APPENDIX E

Imperial Irrigation Decision Support System (IIDSS) Summary Report

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Imperial Irrigation Decision Support System Summary Report

Prepared for

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SECTION 1

Introduction

Imperial Irrigation District (IID or District) is considering a temporary transfer of Colorado River water that IID is entitled to divert under its Colorado River entitlement. The Proposed Project will implement two agreements: the first agreement is exclusively with the San Diego County Water Authority (SDCWA); the second agreement includes partial transfer to SDCWA, Coachella Valley Water District (CVWD), and possibly the Metropolitan Water District of Southern California (MWD). For either agreement, the transfer will result from water conservation within the IID water service area[1].

The Imperial Irrigation Decision Support System (IIDSS) was developed to support the understanding of how the irrigation and drainage network in IID would respond to a variety of water conservation programs. Specifically, the IIDSS simulates water conservation measures and the associated changes to water quality and quantity in the agricultural canals and drains.

The primary purpose of this summary report is to provide an overview of the logic, design, and operation of the IIDSS, and some key findings.

This Summary Report is organized into the following sections:

- Section 1—Introduction
- Section 2—Design of the Imperial Irrigation Decision Support System
- Section 3—Alternative Conservation Program Assessments

IID Irrigation and Drainage Systems

IID diverts their entire water supply from the Colorado River through the All American Canal. Service is provided 12 months per year to some 5,300 farm gates to irrigate over 460,000 acres of crops. Since 1988, IID annual diversions at Pilot Knob on the All American Canal has varied from 2.62 to 3.25 million acre-feet per year (ac-ft/yr). Figure 1-1 shows the location of IID. (Figure 2-2 illustrates key IID delivery facilities.)

IID's water supply is regulated by the Colorado River Water Storage and Supply System. Water is diverted from the Colorado River at Imperial Dam, 18 miles northeast of Yuma, Arizona. However, the water supply above Imperial Dam is controlled by major federal water works upstream of the diversion point. The storage and control facilities that provide a constant year-round supply to match IID demands include Hoover Dam and Lake Mead (32.5 million ac-ft capacity when constructed), Glenn Canyon Dam and Lake Powell (active capacity of 20.9 million ac-ft when constructed), Davis Dam, Parker Dam, and Imperial Dam. These facilities, with the exception of Imperial Dam, are operated by the

[1] For this report, the term IID is meant to be the IID water service area.

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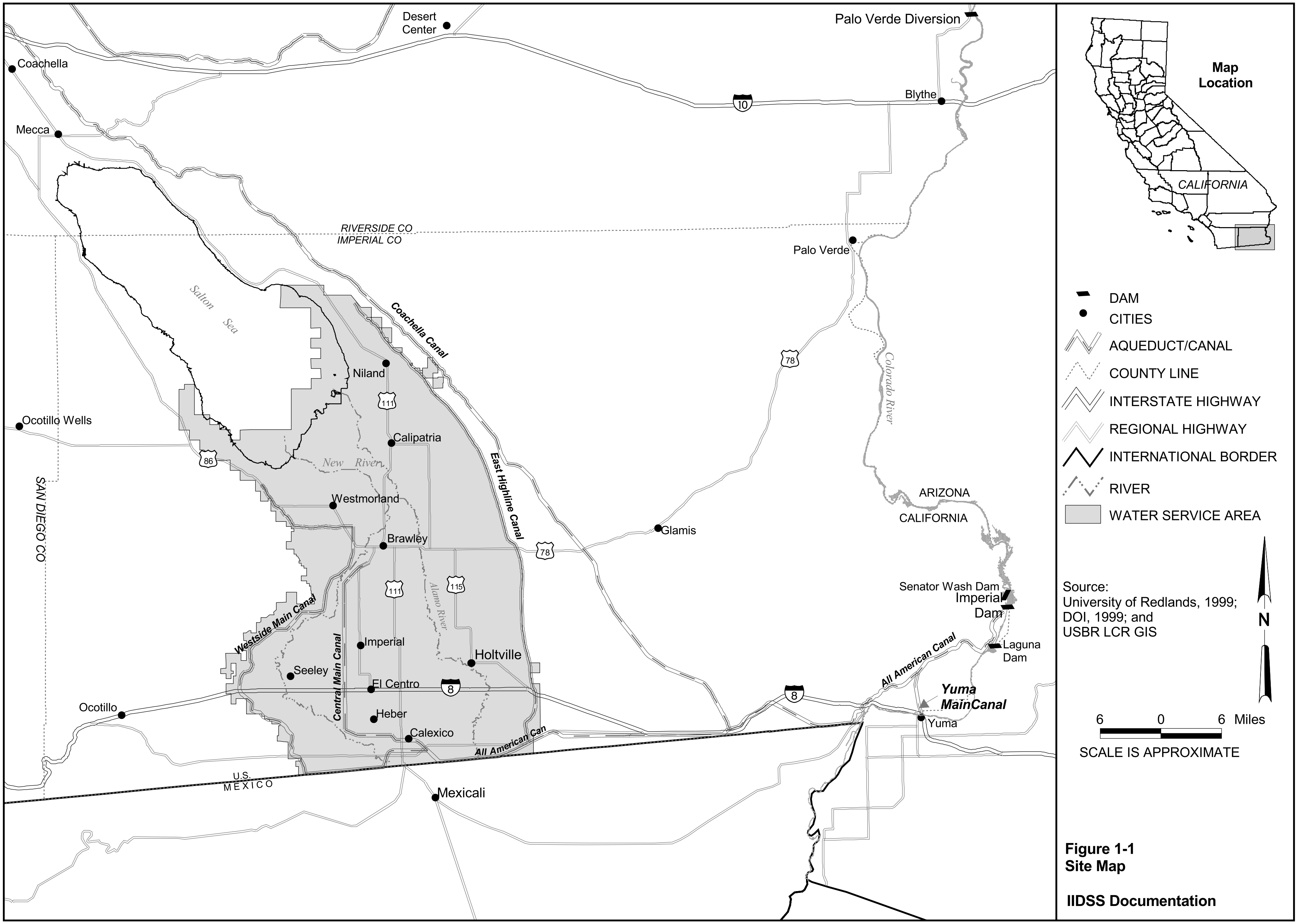

Figure 1-1
Site Map

IIDSS Documentation

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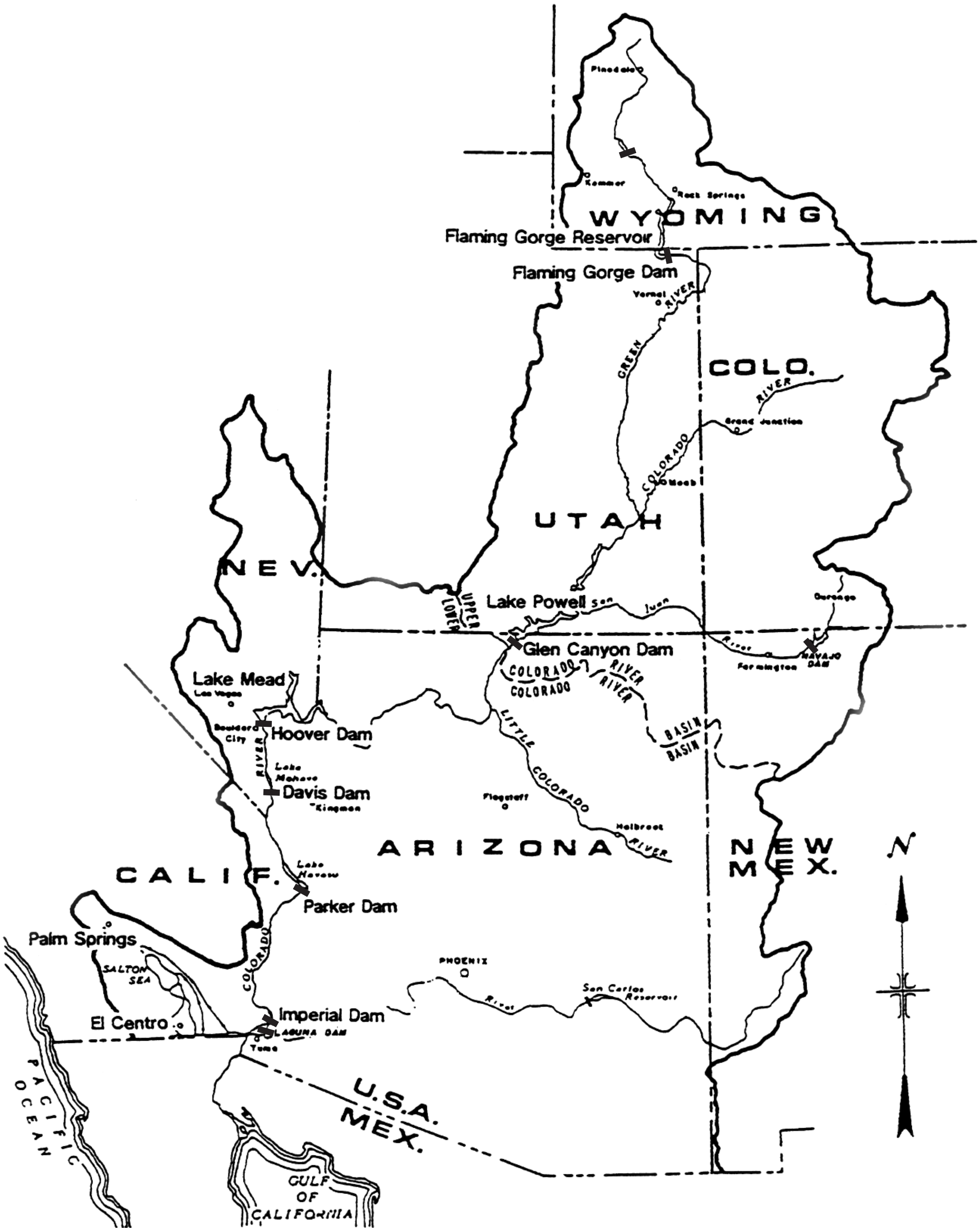

Figure 1-2
Selected Colorado River Water Projects
IIDSS Documentation

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U.S. Department of the Interior, Bureau of Reclamation (USBR). Figure 1-2 shows key hydrologic elements and water projects for the Colorado River Basin. IID orders water 1 week in advance to allow for travel time from Lake Mead. The USBR delivers these orders to Imperial Dam for diversion into the All American Canal and related IID facilities, which are operated by IID. The maximum canal capacity at the headworks is 15,150 cubic feet per second (cfs). This capacity decreases below the delivery points and is about 7,000 cfs below Drop 1, the delivery turnout for the Coachella Canal. The All American Canal provides flow to the Pilot Knob power plant and passes through five drop structures and hydroelectric power plants. Check structures and power plants provide control for water flow rates and elevations along the canal length. The canal is mostly unlined (earth section), has a typical depth of 21 feet, and is 160 feet wide at water level.

The All American Canal runs in a westerly direction and delivers water to three main canal systems within IID. These three canals, East Highline, Central Main, and Westside Main, generally run north and deliver water to the District's lateral canal system. There are about 1,672 miles of canals and laterals, 1,102 miles of which are concrete lined. All of these canal systems provide gravity service. Farm turnouts/delivery points are from the lateral canals. The turnout facilities are owned and operated by the District, with each turnout having a control gate and flow measurement device.

To improve water delivery service and water use, the District has constructed seven regulating reservoirs with a total capacity of 2,256 ac-ft. These reservoirs level out the variability in supply (ordered 1 week earlier), providing delivery more consistent with farmer needs. In addition, three lateral interceptor systems capture operational water discharges for reuse within the irrigation system. Like the regulating reservoirs, these systems are planned to conserve water and provide improved service to the farmers.

The District drainage system (Figure 2-3) consists mainly of surface drains and the Salton Sea. Approximately 1,500 miles of surface drains are maintained by the District to collect field operational (tailwater) and system operational discharge and subsurface tile drain (tilewater) flows. These drains flow either to the Salton Sea via the Alamo and New River systems or directly into the Salton Sea itself. The 33,000 miles of tile drainage systems under irrigated fields are owned by the individual farmers and discharge into the surface drains.

The Colorado River at Imperial Dam is high in salinity and selenium. Historically, salinity has varied from about 600 milligrams per liter (mg/L) to nearly 1,100 mg/L, with an average salinity during the IIDSS study period of 747 mg/L. Selenium during this same period was slightly greater than 2 micrograms per liter (µg/L) (0.002 mg/L). Although there is a time lag, farmers eventually increase water diversions for leaching of salts that accumulate in their soils.

The Salton Sea serves as a drainage basin for irrigation and storm runoff in the Imperial, Coachella, and Mexicali valleys. The Salton Sea has officially been designated as a repository for agricultural drainage by the federal government.

Water Transfer Basics

Both transfer agreements stipulate that any water transferred will be the result of water conservation. The duration of transfer will be from 45 to 75 years. The minimum annual volume transferable is 130,000 ac-ft, with a maximum potential of 300,000 ac-ft/yr. This is in addition to the present 106,500 ac-ft now being conserved and transferred to MWD.

Conservation projects are categorized as on-farm and system. On-farm conservation is a voluntary program and farmers will choose their own conservation methods that may include fallowing. The farmers will also decide how much water they will conserve with a possible maximum annual amount per acre set by IID. On-farm conservation is measured by the reduction in historical water deliveries (1987 to 1998) at farm turnouts. In addition, the length of time a farmer participates in the program will likely vary, meaning participants may be moving into and out of the conservation program. In summary, the variables associated with defining an on-farm conservation program are nearly endless, and include spatial distribution, voluntary participation over given time frames, the volume and efficiency of any conservation method, and the total variability of irrigation demand and performance in space and time. System conservation projects include lateral interceptor systems, seepage collector systems, mid-lateral and operational reservoirs, canal lining projects, and the possibility of fallowing by IID.

Imperial Irrigation Decision Support System

From the above discussion, the conclusions are: (1) The IID system is extremely large and hydrologically complex, (2) the conservation programs will include conservation projects that will be dynamic and changing over time, and (3) the potential impacts to drainwater quality will vary in both space and time. In addition, verification of conserved water will be difficult in the complex IID canal and drainage system. Conservation will change the water quality in the IID drainage system according to the conservation amounts, methods, and spatial density. As a result, it was determined that more than an analytical or numerical model would be required to simulate and predict the effects of water conservation within the IID water service area. It was concluded that decision support system technology would be used to develop a predictive tool for analyzing the effects of conservation within the IID.

IID System Representation

The IIDSS simulates the physical input and output processes that occur in delivering water to a farm, irrigating a crop, and predicting the resultant drainage outflow. The IIDSS includes three modules: a Delivery System Module, an On-farm System Module, and a Drainage System Module. Working together, these modules will provide the needed results to identify "wet water" conservation savings and changes in quality and quantity of drainage waters.

IIDSS Purpose

For conservation projects that are implemented, or planned, the IIDSS will do two things: (1) determine the amount of *net* conserved water resulting from all conservation measures within a conservation program, and (2) predict the change in water quality and quantity in drains and rivers flowing through IID. Obviously, the power of the IIDSS is its ability to track multiple conservation measures and to account for temporal changes and spatial movement of those measures around the irrigated service area. Having that ability will facilitate analysis of the relative impacts of different conservation programs and the comparison of those impacts to other conservation programs or a projected future with no conservation programs. In essence, the IIDSS allows "what if" analysis.

The water quality parameters to be tracked in the IIDSS include salinity, selenium, sediment, nitrogen, phosphorus, boron, and organochlorine and organophosphorus insecticides.

Peer Review

To validate the IIDSS and provide additional quality control, a Peer Review Team was assembled for review of the IIDSS and its documentation. A detailed presentation was made to this team on the development and operations of the IIDSS. This same Team reviewed several versions of the documentation and commented on the IIDSS concepts, structure, science, and logic. This Team found the IIDSS to be a valid representation of conditions at IID. Clarification was added to the documentation as a result of this review.

SECTION 2

Design of the Imperial Irrigation Decision Support System

Irrigation System Overview

IID's irrigation system diverts water from the Colorado River to over 5,000 tenants that are distributed throughout the 1,000 square miles of the district. As shown on Figure 2-1, water for irrigation is diverted from the Colorado River and distributed to farms, municipal and industrial (M&I), and other users via the delivery system. The drainage system collects the return flows from these users and discharges to the Alamo and New rivers and the Salton Sea. Figure 2-1 provides a conceptual overview of all the external and internal IID water flow paths described in this chapter.

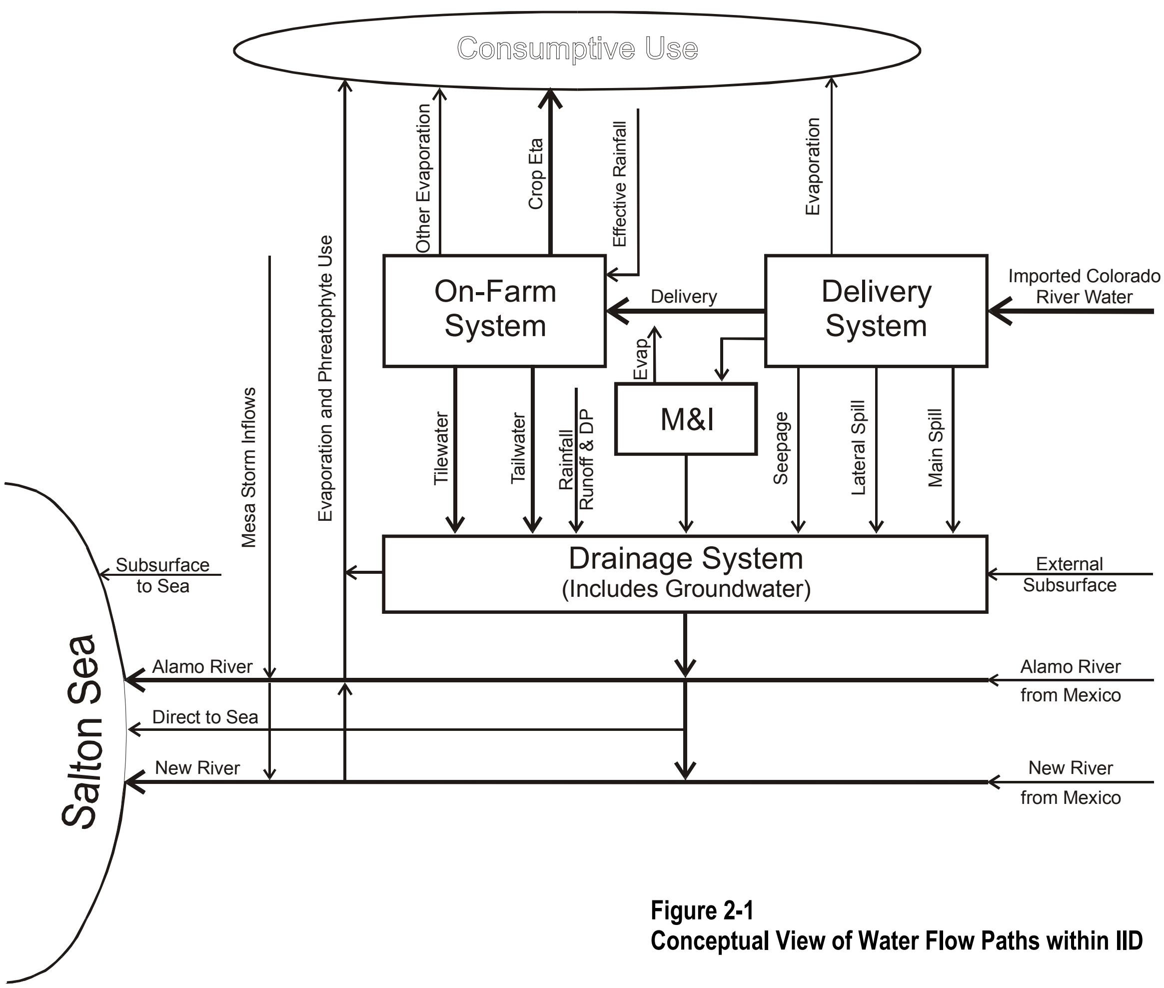

Figure 2-1
Conceptual View of Water Flow Paths within IID

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Rectangular boxes on Figure 2-1 represent the delivery, on-farm, municipal and industrial (M&I), and drainage systems that define water demands, canal and drain flows, and water quality throughout the delivery canals and drains. The oval at the top of the figure, labeled consumptive use, represents the discharge of water to the atmosphere via evapotranspiration (ETa) from farm fields, evaporation from water surfaces, and transpiration by phreatophytes growing along canals, drains, and rivers. Approximately two-thirds of the water diverted from the Colorado River to the IID water service area is consumptively used. The remaining third of imported water discharges to the Salton Sea, which is represented by the open oval on the left-hand side of Figure 2-1. Arrows connecting the system boxes and discharge ovals represent the modeled water flow paths throughout IID.

The weight of the arrows on Figure 2-1 indicates the relative volume of flow along the associated flow paths. Table 2-1 gives the measured and simulated mean annual flows for these flow paths for the 12-year (1987 to 1998) calibration and validation period.

TABLE 2-1
Measured and Simulated Mean (1987 to 1998) Annual Flows (ac-ft) along Major Flow Paths within IID

Description	Recorded	Modeled
Imported Colorado River Water	2,865,700[a]	2,857,000
Canal and Reservoir Evaporation		20,800
Canal Seepage		122,700
Main Canal Spills		6,700
Lateral Spills		116,900
Sum of Delivery System Losses	271,600[b]	267,100
Delivery to Farms	2,489,600	2,489,700
Crop Eta		1,806,200
Other Evaporation		-
Effective Rainfall		100,700
Tailwater		390,000
Tilewater		394,200
Delivery to M&I + Stock + Misc.	104,500[c]	104,500
Consumptive Use from M&I + Stock + Misc.		76,300
Return Flow from M&I + Stock + Misc.		28,200
Change in Soil Water and Groundwater Storage		-
Recovered Return Flow from Mesa Lateral 5		4,400
Rainfall Runoff and Deep Percolation		36,800
Evaporation and Phreatophyte Use		125,100
Mesa Storm Inflows		7,900
Subsurface Inflow (Estimated)	20,000	20,000
Alamo River from Mexico	1,700	1,700
New River from Mexico	164,700	164,700
Alamo River to the Salton Sea	604,500	605,100
New River to the Salton Sea	453,500	453,000
Direct to Sea	100,200	101,200
Subsurface to Sea (Estimated)	1,000	1,000

[a]All American Canal at Mesa Lateral 5 by water balance from recapitulation data.
[b]Sum of delivery system losses is calculated from the difference in recorded diversions less deliveries.
[c]Includes estimates of deliveries to rural pipes and community greens.

A water balance is kept for each system (rectangle) shown on Figure 2-1, so that the sum of the inflows is equal to the sum of the outflows plus the change in storage within each system. The storage capacity within IID's delivery system is very small relative to the annual flow so the annual change in storage within the delivery system is always near zero. The soil water storage capacity of IID's farm fields and the drainable shallow groundwater storage are relatively large. However, over the course of several years the change in stored water within the on-farm and drainage systems is small and assumed to be zero. Thus, the data in Table 2-1 show that the summation of mean annual flows into each system is exactly equal to the summation of the flows out of each system. Likewise, a water balance can be computed for the IID water service area as a whole showing that the sum of inflows equals the sum of outflows.

Delivery System

Figure 2-2 shows the Geographic Information System (GIS) representation of the extent and configuration of IID's delivery system. Using the 12-year (1987 to 1998 calibration period) modeled mean values presented in Table 2-1, the delivery system imports 2,857,000 ac-ft/yr from the Colorado River via the All American Canal[2]. From this, 2,489,700 ac-ft are delivered to IID farms and 104,500 ac-ft are delivered to M&I users, stock, rural pipes, and community greens, leaving a net delivery system loss of 267,100 ac-ft/yr (accounting for return flows to the delivery system). Of this net delivery system loss, approximately 8 percent is canal and reservoir evaporation, 46 percent is canal seepage, 2 percent is main canal spills, and 44 percent is lateral spills.

On-farm System

Water flows through the delivery system and is delivered to a farm or farms, group of fields, or another type of user through a turnout. There are approximately 5,300 turnouts in IID. Of these, roughly 35 percent are solely for agricultural irrigation, 3 percent are for other uses, and the remaining 62 percent of the turnouts serve a combination of agricultural and other uses. Agricultural irrigation accounts for 96 percent of the total water use within the IID[3] water service area.

Water delivered through a farm turnout is either consumed or discharged to the drainage system. Crop uptake and evapotranspiration are the water consumption mechanisms; tailwater and tilewater are the methods of discharge. This partitioning of on-farm water into consumptive use and tailwater and tilewater return flow components is a complex process within the on-farm system.

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[2] The upstream boundary of the study area is the All American Canal at Mesa Lateral 5, which is just upstream of the East Highline Canal heading. Relatively small amounts of water are delivered to IID users off the All American Canal upstream of the Mesa Lateral 5 heading (3,400 ac-ft per year) and along the Coachella Canal (4,100 ac-ft per year) and are excluded from this analysis. Additionally, there are approximately 99,400 ac-ft per year of seepage and evaporation loss along the All American Canal between Pilot Knob and the East Highline Canal charged to IID's total Colorado River diversion. Thus, the modeled mean (1987-1998) IID annual diversion of Colorado River water is 2,857,000 + 3,400 + 4,100 + 99,400 = 2,963,900 ac-ft.

[3] Other uses are composed mainly of M&I demands, but also include stock, rural pipe deliveries, and water for irrigating community greens (e.g., parks, school grounds). Other uses are not modeled in detail. Deliveries to M&I (72,600 ac-ft per year) and stock (10,300 ac-ft per year) uses are recorded. Rural pipe deliveries and deliveries to community greens are estimated to be 11,600 ac-ft per year and 10,000 ac-ft per year, respectively. The total of all other uses is 104,500 ac-ft per year. Consumptive use by all other uses is assumed to be 70 percent of deliveries except for stock, which is assumed to be 100 percent. Thus, the mean annual consumptive use from all other uses is estimated at 76,300 ac-ft. The mean annual return flow from these uses is 104,500 – 76,300 = 28,200 ac-ft.

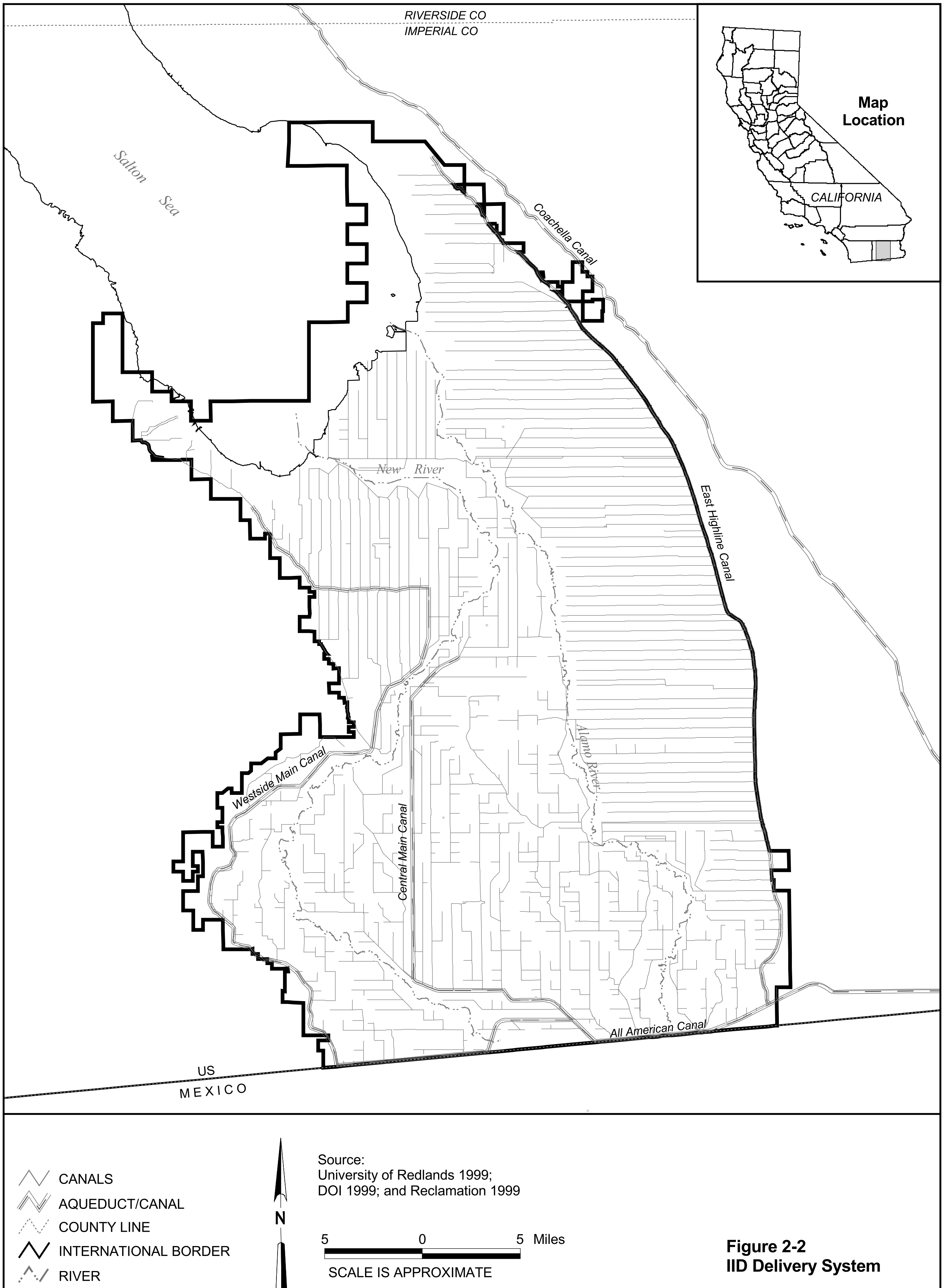

Figure 2-2
IID Delivery System

IIDSS Documentation

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Using the 12-year modeled mean values presented in Table 2-1, the average annual deliveries to IID farms are 2,489,700 ac-ft. Of this, approximately 390,000 ac-ft returns to the drainage system as tailwater and 394,200 ac-ft as tilewater. The balance, 1,705,500 ac-ft, makes up the consumptive irrigation volume. The estimated average annual effective[4] precipitation is 100,700 ac-ft. Thus, the estimated total average annual crop consumptive use is 1,806,200 ac-ft (1,705,500 + 100,700).

Drainage System

The third major component of the IID irrigation system is the drainage system that consists of approximately 1,500 miles of surface drains. The drains collect tilewater and tailwater flows from the farms, and pass them either directly to the Salton Sea or discharge them to the New or Alamo rivers. Figure 2-3 illustrates the extent and configuration of IID's drainage system.

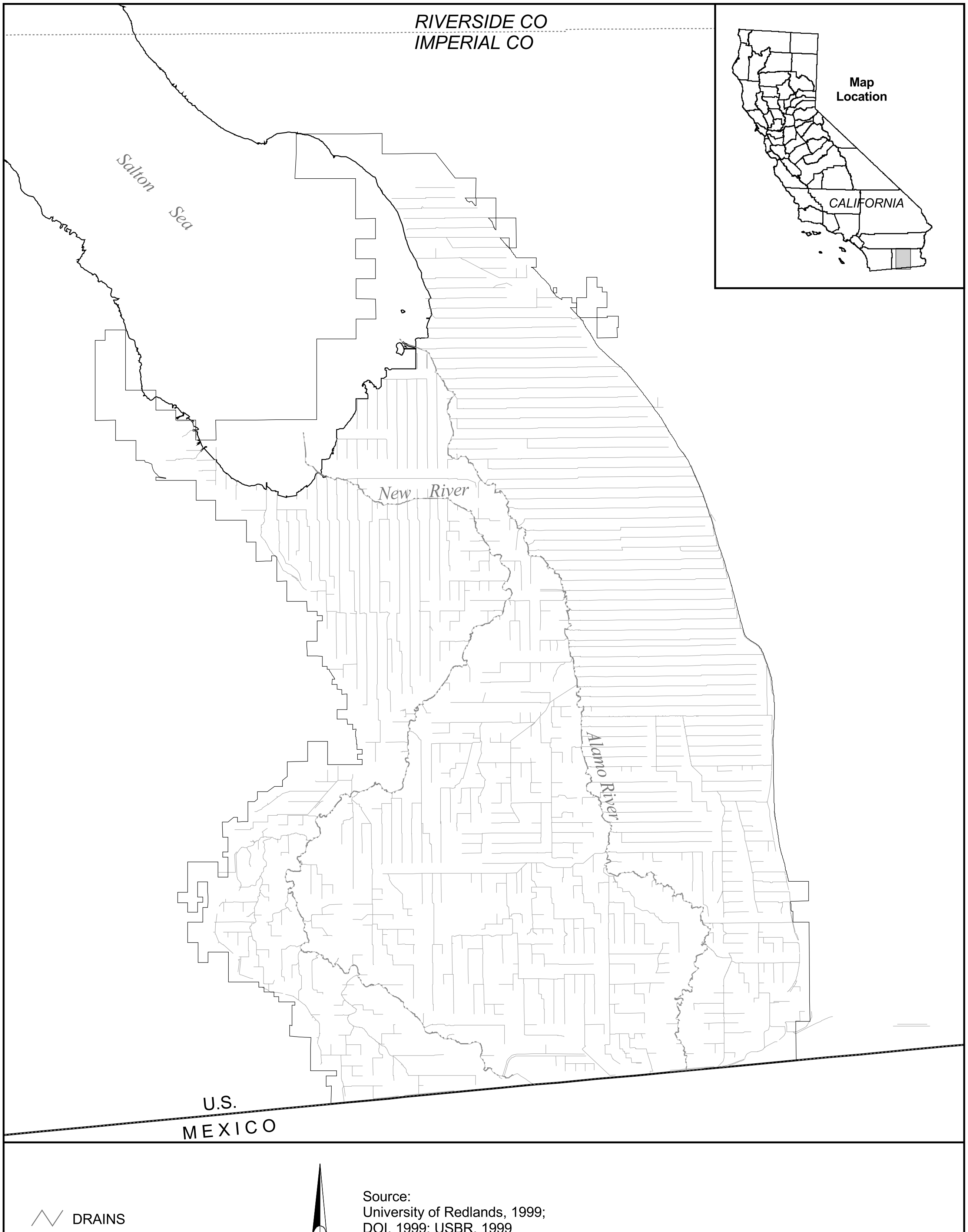
Using the 12-year modeled mean values presented in Table 2-1, the average annual discharge to the Salton Sea is 1,160,300 ac-ft (605,100 ac-ft via the Alamo River + 453,000 ac-ft via the New River + 101,200 ac-ft via drains discharging directly to the Salton Sea + an estimated 1,000 ac-ft of subsurface flow). Of this total drainage system discharge to the Salton Sea, 186,400 ac-ft/yr on average comes from Mexico (1,700 ac-ft via the Alamo River + 164,700 ac-ft via the New River + an estimated 20,000 via subsurface inflows) and an estimated 44,700 ac-ft comes from rainfall runoff and deep percolation and mesa storm inflows (36,800 ac-ft and 7,900 ac-ft, respectively).

An estimated 125,100 ac-ft evaporates annually from the drainage system via phreatophyte use and direct evaporation from water surfaces. A water balance on the drainage system (inflows – outflows = change in storage) shows that the average annual change in storage is zero (390,000 ac-ft of tailwater + 394,200 ac-ft of tilewater + 28,200 ac-ft of M&I and miscellaneous return flow + 122,700 ac-ft of canal seepage + 6,700 ac-ft of main canal spill + 116,900 ac-ft of lateral canal spill + 186,400 ac-ft from Mexico + 44,700 ac-ft from rainfall and mesa storm inflows – 1,160,300 ac-ft of total discharge to the Salton Sea – 125,100 ac-ft of evaporation and phreatophyte consumptive use – 4,400 ac-ft of recovered return flow from Mesa Lateral 5 = 1,289,800 ac-ft of drainage system inflows – 1,289,800 ac-ft of drainage system outflows = 0).

Data Review

The IIDSS determines the effectiveness of water conservation measures and the associated impacts to water quality and quantity in the drains. The basis for these determinations are water and water constituent mass balances. These balances track the flow of water and associated water quality constituents into and through IID to the atmosphere and Salton Sea as shown on Figure 2-1. To model each of the processes illustrated on Figure 2-1, large amounts of data were required, though they were not always readily available. This section briefly describes the data review process and data issues that were identified.

[4] Effective precipitation is the portion of precipitation that contributes to the total consumptive use of irrigated crops.



Source:
University of Redlands, 1999;
DOI, 1999; USBR, 1999

Figure 2-3
IID Drainage System

IIDSS Documentation

Data Collection and Analysis

Historical flow data were retrieved from IID's database through a series of queries. These data represented the measured amounts of water that were delivered to each of the 5,287 turnouts during the 12-year span from 1987 to 1998. This 12-year period from 1987 through 1998 was selected for model development, calibration, validation, and verification since this was the only period of full monthly water deliveries and cropping information available in electronic form[5]. Data gaps were identified and assumptions were made to fill them.

Because the amount of data was large, an IIDSS database, written in Microsoft Access, was used to store this information. Data from this database were included in the IIDSS Configuration Manager that was used to prepare input data sets for simulation of various alternatives by the MODSIM hydrologic model.

Delivery System Issues

Using the historical record of deliveries, a water balance was constructed to determine system losses between the All American Canal at Mesa Lateral 5 Heading and the sum of all deliveries. This water balance identified the sum of evaporation and seepage loss volumes plus spill volumes. Because main canal spillage was the only recorded delivery system loss, models of canal seepage and evaporation and lateral spillage as functions of flow in each canal reach had to be developed.

The delivery system is represented in the MODSIM link-node model using approximately 7,800 links and 7,800 nodes. Links correspond to the canal reaches and nodes represent canal branch points, turnouts, and termini. A GIS with a networking algorithm was used to populate the model with the link-node data necessary to simulate the delivery network. Link-node model time variant data included turnout demands and spills, delivery system information, and lateral interceptor systems and canal capacities.

Analysis of the system configuration identified multiple paths (canals) that water deliveries could follow to a particular turnout. Because MODSIM computes the optimum flow paths, a method of assigning a "delivery cost" was employed and calibrated to simulate the actual flow paths observed at IID.

Modifications were required to account for the time-varying system modifications, such as lining of canals and construction of lateral interceptor systems, under the conservation program developed pursuant to the 1988 IID/MWD Agreement. Synthetic demands were developed to represent water that was lost to canal seepage and evaporation prior to lining.

On-farm Issues

Available on-farm data consisted of time series of crop acreage, crop type, and irrigation method; soil type; and name of delivery turnout. To simulate on-farm processes, more data than were readily available were required. Reviewing literature and performing a series of analyses were used to develop crop evapotranspiration, tailwater, tilewater, and irrigation

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[5] Electronic data on IID water orders, deliveries, and charges began May 1986 and, at the time of IIDSS model development, ran until mid-November 1999. Coincident with executing and logging water deliveries the zanjeros (ditch riders) also noted crops and planting and harvest dates. These crop history data were also stored in an electronic database covering the same time period as the delivery history database.

performance data. Methods to simulate the effectiveness of water conservation were also developed. Each farm turnout was simulated using two nodes: a delivery node and a drainage node.

Drainage System Issues

Because only limited flow measurements in the drainage system were available, professional judgment was used to determine the fractions of water deliveries that returned to the drainage system. In particular, return flow fractions needed to be determined for on-farm agricultural practices, M&I, other uses, and recovered water that was previously lost through canal seepage and spillage.

The drainage system is represented in MODSIM using approximately 1,500 links and 1,500 nodes. As with the delivery system, GIS software (a networking algorithm) was used to spatially connect the drainage nodes and links.

Boundary Inflow Issues

The drainage systems in the IID water service area ultimately discharge to one of three locations: directly to the Salton Sea, the New River, or the Alamo River. As a result of the drainage flows commingling with flows in the rivers, it was necessary to determine the volume of water that entered the IID service area via the rivers at the boundary.

Water Quality Issues

Water quality data were obtained and reviewed for nine chemicals of concern: salinity, sediment, boron, nitrogen, phosphorus, selenium, organochlorine insecticides (DDT, also used to represent its metabolites, and toxaphene), and organophosphorus insecticides (diazinon and chlorpyrifos).

Water quality data were compiled from various data sources to describe concentration and flow data from the Colorado River, the All American Canal, IID open drains, and for the Alamo River and the New River at the international border and their outlets to Salton Sea. Individual measurements were averaged into monthly values for the period from 1970 to 1999, and a subset of these monthly values for the 1987 to 1998 model calibration period was used in the model runs. Out of a possible 144 monthly water values for the 12-year modeling period, the number of data points for the non-pesticide constituents varied generally between 12 and 114; the number of organochlorine pesticide measurements was less than 5 values in this period.

In general, salinity, boron, and selenium are imported into the system from the Colorado River with the irrigation water. Small amounts of nitrogen and phosphorus, and sediment are also introduced through the irrigation water, but the primary source of these constituents is irrigated fields. In addition, pesticides come exclusively from farm runoff and pass through the drain system. Once in the drainage system, TDS and boron behave as conservative constituents, and selenium, nitrogen, and phosphorus appear to be influenced by chemical and biological activity. The coarse sediment largely settles in the drains and the finest suspended sediment continues through the rivers to the Sea. The measured concentrations for the constituents in the irrigation water, drains, and rivers to the Salton Sea are summarized in Table 2-2.

TABLE 2-2
Mean Flows and Concentrations for Water Quality Parameters

Parameter	Irrigation Delivery	New River			Alamo River		
		Border	Drains	Outlet	Border	Drains	Outlet
Daily mean flow (cfs)	3,934	250		622			843
Instantaneous flow (cfs)		193			2		
Total dissolved solids (TDS) (mg/L)	771	3,894	2,116	2,997	3,191	2,375	2,458
Total suspended solids TSS (mg/L)	86	117	193	313	360	318	479
Selenium (Se) (µg/L)	2.5	3.0	7.4	7.1	5.9	7.9	7.7
Nitrate (NO_3) (mg/L)	0.28	0.84	7.49	4.37	1.87	8.14	7.81
Total phosphorus (mg/L)	0.05	1.42	0.78	0.81	0.47	0.84	0.63
Total Phosphorus (Total P) in sediment (mg/kg)		535	1,300	1,600			1,100
DDT (µg/L)	0.001	0.088	0.013	0.016	0.011	0.020	0.016
DDT in sediment (µg/kg)		0.1	2.6	11.0	0.1	14.6	0.1
Diazinon (µg/L)			0.025				0.025
Chlorpyrifos (µg/L)			0.025				0.025
Boron (ug/L)	170	1,600	804	1,172	1,798	683	695

Baseline

Utilization of the IIDSS to determine water conservation resulting from various on-farm and system measures and the impact of such conservation on water supply and quality in the drainage courses of the IID water service area over the 75-year term of the Proposed Project requires establishment of a Baseline against which to measure change. To be meaningful, the baseline must represent the expected variability in drain flow and quality that could reasonably be expected in the future, based on the present state of irrigation within the District, but without implementing any new water conservation measures. It must also represent a sufficiently long record to allow assessment of long-term variability. Once the Baseline conditions are established, impacts can be assessed by applying the expected range of conservation measures to the Baseline condition.

The Baseline hydrology and water quality represents the physical conditions at a point in time (NOI and NOP for the Transfer EIR/EIS) and reasonable anticipated future variability in these conditions. Hydrology and water quality are resources that change over time and cannot be properly represented at a point in time. Therefore, a 75-year predicted Baseline was developed using the IIDSS, and based on 12 years (1987 to 1998 model calibration period) of available data representing river diversions, canal flows, farm turnout flows, climatic information, crops irrigated, drain flows, and water quality in the canals and drains. These data were adjusted according to reasonable anticipated future changes such as an increase in Colorado River salinity and for the effects of the 1988 IID/MWD Agreement. Finally, the data were projected to 75 years using a correlation based on 75 years of historical weather data compared to the 12-year data period. The Baseline prediction included an adjustment to limit the diversion of Priorities 1, 2, and 3 for normal year hydrology in the Colorado River to 3.85 maf/y.

The basic assumptions listed below represent reasonable anticipated future conditions and were used to develop the Baseline:

- The crop-mix represented during the 12-year period is a reasonable representation of what is likely to be grown in the future.
- Climatic variability is a reasonable proxy for the variability in diversion and delivery from year-to-year that is independent of farming practices.
- Salinity of supply water from the Colorado River will be maintained by Reclamation at an average 879 mg/L pursuant to the Salinity Control Act.
- Flow and water quality from Mexico over the past 12 years is the best reflection of future conditions.
- Changes in diversion and delivery as a result of conservation measures employed to date (pursuant to the 1988 IID/MWD Agreement) are best represented by the conservation verification estimates reported each year by the IID/MWD Conservation Verification Consultant Committee.

Structure of Imperial Irrigation Decision Support System

Overview

The general goal of the IIDSS was to support the understanding of how the irrigation and drainage network in the IID water service area would respond to a variety of water conservation alternatives. Specifically, the IIDSS is concerned with the effectiveness of water conservation measures and the associated impacts to water quality and quantity in the drains. This was accomplished by creating mathematical and numerical representations of each process and system presented on Figure 2-1. Collectively, these mathematical and numerical representations are integrated into a decision support system framework consisting of user interfaces, databases, analysis tools, and models collectively referred to as the IIDSS.

IIDSS was designed to simulate irrigation and drainage within IID for a 75-year period using a 12-year calibration and verification period. As explained above, the 12-year calibration period from 1987 through 1998 was selected because it covered the full availability of electronic data on IID gate deliveries and crop acreages, data that are key to the conceptual design of the IIDSS. The 75-year simulation capability was developed to analyze how the IID irrigation and drainage networks would respond over 75 years of water conservation[6], which is the full operations term of the Proposed Project.

[6] On April 29, 1998, IID and SDCWA executed the IID/SDCWA Water Conservation and Transfer Agreement, which defines the negotiated, contractual terms of the proposed water conservation and transfer to SDCWA. One of those terms is the length of the transfer. The agreement has an initial term of 45 years after the transfers commence. IID and SDCWA each have an option to extend the term for an additional 30 years. Thus the water transfers between IID and SDCWA could continue for up to 75 years. The proposed Quantification Settlement Agreement (yet to be executed) provides for a comparable term.

Components

As shown on Figure 2-4, the IIDSS uses three major components that are linked together to perform each simulation. These components are the IIDSS Database, the Configuration Manager, and the MODSIM hydrologic model[7].

Geographic Information System

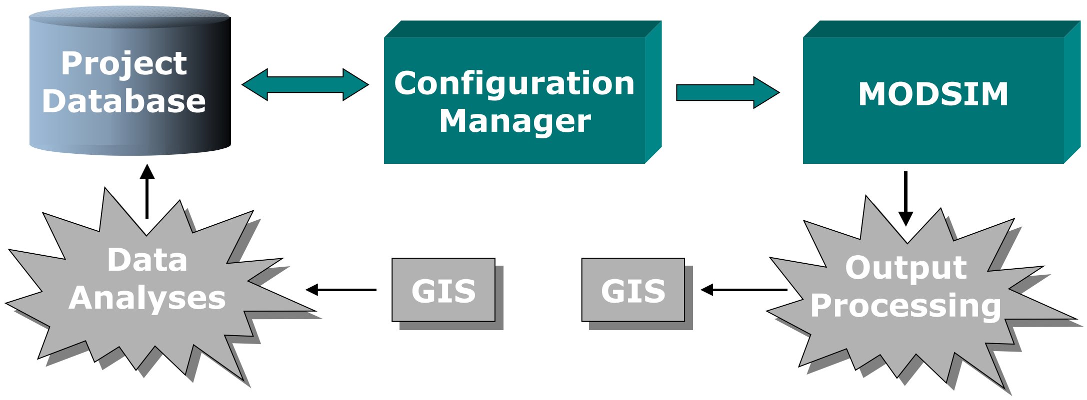

Figure 2-4
Components of the Imperial Irrigation Decision Support System

The GIS is an electronic spatial database that contains physical descriptions of the canal and drainage networks. The GIS exploits the spatial relationships of the data it contains. For example, a spatial query was performed to determine discharge points in the model, as in "*Show me the closest node in the drainage system that is downstream of this turnout in the supply system.*" The spatial relationships and physical data were exported from the GIS and stored in the IIDSS Database so that they were available to other IIDSS components.

Because the hydrologic model MODSIM and GIS share common names for canals, drains, and turnouts, simulation data can be extracted from the modeling environment and displayed and queried in the GIS environment. Linking MODSIM results to the GIS helps the understanding of differences among simulations.

Data Analyses

Analyses were performed on multiple forms and sources of data to gain an understanding of the processes shown on Figure 2-1. Many of these analyses addressed the data issues presented above:

[7] Labadie, J. 1995. MODSIM River Basin Network Flow Model for Conjunctive Stream—Aquifer Management, Program Users Manual and Documentation, Department of Civil Engineering, Colorado State University, Ft. Collins, CO.

- Delivery System: Seepage and evaporation rates as fractions of canal flow were determined and stored in the IIDSS Database with the GIS data. Correlation parameters between flow volumes, delivery frequency, and spill volumes were determined and incorporated into the Configuration Manager and passed to MODSIM.
- On-farm: Flow paths and water quality analyses resulted in irrigation schedules that were stored in the IIDSS Database. Tailwater and tilewater algorithms and water quality relationships were developed and applied within the Configuration Manager.
- Drainage System: Parameters relating phreatophyte uptake to canal size were determined and incorporated into the Configuration Manager. Fate and transport parameters of water quality constituents were determined and incorporated into the Configuration Manager and passed to MODSIM.

The findings of these analyses were either incorporated into the IIDSS Database as a series of lookup tables or incorporated directly into the Configuration Manager as algorithms and procedures.

IIDSS Database

The IIDSS Database consists of several tables stored in a Microsoft Access database. The data sources included historical data obtained from IID, physical data obtained from the GIS, and computed ET data that correspond to the historical data on deliveries, crops, and irrigation methods. This single repository served to consolidate all of the historical data used to develop the IIDSS. The elements of the database are described in each of the relevant sections of this report.

Configuration Manager

The Configuration Manager is a standalone computer application written in Visual Basic that performs two main tasks: (1) conducts and manages simulations, and (2) prepares input files for MODSIM.

The Configuration Manager simulates on-farm processes (computes the tailwater and tilewater flow to drainage and shifts in water delivery requirements resulting from voluntary on-farm water conservation programs), subsurface (tilewater) flow lagging, and water quality transformations resulting from on-farm irrigation practices. The results of these simulations are added to the tables in the IIDSS Database.

To configure the MODSIM simulations, the Configuration Manager converts data stored in the database into several tab-delimited text files. One set of files is prepared for each simulation.

The water quality modeling consists of calculating loads – imports from the Colorado River and from Mexico, constituents added at the field level, and subsequent transport through drains and rivers to the Salton Sea. Constituents moving through the groundwater were modeled using tanks with lagged tile flow. Non-agricultural sources were included in the water quality calculations based on data from National Pollutant Discharge Elimination System (NPDES) permitted sites. Because this part of the water quality model was intertwined with the on-farm hydrology, the Configuration Manager calculates these components of the overall model before passing the water quality loads and tile flows by drain node to MODSIM.

MODSIM

The MODSIM link-node hydrology model was employed to simulate the monthly operation of the IID system for a 12- and 75-year time period. MODSIM simulates the routing of water through the delivery system to delivery points throughout the IID water service area and computes the overall water demand in the All American Canal at Mesa Lateral 5. System constraints, including maximum canal and drain flows, system spills, maximum and minimum reservoir capacities, and conveyance losses are included in the simulation.

MODSIM also routes mass and flows through the IID drainage network and through the New River and the Alamo River. MODSIM adds loads from canal seepage and spills to the network. Loss functions were used to simulate physical, chemical, or biological decay or losses of constituents in the drainage/river system. From the MODSIM output of flows and loads, concentrations can be calculated at any drain or river node throughout the drainage/river network. The constituent concentrations measured at the outlets of the New River and of the Alamo River to the Salton Sea are used for model calibration.

Output Processing

Voluminous MODSIM output is summarized and placed into comma-delimited (*.csv) text files that are imported into spreadsheets, databases, GIS, and other programming environments for further processing and reporting. Drainage flows predicted by MODSIM are adjusted for storm runoff and phreatophyte depletions. For water quality analyses, concentration calculations are carried out using the predicted water quality loads and dividing by these adjusted drain flows.

SECTION 3

Alternative Conservation Program Assessments

Overview

The primary purpose for IIDSS is the detailed estimation of conservation programs and resulting changes in water quantity and quality in the drains, rivers, and discharge to the Salton Sea. Under the Proposed Project and alternatives, conservation will be achieved through a variety of methods, including on-farm projects, improved water management, fallowing, and system conservation projects. Each of these conservation projects impacts water quality in the drains differently for each of the water quality constituents of concern. The volume of conservation has a significant impact on changes to these water qualities. IIDSS will track conservation volumes individually and cumulatively anywhere within the IID system. Estimates of water quantity and quality changes can also be developed at the end of any surface drain, at any drain junction on a river system, and at all discharge locations to the Salton Sea.

This section of the report describes the conservation projects and programs evaluated by IIDSS, the water quality parameters evaluated, the criteria used in IIDSS for development of alternative program runs, and key findings developed from the alternative programs.

Conservation Projects and Programs

Under the Proposed Project and alternatives, conservation will be achieved through a variety of methods. These methods are categorized as on-farm, including fallowing, and irrigation delivery system methods. The conservation program consists of a combination of methods that achieves a target conservation volume, and the combination of methods is expected to vary over the 75-year term to respond to varying conditions and farm ownership participation.

On-Farm Conservation Projects

On-farm conservation can be achieved through a combination of on-farm irrigation system improvements, fallowing, and improved water management. Farmer participation in the conservation and transfer program is voluntary. It is anticipated that farmer participation will be dynamic in location, annual conservation volumes, length of participation, methods used to achieve conservation, and the efficiency in water management necessary to achieve on-farm conservation. Hence, the expected methods of on-farm conservation can only be estimated at this time and will likely vary over time. Unless previously arranged, selection of on-farm participants is done randomly by the Configuration Manager.

Numerous on-farm irrigation methodologies exist for reducing on-farm water use. To compute conservation at the farm level, IIDSS uses the change in On-farm Irrigation

Performance Index (PI), which is computed for each participating farm. The change in the PI to compute conservation is not dependent on the on-farm improvement method. Hence, the hardware and management improvements used to achieve on-farm conservation are not described in the IIDSS and are not required model inputs.

For the EIR/EIS, an assessment of potential on-farm conservation methods was made to support the socio-economic evaluations and intent of the water transfer program. All reasonable on-farm improvement methodologies were assessed for potential use in the IID water service area, considering ongoing practices, soils, and crops. In consultation with IID staff and knowledgeable local farmers, the following on-farm methods were selected as the most likely for potential use:

- Level basins
- Shortened furrows/border strips
- Tailwater return systems
- Narrowed border strips
- Cutback
- Laser leveling
- Multi-slope
- Cascading tailwater
- Drip irrigation
- Water management

In addition, fallowing is considered an on-farm conservation method. Fallowing is defined as non-use of farmland for crop production to conserve water. The average per-acre savings from fallowing is 5.63 ac-ft/ac. This value is based on the 12-year IIDSS database of annual turnout deliveries and average irrigated acreage. Fallowing can be rotated from field to field. For purposes of alternative simulation runs, fallowed land was randomly selected, with no annual rotation assumed. A series of alternative simulations indicated that spatial changes in water quality were very minor for this assumption.

Irrigation Delivery System Projects

Five types of irrigation delivery system conservation projects have been identified as potentially feasible within IID. Detailed descriptions, potential conservation volumes, and cost for each type of project are shown in a report by Imperial Valley Engineering Services (as modified). The projects include:

- Lateral interceptor systems
- Canal lining
- Mid-lateral reservoirs
- Seepage collector systems
- Drainwater treatment and reuse

Conservation Programs for IIDSS Simulation

For purposes of simulations, a conservation program is a combination of projects/methods that will achieve an annual target conservation volume. The program can include a combination of on-farm projects, delivery system projects, and fallowing that will achieve the desired annual conservation volume. Table 3-1 lists the conservation programs to be assessed in the EIR/EIS.

Table 3-1 also illustrates the interaction between the two potential agreements, the IID/ SDCWA Transfer Agreement and/or the proposed Quantification Settlement Agreement (QSA). One or both of these agreements requires that:

1. At least a 130,000 ac-ft of annual conservation will be by on-farm methods (the minimum program). Fallowing is included as an on-farm method.
2. Farmer participation in the transfer program is voluntary. The conservation method(s) and length of participation in the on-farm water conservation program is the farmers' choice. IIDSS computes the on-farm conservation volume as the reduction in delivered water from a quantified amount defined from turnout delivery records for the years 1987 through 1998.
3. The potential maximum annual transfer is 300,000 ac-ft.
4. For annual transfers greater than 130,000 ac-ft, achieved under the IID/SDCWA Agreement, the additional conservation volumes can be achieved by a mix of on-farm, system, and fallowing conservation methods. Potentially, 300,000 ac-ft can be transferred out of the Salton Sea basin (for transfer to SDCWA alone or SDCWA and MWD).
5. If the QSA is implemented, annual conservation can be achieved by a mix of on-farm, system, and/or fallowing projects. It is assumed that water transferred to CVWD remains in the basin and can eventually contribute to runoff that reaches the Salton Sea. If CVWD exercises their options to acquire 100,000 ac-ft per year, the minimum transfer under the QSA is 230,000 ac-ft per year.
6. The transfer will last a minimum of 45 years and can be extended to 75 years.
7. The ramp-up schedule for conservation and transfer is shown in Table 3-2 for the QSA. Ramp-up to volumes required by the IID/SDCWA Agreement occurs in 20,000-ac-ft increments for the first 10 years, then 10,000-ac-ft increments for the next 10 years.

The conditions sited above define the broad setting for alternative conservation programs necessary to satisfy the Proposed Project for water transfer and associated conservation programs.

TABLE 3-1
Simulated Water Conservation Programs

Proposed Project and Alternatives	IID/SDCWA Transfer Agreement Implementation Only	With QSA Implementation	Corresponding Model Runs	
			IIDSS	Salton Sea Model[a]
Proposed Project	a) At least 130 KAFY via On-farm to SDCWA b) Additional 70 KAFY via On-farm and/or WDS[C] to SDCWA. Total of 200 KAFY to SDCWA. c) Remaining 100 KAFY via On-farm and/or WDS to SDCWA[b] Total of 300 KAFY to SDCWA	a) 100 KAFY via On-farm, WDS, and/or fallowing to CVWD or MWD b) 100 KAFY via On-farm, WDS, and/or fallowing to CVWD or MWD c) N/A	Model Run: 12-year (200 + 100); in-basin Model Run: 75-year (200 + 100); in-basin	200KAF to SDCWA and 100KAF to CVWD via On-farm and System Conservation 300 KAF to SDCWA (out of basin)
Simulation 1: No Project	N/A	N/A	Model Run: 12-year capped Baseline Model Run: 75-year capped Baseline	Baseline Conditions
Simulation 2: 130 KAFY	130 KAFY via On-farm to SDCWA	N/A	Model Run: 12-year 130 On-farm Model Run: 75-year 130 On-farm	130 KAF to SDCWA
Simulation 3: 230 KAFY	a) At least 130 KAFY via On-farm to SDCWA b) Additional 100 KAFY via on-farm and/or WDS to SDCWA[b] Total of 230 KAFY to SDCWA	a) 100 KAFY via On-farm, WDS, and/or fallowing to CVWD or MWD b) N/A	Model Run: 12-year 230 On-farm Model Run: 75-year 230 On-farm	130K to SDCWA and 100K to CVWD via On-farm Conservation
Simulation 4: 300 KAFY*	300 KAFY via fallowing to SDCWA	300 KAFY via fallowing to SDCWA, CVWD or MWD	Model Run: 12-year 300 DW Fallow Model Run: 75-year 300 DW Fallow	200K to SDCWA and 100K to CVWD via Fallowing

Notes:
[a] Salton Sea analysis for water surface elevation, surface area, and salinity.

[b] Up to 100 KAFY can be conserved via WDS and a maximum of 230 KAFY can be conserved via On-farm.

[c] WDS – water delivery system

*This alternative would require waiver or modification of existing IID/SDCWA Transfer Agreement.

TABLE 3-2
IID Water Conservation - Ramp-up Schedule (Assuming Implementation of QSA)

Year	SDCWA AT 130 KAF	CVWD/MWD (KAF)	Total KAF with QSA (SDCWA at 130 KAF)	SDCWA AT 200 KAF	Total KAF with QSA (SDCWA at 200 KAF)
2002	20.0		20.0	20.0	20.0
2003	40.0		40.0	40.0	40.0
2004	60.0		60.0	60.0	60.0
2005	82.5	2.5	85.0	82.5	85.0
2006	105.0	5.0	110.0	105.0	110.0
2007	122.5	7.5	130.0	122.5	130.0
2008	130.0	10.0	140.0	140.0	150.0
2009	130.0	15.0	145.0	160.0	175.0
2010	130.0	20.0	150.0	180.0	200.0
2011	130.0	25.0	155.0	200.0	225.0
2012	130.0	30.0	160.0	200.0	230.0
2013	130.0	35.0	165.0	200.0	235.0
2014	130.0	40.0	170.0	200.0	240.0
2015	130.0	45.0	175.0	200.0	245.0
2016	130.0	50.0	180.0	200.0	250.0
2017	130.0	55.0	185.0	200.0	255.0
2018	130.0	60.0	190.0	200.0	260.0
2019	130.0	65.0	195.0	200.0	265.0
2020	130.0	70.0	200.0	200.0	270.0
2021	130.0	75.0	205.0	200.0	275.0
2022	130.0	80.0	210.0	200.0	280.0
2023	130.0	85.0	215.0	200.0	285.0
2024	130.0	90.0	220.0	200.0	290.0
2025	130.0	95.0	225.0	200.0	295.0
2026	130.0	100.0	230.0	200.0	300.0

Strategy and Criteria for Selection of Alternative Conservation Programs

IIDSS simulation runs illustrated in Table 3-1 were established to produce the reasonable best and worst case (bookend) impacts to changes in water quality (selenium and salinity) in the IID drains and rivers. In addition, alternative simulations to establish bookend impacts on salinity to the Salton Sea were developed[8] and are listed in Table 3-1. The strategy and method for selection of the alternative programs is discussed below.

Proposed Project

The Proposed Project is one that meets the intent of the IID/SDWCA Transfer Agreement or the IID/SDCWA Agreement as modified and supplemented by the QSA. These two agreements and required transfer volumes that will be achieved by conservation and/or fallowing are discussed above. The IIDSS conservation program simulations for the EIR/EIS analysis were developed to bookend the changes in water quality in the drains, rivers, and discharge to the Salton Sea.

8 Output from IIDSS for IID salinity loading was provided to the USBR for modeling of Salton Sea surface elevations, surface area, and changes in salinity.

The key water quality impacts are those from increased selenium and salinity concentrations. For selenium, the significant increases in concentration occurs in the IID drains and in the rivers. The major concern for the Salton Sea is the increased concentration and loading of salinity and the reduction in water elevations resulting from reduced inflows. There is also concern for increased salinity concentrations in the IID drain system. The conservation program will improve concentrations associated with other water quality parameters that originate from on-farm cultural practices. Boron concentration is well below environmental and crop use standards. The greatest increase to selenium and salinity concentrations occurs at maximum conservation (for transfer purposes) of 300,000 ac-ft/yr when fallowing is not part of the alternative program. Minimum increases to these concentrations occur at the minimum program of 130,000 ac-ft of on-farm conservation.

Evaluations for impacts other than water quality are not part of the IIDSS simulations. However, information from the IIDSS output and database is of value to the socio-economic assessment.

No Project

For this project, the "no project" scenario is the same as the project Baseline over the next 75 years. As stated, the significant changes from recent historical conditions that formulate the project Baseline are the changes in salinity of source water and an annual entitlement of 3.43 million ac-ft shared between IID and CVWD. Crop mixes and water diversions remain as in the historical database except as identified below.

An increase in the Colorado River salinity from the historical (1987 – 1998) average of 747 mg/L to 879 mg/L is reflected in the Baseline and will increase required water delivery needs in the IID water service area to satisfy crop leaching requirements. The increase in on-farm diversion for leaching is modeled as taking place only on fields where analysis of simulated ET demand together with historical delivery and cropping data indicate that additional leaching would be necessary to respond to the increased salinity of the delivered water.

The California agricultural Colorado River entitlements (Priorities 1, 2, and 3) are limited to 3.85 maf per year. If Priorities 1 and 2 are assumed to average 420 kaf per year, the remaining 3.43 maf per year is available for Priority 3, IID and CVWD. Therefore, the combined IID and CVWD diversions cannot exceed this 3.42 maf in a normal Colorado River water year. As a result, the Baseline assumes that this annual volume of 3.43 maf will be enforced.

Fallowing as an On-Farm Project

For a given conservation target, fallowing creates the least change in salinity and selenium concentrations in the IID drain and river systems. As a result, the least change to these concentrations is attributed to fallowing for 300,000 ac-ft of transfer.

IIDSS Conservation Programs Simulation Criteria

To capture a reasonable maximum and minimum change to water quality (selenium and TDS) created by the Proposed Project and alternatives, the following criteria were used:

- Minimum change in water quality occurs when fallowing is the conservation method. This was simulated using a fallowed conservation volume of 300,000 ac-ft/year.
- If fallowing is not used for conservation, the minimum changes to water quality in the drains occur for an on-farm conservation program of 130,000 ac-ft/yr.
- The maximum impact program is 300,000 ac-ft of conservation for transfer purposes. To ensure maximum water quality changes, 300,000 ac-ft of on-farm and a combination 300,000 ac-ft (200,000 ac-ft on-farm and 100,000 ac-ft system, which is near the maximum achievable level of system conservation) programs are simulated. Analysis shows that for a given conservation volume, delivery system conservation results in slightly higher concentrations of selenium and salinity in the drains and rivers.
- 75-year IIDSS simulations are made for each conservation program.
- Within the IID water service area, the evaluations are for the worst-case water quality impacts/changes. IIDSS simulation runs assume a "steady state" and start with full implementation (no ramp-up).
- Water demands in IID can be met at all times, that is, supply is not limited, subject to enforcement of entitlements.
- For simulation purposes, the number of farms/participants was varied to achieve the on-farm conservation target.
- The Salton Sea is a "declining" resource, with salinity and water surface elevation sensitive to timing of implementation. The conservation ramp-up schedule shown in Table 3-2 was used to prepare the 75-year flow and salt loading inputs for analysis of the Salton Sea salinity, elevation, and surface area changes for transfers assuming full QSA implementation. For the IID/SDCWA Agreement, the conservation ramp-up schedule occurs in increments of 20,000 ac-ft/year.
- Participation in on-farm conservation is accomplished by random selection. The improvement in on-farm irrigation performance is simulated using the Irrigation Performance Index for the various cropping families. Potential improvements in this index are based on existing on-farm performances within IID.
- Simulated programs use historical cropping patterns (1987 through 1998) and evapotranspiration along with historical delivered water to estimate conservation volumes.
- The maximum average annual system conservation is estimated to be approximately 104,000 ac-ft. The least cost ($/per ac-ft) projects are used in the simulation runs.
- Mid-lateral reservoirs and lateral interceptor systems create duplication for given service areas. Lateral interceptors are considered the most cost-efficient method and were used

for simulation analysis. Except for very site-specific conditions, there is no change in water quality impacts between the two system conservation methods.

- The maximum combined IID/CVWD entitlement at Pilot Knob is 3.43 maf per year. The modeling assumption is that the IID's diversion cap pursuant to the QSA is in force (3.1 maf to IID) and IID is conserving the necessary payback volume in addition to the transfer volume to achieve compliance. For the 75-year runs, the payback amounts to an average of an extra 59,210 ac-ft of conservation every year. Actual payback is to occur in the year(s) following the year entitlement is exceeded.
- Once established, the random selection for on-farm conservation and on-farm fallowing participants was fixed. Simulation of annual rotations was not necessary. The sensitivity of this assumption was tested by making several simulation runs with conservation at 130,000 ac-ft, with each simulation having random farm participation. This analysis showed very little difference in spatial impacts and changes in water quality concentrations for selenium and TDS in any given drain, and hence along the river reaches.

Ramp-up Simulation Criteria

For most water quality constituents, the concern for changes in water quality occur at full transfer and are simulated as a steady-state condition. However, the impacts of salinity on the Salton Sea depend on the implementation schedule. When salinity in the Salton Sea reaches a certain threshold value, wildlife and aquatic impacts become significant. To assist the USBR in determination of when salinity thresholds would be reached, annual salt loading to the Salton Sea were determined from IIDSS output for use in USBR modeling efforts using the ramp-up schedules shown in Table 3-2.

Figure 3-1 demonstrates that reductions in drainage flow are almost linear to the reductions in IID diversions that result from conservation. Figure 3-2 illustrates that the reduction in salinity loading in the IID drainage system is also a linear function of diversion salt loading. For a salinity concentration of 879 mg/L, this simply means that a 1-ac-ft reduction in diversion reduces salt loading in the IID drainage system by 1.1954 tons. This factor was used to determine salt loading to the Salton Sea during the ramp-up phase of a water transfer.

Salt loading to the Salton Sea during fallowing is also a linear function of the diversion volume. However, the drain water salinity and selenium concentrations for the fallowing alternative are less, as 31.1 percent more water remains in the drains for each acre-foot of transferable water.

Key Findings

Operation of the IIDSS provided considerable information regarding implementation of a water conservation and transfer program for IID. IIDSS was designed to spatially estimate changes in IID hydrology and in drain water quality. Those changes, along with other miscellaneous findings, are reported herein.

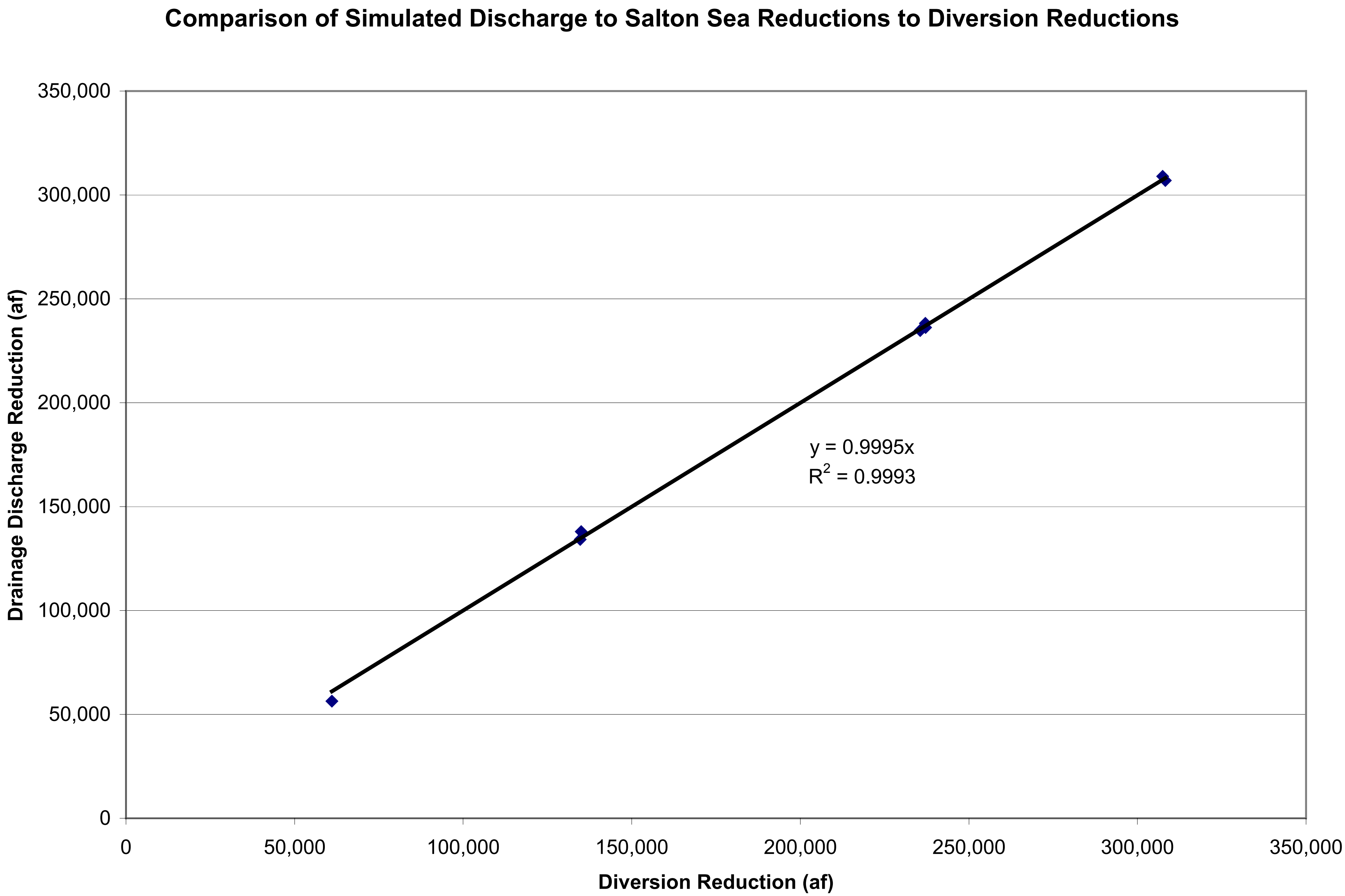

Figure 3-1
Diversion and Drainage Flow Relationships

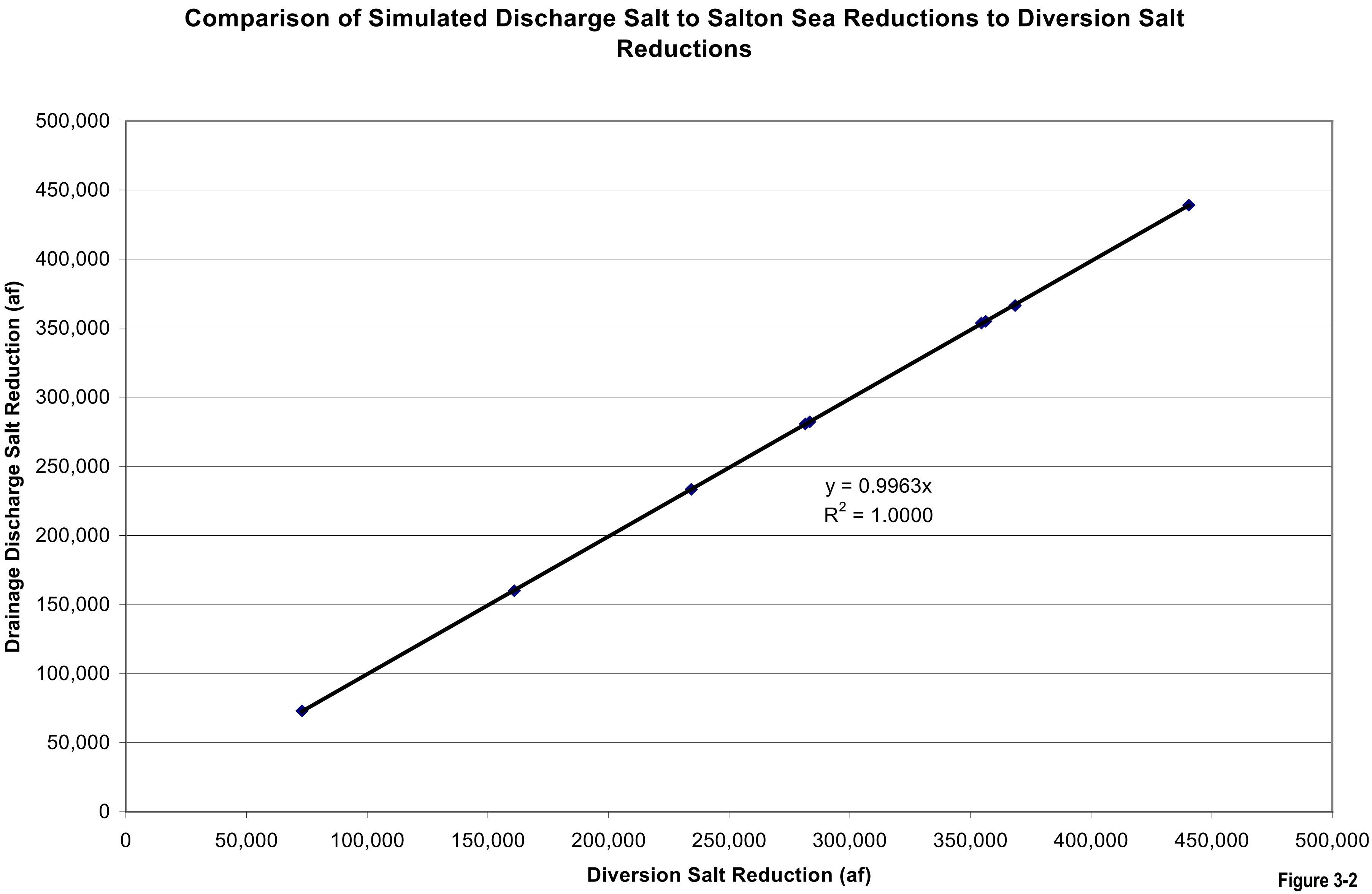

Figure 3-2
Relationship of IID Salinity Diversions to Salinity and Discharge to Drainage

IID Hydrology

Simulated water balance data from IIDSS are shown in Table 3-3. Historical data, IIDSS calibration data, and Baseline information are shown for reference. Note that the IIDSS water balance is computed in the All American Canal, just upstream of the East Highline Canal at Mesa Lateral 5. The IID diversion point is considered to be at Pilot Knob on the All American Canal nearly 40 miles upstream. IID's share of the All American Canal losses between Mesa Lateral 5 and Pilot Knob are added to the water balance data to determine IID's actual diversion.

Table 3-3 shows a water balance for four conservation programs. Slight differences between target and actual conservation (Baseline diversion less program diversion) are noted. This difference is attributed to two things. First, actual acreage needed for on-farm or fallowed conservation is slightly exceeded (the last randomly selected participatory farm will create a conservation volume in excess of the target), and second an additional 4 percent conservation above on-farm and fallowing transfer volumes is associated with reduced system losses due to lower delivery volumes.

Water Quality in the IID Drainage System

Water quality changes are computed at the ends of all IID drains and along the Alamo and New rivers at drain intersections for all IIDSS simulations. Table 3-4 presents a general overview of water quality changes for three constituents (TDS, selenium, and TSS) at key locations within the IID water service area for a 300,000-ac-ft per year transfer program that includes 200,000 ac-ft of on-farm conservation and 100,000 ac-ft of water delivery system (WDS) conservation. The percentages shown are for the predicted change from Baseline conditions. Table 3-5 demonstrates changes in water quality for 300,000 ac-ft per year of transfer developed by fallowing. For all water quality parameters, there is a slight improvement in water quality using fallowing to achieve the water transfer.

The data shown in Tables 3-4 and 3-5 are average annual concentrations for the 12-year simulations. Output from IIDSS is monthly and shows all water quality constituent concentrations varying on a monthly basis.

General observations are:

- The percent change associated with selenium and TDS concentrations is always an increase, and nearly identical. The changes in the Alamo River Basin are greater than changes in the New River Basin.
- New River inflows from Mexico buffer changes in the three constituents whose primary source is Colorado River water. This tends to minimize the increase in concentration when compared to the drains and the Alamo River.
- TSS concentrations are reduced. This is directly related to on-farm conservation and a resulting decrease in tailwater discharge.
- TSS concentrations are decreased only slightly in the direct-to-sea drains. This is related to farming methods and cropping patterns, as well as soil types. Most of the soils are very sandy (heavy) along these drains.

TABLE 3-3
IIDSS Simulated Water Balance

Description	Recorded	Calibration	Baseline	200 kaf on-farm plus 100 kaf system	230 kaf on-farm	130 kaf on-farm	300 kaf DW fallowing
Imported Colorado River Water [a]	2,866,000	2,857,000	2,803,000	2,495,000	2,566,000	2,668,000	2,490,000
Canal and Reservoir Evaporation	-	21,000	19,000	17,000	17,000	18,000	17,000
Canal seepage	-	123,000	111,000	89,000	104,000	107,000	100,000
Main canal spills	-	7,000	-	-	-	-	-
Lateral spills	-	117,000	99,000	15,000	99,000	99,000	99,000
Sum of Delivery System Losses [b]	272,000	268,000	229,000	121,000	220,000	224,000	216,000
Delivery to Farms	2,490,000	2,490,000	2,458,000	2,258,000	2,229,000	2,328,000	2,158,000
Crop Eta	-	1,807,000	1,807,000	1,806,000	1,806,000	1,806,000	1,593,000
Other Evaporation	-	-	-	-	-	-	-
Effective Rainfall	-	101,000	101,000	101,000	101,000	101,000	101,000
Tailwater	-	390,000	344,000	197,000	178,000	252,000	305,000
Tilewater	-	394,000	408,000	356,000	346,000	371,000	361,000
Delivery to M&I + Stock + Misc [3]	105,000	105,000	120,000	120,000	120,000	120,000	120,000
Consumptive Use from M&I + Stock + Misc	-	76,000	86,000	86,000	86,000	86,000	86,000
Return Flow from M&I + Stock + Misc	-	29,000	34,000	34,000	34,000	34,000	34,000
Change in Soil Water and Groundwater Storage	-	-	-	-	-	-	-
Recovered return flow from Mesa Lateral 5	-	4,000	4,000	4,000	3,000	4,000	4,000
Rainfall Runoff and Deep Perc	-	34,000	38,000	36,000	37,000	37,000	38,000
Evaporation and Phreatophyte Use	-	125,000	125,000	125,000	125,000	125,000	125,000
Mesa Storm Inflows	-	8,000	8,000	8,000	8,000	8,000	8,000
Subsurface Inflow (Estimated)	20,000	20,000	20,000	20,000	20,000	20,000	20,000
Alamo River from Mexico	2,000	2,000	2,000	2,000	2,000	2,000	2,000
New River from Mexico	165,000	165,000	165,000	165,000	165,000	165,000	165,000

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TABLE 3-3
IIDSS Simulated Water Balance

Description	Recorded	Calibration	Baseline	200 kaf on-farm plus 100 kaf system	230 kaf on-farm	130 kaf on-farm	300 kaf DW fallowing
Alamo River to the Salton Sea	604,000	605,000	576,000	401,000	448,000	503,000	517,000
New River to the Salton Sea	454,000	453,000	431,000	335,000	346,000	382,000	399,000
Direct to Sea	100,000	101,000	92,000	56,000	70,000	80,000	86,000
Subsurface to Sea (Estimated)	1,000	1,000	1,000	1,000	1,000	1,000	1,000

Notes:

1) AAC at Mesa Lateral 5 by water balance from recapitulation data.
2) Sum of delivery system losses is calculated from the difference in recorded diversions less deliveries.
3) Includes estimates of deliveries to rural pipes and community greens.

TABLE 3-4
IIDSS Simulations of Water Quality - General Overview
On-farm Conservation = 200,000 ac-ft and System Conservation = 100,000 ac-ft

	New River Basin						Alamo River Basin					
	Baseline			Proposed Project			Baseline		Proposed Project		Direct to Sea Drains	
Parameter	Mexico Inflows	Surface Drains	River at Sea	Mexico Inflows	Surface Drains	River at Sea	Surface Drains	River at Sea	Surface Drains	River at Sea	Baseline	Proposed Project
TDS (mg/L)	2,719	2,585	2,617	2,719	3,294 (+27.4 percent)	3,075 (+17.5 percent)	2,492	2,465	3,559 (+42.8 percent)	3,101 (+25.8 percent)	1,892	2,637 (+39.4 percent)
Se (µg/L)	2.25	6.51	3.30	2.25	8.30 (+27.5 percent)	3.77 (+14.2 percent)	6.32	6.25	9.03 (+42.8 percent)	7.86 (+25.8 percent)	4.80	6.69 (+39.4 percent)
TSS (mg/L)	50	294	238	50	232 (-21.2 percent)	175 (-26.7 percent)	252	264	193 (-23.4 percent)	209 (-20.8 percent)	136	132 (-3.0 percent)

TABLE 3-5
IIDSS Simulations of Water Quality - General Overview
Fallowing for 300,000 ac-ft per year

	New River Basin						Alamo River Basin					
	Baseline			Proposed Project			Baseline		Proposed Project		Direct to Sea Drains	
Parameter	Mexico Inflows	Surface Drains	River at Sea	Mexico Inflows	Surface Drains	River at Sea	Surface Drains	River at Sea	Surface Drains	River at Sea	Baseline	Proposed Project
TDS (mg/L)	2,719	2,585	2,617	2,719	2,585 (0 percent)	2,606 (-0.4 percent)	2,492	2,465	2,403 (-3.6 percent)	2,418 (-1.9 percent)	1,892	1,815 (-4.1 percent)
Se (µg/L)	2.25	6.51	3.30	2.25	6.51 (0 percent)	3.18 (-3.6 percent)	6.32	6.25	6.10 (-3.5 percent)	6.13 (-1.3 percent)	4.80	4.61 (-4.0 percent)
TSS (mg/L)	50	294	238	50	285 (-3.1 percent)	226 (-5.0 percent)	252	264	247 (-2.0 percent)	259 (-1.9 percent)	136	136 (0.0 percent)

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- Fallowing results in minor reductions in salinity and selenium concentrations in the IID drains and rivers.

Miscellaneous Findings and Conclusions

The following findings are considered significant for implementation of the water transfer:

- For a fixed level of farm participation and selected performance index, the annual conservation volume can vary by plus or minus 35 percent.
- The maximum average annual system conservation is estimated at 104,340 ac-ft. This conservation is attributed to:
  - Lateral interceptors 89,069 ac-ft
  - Seepage collectors 15,051 ac-ft
  - Canal lining 224 ac-ft
- The 5.63-ac-ft per-acre fallow transfer was computed from the average annual turnout delivery divided by the average annual acreage considered in production. Monthly delivery data were used to establish the average annual acreage.
- On-farm conservation reduces the contribution of TSS in the drains and rivers. This reduction varies as a result of soil type and cropping mix, as well as farm practices (families).
- The average IID/CVWD overrun volume (diversions above 3.43 maf at Pilot Knob) from the 12-year historical database is 59,210 ac-ft. This overrun volume was assumed to be repaid during each year for all 75-year simulations.
- The spatial impacts to water quality based on random selection of on-farm participation were assessed. For a 130,000 ac-ft/yr program, 10 random simulations using 12-year runs were planned. Five simulation runs showed that for any given drain, random placement of on-farm projects caused little change in water quality. In addition, no measurable water quality differences were found in the rivers among the five runs.
- Using on-farm conservation and fallowing to create transferred water reduces flows in the delivery system. On the basis of several simulations, system seepage and evaporation losses were reduced by about 4 percent. This additional conservation was not reported in any of the alternative conservation programs. Hence, the reduction in drain water quality is overstated.