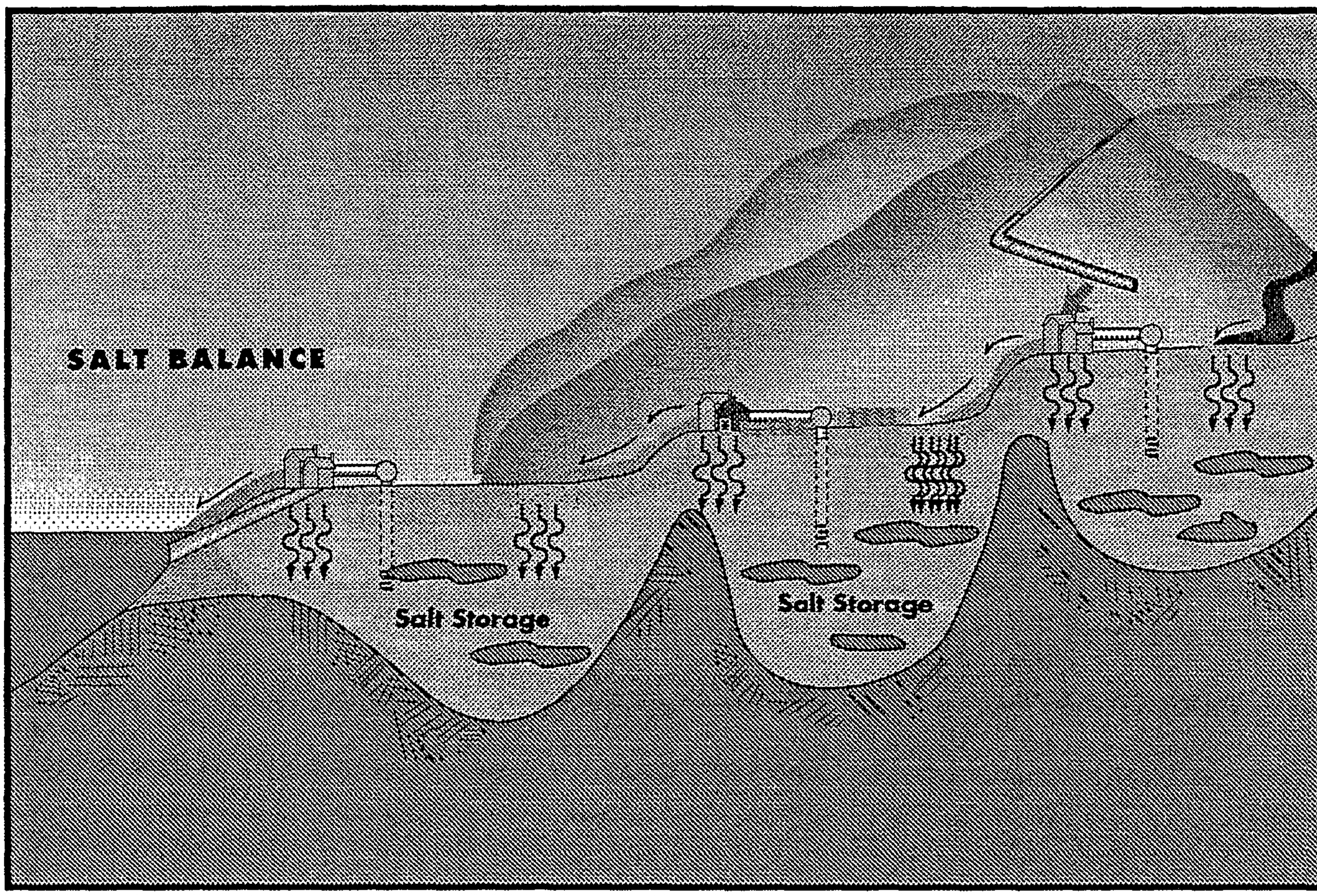
SALINITY MANAGEMENT STUDY

PHASE 1

Progress Report

February 1997



MWD
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

D-054928

D-054928

MWD/USBR SALINITY MANAGEMENT STUDY

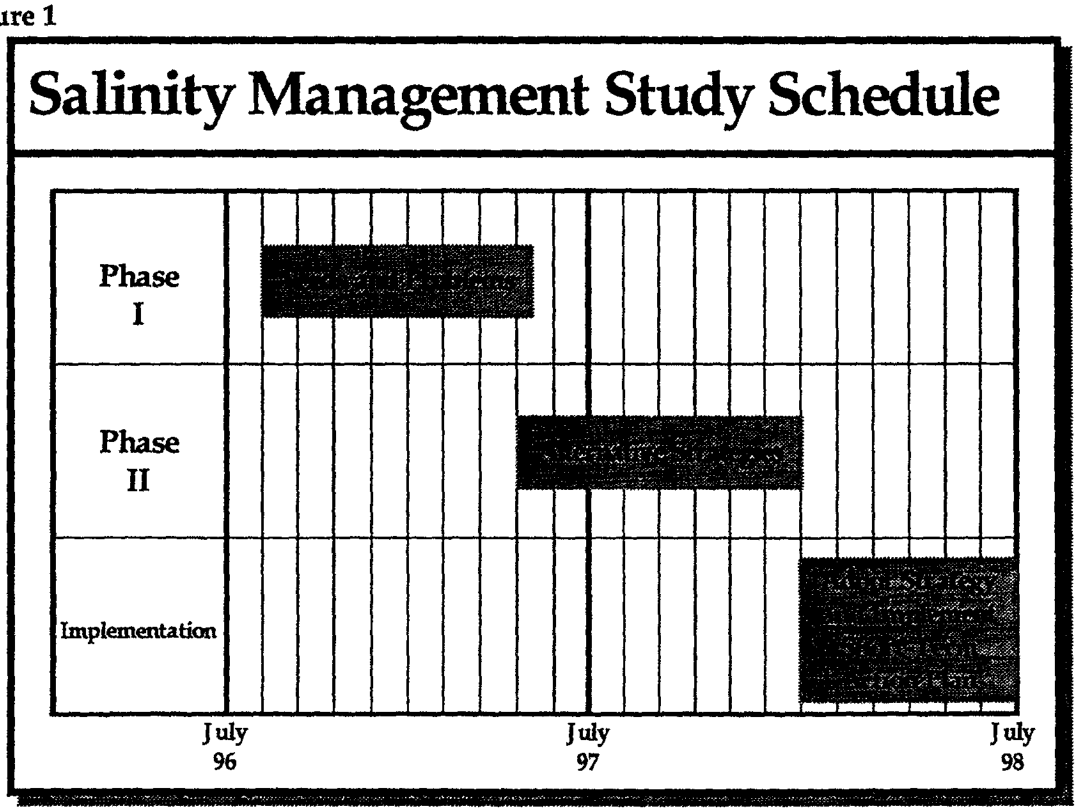
PHASE I PROGRESS REPORT

INTRODUCTION

This report summarizes the progress of Phase I of a two-phased comprehensive salinity management study of The Metropolitan Water District of Southern California (Metropolitan) service area. The purpose of the study is to develop information to support adoption of regional salinity management policies by Metropolitan's Board of Directors and to coordinate interagency action to solve salinity problems. The two phases are to accomplish the following:

- Phase I — Identify problems and salinity management needs of the service area.
- Phase II — Formulate and evaluate salinity management strategies.

Figure 1

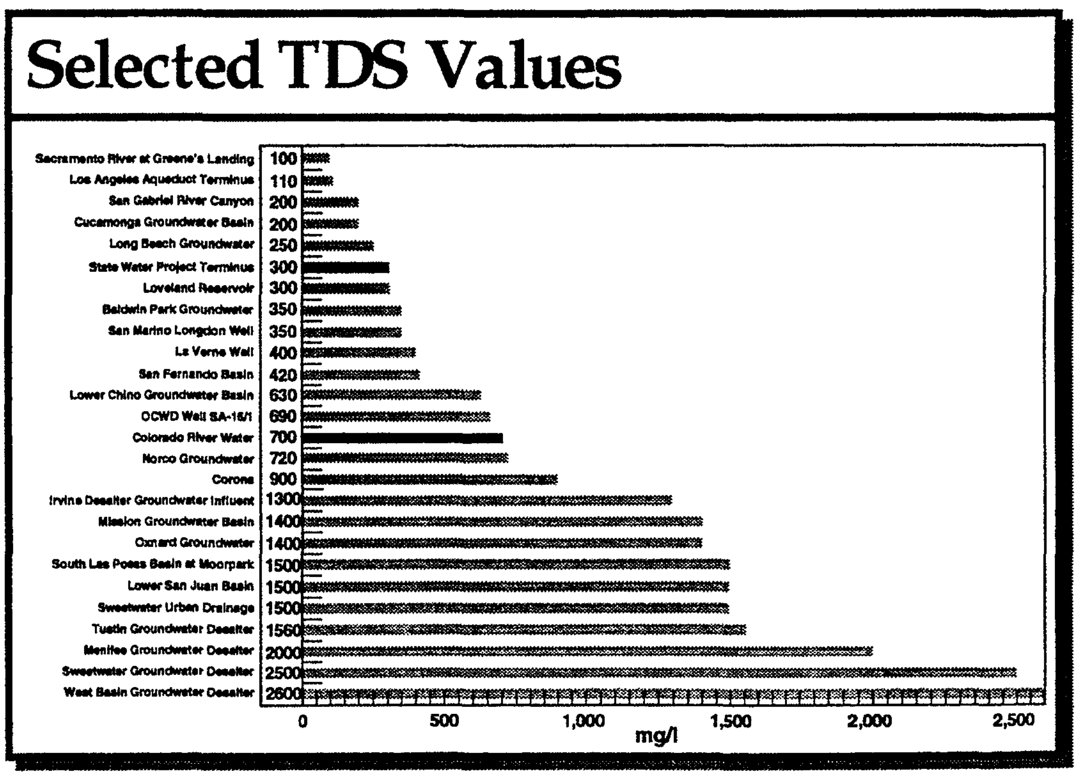


Salinity or total dissolved solids (TDS), commonly expressed in milligrams per liter (mg/L), are natural mineral salts dissolved in water. The management of salinity in Southern California's water supplies has been a concern to water resource managers for a long time. For example, the average salinity level in Colorado River water (CRW) in 1996 was nearly double the historic salinity level in State Water Project (SWP) supplies.

- 700 mg/L Colorado River
- 300 mg/L State Water Project

The City of Los Angeles' water supply from the eastern Sierra Nevada is significantly lower in salinity, typically about 100 mg/L. TDS levels in local groundwater supplies in Southern California vary considerably, ranging from 200 mg/L (e.g., Cucamonga Basin near Upland) to over 1,000 mg/L (Arlington Basin near Corona). Figure 2 provides TDS values in selected water supplies.

Figure 2



Salinity is a significant water quality problem. Plants experience restricted growth, even death when salinity becomes too high. Salinity is typically the primary water quality constraint to recycling wastewater. Salinity in water also adversely affects the way we use water. For example, laundry detergents work less well with salty water, plumbing fixtures and home appliances wear out faster with higher salinity, and industrial users have to pretreat salty water to use in their cooling towers and boilers. A more complete listing of salinity concerns appears on the following page.

SALINITY CONCERNS

- Irrigation/Recycling
  - Leaf Damage
  - Soil Binding
  - Crop Yields
- Discharge Permits
  - Antidegradation
  - Fish and Wildlife
- Consumer Impacts
  - Hardness
  - Corrosion
  - Taste
  - On-site Treatment
- Groundwater
  - Salt Balance
  - Blending
- Drinking Water Standards

As shown below, sources of salinity in water result in large part from use of the imported supplies for urban and agricultural purposes. Seawater intrusion into our coastal groundwater aquifers and the Delta also contributes salt.

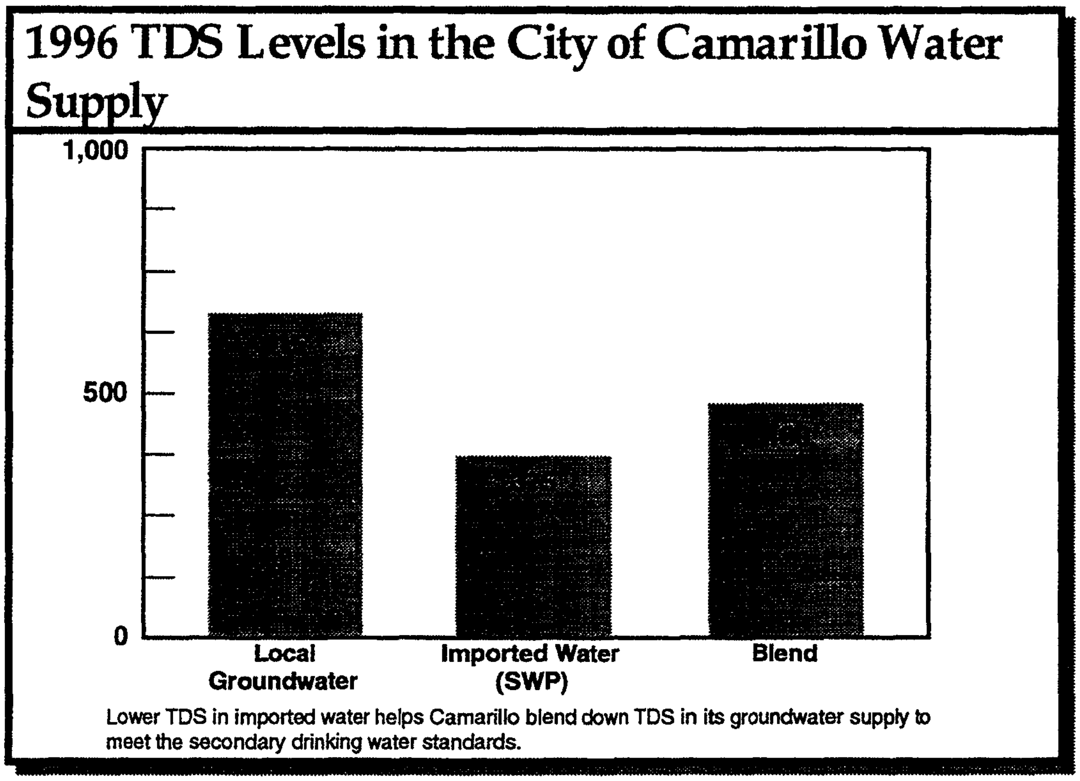
SALINITY SOURCES

- Rivers and Streams
  - Local
  - Owens Valley
  - SWP
  - Colorado River
- Urban Use
- Residential Water Softener
- Commercial/Industrial
- Agriculture
- Seawater Intrusion
  - Sewer Infiltration/Inflow
  - Groundwater

Background and History

Salinity has been a concern of water resource managers in Southern California for most of the 20th century. Agricultural activities since the 1880s have increased TDS (and nitrates) in many groundwater basins. Some areas have relied upon imported water to blend down high TDS levels in their groundwater supply (see Figure 3). Severe groundwater overdraft along the coastline has caused seawater intrusion, impairing the quality of freshwater aquifers. In addition, without an ocean outfall or stream discharge, some inland agencies that reuse wastewater have the problem that salt in water continues to cycle and build up in their groundwater systems, never being removed. Some inland agencies have access to a "brine line" for exporting salt and concentrated wastes to a coastal treatment plant and ocean outfall, while others have not found construction of a brine line economical to date.

Figure 3

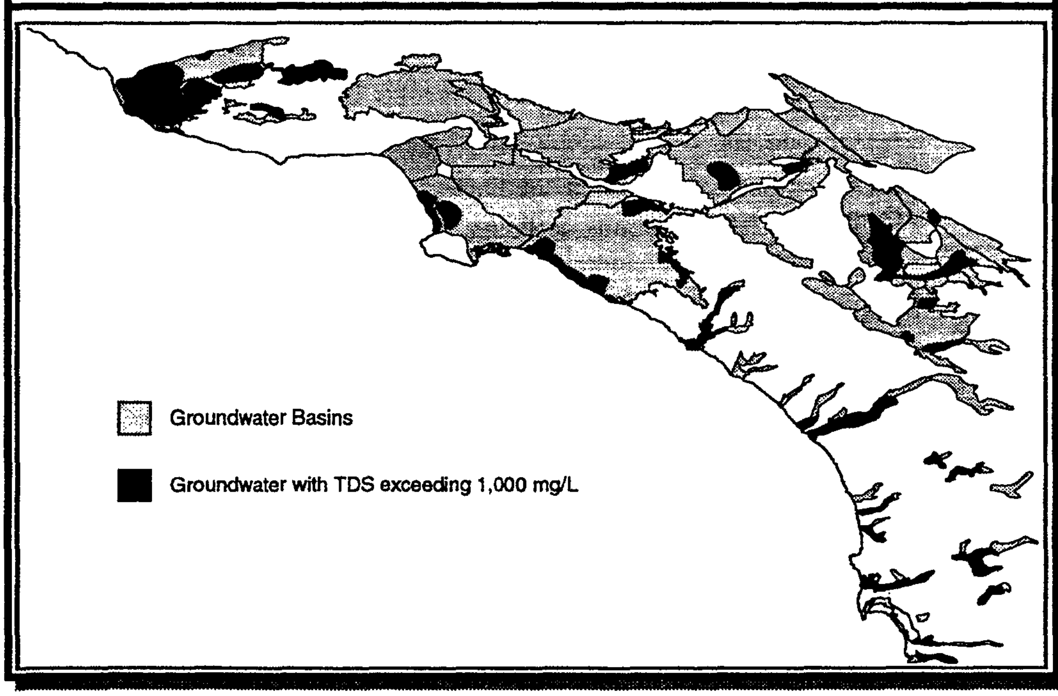


During the 1950s and 1960s, over 2 million acre-feet of CRW was spread in the Santa Ana and San Gabriel Rivers to alleviate severe groundwater overdraft. In addition, seawater barriers were constructed and placed into operation to prevent further seawater intrusion. Over one million acre-feet of imported water has been injected into these barriers (Central and West Coast Basins). The higher TDS of CRW, compared to local groundwater, increased the salinity of these groundwater basins. The current high-salinity problem areas in the groundwater basins are shown on Figure 4. About 11 percent of the regional groundwater production has salinity in excess of 1,000 mg/L. An additional 11 percent of production exceeds 500 mg/L (see table below).

TDS OF WELLS		
TDS Concentration (mg/L)	Annual Production (Million Acre-feet)	Percent
Less Than 500	1.06	78
500 to 1,000	0.15	11
Greater than 1,000	0.15	11
	1.36	**100**

Figure 4

Groundwater Basins in Southern California



Colorado River salinity has long been identified as a problem. The very high TDS impacts on Mexico in the mid-1960s and the Federal Water Pollution Control Act amendments led to Minute 242 and the Colorado River Basin Salinity Control Act in 1973 and 1974, respectively. The Bureau of Reclamation has developed sophisticated Colorado River modeling and salinity management plans to reduce the salt load. In addition, the seven basin states formed the Colorado River Basin Salinity Control Forum to coordinate federal and state policies related to Colorado River salinity programs. This led to development of economic impact estimates of many hundreds of millions of dollars annually from use of CRW in the lower basin (1978, 1980, 1988).

Starting in the early 1970s with the initial Metropolitan deliveries from the SWP, blending of SWP and CRW supplies or using the SWP's relatively low TDS supplies for groundwater replenishment became a policy objective in some areas (see Figure 5 for the historic SWP and CRW salinity, 1972 to present). For example, the Santa Ana Watershed Project Authority (SAWPA) was formed to develop a Basin Plan to address basin-wide salt balance issues. Use of SWP supplies for replenishment is an important component of SAWPA's watershed policies as well as those of the Santa Ana Regional Water Quality Control Board.

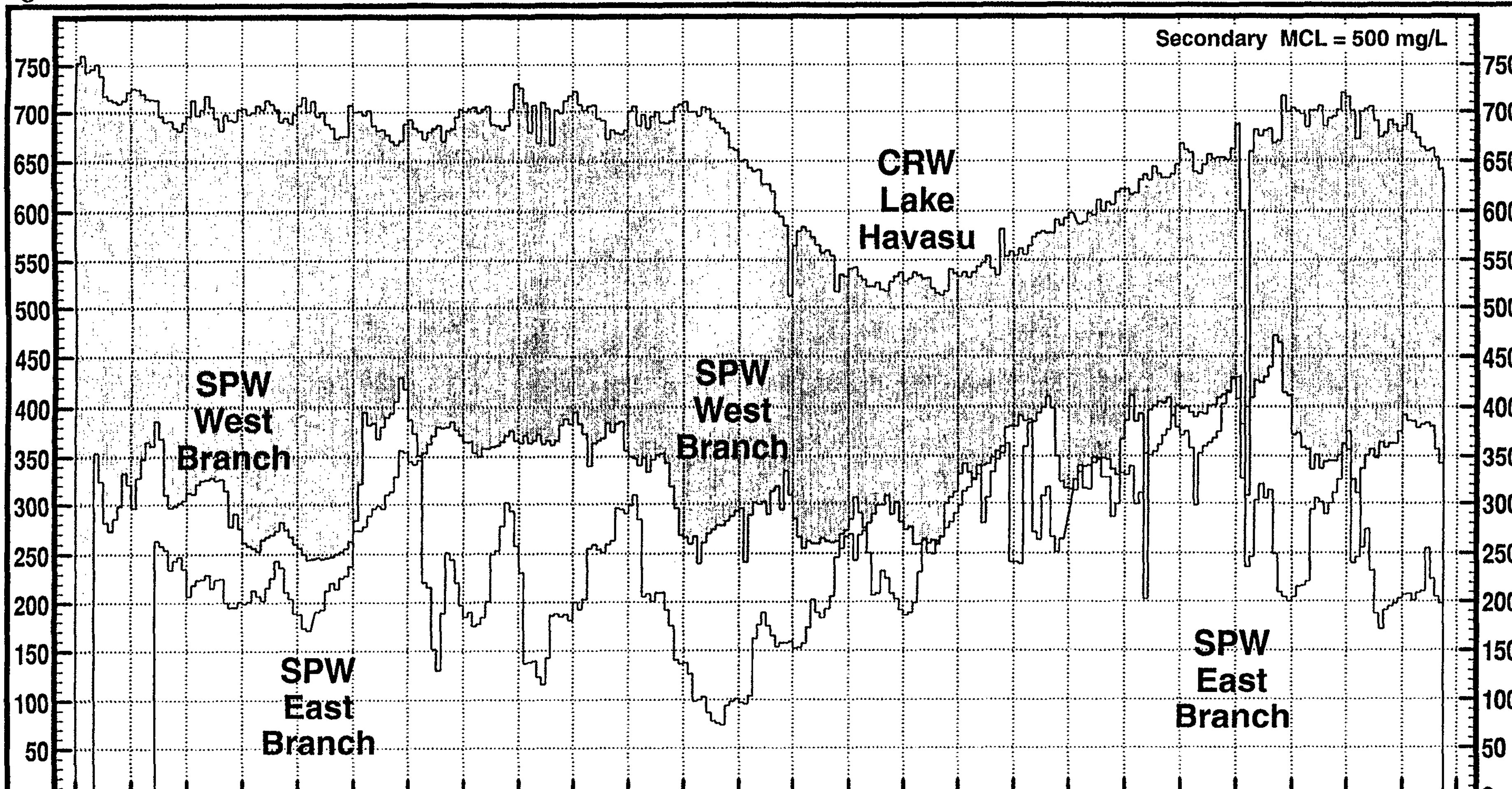
Most Basin Plans developed by Regional Water Quality Control Boards include discussions of water supply and salt balance issues. In some cases, Basin Plans have been based on optimistic assumptions made in the 1970s about the amount of SWP water available, and expected improvements in quality of imported water. These assumptions were the basis for the Regional Boards to identify which specific groundwater basins had assimilative capacity for reclaimed water. During the historic high Colorado River flows (1983-1986), TDS levels in monthly samples dropped significantly to about 525 mg/L, the lowest sustained salinity concentrations since the Colorado River Aqueduct was completed (see Figure 5). SWP salinity levels increased significantly during the 1987-1992 drought. The cumulative effect was that TDS levels in imported water supply actually rose between 1987 and 1992, making it difficult for reclaimed water producers to comply with Basin Plan objectives. During the next drought period, CRW supplies could exceed 900 mg/L (a 5 percent probability), as illustrated in Figure 6 below.

Urban and agricultural irrigation uses of imported water and recycled water are especially sensitive to these events. Wastewater agencies also experience difficulty complying with waste discharge permit requirements designed to protect groundwater basins and the environment. Such an experience during the 1986 - 1991 drought resulted in the Los Angeles Regional Water Quality Board adopting a new chloride policy for its region.

Where local groundwater or reservoir water is of good quality, the impacts of these episodic conditions are reduced through blending of local and imported water. However, at locations where the changes in imported supplies are not mitigated by local supplies the impact will be more significant. Furthermore, agencies using SWP water to blend down high salinity groundwater would experience extra blending costs and reduced use of local supplies when SWP salinity is high.

The apparent dilemma for the region is that during droughts when the use of recycled water projects and marginal quality groundwater are most important, use of some of these local supplies may be constrained by the quality changes in imported supplies unless expensive demineralization facilities are developed.

Figure 5



	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	
CRW	732	704	699	701	695	685	684	699	700	693	696	690	616	559	529	528	546	575	603	632	653	644	699	691	668	CRW
WB	309	330	311	265	250	305	366	362	371	373	333	271	299	263	283	269	328	350	337	353	403	425	353	338	376	WB
EB	--	248	213	212	205	379	244	229	163	251	214	98	149	200	240	251	337	317	326	380	372	277	279	243	213	EB

1972-96 TDS in East Branch SPW (Devil Canyon), West Branch SPW (Jensen Influent), and CRW (Lake Havasu)

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Colorado River

Colorado River salinity has returned to its long-term average of nearly 700 mg/L at Metropolitan's point of diversion in Lake Havasu. The river experienced temporary lowering of salinity to about 525 mg/L in monthly samples during the 1983-86 wet period.

Continued agricultural and urban development are adding salts to the Colorado River. The Colorado River Basin Salinity Control Program, which is managed by the federal government and the basin states, is undertaking measures to offset those salinity increases to meet the adopted salinity criteria:

Location	Numeric TDS Objectives (mg/L)
Below Hoover Dam	723
Below Parker Dam	747
At Imperial Dam	879

Metropolitan and its member agencies benefit appreciably from this program and have actively supported federal appropriations since its initiation in the 1970s. Continued funding is critical to the program's success. Implementation of additional salinity control measures are planned between 1996 and 2015 with $26 million in Federal Funding needed annually.

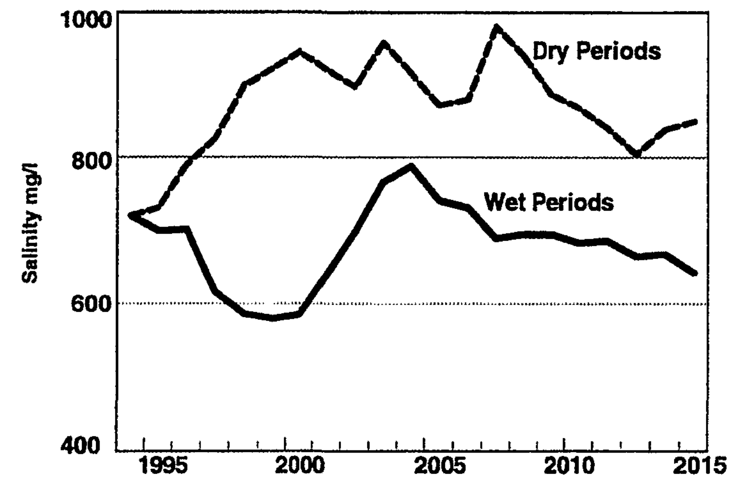
However, even with full implementation of all recommended salinity control measures, modeling studies show about a 30 percent chance of 800 mg/L and 5 percent chance of 900 mg/L TDS concentration at Parker Dam during dry periods.

State Water Project

SWP salinity changes relatively rapidly, responding to routine seasonal changes and periodic drought and flood events. Historic SWP salinity levels for Metropolitan's service area have averaged 300 mg/L (1974-1995, the average of the East Branch and West Branch). Typical variations are 100 to 400 mg/L on the East Branch and 250 to 450 mg/L on the West Branch. In comparison, salinity at Greene's Landing (on the Sacramento River upstream of the Delta) is relatively stable with variations ranging from 50 to 150 mg/L. Chloride levels in SWP water quality, an indicator of seawater mixing with freshwater, increases during droughts (see Figure 7).

Figure 6

Salinity at Parker Dam

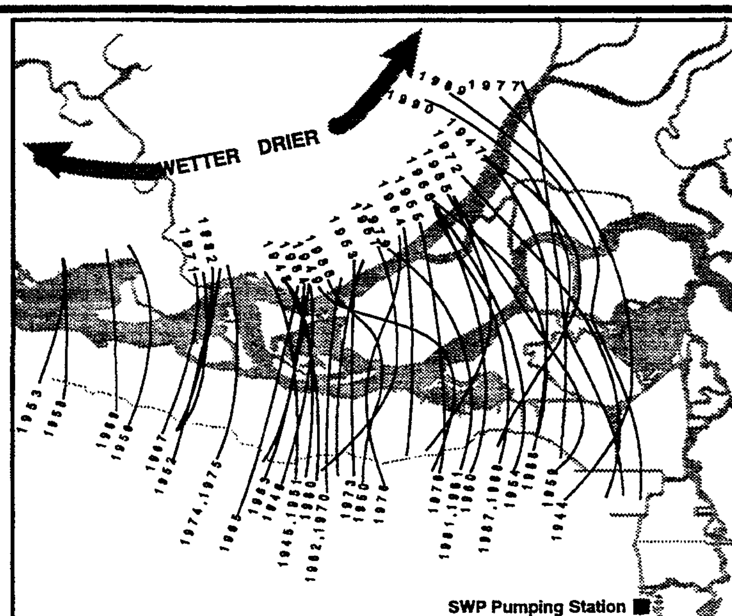


Although the TDS criteria at Parker Dam is 747 mg/L, the Colorado River TDS changes in high and low runoff conditions. The above modeling results, prepared by the U.S. Bureau of Reclamation, show how the River will respond to a repeat of either the wettest or driest years of the record.

Figure 7

Chloride Intrusion into the Delta 1944 - 1990

Lines represent 1,000 mg/L of chloride measured 1 1/2 hours after high tide. Chloride levels in State Project water increases during drought years. Data obtained from State Water Resources Control Board and Department of Water Resources.



As with the Colorado River, hydrologically driven short-term salinity increases in the Delta are unavoidable. During drought, agricultural return flows have greater influence and tidal action raises chloride levels. Tidal waters also bring in bromide which may be transformed into bromate, an undesirable disinfection by product. Studies show that treatment measures needed at Metropolitan's filtration plants to mitigate bromate formation would add about 60 mg/L of TDS to Metropolitan's treated water during periods of serious seawater intrusion.

Seasonal Delta pumping patterns influence SWP salinity, with higher concentrations normally expected in the drier fall months. Central Valley Project water pumped at Tracy is typically higher in salinity content than SWP water pumped at the H.O. Banks facility because of the poor quality San Joaquin River water pumped into the Tracy pumps. Hence, when the two export pumping systems commingle at the San Luis Reservoir, the SWP experiences 20 to 30 mg/L of TDS degradation.

In Southern California, Piru Creek contributes high salinity into Pyramid Lake on the West Branch. This condition, combined with the greater amount of water in reservoir storage and seasonal pumping patterns, results in the West Branch having somewhat higher but more stable salinity concentrations than the East Branch. West Branch and East Branch salinity average 350 mg/L and 300 mg/L, respectively.

Metropolitan is actively working through the CALFED process and through its role as a SWP contractor to monitor and address actions which would reduce the salinity content of SWP water. Current TDS objectives cited in the State Water Service Contracts for the SWP are:

Constituent	Monthly Average (mg/L)	10-Year Average (mg/L)
TDS	440	220
Chlorides	110	55

Wastewater and Recycling Issues

Wastewater managers have addressed salinity issues since the 1950s. The landmark 1964 water reuse plan prepared by the Los Angeles County Sanitation Districts identified a blueprint for protecting upstream "high quality wastewater" for beneficial reuse, and diverting poor quality industrial and commercial brine waste streams to the ocean. This strategy has become a prototype regional policy for most Basin Plans and wastewater agencies. However, not all inland wastewater agencies have access to an ocean outfall or a brine line. Regional brine lines are expensive and usually require multiple agency cooperation and financing.

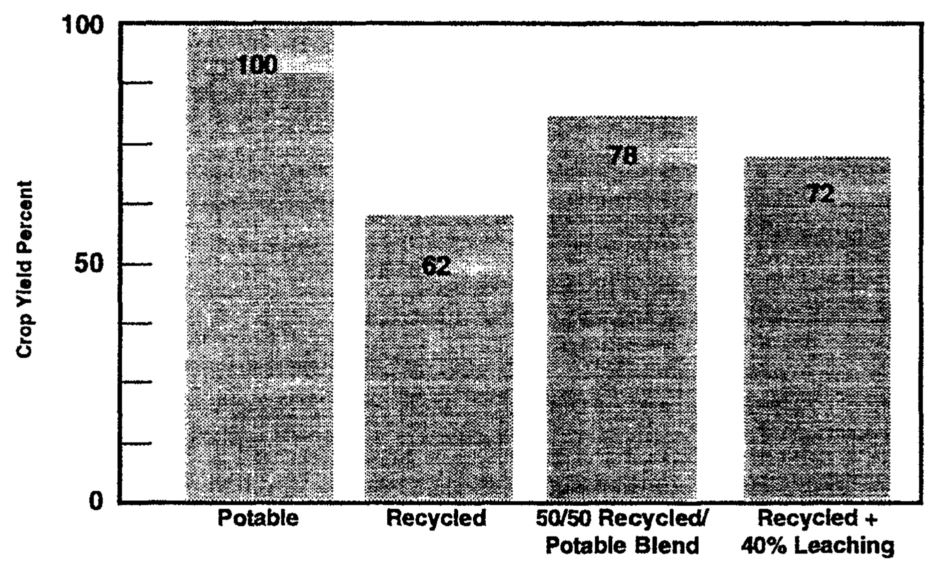
In addition, with the 1972 Clean Water Act and the large expenditures of federal and state grant funds in the 1970s, many leaky sewer systems with infiltration/inflow problems (typically high TDS brackish water) were identified to be in need of rehabilitation. While there is a direct correlation between water supply and wastewater TDS concentrations, other sources of salts flowing into wastewater collection systems are recognized as a significant contribution of salinity to wastewater treatment plant discharges. Certain types of water softeners for example, are controversial sources of salts in wastewater. Industrial and commercial dischargers to sewer systems are typically not regulated for TDS by pretreatment programs. Water conservation efforts in recent years have prompted many industries to increase internal recycling, which results in higher TDS concentrations in their waste streams. In addition, indoor water conservation measures reduce water use, increasing salinity concentrations of residential wastewater by 2 to 5 percent.

Beginning in the mid-1980s, with the expansion of water recycling programs, concerns about wastewater TDS have grown significantly. In general, TDS over 1,000 mg/L is a quality problem for irrigation and industrial reuse customers. In addition to TDS, specific mineral concentrations, such as boron, chloride, and sodium, must be within certain limits for certain crops (e.g., boron for citrus and avocados). A University of California study of avocado crop yields documented lower crop yields from higher TDS water (see Figure 8). Furthermore, in order to protect existing water quality in high-quality groundwater basins, the Regional Boards often set groundwater quality objectives well below 1,000 mg/L of TDS. In some cases, chlorides, not TDS, are the controlling parameter affecting reuse potential and basin water quality objectives. Reclaimed water users that irrigate or recharge groundwater with reclaimed water of higher TDS than these objectives must either provide expensive solutions such as desalters, blend with lower TDS potable supplies, or practice less reuse. Expensive studies may also be needed to address potential impacts to groundwater. Metropolitan's Integrated Resources Plan (IRP) has targeted increased water recycling as a key component of the region's water supply strategy. However, during future droughts, SWP supplies will increase in chlorides (see Figure 7), resulting in higher wastewater chloride levels (see Figure 9). Therefore, managing TDS in wastewater systems to allow for beneficial reuse is a critical issue.

High TDS water has economic impacts to both potable and reclaimed water customers. It adversely affects agricultural and landscape users, industrial processes, and homeowners through corrosion and scaling of plumbing fixtures and appliances. These customer issues need to be addressed in a comprehensive salinity management strategy.

Figure 8

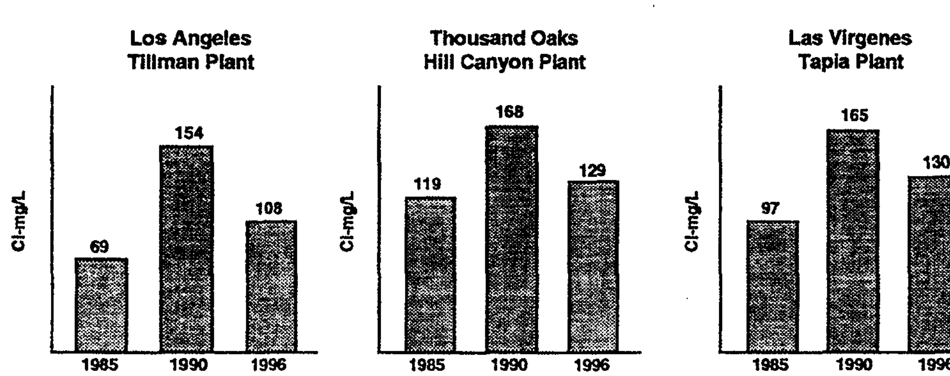
Escondido Avocado Study



The study indicated that avocado production suffers from high TDS in water. During testing, the TDS of potable water was between 200 and 700 mg/L and TDS in recycled water was kept at 1,000 mg/L.

Figure 9

Chloride Levels in Wastewater



During drought periods, chloride levels in wastewater discharge escalate drastically, which can create problems to meet discharge requirements.

RELATIONSHIP TO METROPOLITAN'S INTEGRATED RESOURCES PLAN

In January 1996, Metropolitan's Board of Directors approved the IRP as a planning guideline to be used for water supply and capital facility investments. Key to the IRP is a balanced strategy of utilizing imported water supplies with local resource management through conservation, water recycling and groundwater conjunctive use storage. Salinity is a major issue and possible constraint to the effective implementation of the IRP.

The IRP process relied upon detailed analyses of water supply options, alternative resource development strategies, and operational performance of the preferred resource mix to achieve regional water supply reliability goals. The methodology employed least-cost principles and the potential water resource options considered included the following elements:

- Water Conservation
- Water Recycling
- Groundwater Recovery of Brackish Waters
- Colorado River Aqueduct Supply Improvements
- State Water Project Supply Improvements
- Regional Surface Reservoirs
- Groundwater Conjunctive Use Storage
- Central Valley Water Transfers

The success of the IRP in meeting the water supply reliability needs of Southern California is dependent upon achieving regional water quality objectives adopted in the IRP. Relatively lower TDS supplies delivered from northern California by the SWP are critically important to maintain the salt balance in the region. Blending of SWP and CRW supplies is enhanced with the completion of Metropolitan's Inland Feeder and Eastside Reservoir. However, salinity management issues are complex and require that additional local control strategies be developed to achieve the regional water quality objectives. Therefore, the Salinity Management Study was a logical next step in the IRP planning process.

U.S. BUREAU OF RECLAMATION AND METROPOLITAN WATER DISTRICT FUNDING PARTNERSHIP

The U.S. Bureau of Reclamation (USBR) and Metropolitan agreed in August 1996, to cooperate and jointly fund this salinity management study. Each agency agreed to provide $200,000 in funding and to provide significant in-kind services. USBR funding was authorized and budgeted from the Southern California Comprehensive Water Reclamation and Reuse Study Program (Title XVI, P.L. 102-575).

WORK PLAN AND COLLABORATIVE TEAM APPROACH

The primary objective of Phase I was to provide a comprehensive analysis of the constraints and benefits to water management practices associated with salinity levels of imported, local and recycled water in Southern California. Problems and issues were identified through a participative technical work group process. Focused issue papers documenting problems and detailed technical memoranda were prepared and reviewed by interested agencies.

In general, the issue papers and technical memoranda covered the following areas:

- Common factors and needs assessment characterizing the region's current salt balance and sources (e.g., sewer infiltration and inflow, industrial sources, brine disposal)
- Sub-regional problem areas
- Significant/unique problems and needs assessment
- Salinity management problems (both short- and long-term)

Metropolitan formed a work group of member agencies to periodically interact with the study team and USBR during Phase I.

OUTREACH, INTERAGENCY COORDINATION AND WORKSHOPS

The scope and budget for the Salinity Management Study was based on utilizing existing, documented agency data and "expert opinion" in an efficient networked fashion. Interagency coordination through task force representation allowed effective communication and support of salinity management strategies. Many contacts with individual water/wastewater agencies and associations were conducted during Phase I as highlighted below:

- Member Agency managers -- Review and discuss options and formulate SWP and Colorado River operating strategies that have strong member agency support. Evaluate local facility options.

- Metropolitan, USBR and DWR operating personnel -- Document current system operations and evaluate potential alternative operating strategies.

- Santa Ana Watershed Project Authority (SAWPA) -- Suggestions from ongoing TDS and nitrogen study team were incorporated into this study.

- SCAP (Southern California Alliance of Publicly Owned Treatment Works) -- Through the existing committee structure of SCAP, discussed POTW's concerns with TDS for recycling and discharge permit requirements, as well as the use of pretreatment requirements that address salinity control.

- AGWA (Association of Groundwater Agencies) -- Identified groundwater replenishment issues and basin salinity management strategy.

- Los Angeles, Santa Ana and San Diego RWQCBs -- Discussed current basin plans and discharge permit policies and identified long-term salt management problem areas.

- WateReuse Association -- Informed statewide association of study and identified common water recycling issues and problems related to TDS quality.

- USBR Southern California Comprehensive Water Reclamation and Reuse Study -- Coordinated salinity management study findings with the participants. Identified needs for USBR study to address salinity problems for water recycling projects (regional brine disposal facilities need to be constructed).

PHASE I NEEDS ASSESSMENT FINDINGS

Salinity problems resulting from all sources of TDS in Southern California have not been previously documented in a comprehensive manner. Documentation of the specific problems resulting from relatively high salinity in Southern California were assessed through a collaborative task force effort utilizing the expertise of the project team and all the water and wastewater agency managers (and staff) in the region.

During Phase I, a set of issue papers and technical memoranda describing salinity problems was prepared and coordinated with concerned agencies through an extensive iterative review and revision process. The documents are currently being retained in draft status to allow further revisions as the study enters into Phase II, and are being revised at the writing of this Progress Report. The issue papers and technical memoranda (listed below) have been consolidated in a three ring notebook to serve as a handy and easily updated reference.

PHASE I -- ELEMENTS

- ☑ Introductory Paper
- ☑ Colorado River Supply
- ☑ State Water Project Salinity
- ☑ Constituent Impacts
- ☑ Hardness/Water Softeners
- ☑ Metropolitan System Operations
- ☑ Consumer Impacts
- ☑ Regional Board Practices and Basin Plan Policies
- ☑ Salt Balance Tech Memo
- ☑ POTW/Recycling Water Quality Tech Memo
- ☑ CRA Desalting
- ☑ Final Report - Phase I Progress Report

PHASE I -- FINDINGS

1. On-going Long-Term Impacts (scale of decades)
   a. Groundwater Salinity Degradation - negative salt balance trends.
   b. Significant Domestic Consumer Impacts - plumbing fixtures and appliances wear out faster.
   c. Modest Industrial Impacts - more expensive to use higher salinity water for cooling towers and boiler systems.

2. Impacts of Short-Term Drought-Related TDS Increases (scale of several months to several years)
   a. Water Recycling and Irrigation - salinity over 1,000 mg/L unacceptable.
   b. Wastewater Discharge Permit Compliance - RWQCB policies regulate salinity.
   c. Groundwater Blending - need SWP for replenishment.

3. Colorado River
   a. Baseline TDS increasing because of continued agricultural development in the Upper Basin and urban growth in Las Vegas (future droughts may cause TDS to exceed 900 mg/L).
   b. Salinity Control Program will mitigate increases if funds are appropriated (congressional support for funding).
   c. Hydrologically driven short-term increases exceeding Parker Dam numeric criteria of 747 mg/L are unavoidable (See Figure 6).

PHASE I -- FINDINGS (Continued)

4. State Water Project
   a. Commingled CVP water causes 20 to 30 mg/L degradation (Tracy pumps receive saltier San Joaquin River water at times during the year).
   b. Piru Creek salt load into Pyramid Lake (geologic formations cause high salinity runoff).
   c. Dry period and seasonal TDS variations/pumping patterns affect TDS (SWP exceeded 450 mg/L in 1991).
   d. Hydrologically driven short-term increases are unavoidable (future droughts will increase SWP salinity, see Figure 5).

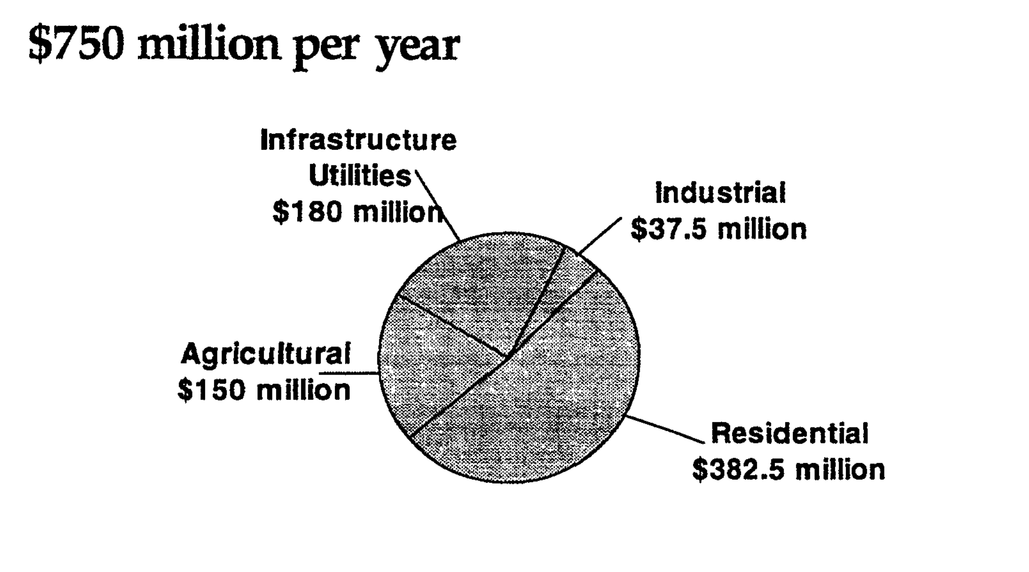
5. Local TDS Sources
   a. Urban Sewage - contributes 250 mg/L to 400 mg/L.
   b. Domestic and Commercial Water Softeners (contribute about 5 - 20 percent increase in salinity of wastewater).
   c. Industrial - Commercial Brines (e.g., oil refineries discharge into sewers high TDS water).
   d. Sewer Infiltration/Inflow - from shallow brackish groundwater.
   e. Indoor Conservation (lower water use has a small impact on TDS concentrations).
   f. Agricultural Return Flow - may be a significant salt load in some groundwater basins.
   g. Degraded Groundwater - local groundwater salinity may be higher than imported supplies (see Camarillo example, Figure 3).

The Colorado River is relatively high in salinity and does cause significant economic impacts on water customers. Based upon U.S. Bureau of Reclamation studies, it is estimated that approximately $750 million per year (1996) in economic impacts in the Lower Colorado River Basin result from CRW at current levels of concentration (about 700 mg/L at Parker Dam), as compared to water with a TDS concentration of 500 mg/L (see Figure 10 below).

USBR's modeling for Metropolitan's service area indicates significant consumer cost impacts result from salinity increases. Consumer impacts range from $150 to $250 million per year when salinity of Metropolitan's two imported sources average 325 mg/L in the SWP and 700 mg/L in the Colorado River Aqueduct. While technical debate continues regarding the accuracy of USBR's economic analysis and the extrapolation of that data to Metropolitan's service area, there is relatively common acceptance within the region that municipal consumers, industry, agriculture, and public water and wastewater systems experience significant costs from sustained levels of high salinity. Phase II will include further investigation into consumer impacts.

Figure 10

Current Annual Salinity Damages in the Lower Colorado River Basin

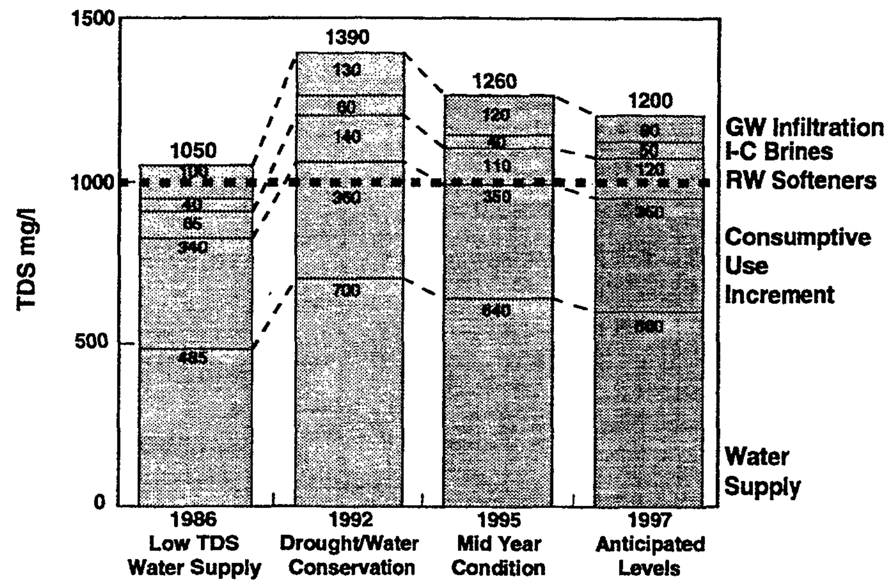


The SWP was originally planned and expected to deliver 220 mg/L TDS water to Southern California. However, the average TDS level over the last 10 years has exceeded 300 mg/L and during the last drought was as high as 450 mg/L. Therefore, it was concluded in the Phase I - Needs Assessment that SWP salinity is a significant component of the salt balance requirements of the region.

A variety of sources contribute salinity within the region. Local sources of salinity also contribute significantly to the problems within the region. Urban uses of water contribute between 250 to 400 mg/L of salts into the wastewater. Key sources of local salts include the use of water softeners (typically contribute from 5 to 20 percent of the salt load) and industrial processes. Irrigation of urban landscapes and agricultural fields concentrates salts through water consumption and leaches fertilizers and naturally occurring minerals in the soil structure as water returns to the water table. Wastes from dairy and poultry farms contribute salts to the local environment. In addition, leaky sewers along the coast may allow brackish saline groundwater to infiltrate into the sewers and will result in significant increases in the wastewater salinity (see Figure 11). All of these factors can dramatically affect the ability to reuse and recycle wastewater (a high priority new water supply for the region). In some coastal areas, seawater intrusion has been a problem for groundwater basins. Options to better manage these long-standing local contributions will be explored in Phase II.

Figure 11

Sources of TDS at a Water Recycling Plant



Demineralization is needed to meet recycled water quality requirements (TDS <1,000 mg/l) for intended uses. Various sources contribute TDS to sewage collection system. Example is North City Water Recycling Plant.

The long-term salt balance of the groundwater basins is also an important management problem. Smaller basins like the Arlington and Mission Groundwater basins were abandoned for municipal supply years ago because of high salinity levels. Only recently these basins have been restored to use through construction of expensive demineralization projects. The larger basins, by virtue of their storage capacity, serve as "shock absorbers" when droughts cause TDS to increase in imported supplies. Unfortunately, there is general acceptance that even large basins are experiencing progressive salt buildup despite the extensive regulatory and management practices in place. Figure 12 illustrates the conceptual salt balance problem of multiple uses of water in a river basin. Overall the salt balance is in a negative trend, current annual accumulation is approximately 627,000 tons per year. The current inflow and outflow of salts in the region are shown in Figure 13.

The Salt Balance Problem

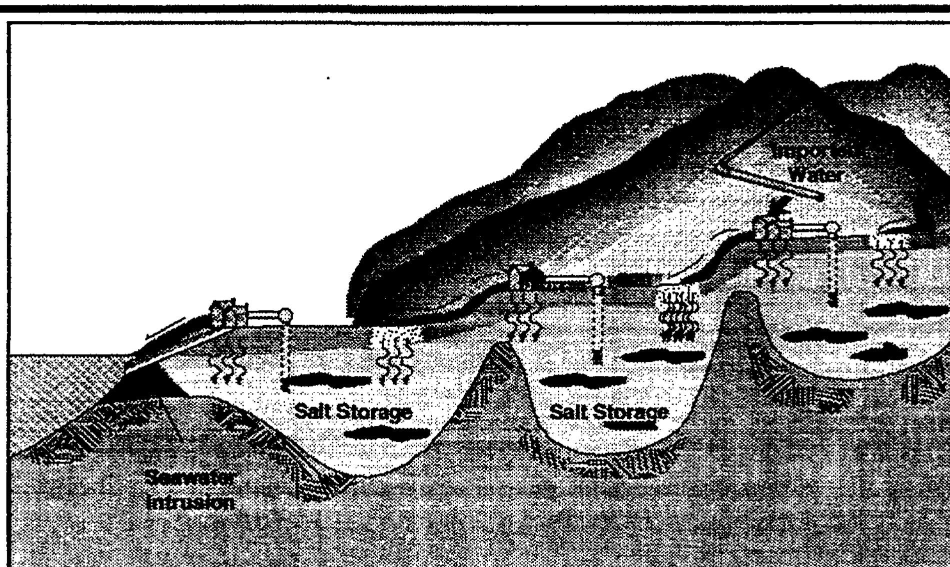
Southern California Annual Salt Balance

Inflow	3,110,000 tons per year
Outflow	2,483,000 tons per year
Annual Accumulation	**627,000 tons per year**

- 44 Percent of Salt Inflow is from imported water
- 95 percent of Salt Outflow is through wastewater discharged to ocean
- Accumulation is in Groundwater Basins
- Long-Term Salt Balance Strategy Needs to Be Developed

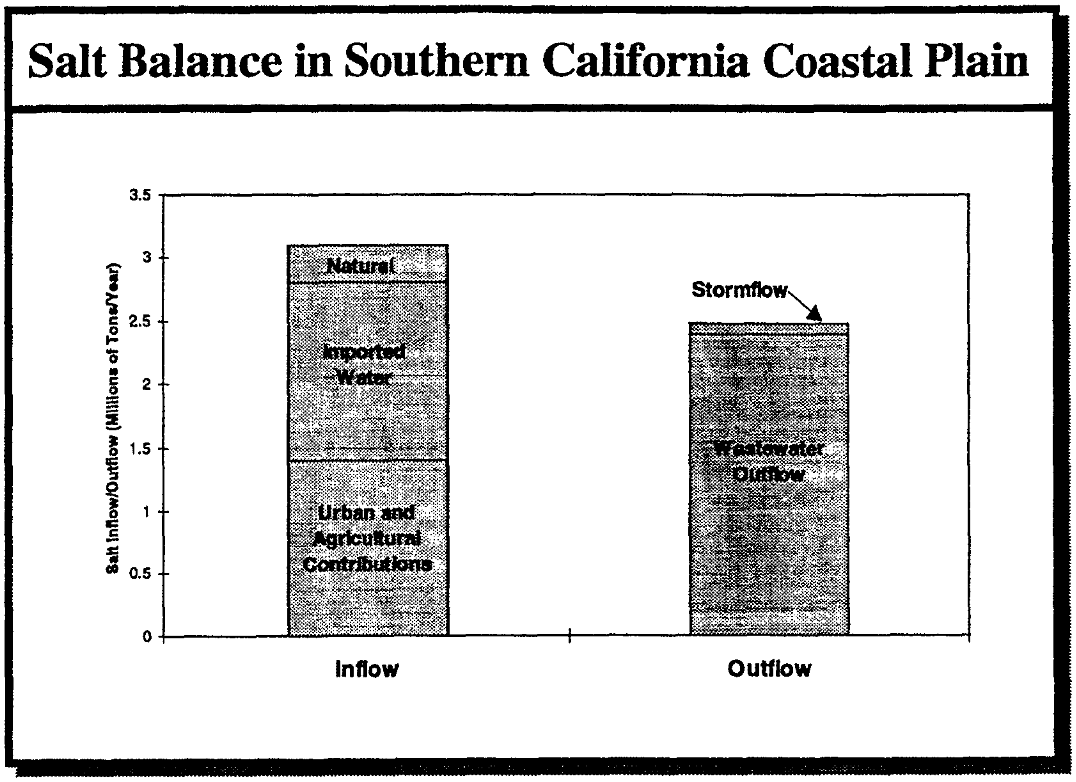
Figure 12

Salt Balance



Urban and agricultural water uses concentrate and add salt to water supplies as water travels from the foothill areas to the ocean. Groundwater recharge with imported water also adds salts to some basins. Groundwater basins are experiencing salt build-up in the process.

Figure 13



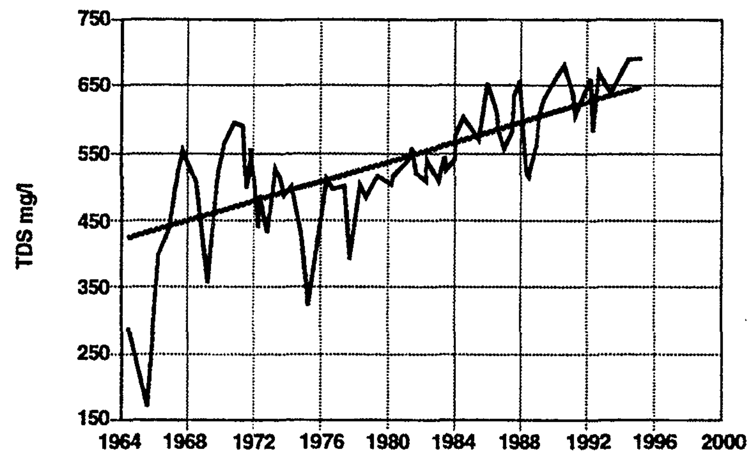
The Orange County groundwater basin has measured salinity concentrations at a number of key wells for a long time. As documented in Figure 14 at a well in Santa Ana, the long-term trend has been an increasing concentration of salinity of about 7 mg/L per year.

Inland agencies such as the Eastern Municipal Water District need to construct brine disposal facilities to the ocean, otherwise the long-term salt load impacts will dramatically increase the TDS levels in its local groundwater supplies (see Figure 15).

Figure 14

Groundwater Trends

(OCWD Well No. Sa-16/1)

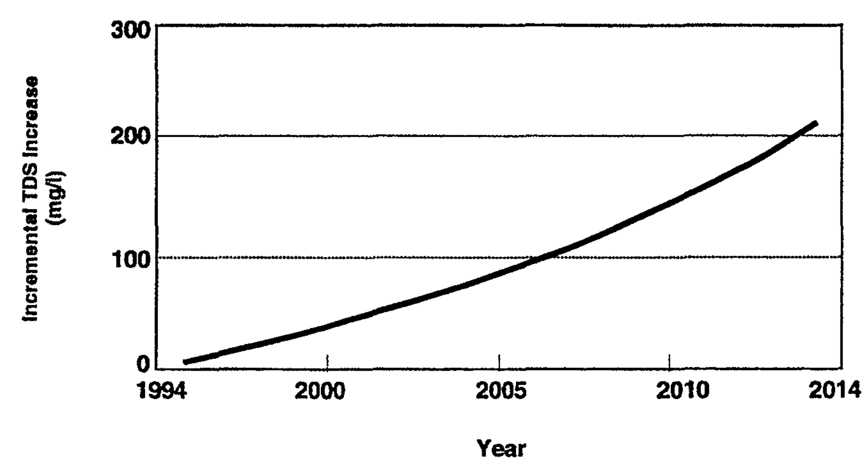


This well is illustrative of increasing salinity in the Santa Ana portion of the Orange County Groundwater Basin. Salinity is increasing at a rate of 7.35 mg/L annually.

Figure 15

Eastern MWD Salt Load Analysis

"Zero" Discharge Scenario



If ocean discharge options are not available to Eastern MWD, salt will accumulate in Eastern MWD's groundwater basins.

PHASE II - ALTERNATIVE SALINITY MANAGEMENT STRATEGIES

Alternative salinity management strategies will be formulated and evaluated during Phase II. A comprehensive set of options including imported water supplies (Colorado River and northern California sources), recycled water, and other local sources of salinity will be evaluated. A list of possible salinity management actions are described below.

Alternatives are anticipated to include combinations of the following list of possible actions, with each measure being considered to different degrees of implementation based on suggestions from concerned agencies.

POSSIBLE SALINITY MANAGEMENT ACTIONS

I. Imported Water Source Control
   A. Colorado River Salinity Control Program
   B. CALFED Bay - Delta Program

II. Imported Water Blending Options

III. State Water Project Options
   A. Shift CVP Delta Diversions from Tracy to Banks Pumping Plant in certain months.
   B. Minimize saline groundwater pumpbacks into the California Aqueduct.

IV. Eastside Reservoir - Store Low Salinity Water During Wet Years

V. Desalination Options
   A. Recycled Water
   B. Wastewater Discharges to Basins
   C. Groundwater Recovery Program
   D. Colorado River Aqueduct
   E. Piru Creek

VI. Groundwater Strategies
   A. Maximize Storgae of Imported Water When TDS is Low
   B. Summer Recharge Deliveries
   C. Flexible Wastewater Discharge Permits for Long-Term Salt Balance

VII. Wastewater Source Control
   A. Fix Sewer Infiltration
   B. Construct New Brine Lines to Bypass Water Reclamation Plants
   C. More Stringent Industrial Sewer Permits

VIII. Reduce or Eliminate Water Softening Impacts on Water Recycling

It is currently envisioned that the alternative strategies will also be organized into three time frames: short-term (1997-2000); mid-range (2001-2005); and long-term (2006-2050).

TDS management options will include an evaluation of desalting source supplies (Colorado River), imported water blending strategies, desalting at the point of use (brackish groundwater and at wastewater treatment plants), dilution at point of use, source control regulations, and corresponding changes in Basin Plan requirements. Phase II will also include feasibility level cost estimates for various salinity management strategies.

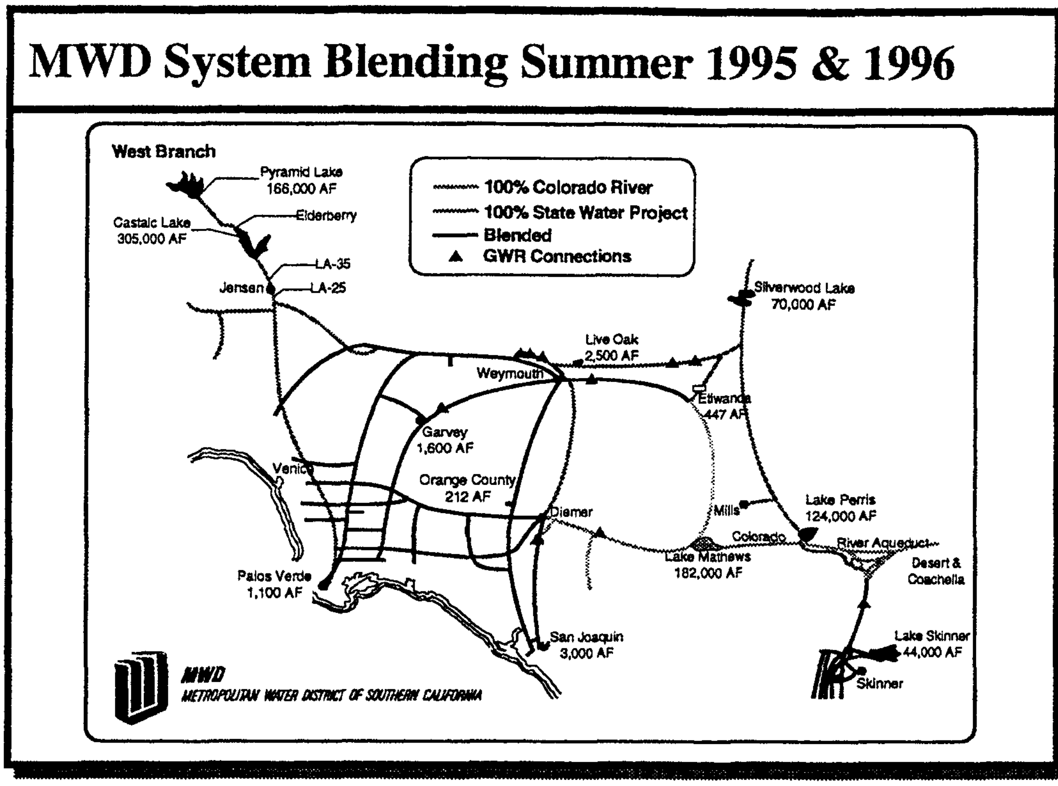
Short-Term Strategies (1997-2000)

The current interim strategy is that Metropolitan operate with a 25 percent blend during April - September (see Figure 16). This blend operational target will be assessed through discussions with groundwater basin managers and wastewater treatment plant operators to determine how it is working and what localized measures should be considered as a part of this strategy. Feedback and policy support for Metropolitan operational plans should be carefully fostered and made a part of the short-term strategy. Key options to be considered include:

- Setting a target: percent blend vs a mg/L objective
- Customized blending targets for unique local needs
- Source protection strategies (Colorado River salinity control and SWP Bay/Delta issues)

However, it should be noted that both Colorado River and SWP salinity will vary significantly, depending upon wet and dry hydrology. Blending strategies may need to be adjusted during dry periods.

Figure 16



Other possible short-term salinity management strategies that will be considered include:

- Encouraging more active groundwater protection strategies to reduce salinity contamination of aquifers (e.g., seawater barrier operations) and evaluation of new brackish groundwater desalter/sewer brine disposal projects to the ocean to export salts from aquifers.

- Consider wastewater demineralization to reduce salinity for recycled water customers. In addition, wastewater agencies should consider improvements to their sewer systems to reduce brackish water infiltration and inflow.

- Coordinate activities with RWQCBs to ensure consistent salinity management policies.

- Initiate research and development into new desalting technologies.

- Consider regulation and higher efficiency standards for water softeners.

Mid-Range Strategies (2001-2005)

With the fill and initial operation of the Eastside Reservoir, significant improvements in operational flexibility may be constrained by availability of supply and demand for groundwater replenishment deliveries. Documenting local basin management needs and the constraints on wastewater treatment plants for water recycling customers will allow development of an operational strategy that provides the least costly regional solution.

Key SWP/Colorado River operational blend criteria should be re-evaluated with a completed Eastside Reservoir. In addition, protection of Delta water quality through improvement from the CALFED Bay/Delta Program will have a significant effect on the salt balance of the region. For example, strategically shifting CVP export pumping from the Tracy pumping plant to the SWP Banks pumping plant may reduce the salinity in the SWP supplies to Metropolitan. The shift could occur in certain months of the year, consistent with environmental concerns and available pumping capacity, to reduce high-salinity San Joaquin River water entering the O'Neil Forebay and San Luis Reservoir. Continuing to oppose brackish groundwater pumpback projects into the SWP aqueduct will also be a high priority.

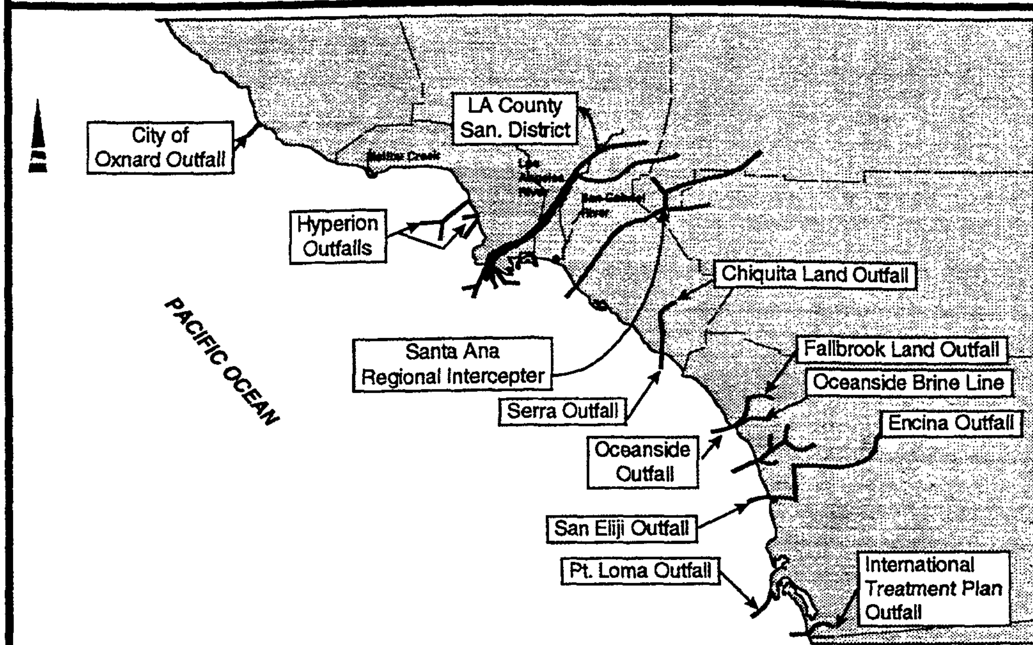
Long-Term Strategies (2006-2050)

CALFED, Colorado River salinity control, Metropolitan's IRP, local basin (RWQCB) management plans and water recycling programs need to be comprehensively addressed in this study to ensure consistent planning strategies are developed. Salinity management strategies will be identified that will protect the long-term salt balance of the area's groundwater basins and allow the beneficial reuse of wastewater. Regional brine lines to export salts to the ocean will likely be a key long-term management strategy (see Figure 17).

Without a doubt the overall salinity management strategy will need to be comprehensive: identifying actions to reduce salinity from our supply sources (Colorado River and SWP), managing our groundwater basins to maintain their long-term salt balance, and minimizing the incremental increases in salinity at the water reclamation plants to ensure that recycled water customers receive the lowest TDS possible.

Figure 17

Ocean Outfalls



REVISED ON 3/25/97