DRAFT

SALTON SEA NUTRIENT TOTAL MAXIMUM DAILY LOAD

DATA GAP ASSESSMENT

Prepared by

California Regional Water Quality Control Board Staff
Colorado River Basin Region

JANUARY, 2002

Introduction

The purpose of the data gap assessment is to determine what information is missing from the available sources of data required to complete the TMDL study. By establishing the major data gaps, a field monitoring procedure can be developed and implemented to address any deficiencies.

Due to the arid climate in the Imperial Valley, nutrient accumulation in the Salton Sea watershed is mainly a function of climate, anthropogenic (human) activities, geology, and topography. The most significant source of the nutrients in the Salton Sea is direct and indirect agricultural discharges. Other sources of nutrients in the Salton Sea tributaries are in-stream erosion, dredging of agricultural drains, stormwater and urban runoff, wastewater treatment plants, animal waste, waste from Mexico, and wind deposition. These sources can be classified as either natural or originating from human activities, and can be further classified as either point sources, such as wastewater treatment plants, which have a single point of origin, or nonpoint sources such as agricultural discharges and stormwater runoff. Figure 1 illustrates the sources of nutrients to the Salton Sea as they fit into these classifications. For the purpose of this assessment, the contributions from the Alamo and New Rivers from Mexico at the International Boundary are treated as non-point sources of pollution from anthropogenic activities.

Nutrients in the Salton Sea

The Salton Sea Transboundary Watershed is located in southeastern California in the Colorado Desert region of the Sonoran Desert. The watershed drains approximately 8360 square miles and contains five main surface water bodies: Salton Sea, Alamo River, New River, Imperial Valley agricultural drains, and the Coachella Valley storm water channel (Whitewater River channel). All five of these surface waters are on the 303(d) list of impaired water bodies.

Pursuant to Section 303(d) of the Clean Water Act (CWA), the Colorado River Basin Regional Water Quality Control Board (Regional Board) is developing a Nutrient Total Maximum Daily Load (TMDL) for the Salton Sea. This TMDL is being developed because the list of impaired waterbodies for the State which (303(d) list) identifies the Salton Sea as water quality limited, in part, because nutrient concentrations (biostimulatory substances) violate the water quality standards (WQS) established by the State and Regional Boards to protect the beneficial uses of the lake. Nutrient concentrations are high in the Salton Sea and lead to frequent algal blooms, which in turn contribute to low dissolved oxygen concentrations.

The beneficial uses of waters for the Salton Sea are aquaculture; warm freshwater habitat; wildlife habitat; preservation of rare, threatened, or endangered species; water contact recreation; non-contact water recreation; and potential industrial service supply.

DRAFT

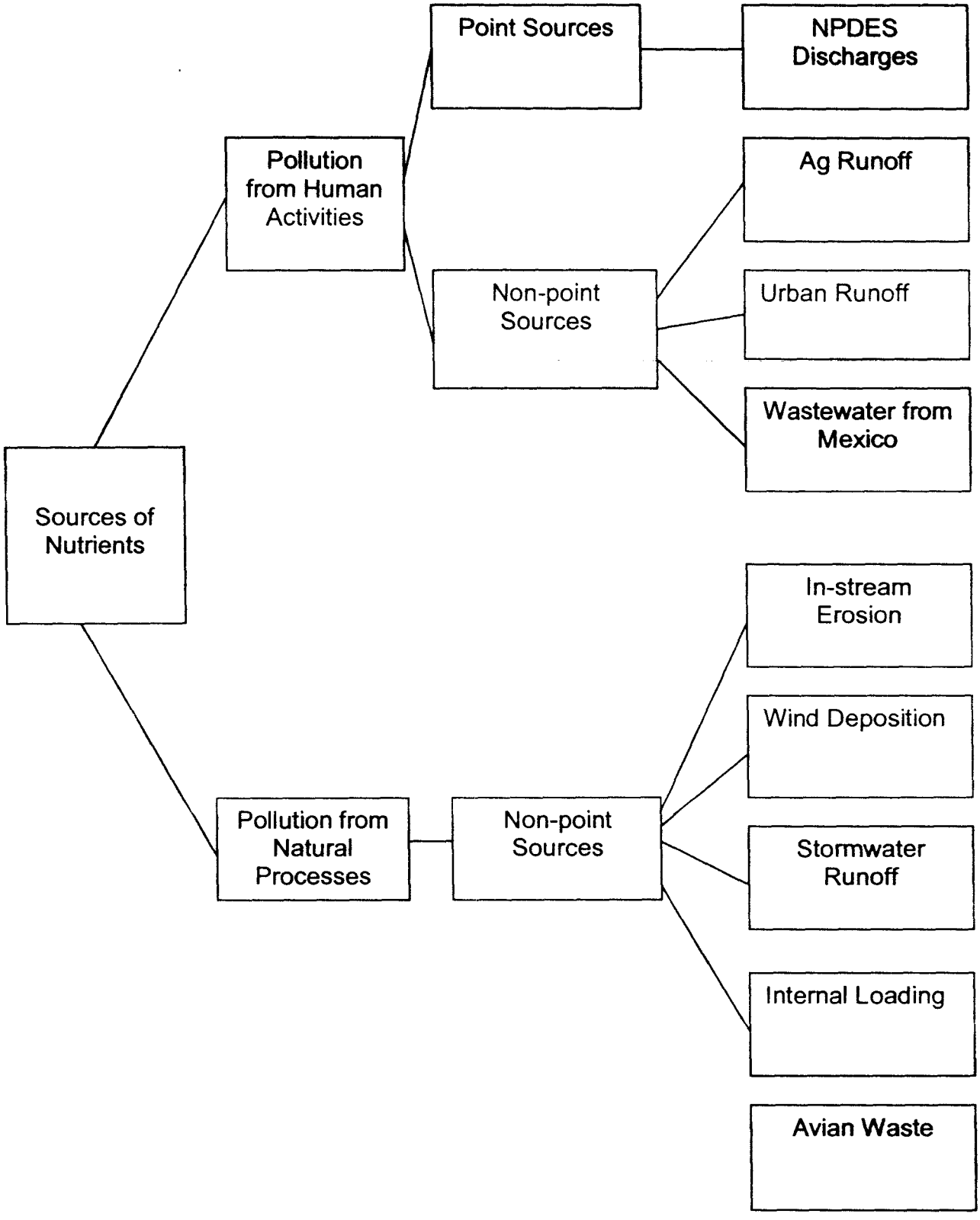

Figure 1: Sources of nutrients to the Salton Sea

In addition, the water quality objectives for the Salton Sea include aesthetic qualities, dissolved oxygen, biostimulatory substances, and turbidity.

The Alamo and New Rivers transport agricultural discharge and municipal effluent from the Imperial Valley to the Salton Sea. In addition, the New River transports municipal and industrial effluent from Mexicali, Mexico. Simultaneously, the Whitewater River transports agricultural discharges, municipal and industrial effluent from the Coachella Valley. In addition, agricultural drains discharging directly to the Sea are a significant source of agricultural discharges.

The Salton Sea is classified as a eutrophic lake – impaired by nutrients, which results in low dissolved oxygen, high ammonia and phosphorus levels, algal bloom and foul odors. The Salton Sea is a designated repository for agricultural, surface, and subsurface drainage waters from the Imperial and Coachella Valleys by the US Department of Interior (1924) and State of California (1968). Over 85% of the freshwater inflows to the Sea consist of agricultural drain water from Imperial Valley. The Sea is a terminal lake, its only outflow is through evaporation at a rate of 152 cm/year. This results in an increasing concentration of nutrients creating eutrophic conditions.

Great concern has been expressed about the increasing concentration of nutrients in the Salton Sea and its relation to algal blooms, low dissolved oxygen and large fish die-offs between 1992 and the present date. Concern is increased due to the importance of the Salton Sea ecosystem to the Pacific Flyway and endangered species.

Data Selection Criteria

The data selection was done by answering the following questions positively:

1. Was the study/sampling done within the Salton Sea Watershed?
2. Were nutrient related parameters collected?
3. Is the data available?
4. Is there a detailed description of the purpose of the study, and the constituents sampled and analysis methodology?
5. Was there a quality control to validate the data?
6. Can the data be used for at least one of the following purposes:
    - Assessment of the current nutrient condition of the Salton Sea Watershed
    - Characterization of the nutrient impairment
    - Estimating the nutrient load to the Salton Sea
    - Data input and validation of the nutrient model
    - Establishing a link between impairment and beneficial uses.

Data Available for Source Analysis

The available data or summary data follows. The main studies that are relevant to the Salton Sea TMDL nutrient will be described first.

Nutrient Studies within the Salton Sea

Anderson, M. and C. Amrhein. 1999-present. Nutrient Cycling in the Salton Sea (sponsored by Salton Sea Authority). Bioavailability, Resuspension and Control of sediment-Borne Nutrients in the Salton Sea (sponsored by Regional Board). Dept. of Environmental Sciences, UC Riverside.

Description: These are two complimentary projects. Samples are being collected on an 80 point grid design of the Salton Sea during a one year period (summer 2000-summer 2001). The samples include water column, suspended sediment and bottom sediment that are being analyzed for several chemical and physical parameters. The sampling frequency varies from biweekly (water column) to every three months (bottom sediments and suspended sediments). Water is sampled for nutrients at three depths. Meanwhile, the water is being sampled every 1-2 m for the other parameters. Duplicates of each sample are analyzed. The final goal is to develop a model that describes the nutrient fluxes in the Salton Sea. Preliminary reports were submitted to the Salton Sea Authority.

Assessment: This is the most comprehensive research plan for assessing and describing nutrients the Salton Sea to date. A very detailed research in terms of parameters measured, spatial description, temporal variation that is going to be used to validate a nutrient cycling model. This research will supply the scientifically defensible data for the Salton Sea Nutrient TMDL. However, most of the data and the model will not be available before December 2002.

Arnal, E. A. 1961. Limnology, Sedimentation, and Microorganisms of the Salton Sea, California. Geological Society of America Bulletin, 72:427-478.

Description: A detailed study of sediments at the Salton Sea. It describes and discusses chemical and physical characteristics and spatial distribution of the sediments. It also describes the species of phytoplankton at the Sea.

Chris Holdren and Andrew Montano, 1999. SEASONAL VARIATION OF NUTRIENT, MAJOR ION, AND METAL CONCENTRATIONS IN THE SALTON SEA, 1999. U.S, Department of the Interior, Bureau of Reclamation.

Description: A one-year sampling program was conducted to assess the current chemical and physical conditions in the Salton Sea. Analyses included general physical conditions and water quality parameters, nutrients, trophic state variables, major cations and anions, trace metals and organic compounds. Samples were collected from three locations in the main body of the lake and from the three major tributaries during 18 sampling events throughout the year.

Coachella Valley Water District. On one sampling date in the years 1990, 1992, 1994, and 1997 major ions and some heavy metals were collected at 7-10 sampling sites in the Salton Sea.

Gonzalez, M. R., C. H. Hart, J. R. Verfaillie, S. H. Hurlbert. 1998. Salinity and fish effects on Salton Sea microecosystems: water chemistry and nutrient cycling. Hydrobiologia 381:105-128.

Strength: a detailed experiment that may be a model of how salinity and fish affect the water chemistry and nutrient cycling of the Salton Sea. Other: there is a good table of nutrients in the Salton Sea collected 1955-1956 and 1968-1969 demonstrating that the problems with N and P (eutrophication) were already high 45 years ago. Limitation: the artificial microcosms may have a different chemistry and evolution than a natural large scale system.

Hurlbert Group. 1997-2000. Salton Sea Ecosystem Research Group (SSERG), Center for Inland Waters (CIW), San Diego State University.

Nutrients, plankton, temperature and D. O. profiles were collected at several stations throughout the Salton Sea. This study was sponsored by Salton Sea Authority and it will be published at Hydrobiologia Journal June 2002.

Imperial Irrigation District. 1996 data. Drain Water Quality Sampling Program.

Description: Monthly sampling of the New River outlet and Alamo River outlet. They are analyzed for ammonia, nitrate, total phosphorus and several other parameters.

Imperial Irrigation District. 1993 to present. Surface Water Monitoring at the Salton Sea Program.

Description: Water sampling at 5 sites located on the beach of Salton Sea on a semi-annual basis (April/May and October/November). Chemical and physical parameters are being analyzed like conductivity, pH and TDS. There are no nutrient specific constituents.

Region 7 – NPDES monitoring program. New permits (starting 98-99) have nutrient parameter requirements. Permits earlier than 1998 may not have nutrient parameter requirements.

Region 7 Trend Monitoring Program Data. 1980-1993. Sampled at fourteen locations in the Salton Sea Watershed quarterly intervals and analyzed for nutrient related water quality parameters.

Schroeder, R., M. Rivera, and others. 1993. Physical, chemical, and biological data for detailed study of irrigation drainage in the Salton Sea area, California, 1988-90. United States Geological Survey, Open-file Report 93-83.

Description: A study of trace elements concentrations in soil, irrigation water, drainwater, surface water, groundwater, and biota was conducted during three years. Monthly monitoring of ammonia, nitrate, nitrite, organic nitrogen, and orthophosphate

was conducted at six locations (including Alamo river outlet and New river outlet) at 17 sampling events during one year.

Schroeder, R., C. Roberts, and J. Setmire. 2001. Detailed Study and Assessment of Irrigation Drainage in the Salton Sea Area, Imperial Valley, California. Nutrient Dynamics in the Salton Sea Basin – Implications from Calcium, Uranium, Molybdenum, and Selenium. USGS project # CA470.

Description: A study of nutrients and trace elements of the Salton Sea was conducted in 1999. Water samples and sediment grab samples from 11 location transect and sediment cores from 2 locations in the Salton Sea were collected. The data was presented at the Salton Sea Symposium in 2000 (Schroeder, R. and W. Orem. Nutrient Dynamics in the Salton Sea Basin – Implications from Calcium, Uranium, Molybdenum, and Selenium.). The authors are currently writing it as a paper format.

The data suggests that the nitrogen level at the Salton Sea has increased by an order of magnitude since 1950s. In contrast, the phosphorus concentration has slightly increased at the same time. The authors suggest that internal cycling and sequestration in bottom sediment are responsible for keeping the phosphorus concentration stable.

Setmire, J. G., J. C. Wolfe, R. K. Stroud. 1990. Reconnaissance investigation of water quality, bottom sediment, and biota associated with irrigation drainage in the Salton sea area, California, 1986-87. United States Geological Survey, Water Resources Investigations Report 89-4102.

Description: A study of trace elements and pesticides concentrations on water, bottom sediment and biota was conducted during 1986-87 at localized areas of Coachella Valley/North Salton Sea and Imperial Valley/ South Salton Sea. Total phosphorus, organic nitrogen, ammonium, nitrate, nitrite, organic carbon and inorganic carbon were analyzed at bottom sediments at one sampling event.

Setmire, J. G., Holdren, C., Robertson, D., Amrhein, C., Elder, J., Schroeder, R., Schladow, G., McKellar, H., and Gersberg, R. 2001. Eutrophic conditions at the Salton Sea. A topical paper from the eutrophication workshop convened at the University of California at Riverside, September 7-8, 2000. Http://www.lc.usbr.gov/~saltnsea/pdf_files/scidocs/eutrofin.pdf

Description: The paper summarizes discussions and recommendations at the workshop. The paper discusses the evolution of the nutrients in the Salton Sea during the previous 30 years. It compares 1968-1969 data (Department of the Interior) with the 1999 data (Holdren, in preparation). It comprehensively describes the nutrient load and its impact in the Salton Sea. This paper establishes phosphorus as the limiting nutrient in the Sea.

Tiffany, M.A., K. M. Reifel, B. K. Swan, M. McCoy, and J. D. Faulkner. 1999. Reconnaisance of the Biological Limnology of the Salton Sea. Progress Report 2: Phytoplankton and algal toxins. Salton Sea Science Office, La Quinta, CA.

Description: This report presents the information on phytoplankton of the Salton Sea, their seasonal variation, and their possible toxicity analyzed October 1997-April 1999. Chlorophyll a concentrations, which are an indication of the phytoplankton abundance, were high in the Salton Sea. The highest chlorophyll a concentrations tended to be in the winter months after a period of continuous mixing. Recycling of plant nutrients to the photic zone from the deeper strata and sediments during these months may allow high growth of phytoplankton. In summer, deep mixing only occurred at irregular intervals. Surface nutrient concentrations may have been somewhat depleted during stratification events, limiting the phytoplankton growth.

Several samples of algae showed toxicity when extracts of them were submitted to a brine shrimp assay. A dieoff of tilapia occured 2-4 weeks before the first coccolithophore *P. pseudoroscoffensis* samples were taken. Most likely, the dieoff was not caused by the toxin found but occurred earlier and may have fueled the coccolithophore bloom by providing nutrients.

Tiffany, M.A. and J. Watts. 1999. Reconnaisance of the Biological Limnology of the Salton Sea. Progress Report 3: Zooplankton, 1997-1998. Salton Sea Science Office, La Quinta, CA.

Description: This study determined the species of zooplankton presently existing in the Sea and documented the seasonal and spatial variation in their abundance. This report summarizes the samples analyzed to date for three mid-lake stations for 1997-1998. Two more southerly stations have been added to the monitoring program in 1999 (not analyzed in this report).

The metazooplankton of the Salton Sea was dominated by few species. An abrupt and major decrease occurred in the zooplankton densities in September 1998 when there was a very low oxygen content throughout the water column. This sort of decline could have serious consequences to fish present in the Sea if they are dependent on zooplankton as food source. In this particular event the zooplankton had recovered substantially by the next sampling date two months later.

United States Department of the Interior. 1970. Salton Sea, California. Water quality and ecological management considerations.

Description: There are tables summarizing the nutrients / water quality data collected by Federal Water Quality Administration Pacific Southwest Region in 1967-69. It is organized as the concentration and loads of the tributaries to the Salton Sea, as well as, the water quality concentrations from the surface of the Salton Sea from four sampling dates. Also there are chemical analyses of sediments from several stations at the Salton Sea.

United States Geological Survey. 1980-1994. Water Resources Data. California. Volume 1

Description: One monitoring station at the Salton Sea and only measuring water level (elevation). The other stations are located at the tributaries and only three (3) monitor water quality. Data from 1980-1994 are available in the Regional Board library. A request will be made for the 1995-2000 issues.

University of Redlands. Salton Sea Database Program. Salton Sea Watershed Water Quality Monitoring Program Inventory and Assessment.
Clearinghouse of information regarding Salton Sea Watershed. It houses information concerning responsible agency, scope of the project, sampling and analyses methodologies, sampling locations in a GIS format, frequencies, constituent analyzed, etc. However, University of Redlands does not necessarily store the data.
http://cem.uor.edu/salton/

Watts, J. M., B. K. Swan, , M. A. Tiffany, , and S. H. Hurlbert. 1999. Reconnaisance of the Biological Limnology of the Salton Sea. Progress Report1: Temperature, dissolved oxygen, pH, ammonia, and light penetration. Salton Sea Science Office, La Quinta, CA.

Description: This report presents and interprets measurements of temperature, dissolved oxygen, pH, ammonia, Secchi disk depth, and light penetration made at the Salton Sea during 1997-1999.

Mean total ammonia (NH_3+NH_4^+) concentration appears to have increased three-fold since 1968-1969 (USDI 1970). Ammonia (NH_3) concentrations for individual samples ranged from 6 to 35 µM, below levels considered acutely toxic to fish and invertebrates (acute toxicity is usually found starting at 45 to 300µM). Ammonium ion (NH_4^+) concentrations ranged from 10 to 250 µM.

Watts, J. M., L. Thurn, and S. H. Hurlbert. 2000. Reconnaisance of the Biological Limnology of the Salton Sea. Progress Report19: Phosphorus, nitrogen, and silica in the Salton Sea, 1997-1998. Salton Sea Science Office, La Quinta, CA.

Description: The focus of this study is on general patterns, interannual and seasonal variation, and ratios of these nutrients.

The Salton Sea is a wind driven system with two major periods of import to nutrient cycling. The stratification period occurs from February to August/September when the Sea is warming and prone to thermal stratification. When stratified, surface waters where primary production occurs are separated by complex density gradients from anoxic bottom waters where decomposition and nutrient release from the sediments occur. Unlike most lakes, however, wind events break down stratification and mix the Sea from surface to bottom at intervals throughout these months. During the rest of the year, September to January, the Sea is cooling and mixes daily or nearly daily. During this period bottom and surface waters are well mixed. Water temperatures are lower and conditions are oxic.

TP showed 2-3 fold variation during 1997 and 1998, mainly due to two large increases in July and September of 1998 of both DOP and PP. The two notable increases of TP coincided with maxima of zooplankton abundance.

The nutrient ratios were always above the generalized aquatic biomass N;Pratio of 16:1 by 3-4 fold. This suggests that phosphorus, not nitrogen, is limiting aquatic growth.

Other Nutrient Studies in the Salton Sea Watershed

Regional Water Quality Control Board (R7). 1975-Present. New River / Mexicali Sanitation Program.

Regional Water Quality Control Board (R7). NPDES reports with related nutrient water quality data.

Setmire, J. G., R. A. Schroeder, Jill N. Densmore, S. L. Goodbred, D. J. Audet, and W. R. Radke. 1993. Detailed study of water quality, bottom sediment, and biota associated with irrigation drainage in the Salton Sea area, California, 1988-90. United States Geological Survey, Water Resources Investigations Report 93-4014.

Description: A detailed study of selenium, boron and DDT concentrations in irrigation drainage and wells and its effect on the migratory and resident birds of the Salton Sea Area during three years. They monitored concentrations in water, sediments, birds and fishes. There is a limited amount of information regarding ammonia and nitrate concentrations in waters collected in wells and lysimeters.

Flow Data

- Point Source (NPDES) Facilities – Daily flow data for NPDES facilities discharging into the Salton Sea watershed are available in the Regional Board's files.
- Alamo and New River Outlets - Monthly flow data spanning 1994-2001 has been obtained from the USGS.
- Alamo and New River at the International Boundary – Monthly flow data at the international boundary has been obtained by USGS for the 1994-2001 period.
- Imperial Valley Drains – IID has provided January 1994 through May 2001 monthly flow data for twenty six (26) drains. This data set contains relatively few missing data points.
- White Water River – monthly flow data spanning 1994-2001 has been obtained from USGS at the outlet.
- Irrigation Deliveries – IID provided a database with the records of the daily January 1994–May 2001 irrigation water deliveries for the subwatershed. Database fields include canal, drain, drain prefix, drain suffix, and delivery date, and delivery quantity in acre-feet.
- Daily recorded precipitation data are also available for the Coachella and Imperial Valley areas from California Department of Water Resources 1994 through 2001.

The Data Gaps

The available data covers limited area in space (few sampling locations) and time (few sampling dates over a year) of Salton Sea. A characteristic of most of data sets is that there is no continuity with their projects. There is a lack of comprehensive data regarding nutrients and associated parameters within the Salton Sea.

There is lack of data regarding nutrient and associated parameter load from the individual agricultural drains into the Salton Sea.

We are lacking information regarding the dynamics of biological indicators (algae, benthic organisms, etc.) within the Sea. There is lack of a comprehensive study of algae growth and its linkage to nutrients. The other deficient area is the lack of a nutrient model that predicts variation of nutrient content and algae growth as the nutrient load and water flow fluctuates.

Present and Proposed Activities to Fill the Gaps

The University of California Riverside project (funded by Salton Sea Authority) will supply comprehensive information on the nutrient dynamics within the Sea which was studied for a period of one year (80 location grid design, water column, monthly measurements, sediment-water interface).

The Colorado River Basin Regional Water Quality Control Board is developing a monitoring program to quantify the load of nutrients to the Salton Sea. This program will monitor the three main tributaries and twelve (12) agricultural drains on both the southern and northern shores of the Sea monthly for two years. Each sampling will be analyzed for 20 nutrient related water quality parameters. The first sampling is expected to start in March 2002. This data will be used for the load estimation into the Salton Sea. The Quality Assurance Project Plan (QAPP) will be distributed to the Salton Sea Nutrient TMDL Technical Advisory Committee for review.

The Colorado River Basin Regional Water Quality Control Board will be monitoring the water column of six (6) sites within the Salton Sea on a quarterly basis as part of the Surface Water Ambient Monitoring Program (SWAMP). This program will start in Spring 2002.

The Colorado River Basin Regional Water Quality Control Board contracted the University of California Riverside to develop a nutrient cycling model for the Salton Sea. This model will predict phosphorus and algae concentrations within the Sea. This project started November 2000 and is expected to take one year. Another year will be required to learn the model and how it may be used for source analysis.

DRAFT

The Colorado River Basin Regional Water Quality Control Board is contemplating a contract to develop a dynamic nutrient model for the Salton Sea. This model will link nutrients levels to dissolved oxygen concentrations within the Sea.

The comprehensive San Diego State University Biological Assessment of the Salton Sea (funded by Salton Sea Authority) is expected to be published in the Hydrobiologia Journal June 2002. This is a qualitative assessment of the nutrient related biological indicators and may indicate what the next step in this matter should be.

The Colorado River Basin Regional Water Quality Control Board will request Coachella Valley Water District for data regarding water delivery, water flows from agricultural drains, etc.

The Colorado River Basin Regional Water Quality Control Board will request Salton Sea Authority and/or Salton Sea Science Office for fish/tilapia population and their nutrient content estimation.