this document. Chapters 2 to 6 provide metadata information on major data sources of ground water, surface water, wastewater, confined animal facilities, and fertilizer applications, respectively. Each chapter includes, if available, a list of data sources, summary tables, graphs of temporal coverage with short narratives, maps of spatial coverage with brief comments on data gaps and data availability. If applicable, it includes a detailed list of source data attributes and descriptions. Chapter 7 recommends future work using Geographic Information System data models, integrated database development, and hydrologic simulation models to further support salinity management and policy development.