State Water Resources Control Board
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NRCE

HISTORY OF WATER CONSERVATION WITHIN THE IMPERIAL IRRIGATION DISTRICT

NATURAL RESOURCES CONSULTING ENGINEERS, INC.®

Civil, Environmental, and Water Resources Consultants

HISTORY OF WATER CONSERVATION WITHIN THE IMPERIAL IRRIGATION DISTRICT

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EXECUTIVE SUMMARY

This report describes the history of water conservation within the Imperial Irrigation District (IID/District). The information in the report was obtained from a review of previous reports concerning water conservation within IID, as well as discussions concerning irrigation and water use with farmers, irrigators, and IID personnel. The reconnaissance-level review did not include verification of water conservation estimates and activities. If available, recorded expenditures for water conservation costs were reported; for expenditures not recorded, estimates of current costs were obtained from local contractors and farmers.

Mindful that the amount of Colorado River water is finite and that future water use in southern California will out-pace the available water supply, IID has, for the past half-century, continually improved its irrigation system to enhance water management and conserve water. Only during the last 20 years have federal and state agencies, irrigation districts, municipal water distributors, and some individual citizens pressed IID to conserve even more water and reduce return flows into the Salton Sea. However, over the past 50 years the District has spent millions of dollars, without pressure from outside entities, to implement various conservation measures, such as concrete lining approximately three-fourths of the District's canals and laterals to stop water seepage. While the District was improving its facilities to increase water management capabilities and conserve water, unused apportionment water from Arizona and Nevada was diverted by other California water users. IID recognized, however, that this unused available water supply from out of state was only temporary and was not a firm, dependable water supply. In essence, IID was spending millions of dollars and resources at a time when ample water was available, knowing that it was only a matter of time before Nevada and Arizona would use their full apportionments from the Colorado River.

In addition, IID faces some difficulties that other similar irrigation districts upstream along the Colorado River do not. IID is located in a closed basin with no drainage to the ocean or back to the Colorado River. In fact, much of the irrigated area in the Imperial Valley (Valley) is below sea level. Approximately 460,000 acres of cropped land are irrigated every year, and some of these acres are multiple cropped. Unlike the upstream irrigation districts irrigating with water diverted from the Colorado River where the return flows go back into the Colorado River, IID's irrigation return water flows only to the Salton Sea. The level of the Salton Sea has increased, because the amount of natural runoff and return flow water from IID, the Coachella Valley Water District (CVWD), and Mexico flowing into the Salton Sea has been greater than the amount of water lost from the sea through evaporation. The rising level of the Salton Sea has been a major cause in directing public attention to water use and conservation within IID.

The universally accepted, single most important measure of irrigation water use within an irrigation project is irrigation efficiency. The California Department of Water Resources (DWR) suggests that, by the year 2020, on-farm irrigation efficiency in California should approach 73 percent. However, the on-farm irrigation efficiency of IID is already about 79 percent, while its conveyance and distribution efficiency is about 90 percent. By the DWR's account, the general 73 percent on-farm efficiency might possibly be generally achieved in California by the year 2020. Thus, IID is more than 20 years ahead in achieving the target on-farm irrigation efficiency. In fact, IID's on-farm irrigation efficiency is one of the highest in the nation.

Given the unique conditions farmers within IID face, there is indeed a loss of water at the farm level in the form of tailwater runoff. Nevertheless, IID still has one of the highest on-farm irrigation efficiencies in the country. When the on-farm efficiency is high, the amount of water lost to tailwater and deep percolation, relative to the amount of water diverted at the headgate, is small. In contrast, if the on-farm efficiency is low, the amount of water lost as tailwater and deep percolation is high, relative to the amount of water delivered at the headgate. Irrigated areas associated with tight soils and saline water, like that of IID, are characterized with high tailwater loss, while irrigation districts such as Wellton-Mohawk and Coachella Valley show relatively high deep percolation because their soils are generally light with higher intake rates. The loss of water via surface tailwater runoff is above ground and visible to the human eye. In contrast, the loss of irrigation water via deep percolation is underground, making it largely impossible to see.

The on-farm irrigation efficiency of IID is higher than that of both Wellton-Mohawk and Coachella, meaning the ratio of water used by the plants to the amount of water delivered to the headgate is lower in those two districts than within IID. Stated differently, both Coachella and Wellton-Mohawk lose more water than IID relative to the respective amount of water delivered to the farms. However, public perception of on-farm efficiency is unfortunately impacted by the visibility of tailwater runoff from IID. Figure ES-1 shows that whether on-farm water goes to either deep percolation or tailwater runoff, the effect is the same: irrigation return flow.

IID's on-farm and conveyance efficiencies are high, surpassing even the DWR's expectation for the next 20 years, which is largely due to the fact that IID and its farmers have continuously invested money and resources to rehabilitate and modernize their irrigation systems in an effort to improve water management and to conserve water. To obtain the high on-farm efficiency, farmers have lined farm head ditches, leveled farmland, and implemented many water management measures. Over the past 50 years, farmers have made a large investment in time and money to conserve water within IID. Collectively, farmers have spent about $340 million (1996 equivalent dollars) to improve their on-farm irrigation systems. As a result of their efforts, IID's on-farm irrigation efficiency is very high with an estimated efficiency of 79 percent (average of 1987-1996). Some of the major measures that farmers have implemented are listed in Table ES-1.

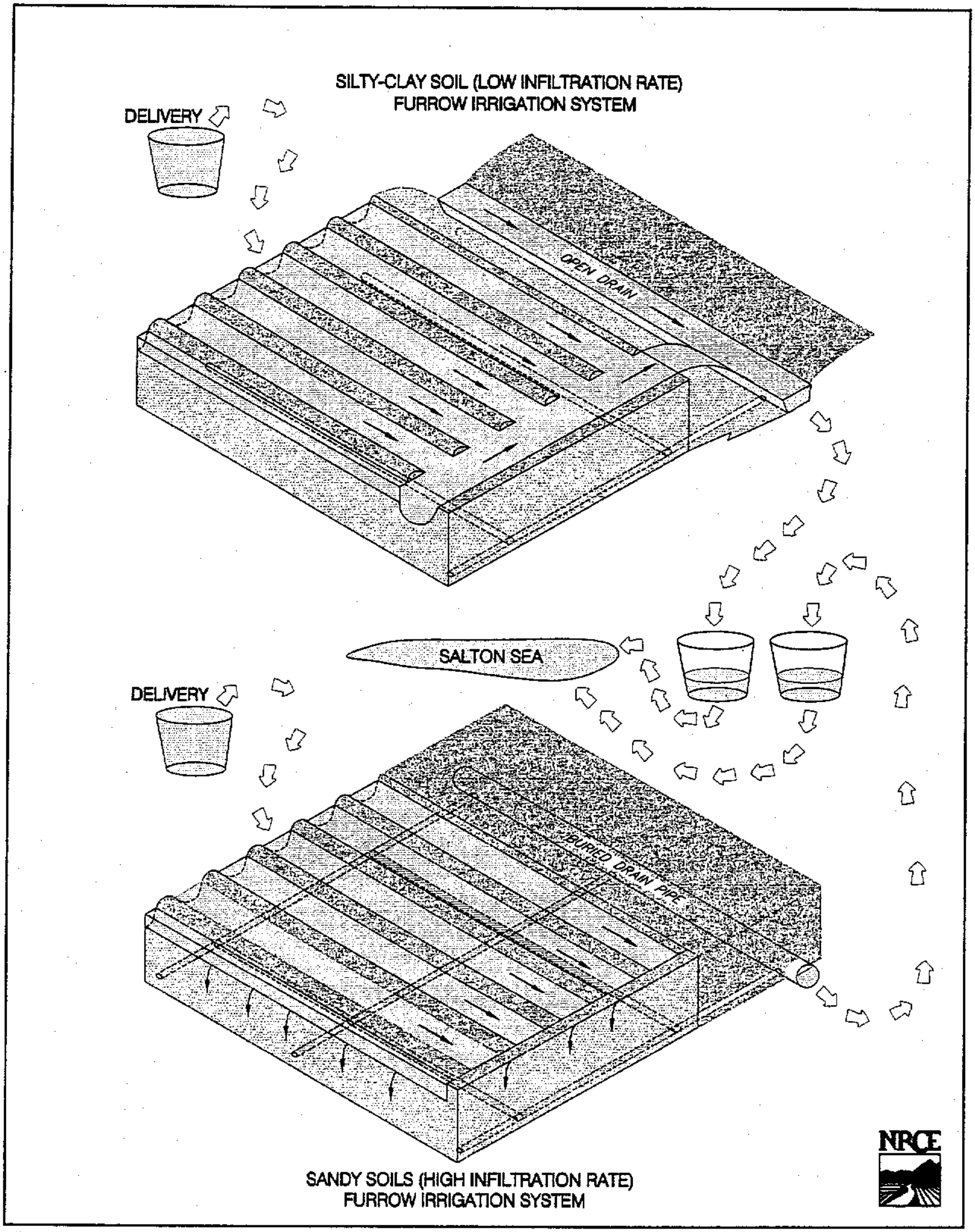


Figure ES-1 Illustrative Comparison of Irrigation Losses from Deep Percolation and Tailwater

Table ES-1 Summary of Water Conservation Measures Initiated by Farmers.		
No.	Water Conservation Activity	Summary of Water Conservation Activities
1.	Lining of Farm Ditches	About 2,600 miles (over 90 percent) of on-farm head ditches have been lined at a present day cost of nearly $200 million.
2.	Tile Drain Installation	Nearly 34,000 miles of tile drains have been installed by farmers.
3.	Land Leveling	Uniform slopes are required for efficient surface irrigation. Based on today's land leveling costs, farmers have invested about $150 million to level land and provide maintenance leveling at a cost of about $60 per acre every 5 years.
4.	Improved On-Farm Irrigation Management	Farmers have achieved an on-farm efficiency of 79 percent through proper irrigation management including, ponding water on the tail of the field during land preparation, cutback irrigation, furrow inflow and outflow control, tailwater reuse, irrigation scheduling, sprinkler and drip irrigation, and deep tillage.

To obtain high conveyance and distribution efficiencies during the last 50 years, the District has lined canals, built regulating reservoirs, implemented canal seepage recovery programs, built interceptor canals, and undertaken many non-structural measures to conserve water. To illustrate, Table ES-2 lists structural and non-structural measures taken by IID. IID spent about $160 million (1996 equivalent dollars) prior to the 1988 conservation/transfer agreement with the Metropolitan Water District of Southern California (MWD). The implemented measures have significantly increased IID's conveyance and distribution efficiency, as shown in Figure ES-2.

In 1989, IID finalized a water conservation/transfer agreement with MWD (IID/MWD Agreement). The agreement provided for MWD to invest in water conservation measures in exchange for conserved water. Over $100 million dollars have been invested in projects that are estimated to conserve about 107,000 acre-feet per year when the project is completed. The primary IID/MWD water conservation programs are listed in Table ES-3. Figure ES-3 shows the cumulative estimated water conservation expenditures by IID prior to the IID/MWD Agreement and after the IID/MWD Agreement. A comparison of total expenditures by farmers, IID, and IID/MWD is shown in Figure ES-4.

Table ES-2
Summary of IID Water Conservation Programs.

No.	Water Conservation Activity	Year	Summary of Water Conservation Activities
1.	Canal Seepage Recovery	1951-present	Drains have been installed parallel to portions of the All-American and the East Highline Main Canals to recover seepage. Each year approximately 24,000 acre-feet are returned to the canals.
2.	Canal Lining	mid 1950s-present	IID has lined over 900 miles of canals with an estimated water savings of about 58,000 acre-feet per year (IID 1987 estimate).
3.	Supervisory Control and Data Acquisition System (SCADA)	late 1950s - present	IID has used available technology to monitor and control water levels within its conveyance and delivery system.
4.	Regulating Reservoirs	1976-present	IID constructed four regulating reservoirs prior to the IID/MWD Agreement. The regulating reservoirs have almost eliminated spills from the main canals.
5.	13-Point Water Conservation Program	1976-87	The program focused on reducing tailwater, canal seepage, and operational water.
6.	Aquatic Weed Control	1981-present	IID helped support the research that developed the sterile Triploid Grass Carp fish that feeds on Hydrilla (aquatic weed) that was clogging canals and drains.
7.	Water Conservation Advisory Board	1979-present	The Advisory Board meets regularly to make recommendations concerning water conservation.
8.	21-Point Water Conservation Program	1980-87	The program includes policies and procedures for ordering water, operating the delivery system, and assessing extra charges for excessive water use.
9.	15-Point Water Conservation Program	1987-present	The program replaced the 13- and 21-Point programs and contain aggressive policies to promote on-farm conservation. The program describes the tailwater triple charge program.
10.	Tailwater Recovery Demonstration Program	1983-90	The program demonstrated the technical feasibility and effectiveness of tailwater recovery systems, showing that about 12 percent of on-farm deliveries can be saved.
11.	Irrigation Certification Program	1994-present	Mandatory irrigation training program for all water managers. The program includes a discussion of IID rules and regulations and water management.
12.	Training for IID Operation Personnel	1995-present	IID sponsors water measurement training for zanjeros and hydrographers at California Polytechnical State University in San Luis Obispo.
13.	Tailwater Box Replacement Program	1976-present	Land owners were contacted with a request to repair or replace tailwater boxes to facilitate better tailwater measurements.
14.	Water Conservation Studies and Reports	1984-present	IID has spent millions of dollars on water conservation studies in a continuing effort to identify water conservation opportunities.

Figure ES-2

IID Conveyance and Distribution Efficiency (Drop 1 to Users)

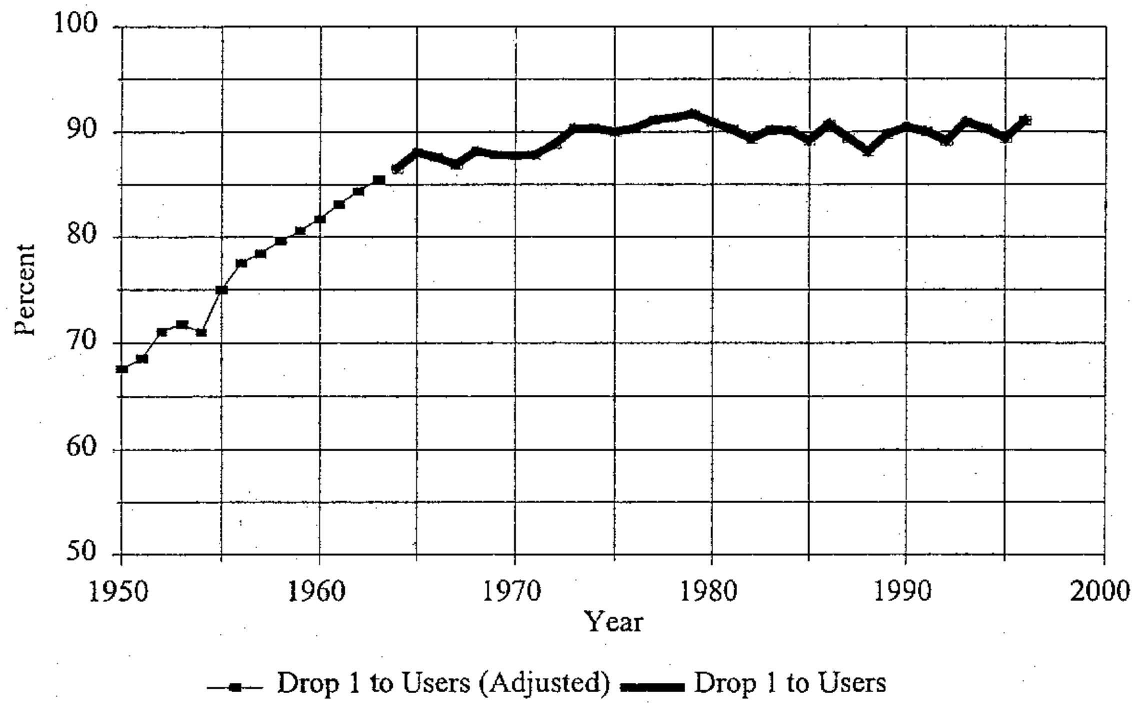


Table ES-3
Summary of Major IID/MWD Agreement Water Conservation Programs.

No.	Water Conservation Activity	Summary of Water Conservation Activities
1.	Water Control Center	The Water Control Center houses the equipment and personnel needed to operate the District water distribution system.
2.	Non-Leak Headgates	Fourteen wooden headgates were replaced with non-leak metal headgates. Estimated 1997 water savings is 630 acre-feet.
3.	Canal Lining	Approximately 200 miles of canal were concrete lined. Estimated 1997 water savings is 26,000 acre-feet.
4.	Automated and Centrally Controlled Water Control Structures	Automated gates were installed at strategic locations to provide better and more timely water adjustments. Estimated 1997 water savings is 13,490 acre-feet.
5.	Regulating Reservoirs	Six regulating reservoirs were constructed, three as part of canal interceptor systems. Estimated 1997 water savings from the reservoirs (Carter and Galleano) is 9,700 acre-feet. The water savings from the other regulating reservoirs are accounted for by the interceptor canals.
6.	Interceptor Canals	The Plum-Oasis, Mulberry-D, and Trifolium Interceptors capture the excess flows of 8, 11, and 15 laterals, respectively. The estimated 1997 water savings is 29,810 acre-feet.
7.	12-Hour Water Delivery	Irrigators are allowed to order in 12-hour time blocks rather than the historical 24-hour time blocks making it possible for irrigators to better match water deliveries to crop needs. The estimated 1997 water savings is 22,290 acre-feet per year.
8.	Tailwater Recovery Systems	Twenty-five tailwater recovery systems were constructed to conserve about 4,670 acre-feet of water per year.
9.	On-Farm Irrigation System	Three lateral move sprinklers and four drip systems were installed with estimated 1997 water savings of 510 acre-feet per year.

Figure ES-3
Estimated Cumulative Expenditures of IID and IID/MWD
for Water Conservation Measures Within IID
(1996 Equivalent Dollars)

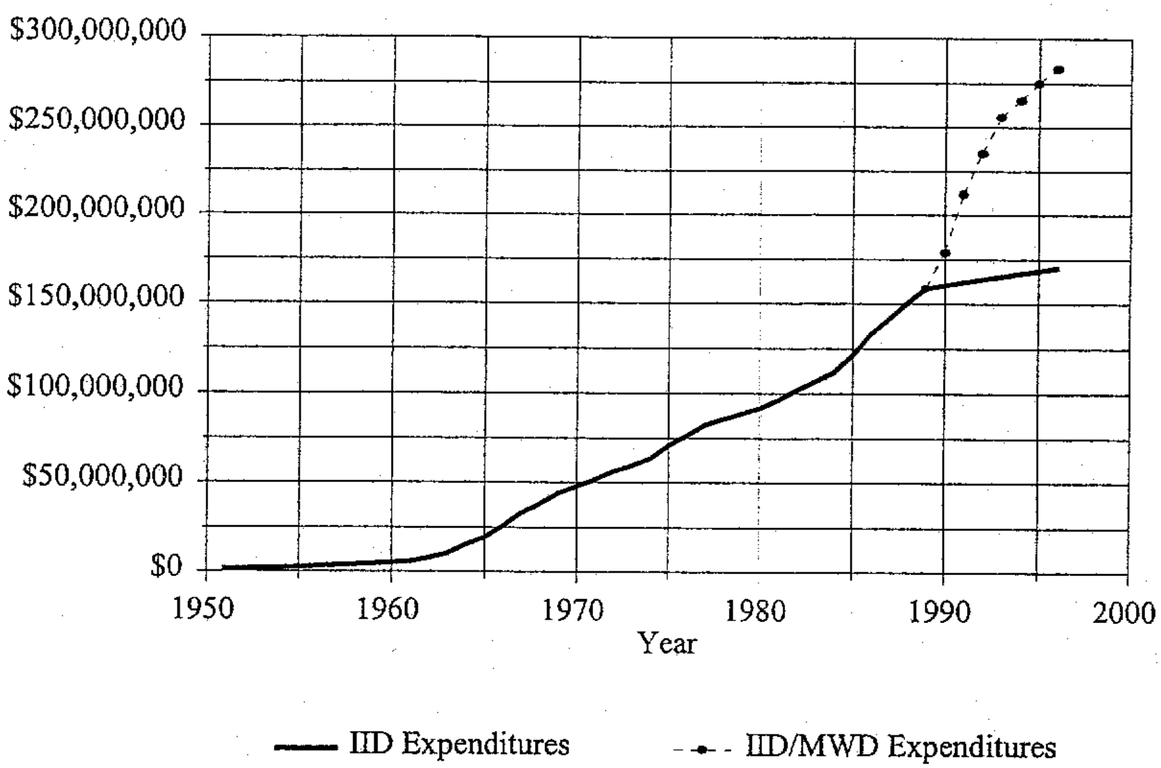
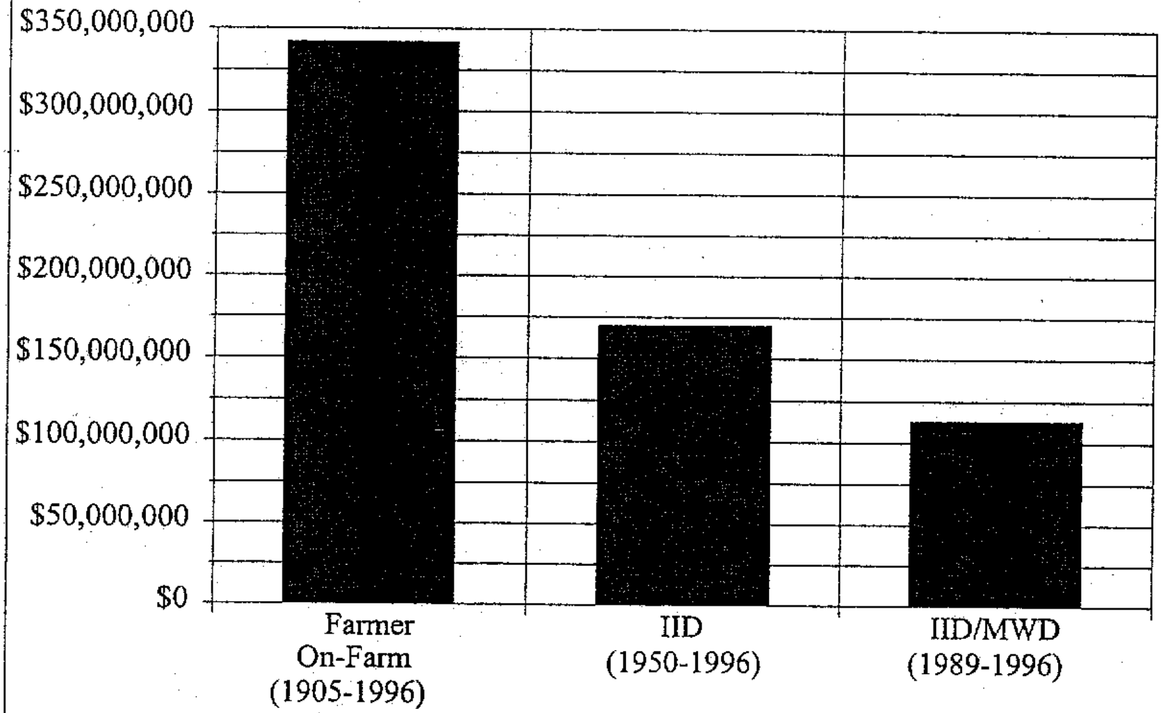


Figure ES-4

Estimated Expenditures for Water Conservation Measures Within IID

(1996 Dollars)



SUMMARY

- Over a period of 50 years, Valley farmers and IID have implemented a broad range of water conservation programs and measures.

- Valley farmers and IID have implemented conservation measures on two fronts:

  1) On-Farm Conservation - It is estimated that farmers have invested approximately $340 million (1996 dollars), resulting in the conservation of about 385,000 acre-feet per year.

  2) Conveyance and Distribution System - It is estimated that IID has invested approximately $160 million (1996 dollars) on water conservation measures (prior to the 1988 MWD agreement), resulting in the conservation of over 100,000 acre-feet per year.

- As a result of the expenditure of hundreds of millions of dollars, Valley farmers have improved on-farm efficiency to approximately 79 percent, which is very high compared to other districts in the Southwest.

- IID's conveyance and distribution system efficiency is now about 90 percent as a result of the expenditure of millions of dollars by IID.

- In 1988, IID entered into an agreement with MWD in order to conserve more than 100,000 acre-feet per year, which would be used in the urban area of southern California. Under the IID-MWD program over $100 million (1996 dollars) have been invested in additional system improvements and on-farm measures.

- In addition to having provided capital improvement funding for conservation measures, IID and Valley farmers face annual operation and maintenance costs to sustain the conservation improvements implemented over the past 50 years. This annual cost is estimated to be $30 million.

SECTION 1 INTRODUCTION

This report describes water conservation activities within the Imperial Irrigation District (IID/District) during the last 50 years. Water conservation measures implemented in the Imperial Valley (Valley) during this period have improved the water distribution system management capabilities, improved system operational efficiencies, and improved on-farm efficiencies and production. Water conservation in the context of this report refers to increased utilization and management of water. While some water conservation measures may reduce diversions, others provide capabilities to better manage and use diverted water.

The information in this report was obtained from reviewing data and reports concerning water conservation previously prepared by others, and from discussions concerning irrigation and water use with farmers, irrigators, and IID personnel. The reconnaissance-level review did not include an independent verification of reported water conservation estimates and/or activities. The costs of conservation activities and measures discussed in this report are from recorded expenditures when available, and cost estimates of non-recorded expenditures were obtained from local contractors and farmers, based on current costs.

The authors of this report discussed irrigation and water use practices with farmers and irrigation managers in the Valley. Discussions were held with twelve farmers who farmland in the Niland, Holtville, Westmorland, Brawley, Callipatria, and Seeley areas, representing a large portion of the soil and cropping conditions found in the Valley. The farmers represent a wide cross-section of interests and include managers of corporate farms, owner/operators, irrigation managers, and tenant farmers that manage farms from a few thousand acres to nearly 18,000 acres. Additionally, to understand how the District operates the conveyance and distribution system, the authors discussed the system operation with water operation managers, District superintendents, and zanjeros (ditch riders). Time was spent with the zanjeros making deliveries to fields and measuring tailwater and canal flows in order to obtain an understanding of IID system operations.

IID operates and manages the water distribution system that delivers water to around 460,000 acres of agricultural land, plus municipal users in the Imperial Valley. Agricultural water use accounts for approximately 97 percent of IID's water deliveries. In addition to the delivery system, IID operates the drainage system that serves the Imperial Valley.

This report will describe water conservation activities of IID farmers and those of the District. Farmers within IID have invested approximately $340 million (1996 equivalent dollars) on water conservation to level land and to construct concrete-lined head ditches. These water conservation measures conserve about 385,000 acre-feet of water per year.

IID has spent approximately $160 million (1996 equivalent dollars) on conveyance and distribution system improvements during the last 50 years to conserve over 100,000 acre-feet of water per year. These expenditures by IID do not include those made as part of the agreement between IID and Metropolitan Water District of Southern California (IID/MWD Agreement). As part of the IID/MWD Agreement, over $100 million has been invested in conveyance, distribution, and on-farm irrigation systems to conserve more than 100,000 acre-feet per year.

SECTION 2 BACKGROUND

This section briefly describes the physical setting and irrigation within the Imperial Valley and provides the background to understand the history of water use and conservation in the Imperial Valley.

I. PHYSICAL SETTING AND LOCATION

The Imperial Valley is an inland valley on the southern border of California approximately 80 miles west of the Colorado River. Each year about 460,000 acres of crop land are irrigated and some of these acres are double or triple cropped. The Valley is a closed basin with no drainage to the ocean or back to the Colorado River, with much of the irrigated area in the Valley being below sea level. Return flow from irrigation in the Imperial Valley enters the Salton Sea. The rising level of the Salton Sea has been one factor in focusing public attention on water use and conservation within IID.

II. CLIMATE

Because of its favorable climate, the Imperial Valley is an ideal location to grow crops year-round. The coldest month of January has an average maximum and minimum temperature of 79.9 and 30.3° F, respectively (1914 - 1996). The Imperial Valley averages less than three inches of rain per year. Low precipitation enhances the area's agricultural potential because rain can interfere with agricultural operations, such as planting, cultivating, and harvesting, and can adversely affect produce quality. The location and topography of the Valley also makes possible the delivery of irrigation water by gravity, which conserves energy and enhances the economic viability of sustained irrigation in a desert climate.

III. SOILS AND TOPOGRAPHY

The majority of soils are silty-clay and require extensive drainage to control soil salinity and water table levels. The slope of the irrigated land is nearly level, ranging from zero to two percent. Although the climatic conditions of the Imperial Valley make it an ideal location for agricultural production, the physical characteristics of the soil, water supply, topography, and location require special water use and management to maintain a sustainable agricultural economy.

IV. WATER SUPPLY

By the time Colorado River water is diverted by IID, it has been used and reused many times. Colorado River water at Imperial Dam has an average salinity of more than one ton of salt per acre-foot of water (total dissolved solids (TDS) range of 700 to 900 ppm). Drainage from the Imperial Valley, with a salinity level of about 4 tons per acre-foot (TDS of about 3,000 ppm), enters the Salton Sea, which is an inland saline lake with a salinity of about 60 tons per acre-foot (TDS of about 43,000 ppm). To maintain salinity levels in the soils suitable for crop production, irrigation water, in addition to that needed for crop evapotranspiration (ET), must be provided to leach salts from the soils.

V. CROPS AND ECONOMY

Over 100 different crops are grown in the Imperial Valley including garden, field, and permanent crops that result in nearly a $1 billion-per-year-industry. The cropping patterns in the Imperial Valley are based on established markets and physical conditions. The Imperial Valley is commonly referred to as the nation's "winter salad bowl," supplying the United States' population with fresh vegetables during the winter months.

While the Imperial Valley is well known for its winter vegetable production, the majority of the cropped area is in field crops (almost 80 percent in 1996). The majority of the field crops are forage, consisting primarily of alfalfa and sudan grass. Forage crops represent an increasingly important crop in the Valley based on the following factors:

- A reliable market exists for alfalfa and sudan grasses grown in the Imperial Valley. The demand for alfalfa in California is so high that the shipment of alfalfa into California from neighboring states has increased more than 50 percent in the last 5 years (Putnam and Kallenbach, 1997).

- The California forage and dairy industries, which are closely linked, produce nearly four billion dollars in direct sales annually and are unquestionably the largest agricultural enterprises in the state. The forage grown in the Imperial Valley provides a significant amount of the feed used in the dairy industry (Putnam and Kallenbach, 1997).

- Alfalfa is an efficient user of water in terms of dry matter, total calories, and protein produced per unit of water. In fact, milk produced from alfalfa-fed dairy cows contains as much protein and calories for human consumption per unit of water consumed as do dry beans grown for direct human consumption (Loomis and Wallinga, 1991).

VI. DISTRIBUTION AND DRAINAGE SYSTEM

The irrigation system operated by IID includes the All-American Canal (82 miles) and 1,675 miles of other canals, serving about 5,600 headgates. There are ten regulating reservoirs with a combined capacity of more than 3,300 acre-feet within IID's service area. The drainage system in the Imperial Valley has about 1,460 miles of drain ditches and 33,627 miles of tile drains that underlie cultivated fields. Flows from the tile drains enter the drain ditches and flow into the New River or Alamo River, or directly into the Salton Sea. The distribution system and the off-farm drainage collection system are operated by IID, while tile drains and tailwater discharge systems have been constructed and are operated by landowners.

Management of the irrigation system is complex because the water travels approximately 400 miles (travel time of about five days) from the primary water storage at Lake Mead on the Colorado River to the field. IID places orders for water each week, typically about five days before the beginning of the week in which deliveries are requested. Farmers in IID order water approximately one to two days in advance of delivery; thus, IID may be requesting water from the U.S. Bureau of Reclamation (USBR) up to ten days before the farmers request water. Users order water in 12- or 24-hour blocks of time, specifying the desired flow rate in cubic feet per second (cfs or feet). In making deliveries, IID diverts water from the main canals to laterals and then to headgates. There is some water regulation on the Colorado River below Hoover Dam at Davis Dam, Parker Dam and Imperial Dam, which allows for daily adjustments at Imperial Dam. However, once the water has been diverted into the All-American Canal, there is only a small amount of storage (0.1 percent of annual diversions) provided to regulate delivery of the water supply within IID.

Zanjeros (ditch riders) open and close headgates and adjust lateral canal checks and gates to deliver water orders at the specified time and flow rate. All headgate deliveries and tailwater outflow are measured at regular intervals during delivery periods. Due to the many complexities and constraints of the present gravity open canal delivery system, it is impractical to control the water, even under ideal conditions, such that all deliveries are met without some operational water discharges at the end of the canals. IID delivers over 90 percent of the Colorado River water entering the Imperial Valley to its users. The water that is not delivered includes evaporation, seepage, and operational water.

VII. ON-FARM IRRIGATION METHODS

IID is located within the desert region of the Southwest, which is often associated with sandy, coarse soils. However, the central irrigated area of the District is an old lake bed below sea level, which is quite level, and contains very deep, fine textured soils. Unlike the central portion of the District, both the East and West Mesas of the District have predominantly coarse desert soils. The dominant soil type in the District is Imperial--silty clay and nearly level--followed by Imperial-Holtville-Glenbar, which is also nearly level with textures of silty clay, silty clay loam, and clay loam.

The soils, topography, and crops in the Imperial Valley are particularly well-suited for surface irrigation methods, including either border, furrow, corrugation, or basin. Other irrigation methods in the Valley include sprinkler and drip. Overall, the on-farm irrigation efficiencies in the Imperial Valley are exceptionally high for the soil, water quality, and other conditions encountered. The average on-farm irrigation efficiency was about 79 percent during the ten year period from 1987 through 1996 (IID Internal Data). In other words, 79 percent of the water delivered to the farmers is consumed by the crop, evaporated from the soil surface, or used for required salt leaching.

The vast majority of crops in the Valley are surface irrigated. Nearly all the presently irrigated soils and crops in the Valley are well suited for surface irrigation. Additionally, surface irrigation is economical, energy efficient, and water efficient when properly managed. Sprinkler irrigation is being used for seed germination, crop establishment, and, occasionally, leaching and land preparation. Drip irrigation is used when it is determined to have an economic advantage, depending on such factors as crop type, water quality management, yield, and economic return.

Irrigators and engineers are often challenged when choosing irrigation systems for certain soils. In order to understand the primary reasons why gravity irrigation is used more in the District than sprinkler irrigation, one has to understand what makes the soils in the central portion of IID more conducive to either sprinkler or gravity irrigation.

1. Surface Irrigation

The following terms are used in the discussion concerning surface irrigation.

Crop ET - The water transpired by crops, retained in plant tissue, and evaporated from plant and adjacent soil surfaces.

Leaching - Water applied in addition to that needed for crop ET to wash salt out of the soil.

Deep Percolation - Water that drains from the soil and is not used for crop ET or leaching.

Inflow Rate - The flow rate of water entering the border or furrow.

Advance Rate - The rate the water front advances from the head of the field to the tail of the field.

Recession Rate - The rate at which water leaves the surface of the field after inflow has stopped.

Intake Opportunity Time - The amount of time that water is in contact with soil at a given location.

Intake Rate - The rate at which water enters the soil during an irrigation. The intake rate of soils vary with time and soil conditions. The intake rate controls the amount of water entering the soil and the advance rate of the water over the field.

Tailwater - Irrigation water surface runoff that leaves the end of the field.

An ideal irrigation system would apply water uniformly throughout a field only in the amount needed for crop ET and leaching. However, all irrigation systems are less than ideal and have demands in addition to the water required for crop ET and leaching. Surface irrigation water requirements, for most conditions in the Imperial Valley, include deep percolation and tailwater.

The tight soils (soils with low infiltration and intake rates) in the Imperial Valley require that the water remain on top of the soil for a relatively long time (up to eight hours for furrow irrigation) to allow adequate infiltration of water into the root zone. If the inflows to furrows were terminated when the water reached the end of the furrow, the lower portion of the field would be short of water. This would result in yield reduction or crop loss and soil salinity buildup. Tailwater results when the water flows into the furrow for sufficient time to allow adequate infiltration at the lower portion of the field. Thus, tailwater is a necessary part of irrigation in the Imperial Valley.

In addition, the intake opportunity time is different along the length of a field, due to the advance time and recession time of the water moving from the head to the tail of the field. This varying intake opportunity time results in different amounts of water entering the soil. In order to adequately irrigate the field's tail end and to avoid crop loss from standing water, it is necessary, under most conditions in the Imperial Valley, for water to run off the field. Figure 2-1 illustrates the necessity of tailwater to irrigate adequately.

Many additional factors influence irrigation requirements and efficiencies. Some considerations unique to the Imperial Valley are listed below:

- Many crops require six to twelve inches of water for tillage and leaching purposes (pre-irrigation and seed bed preparation) prior to planting. Much of the water is used for leaching or is stored in the soil and is available for crop use after planting.

- After planting sugar beets or other row crops, an irrigation is required to allow the water to sub (wet) to the ridge to provide moisture for seed germination. The germination and establishment of sugar beets require that the soil's wetting front move past the seed line to move salts away from the seeds. These irrigations require more water than is necessary for routine crop ET, yet without germination there is no crop.

- After germination, when plants have a shallow root system, they may require a shallow irrigation for establishment. Because a shallow irrigation is difficult to provide using surface irrigation, more water may be applied than necessary.

- The cross slope on fields requires irrigators to construct tanks (small ponds at the head of field) that will regulate the water entering the furrows. Without these tanks it is very difficult to control the amount of water entering each furrow.

- Tractors and other heavy equipment compact the soil and reduce the furrow intake rate. Thus, on adjacent furrows the intake rate is different, requiring adjustments in furrow inflow rates.

- Trash and moss in the water inhibit the flow of water through slide gates, field turnouts, siphons and furrow tubes. This results in non-uniform application of water. Under such conditions, irrigators must focus their continual attention on removing trash, making it more difficult and expensive to irrigate efficiently.

- The salinity and chemistry of soils, especially those with a high clay content, greatly influence the infiltration rate. The salinity at the tail of the field is often higher than at the head of the field. This affects the infiltration rate and adds to the irrigation uniformity problem caused by difference in intake opportunity time along the length of the field.

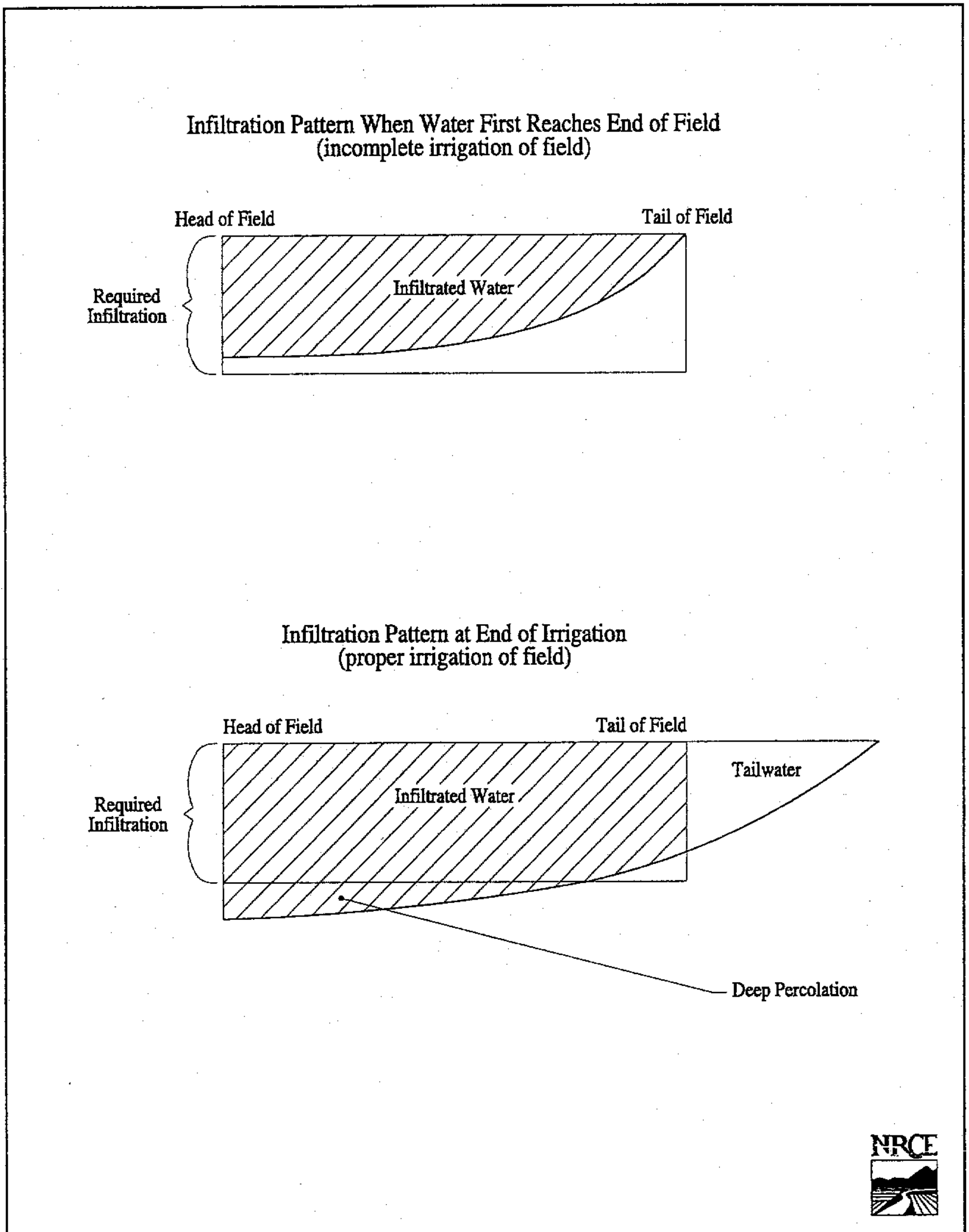


Figure 2-1. Water Infiltration Patterns for Surface Irrigation

2. Sprinkler Irrigation

The majority of the soils in the District have a high clay content with a low intake rate, which causes ponding and may lead to excessive runoff when using sprinkler irrigation. The sprinkler water drops tend to seal the surface of the soil, reducing infiltration, compounding ponding and poor distribution uniformity problems, and, ultimately, resulting in excessive surface runoff. In addition, temperatures in the Valley are high, which increases evaporation of irrigation water even before the water reaches the soil. Another factor is the salinity content in the Colorado River water that is so high that surface contact burns the foliage, damaging most vegetable and some field crops. Although sprinklers are not extensively used in the Valley for the reasons summarized above, they are used, when appropriate, for seed germination, crop establishment, leaching, and in some cases for land preparation.

3. Drip Irrigation

From horticultural and technical perspectives, drip irrigation could be used on many crops grown in the Imperial Valley, but it is only economical for use on high value crops, such as melons, tomatoes, and asparagus. Because of the high cost of drip irrigation systems, they are most practical on permanent crops where the investment is for several years. Most of the crops in the Imperial Valley are not permanent, and crops grown on a specific field can change up to three times in a single year. Since the majority of the irrigated lands in the District are used to grow field and vegetable crops, it is not practical and/or cost effective, in most cases, to serve those lands using drip irrigation.

Drip irrigation requires that the water be filtered to prevent emitters from plugging the system, which adds to the cost of operating a drip system in the Imperial Valley. Also, without proper management, drip irrigation systems' application uniformity can become very poor. Although drip irrigation is often considered to be one of the most efficient irrigation methods, IID's on-farm efficiency is higher than many drip irrigation systems in other irrigation districts. A drip irrigation system has the ability to provide frequent irrigations and the capacity to deliver irrigation water to meet peak crop water requirements. These two characteristics make it easy for a farmer to unknowingly apply more water than required.

4. Summary of Irrigation Methods

IID's on-farm irrigation using surface irrigation remains as one of the most energy and water efficient systems in the western United States. As previously discussed, surface irrigation is the most suitable irrigation method for conditions within IID. The primary disadvantage of surface irrigation in the Imperial Valley is the tailwater that flows to the drains. Sprinkler irrigation is appropriate for seed germination, crop establishment, leaching, and in some cases for land preparation, while the use of drip irrigation is only economical for high value crops, such as melons, tomatoes, and asparagus.

The objective of implementing water management and water conservation measures is to reduce use of water which is not consumed by crops or other required water use components of the agricultural process, such as leaching. This means meeting the crop's irrigation and soil management demands with less water. Because crop water demands vary with crop type, environmental conditions, and water quality, conservation practices may provide for better utilization of water without actually reducing diversions. For example, improved on-farm irrigation can increase production resulting in increased ET by crops.

This section has been divided into four major areas of water conservation efforts: (1) those measures initiated by farmers, (2) those initiated by IID, exclusive of the IID/MWD Agreement, (3) those activities which are part of the IID/MWD Agreement, and (4) those measures sponsored by State and/or Federal Agencies. This section describes water conservation activities which include physical system improvements, management programs, and on-farm improvements. Figure 3-1 shows the location of some of the physical system improvements IID implemented itself and via the IID/MWD Agreement. This map will be referenced several times in this section.

I. FARMER INITIATED MEASURES

Farmers, to a large degree, control the amount of water diverted into the Imperial Valley. IID makes deliveries only to meet water users' orders. Since farmers do not have headgate allotments, they are expected to order only the water necessary for crop production. Most of the water entering the drainage system and flowing to the Salton Sea is from the farm field either as tailwater, tilewater, or farm ditch spills. Therefore, water conservation at the field level is important and farmers have initiated many measures over the past 50 years to conserve water.

1. LINING FARM DITCHES

Most farmers have lined their field ditches in order to conserve water by reducing seepage and obtaining better control of water being delivered to their fields. By 1984, about 80 percent of the head ditches in IID were lined. Figure 3-2 shows the cumulative length lined head ditches within IID. It is estimated that 2,590 miles of farm head ditches have been lined with concrete. The approximate current cost to line these canals is $14.50 per foot (includes pad, shaping ditch, lining, installing gates, and checks) for a total cost of $198 million (1996 equivalent dollars). Over the

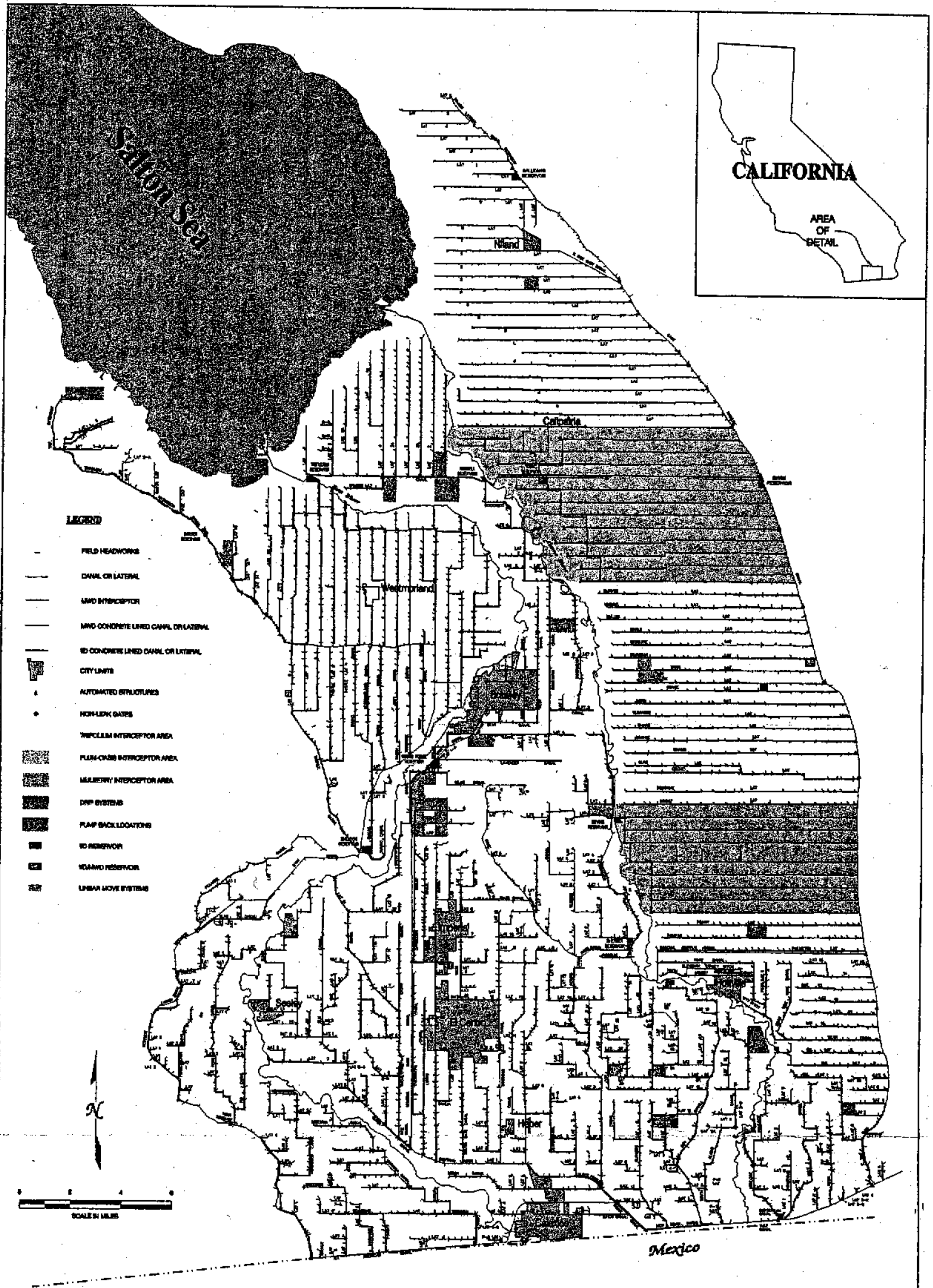


FIGURE 3-1

APRIL 1998

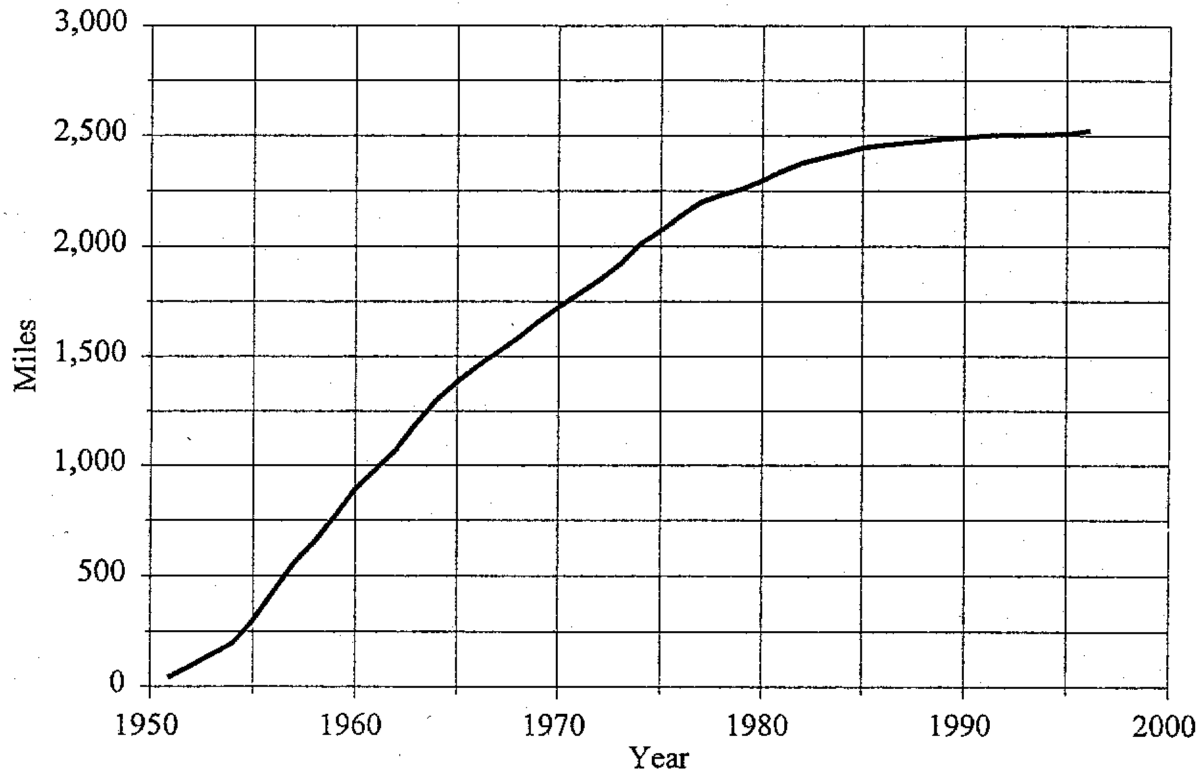
Location Map of Selected IID and IID/MWD Agreement Water Conservation Measures

NRCE

Natural Resources Consulting Engineers, Inc.

Fort Collins, CO Asmara, ERITREA Berkeley, CA

Figure 3-2
Estimated Cumulative Length of Lined On-farm Ditches Within IID



years, the NRCS and ASCS have participated in many of these improvements by providing engineering services and a minimum amount of financial assistance through cost share programs. For example, the average annual cost share for eight of the last ten years (1988-1997, except for data from 1989 and 1990 which is not available) is $147,000. This funding has also been used for tile drains and other purposes in addition to ditch lining.

2. Tile Drain Installations

To date, nearly 34,000 miles of tile drains have been installed. In most areas in the Imperial Valley, tile drains are necessary to keep the water table below the root zone and to remove leaching water for salinity control. A drainage system may not be viewed as a water conservation measure, yet without proper drainage, long-term agriculture would be impossible in the Imperial Valley. The NRCS has provided technical assistance in the design of drainage systems, and the ASCS has provided a minimal amount of funding for installation of drains. Because the tile drains have been installed over a long period of time by individual growers, the year-by-year expenditures are unknown, but the cumulative amount expended by farmers over a 50 year period is very high. If the tile drains were to be installed at today's costs, a conservative estimate of the total cost would be $224 million. This cost is not included in the estimate of water conservation expenditures.

3. Land Leveling

Without significant land leveling, the high on-farm irrigation efficiencies within IID would be impossible. Land leveling provides the proper slopes so that irrigation water can uniformly move over and into the soil. Land leveling occurred as parcels were developed for irrigation. Farmers in the Imperial Valley have invested a considerable amount of time and money in land leveling. The year-by-year expenditures on land leveling is unknown, but based on information obtained during an interview with a land leveling contractor, it is estimated that at today's costs about $150 million ($300 per acre) has been invested in initial land leveling. In addition to initial land leveling, touch up leveling is required every three to five years at a cost of $30 to $60 per acre.

With today's land leveling technology, precision laser leveling of lands has greatly improved the on-farm irrigation efficiencies by maintaining uniform field slopes. Many farmers precision laser level the area between borders to remove the cross slope in order to increase irrigation efficiency. Land leveling, coupled with irrigation management, has significantly increased production and irrigation efficiencies in the Imperial Valley.

4. Improved On-Farm Irrigation Management

Over time, growers and irrigators have gained experience and improved irrigation management skills to better utilize water. On-farm water control has a major impact on water conservation in Imperial Valley because IID does not control the amount of water ordered by the irrigators. As a result of growers' efforts, the average on-farm irrigation efficiency is 79 percent, one of the highest irrigation efficiencies in California, which is excellent for conditions in the Imperial Valley. To achieve this high on-farm efficiency, growers invest in technology and extra labor for water management and control in order to utilize water efficiently. Typically, growers spend as much on labor to efficiently irrigate as they do to purchase water. Many of the interviewed growers use one irrigator per head of water allowing the irrigator to remain in the field during the entire irrigation. Some of the innovative irrigation management techniques in the Imperial Valley include the following:

Ponding Water on Tail of Field - During irrigations for land preparation, when no crop is present, most irrigators pond water on the tail of the field to avoid runoff and increase infiltration and leaching in the area of the field that is often under-irrigated during irrigation of crops. This practice is most applicable to fields with low to moderate slopes.

Cutback Irrigation - Irrigators who have fields with furrow or row irrigation will often set approximately 75 percent of the furrows in an irrigation set. Then, as water in the furrows reaches the tail of the field, the irrigators will decrease the flow to those furrows and start new furrows. This practice is labor intensive but reduces tailwater and improves irrigation efficiencies.

Control of Furrow Inflow - Furrow inflow and outflow is controlled to reduce tailwater runoff. Tablitas (small wooden slats) and fasets (orifice caps) are used to adjust flows through furrow inflow pipes in order to provide a more uniform advance of water down the furrows and to cut back flows when water reaches the end of furrows.

Control of Furrow Outflow - Many irrigators use C-Taps (small plastic or metal dikes) which are placed at the tail of the furrow to increase the depth and infiltration of water and reduce tailwater. Additionally, irrigators construct ponds with drops into the field drain ditches to prevent erosion at the tail of a field.

Tailwater Reuse - In addition to those growers who are participating in the IID/MWD or the IID tailwater pumpback program (described later in this section), some growers have independently developed affordable methods to use their tailwater to increase on-farm efficiency. Some growers use portable pumpback systems with aluminum pipelines, while others who have several adjacent fields use the tailwater from upper fields to irrigate lower fields.

Sprinkler Irrigation - While sprinkler irrigation is not suitable for many conditions and crops in the Imperial Valley, there are times and places where sprinklers provide considerable water savings. With sprinkler irrigation, growers can apply lighter irrigations than is possible with surface irrigation. One of the most beneficial uses of sprinkler irrigation is the germination and establishment of crops with small seeds, such as carrots and lettuce.

Drip Irrigation - Properly designed, installed, and managed, drip irrigation systems can provide efficient irrigation by improving distribution uniformity, decreasing soil evaporation and eliminating tailwater. On a few selected high-value crops in the Imperial Valley, drip irrigation provides an economic advantage and produces higher yields due to increased ability to manage water. The crops and conditions in the Imperial Valley limit the practicality of extensive use of drip irrigation.

Deep Tillage - To improve the infiltration and drainage characteristic of the many soils in the Valley, many growers deep till (tillage depth of 20 to 30 inches) between certain crops. The improved infiltration can increase irrigation efficiency by reducing tailwater runoff.

5. Summary of Farmer-Initiated Measures

Over the last 50 years, farmers have made the greatest investment to conserve water. Table 3-1 lists and briefly describes the major measures implemented by farmers.

II. IID WATER CONSERVATION PROGRAMS (1950-1997) EXCLUSIVE OF IID/MWD AGREEMENT

In the early 1950s, IID started a very ambitious program of canal lining in an effort to reduce seepage and thus conserve water that would be available to the farms. Parallel to the canal lining program, IID initiated a program of water conservation including the automation of a portion of the delivery system to enhance the ability of water operators to track water levels in sections of canals

Table 3-1 Summary of Water Conservation Measures Initiated by Farmers.		
No.	Water Conservation Activity	Summary of Water Conservation Activities
1.	Farm Ditch Lining	About 2,600 miles (over 90 percent) of on-farm head ditches have been lined, at a present day cost of nearly $200 million.
2.	Tile Drain Installation	Nearly 34,000 miles of tile drains have been installed by farmers.
3.	Land Leveling	Uniform slopes are required for efficient surface irrigation. Based on today's land leveling costs, farmers have invested about $150 million to level land and provide maintenance leveling at a cost of about $60 per acre every five years. Frequent precision land leveling is used by most farmers to efficiently irrigate fields.
4.	Improved On-Farm Irrigation Management	Farmers have achieved an on-farm efficiency of 79 percent through proper irrigation management including, ponding water on the tail of the field during land preparation, cutback irrigation, furrow inflow and outflow control, tailwater reuse, irrigation scheduling, sprinkler and drip irrigation, and deep tillage.

which may be carrying surplus water and to provide operators with an early warning system to prevent that surplus water from spilling. IID also augmented the canal lining and automated delivery system by building regulating reservoirs in strategic areas within the District. IID initiated additional non-structural measures such as providing increased flexibility for irrigators to change orders during the last day of the run, charging for excessive tailwater runoff, and promoting water conservation programs on the farm level.

The following briefly describes the water conservation measures and programs implemented by IID exclusive of the IID/MWD Agreement since 1950.

1. Canal Seepage Recovery Program

IID's canal seepage recovery program was started as early as 1951. The main canals, including the All-American Canal, the East Highline Canal, the Central Main Canal, and the Westside Canal, are all unlined.

These canals constitute the primary arteries serving thousands of acres. Taking them out of service for the time required for lining would severely impact thousands of acres. Such a move would create a financial hardship for many of the irrigators within IID.

The majority of the length of the major canals pass through relatively tight soils, where the loss of water through seepage is relatively small. In a search to conserve more water, IID found canal cross sections of sandy soil, which are susceptible to seepage loss, in two areas of the major canals. These areas include the All-American Canal between Drop 3 and Allison Check and six miles of the East Highline Canal. Seepage recovery drains began operation on this section of the All-American Canal in 1951. Likewise, in 1967, IID constructed six miles of seepage recovery lines along the side of the East Highline Canal to recover seepage losses.

Seepage water from both the All-American and East Highline Canals is pumped back into the canals for delivery to farms via laterals. Seepage recovery systems along the All-American and East Highline Canals are estimated to conserve approximately 8,000 and 16,000 acre-feet annually, respectively (IID Water Conservation Activities, 1987). IID's 1985 Water Conservation Plan listed the construction costs of the seepage recovery system at $495,000 with annual costs of $50,000 for operation and maintenance.

2. Canal Lining

The canal lining program, like the canal seepage recovery program, was initiated by IID and the farmers in the early to mid-1950s. During those early years, the landowner would submit a request to the District to concrete line a reach of a canal adjacent to his or her land. Under this program, the landowner would agree to pay between 25 and 30 percent of the concrete lining cost. In addition, the landowner would provide a right-of-way and earth fill for the construction of the embankment. As shown in Table 3-2, by 1984 approximately 870 miles, over half of the District's water conveyance system, were concrete lined. The District also replaced roughly nine miles of earth canal laterals with concrete pipes. Figure 3-1 (in the map pocket at the end of the report) highlights the canals that have been lined by IID. Figure 3-3 shows the cumulative length of lined canals within IID. The canals lined after 1989 were lined under the IID/MWD Agreement.

From the time the canal lining program began to the present, over 1,169 miles (approximately 200 miles as part of IID's agreement with MWD) of canals have been lined. The seepage reduction from canals lined by IID is estimated at 58,000 acre-feet per year (IID Water Conservation Activities, 1987). The cost expended by IID to line these canals was over $35,000,000.

Figure 3-3
Cumulative Length of Lined Canals Within IID

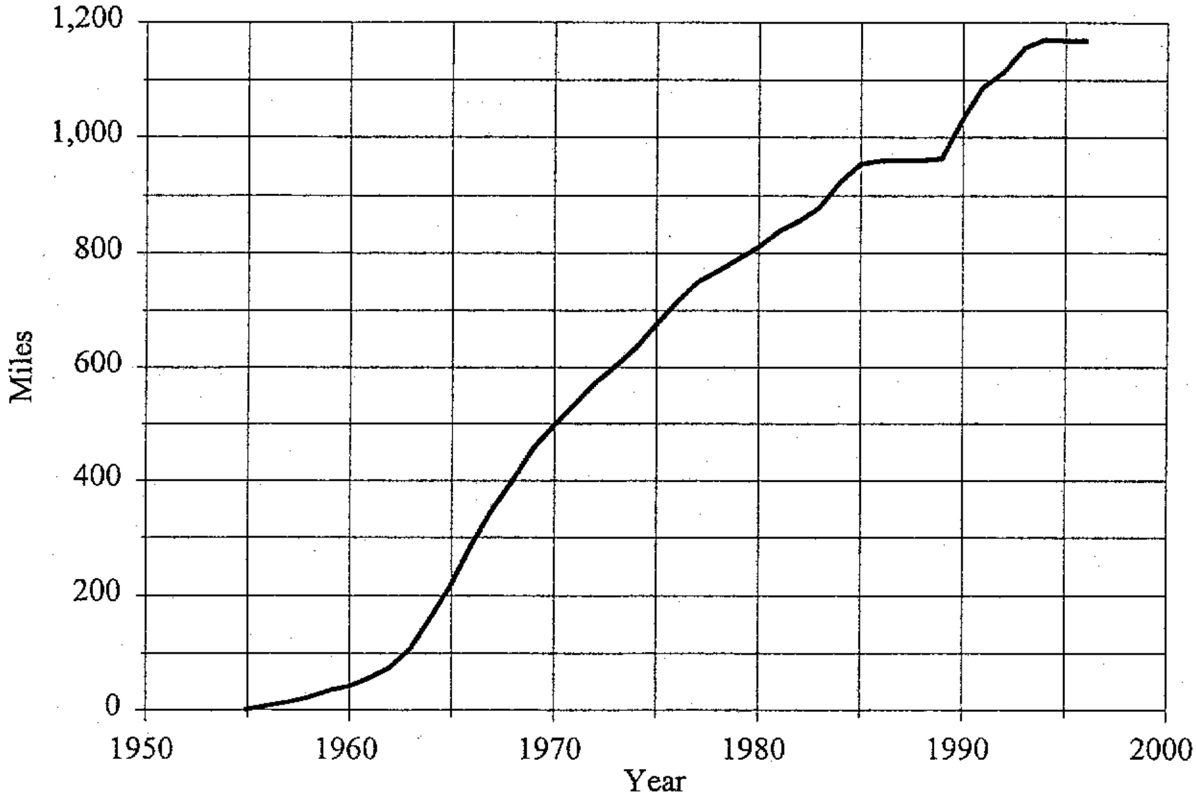


Table 3-2 **Canal Lining Program as of 1984.**				
Canals	Total Miles	Miles Earth Section	Miles Concrete Lined	Miles Pipelined
All-American Canal	82.17	79.57	2.60	0
Main Canals	153.46	144.52	8.94	0
Lateral Canals	1,445.19	578.25	858.15	8.79
Totals	**1,680.82**	**802.34**	**869.69**	**8.79**
Source: IID, Water Conservation Plan, 1985				

3. SUPERVISORY CONTROL AND DATA ACQUISITION

In the late 1950s, IID installed devices to measure and record canal water levels at selected locations. Since that time, IID has made numerous improvements in Supervisory Control and Data Acquisition (SCADA) systems based on available technology. The SCADA system has helped improve the conveyance and distribution system over the last 40 years.

4. REGULATING RESERVOIRS

For a variety of reasons, farmers often make changes on their individual orders of water. When irrigators use less water than originally ordered, a surplus results that could potentially spill at the end of the lateral. Similarly, should an irrigator finish irrigating before the allotted time span, the unused water could spill. In both situations, if such water could be stored temporarily in a regulating reservoir, that water would be conserved. Building regulating reservoirs, therefore, provides operational flexibility. In addition, these reservoirs can supply make-up water to laterals or main canals as needed to meet demands, and they can capture storm runoff that enters the canals.

Beginning in the mid-1970's, the District strived to determine the most effective locations for regulating reservoirs. From 1976 to 1983, IID built four regulating reservoirs with a total capacity of about 1,569 acre-feet. Three of the regulating reservoirs were built on the main canals: the East Highline Canal, the Central Main Canal, and the Westside Main Canal. The fourth reservoir is located on the Rositas Canal. Table 3- 3 lists the regulating reservoirs constructed by IID prior to IID's agreement with MWD. The construction of regulating reservoirs began as part of IID's 13-Point Water Conservation Program, and it has continued during the last 20 years. The total cost of the four reservoirs built prior to 1984 was about $3,367,000. The estimated water savings associated with these reservoirs is about 18,000 acre-feet per year.

Table 3-3 **Regulating Reservoirs Constructed by IID Prior to 1989.**		
Regulating Reservoir	Capacity (acre-feet)	Year of Operation
Kakoo Singh	323	1976
J. M. Sheldon	476	1977
Oscar Fudge	300	1982
H. "Red" Sperber	470	1983
Total	**1,569**	----

5. 13-Point Water Conservation Program

In 1976, IID developed a comprehensive 13-Point Water Conservation Program that focused on reducing tailwater, canal seepage, and operational water entering the Salton Sea. Operational water is the water from main canals and laterals that either spills or is discharged to the drainage system due to mismatches of canal flow rates and deliveries. The program initiated the construction of regulating reservoirs (discussed above), irrigation management programs, and operational changes to conserve water. The program, which was in effect from 1976 to 1987, is summarized in Table 3-4 and listed in Appendix A. In 1987, the program was replaced with the 15-Point Water Conservation Program.

6. Aquatic Weed Control

An aquatic weed, "Hydrilla", was found in the All-American Canal in 1977 and rapidly became a serious problem, clogging canals and drains. To combat the problem, in 1981, IID joined with the California Department of Food and Agriculture, Coachella Valley Water District (CVWD), and the United States Department of Agriculture (USDA) in a research program to correct the problem. As a result of the research, a biological solution to the aquatic weed problem was developed. The introduction of the Triploid Grass Carp, a sterile fish that feeds on the Hydrilla, was found to be a cost effective and environmentally safe method of controlling the aquatic weed problem. IID's Triploid Grass Carp hatchery was completed in 1988, and about 20,000 stockable fish are produced each year. In 1989, as a result of this effort, the USDA awarded IID with the "Distinguished Service

Award for Group Achievement". The annual cost associated with the aquatic weed control program is about $380,000. The control of aquatic weeds is vital to maintaining efficient water delivery and on-farm irrigation systems.

Table 3-4
Summary of IID 13-Point Water Conservation Program (1976).

Point	Description
1	Construct regulating reservoir on Westside Main Canal.
2	Reconstruct farm outlet boxes, as required for water measurement purposes.
3	Assign adequate water regulating personnel to provide more efficient deliveries.
4	Conduct daily inventories of surface field discharge and charge users with excess field discharge three times the scheduled water rate.
5	Develop surface water evaporation ponds to reduce inflow to Salton Sea.
6	Conduct preliminary studies for a regulating reservoir on Central Main Canal.
7	Conduct study of the feasibility of installing water recovery lines paralleling the East Highland and Westside Main Canals to recover seepage.
8	Provide free drainage water to persons willing to pump and use it.
9	Continue the concrete lining program.
10	Initiate a record of accrued water use by computerized billing.
11	Install radio equipment in all water conservation-related vehicles to provide immediate communication.
12	Initiate irrigation management services program.
13	Deliver water off-schedule when possible.

7. WATER CONSERVATION ADVISORY BOARD

In 1979, IID's Board of Directors appointed a Water Conservation Advisory Board, comprised primarily of farmers, to make recommendations regarding water conservation. The 1980 21-Point Water Conservation Program and the 1987 15-Point Water Conservation Program were recommended by the Water Conservation Advisory Board and subsequently authorized by the IID Board of Directors. The Water Conservation Advisory Board continues to meet on a regular basis.

8. 21-Point Water Conservation Program

The 21-Point Water Conservation Program was adopted by IID's Board of Directors in 1980 to supplement the 13-Point Water Conservation Program. The program includes policies and procedures for ordering water, operating the delivery system, and assessing users extra charges for excessive tailwater. The program description is contained in Appendix A. The 21-Point Water Conservation Program was in effect from 1980 to 1987.

9. 15-Point Water Conservation Program

In 1987, IID's Board of Directors adopted a 15-Point Water Conservation Program to combine and supersede the 13- and 21-Point Water Conservation Programs. The 15-Point Water Conservation Program is entitled *Rules Concerning Tailwater Assessments and Delivery Adjustments to Conserve Water*. Table 3-5 contains a summary of the 15-Point Water Conservation Program with the detailed program (IID Resolution No. 18-87) listed in Appendix A. The 15-Point Water Conservation Program is presently in effect.

10. Tailwater Recovery Demonstration Program

Based on the success of tailwater recovery demonstrations conducted in 1983, IID installed five tailwater recovery (pumpback) systems in 1985. The systems were used to evaluate the on-farm technical and economic feasibility of reducing tailwater on a variety of crops. The program results are contained in a report prepared by Boyle Engineering Corporation for IID, entitled *Tailwater Recovery - Demonstration Program Study,* dated September 1990. In summary, the report states that the potential annual irrigation water conservation was estimated at 87 acre-feet per 145-acre block (0.6 acre-foot per acre), soil salinity impacts were varied and non-uniform, and scalding was not a problem.

11. Irrigation Certification Program

In 1994, IID developed a mandatory irrigation certification program for all farm water managers who handle IID's irrigation deliveries. The program consists of a training video presentation and a discussion of IID rules and regulations concerning water deliveries and charges. The farm water managers are encouraged to communicate with IID personnel concerning all water orders and special needs. The training sessions are presented several times in both English and Spanish. At the end of the training sessions, the water managers are presented with a certificate of

Table 3-5
Summary of IID 15-Point Water Conservation Program.

Point	Description
1	Penalty of $100 for unauthorized adjustment of delivery gates.
2	(*Tailwater Triple Charge*) Surface discharge (tailwater) measurements will be taken daily and an assessment shall be levied equal to three times the scheduled water rate if the surface discharge rate is more than 15 percent of the flow ordered for two successive discharge measurements taken not less than 9 hours apart. The rate shall increase by one factor (i.e. 4, 5, etc.) for other subsequent tailwater exceeding 15 percent during the quarter, except for during seed germination.
3	An attempt will be made to notify the water user when tailwater is more than allowed.
4	Exceptions for tailwater triple charge: (a) Tailwater is not allowed when unseeded field is plowed or flat, except for a five percent allowance on the last day of irrigation. (b) When water is being run in furrows to germinate crop seeds and to establish a stand, no assessment charge will be made unless tailwater is over 15 percent between noon and 6:00 pm.
5	Tailwater flow is adjusted by subtracting surplus flows that may be delivered.
6	Tailwater assessments are only based on percentage of grower's order.
7	Tailwater measurements made within four hours after a District change shall apply to the order before the change.
8	Tailwater measurements made after the closure of the headgate are based on the last order running.
9	Right of water user to appeal an assessment.
10	A change in water order can be made for the last day of run by notifying IID by 3:00 p.m. of the preceding day.
11	A change of two cubic feet per second (cfs) or less may be accommodated if within IID ability.
12	A change in order during the last 12 hours of the run will be permitted with proper notice (3:00 p.m. preceding day), and as long as the change does not exceed 50 percent or five cfs and does not disrupt service to other water users.
13	Finish heads can be ordered up to 3:00 p.m. the preceding day of delivery.
14	Routine canal cutouts shall not occur more than once every eight weeks, except under special circumstances.
15	Water may be delivered off-schedule when and wherever possible.

completion. As a follow up to the irrigation certification program, meetings were held in 1995 and 1996 to provide an opportunity for water managers to further meet with IID Division personnel to discuss water operations and address questions.

12. Training for IID Operation Personnel

As part of an on-going commitment to provide training for its operational personnel, IID has developed a training program in cooperation with faculty at California Polytechnic State University, San Luis Obispo (Cal Poly). The training is provided at Cal Poly approximately four times each year. The training includes instruction and workshops on water measurement (over pour, under pour, orifices, weirs, flumes, etc.), lateral and canal operations, and on-farm irrigation management. Approximately 70 percent of IID's zanjeros and hydrographers have attended the training.

13. Tailwater Box Replacement Program

The tailwater box contains a weir used to measure tailwater volumes as part of IID's 15-Point Water Conservation Program. The tailwater box replacement program was initiated to assure that all tailwater boxes are adequate for measurement purposes. The program involves personal telephones calls and follow up letters to landowners who have tailwater boxes which are in disrepair or inadequate to make measurements and to those landowners who requested that the tailwater boxes be replaced or repaired. While installation and maintenance of tailwater boxes are the responsibility of landowners, standardized tailwater boxes are needed to facilitate equitable tailwater measurements.

14. Water Conservation Studies and Reports

IID has commissioned or participated in numerous studies on water conservation, requirements, and availability during the past 15 years. The following is a list of recent reports:

- Bookman-Edmonston Engineering, Inc. *Reports on Statewide Water Perspective; Water Conservation Opportunities; Water Operations; Water Conservation Program and Water Use Efficiency Comparison.* September 1983.

- Bookman-Edmonston Engineering, Inc. *Water Use and Efficiency in Imperial Irrigation District and Coachella Valley Water District.* February 1989.

- Boyle Engineering Corp. *On-Farm Irrigation Efficiency, Special Technical Report. Imperial Irrigation District.* August 1993.

- Imperial Irrigation District. *Water Conservation Plan.* 1985.
- Imperial Irrigation District. *Water Conservation Plan Update.* June 1986.
- Imperial Irrigation District. *Tailwater Recovery Demonstration Program Study.* September 1986.
- Imperial Irrigation District. *Environmental Impact Report. Proposed Water Conservation Program and Initial Water Transfer.* October 1986.
- Imperial Irrigation District. *Water Conservation Activities.* 1987.
- Imperial Irrigation District. *Memorandum. Percent of Tailwater by Crop.* August 9, 1990.
- Imperial Irrigation District. *Water Conservation History.* August 7, 1991.
- United States Bureau of Reclamation. *Water Conservation Opportunities Imperial Irrigation District, California. Special Report.* July 1984.
- United States Bureau of Reclamation. *East Highline Canal Seepage and System Improvement Study. Imperial Irrigation District.* Special Technical Report. August 1989.
- University of California Cooperative Extension Service. *Final Report for Project B 54160, Mobile Agricultural Water Conservation Laboratory.* January 15, 1985.

15. Summary of IID Water Conservation Programs

A summary of IID water conservation programs is contained in Table 3-6.

III. IID AND MWD WATER CONSERVATION AND TRANSFER AGREEMENT

In 1984, IID entered into negotiations with MWD to prepare a water conservation and transfer agreement that was finalized in 1989 (IID/MWD Agreement). In general, the agreement is for MWD to fund water conservation measures within IID in exchange for the conserved water for the duration of the 35-year agreement. As part of this 1989 agreement, MWD has invested over $100 million in water conservation facilities and activities in the IID service area. In exchange for the investment, MWD receives the water conserved as a result of the investment. In 1989, IID received the USBR "Commissioner's Water Conservation Award" for outstanding record of water conservation as a result of this agreement.

Table 3-7 summarizes the projected water conservation for 1997 that relates directly to the IID/MWD Agreement, as determined by Conservation Verification Consultants. The projected water savings for 1997 and available for 1998, from the IID/MWD Agreement, is 107,160 acre-feet (Program Coordinating Committee, 1997, see Appendix B).

The MWD investment focused primarily on water conservation at the District level, with a nominal portion of the funding provided for on-farm tailwater recovery and alternative irrigation systems. The water conservation components of IID's agreement with MWD are described below:

Table 3-6
Summary of IID Water Conservation Programs.

No.	Water Conservation Activity	Year	Summary of Water Conservation Activities
1.	Canal Seepage Recovery	1951-present	Drains have been installed parallel to portions of the All-American and the East Highline Main Canals to recover seepage. Each year approximately 24,000 acre-feet are returned to the canals.
2.	Canal Lining	mid 1950s-present	IID has lined over 900 miles of canals with an estimated water savings of 58,000 acre-feet per year (IID 1987 estimate).
3.	Supervisory Control and Data Acquisition System (SCADA)	late 1950s-present	IID has used available technology to monitor and control water levels within its conveyance and delivery system.
4.	Regulating Reservoirs	1976-present	IID constructed four regulating reservoirs prior to the IID/MWD Agreement. The regulating reservoirs have nearly eliminated spills from the main canals.
5.	13-Point Water Conservation Program	1976-87	The program focused on reducing tailwater, canal seepage, and operational water.
6.	Aquatic Weed Control	1981-present	IID helped support the research that developed the sterile Triploid Grass Carp fish that feeds on Hydrilla (aquatic weed) that was clogging canals and drains.
7.	Water Conservation Advisory Board	1979-present	The Advisory Board meets regularly to make recommendations and regulations concerning water conservation.
8.	21-Point Water Conservation Program	1980-87	The program includes policies and procedures for ordering water, operating the delivery system, and assessing extra charges for excessive water use.
9.	15-Point Water Conservation Program	1987-present	The program replaced the 13- and 21-Point programs and contains aggressive policies to promote on-farm conservation. The program describes the tailwater triple charge program.
10.	Tailwater Recovery Demonstration Program	1983-90	The program demonstrated the technical feasibility and effectiveness of a tailwater recovery system, showing that about 12 percent of on-farm deliveries can be saved.
11.	Irrigation Certification Program	1994-present	The program, mandatory for all managers, includes a discussion of IID rules, regulations, and water management.
12.	Training for IID Operation Personnel	1995-present	IID sponsors water measurement training for zanjeros and hydrographers at California Polytechnical State University in San Luis Obispo.

Table 3-6 Summary of IID Water Conservation Programs.			
No.	Water Conservation Activity	Year	Summary of Water Conservation Activities
13.	Tailwater Box Replacement Program	1976-present	Land owners were contacted with a request to repair or replace tailwater boxes to facilitate better tailwater measurements.
14.	Water Conservation Studies and Reports	1994-present	IID has spent millions of dollars on water conservation studies in a continuing effort to identify water conservation opportunities.

Table 3-7
Projected Water Conservation for 1997 as a Result of the IID and MWD Agreement.

Project Title	1997 Conservation Projection (acre-feet)
Robert F. Carter Reservoir	4,470
Main Canal Lining	1,810
Plum-Oasis Lateral Interceptor	6,650
Bernard Galleano ("Z") Reservoir	5,230
Lateral Canal Lining	24,250
Trifolium Interceptor	14,700
12-Hour Delivery Program	22,290
Non-Leak Headgates	630
Lateral Move Sprinkler and Drip Irrigation System	510
System Automation	13,490
Mulberry-D Lateral Interceptor	8,460
Tailwater Recovery System	4,670
Total	**107,160**

1. Water Control Center

As part of IID's agreement with MWD, a Water Control Center was constructed to house the equipment and personnel needed to operate a Supervisory Control and Data Acquisition (SCADA) system. The SCADA system provides real-time data from remote sites via radio/microwave communication. The data are used to manage IID's complex conveyance and distribution system. The SCADA system monitors flows and/or water levels in main canals and reservoirs and is used to remotely operate water control structures (delivery gates and main canal gates) to decrease canal spills and provide more efficient delivery of water to users. The SCADA system transmits information and instructions to on-site computers that control the water control structures. The Water Control Center was fully operational in 1993. The IID/MWD Agreement SCADA system improvements and the Water Control Center were upgrades to IID's existing SCADA system. The 1997 estimate of annual water conservation resulting from automation is 13,490 acre-feet (includes savings from automated water control structures).

2. Non-Leak Headgates

Twenty-two wooden headgates were replaced with non-leak metal headgates containing rubber seals, 14 of which currently remain in place. The non-leak headgates were located on laterals in locations where reduced leakage lowers the amount of required operational water. The 1997 estimate of water conserved by the non-leak headgates is 630 acre-feet. The locations of the non-leak headgates are shown in Figure 3-1 (map pocket at end of report).

3. Canal Lining

The lining of 200 miles of canals with concrete contributes about 26,000 acre-feet per year, which is currently (1997 projection) about 24 percent of the total water savings for the IID/MWD Agreement. The selection of canals for lining was based on the potential for water savings. The extent of canal lining possible in the IID/MWD Agreement was limited due to the fact that IID had previously lined about 900 miles of canals. The sections of canals lined as part of the IID/MWD Agreement are shown in Figure 3-1. Figure 3-4 shows the percentage of the total lined canals that were lined as part of the IID/MWD Agreement.

4. Automated and Centrally Controlled Water Control Structures

Automated water control structures provide more stable water levels in canals, which results in more uniform irrigation deliveries and fewer canal spills. The water structures, which are run from the Water Control Center make it possible for operators to adjust gate positions in main canals as needed to adjust flows. The 1997 estimate of water conserved through system automation is 13,490 acre-feet (includes savings resulting from water control center). The locations of the 95 automated water control structures are shown in Figure 3-1.

5. Regulating Reservoirs

Six of IID's ten regulating reservoirs were constructed as part of the IID/MWD Agreement. The regulating reservoirs reduce canal spill by capturing excess canal flows and by providing makeup water to meet irrigation deliveries. The Bevins, Young, Russell and Trifolum Reservoirs were constructed to capture water collected by interceptor canals (described below) for temporary storage before being used to make irrigation deliveries in areas downstream of the reservoirs. The estimated water conservation in 1997 from Carter and Galleano reservoirs is 4,470 and 5,230 acre-feet. The other reservoirs are incorporated into the interceptor systems and water conservation is accounted for separately. The locations of the reservoirs built as part of the IID/MWD Agreement are shown in Figure 3-1. Table 3-8 lists the regulating reservoirs constructed as part of the IID/MWD Agreement.

Figure 3-4
Percentages of Canal Lining by IID
and Under IID/MWD Agreement

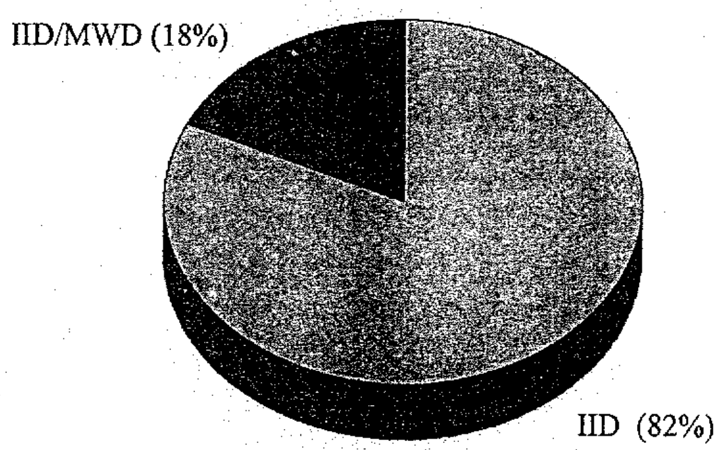


Table 3-8 **Regulating Reservoirs Constructed as Part of the IID/MWD Agreement.**		
Regulating Reservoir	Capacity (acre-feet)	Year of Operation
Robert F. Carter	350	1988
Bernard Galleano (Z)	425	1991
Carl C. Bevins	253	1992
Young	275	1996
Russell	200	1996
Trifolium	300	1997
Total	**1,803**	----

6. INTERCEPTORS

An interceptor is a canal which is constructed near the end of laterals to capture excess lateral flow before it spills into drains. Interceptor canals carry excess water to a regulating reservoir where it can be used to meet deliveries. As part of the IID/MWD Agreement, the Plum-Oasis, Mulberry-D and Trifolium interceptor canals were constructed. These interceptors capture the excess flows of 8, 11, and 15 laterals, respectively. These three interceptors serve about one-sixth of the irrigated farm land within IID. The estimated water conserved from the Plum-Oasis and Mulberry-D interceptors for 1997 is 6,650 and 8,460 acre-feet, respectively. The Trifolium Interceptor system became operational at the end of 1997 and is expected to conserve 14,700 acre-feet in 1997. The locations of the interceptor canals are shown in Figure 3-1.

7. 12-HOUR WATER DELIVERY

Historically, irrigators within IID requested a specific flow of water in 24-hour time blocks. The 24-hour time blocks made IID's water delivery system manageable, especially when there were no regulating reservoirs and limited automated water control structures; but 24-hour deliveries limited the flexibility for irrigators. In an effort to conserve water and provide irrigators more flexibility in ordering and using the correct amount of water, IID, prior to the IID/MWD Agreement, developed and initiated on a program basis a 12-hour irrigation run. This program demonstrated that farmers can conserve water with increased flexibility in water ordering and management. This makes it possible for the irrigators to better match their water orders to existing soil and crop needs, and more irrigation can occur during daylight hours when it is easier to manage water. The projected water conserved by 12-hour water deliveries is 22,290 acre-feet for 1997.

Twelve-hour deliveries require that adjustments in the main canals and laterals be made more frequently than with 24-hour deliveries. For example, at the end of a 12-hour daytime delivery on a headgate located some distance from a main canal, a zanjero would adjust at the head of the lateral, perhaps several hours before the shut-off time, and continue making adjustments (upstream to downstream) in lateral control gates until the time that the headgate was shut. This must be done to avoid excessive operational water spills. These increased adjustments require additional labor from IID's zanjeros and hydrographers and therefore may increase operational water requirements; but the reduced headgate diversions are of greater magnitude than the consequential operational water requirements. From November 1, 1995 to October 31, 1996, there were 22,794 12-hour deliveries made by IID. The primary direct cost of 12-hour deliveries is the additional labor requirements to more efficiently manage water deliveries. In addition, the 12-hour deliveries are more efficient when they are integrated with regulating reservoirs, interceptor systems, and automated water control structures--all a part of the MWD-funded water conservation program.

8. Tailwater Recovery Systems

Tailwater, which is necessary for appropriate surface irrigation in the Imperial Valley, represents a major source of water that flows to the Salton Sea. In 1983, IID, in cooperation with growers, conducted a demonstration and research program concerning tailwater recovery systems (pumpback systems). A tailwater recovery system collects tailwater in a small field reservoir (3-4 acre-feet). The water is then delivered at the appropriate flow rate and time to the head of the field via a pump and pipeline system. The results of the cooperative studies demonstrated that tailwater recovery systems effectively conserve water. The use of tailwater recovery systems require additional labor, equipment, and energy compared to irrigation systems without tailwater recovery systems. Twenty-five tailwater recovery and return systems were constructed and operated as part of IID's agreement with MWD. It is estimated that the tailwater recovery systems will conserve 4,670 acre-feet in 1997. The locations of the tailwater recovery projects within IID are shown in Figure 3-1.

9. On-Farm Irrigation Systems

Three lateral move sprinkler irrigation systems on 305 acres and four drip systems on 156 acres were sponsored during 1997 as part of the water conservation agreement between IID and

MWD. The locations for these systems were determined based on soil conditions, suitability of crops, and participation of growers. The water savings from these systems is estimated at 510 acre-feet in 1997. The locations of these on-farm systems are shown in Figure 3-1.

10. Summary of IID/MWD Water Conservation Projects

A summary of water conservation programs implemented as part of the IID/MWD water conservation agreement is contained in Table 3-9.

IV. FEDERAL/STATE-IID COOPERATIVE PROGRAMS

IID has cooperated with federal and state agencies to develop programs and information to conserve water within the Imperial Valley. These programs are discussed below:

1. California Irrigation Management Information System (CIMIS)

CIMIS consists of numerous automated weather stations that collect temperature, solar radiation, humidity and wind speed data which are used to estimate reference crop ET. This reference ET, as well as rainfall data, is available for irrigators to assist in irrigation scheduling. CIMIS weather stations within IID are located at Mulberry, Seeley, and Meloland. The program is supported by IID, University of California Cooperative Extension Service, and the California DWR. Monthly maintenance of the electronic weather stations is performed by IID personnel.

2. Mobile Agricultural Water Conservation Laboratory

The Mobile Agricultural Conservation Laboratory provides growers in the Imperial Valley with irrigation system evaluations and education programs designed to increase on-farm efficiencies. The laboratory collected information concerning tailwater runoff, deep percolation, and irrigation efficiencies. A final report concerning the initial studies was completed in January, 1985 (University of California Cooperative Extension, 1985).

Table 3-9 Summary of Major IID/MWD Agreement Water Conservation Programs.		
No.	Water Conservation Activity	Summary of Water Conservation Activities
1.	Water Control Center	The Water Control Center houses the equipment and personnel needed to operate the District water distribution system.
2.	Non-Leak Headgates	Fourteen wooden headgates were replaced with non-leak metal headgates. Estimated 1997 water savings is 630 acre-feet.
3.	Canal Lining	Approximately 200 miles of canal were concrete lined. Estimated 1997 water savings is 26,060 acre-feet.
4.	Automated and Centrally Controlled Water Control Structures	Automated gates were installed at strategic locations to provide better and more timely water adjustments. Estimated 1997 water savings is 13,490 acre-feet.
5.	Regulating Reservoirs	Six regulating reservoirs were constructed, three as part of canal interceptor systems. Estimated 1997 water savings from the reservoirs (Carter and Galleano) is 9,700 acre-feet. The water savings from the other regulating reservoirs are accounted for by the interceptor canals.
6.	Interceptor Canals	The Plum-Oasis Interceptor, Mulberry-D and Trifolium Interceptors capture the excess flows of 8, 11, and 15 laterals, respectively. The estimated 1997 water savings is 29,810 acre-feet.
7.	12-Hour Water Delivery	Irrigators are allowed to order in 12-hour time blocks rather than the historical 24-hour time blocks making it possible for irrigators to better match water deliveries to crop needs. The estimated 1997 water savings is 22,290 acre-feet per year.
8.	Tailwater Recovery Systems	Twenty-five tailwater recovery system were constructed to conserve about 4,670 acre-feet of water per year.
9.	On-Farm Irrigation System	Three lateral move sprinklers and four drip systems were installed with estimated 1997 water savings of 510 acre-feet.

3. Irrigation Scheduling Programs

IID encourages and provides support for irrigation scheduling through workshops, neutron probe irrigation scheduling, CIMIS and evaporation pan data. For example, in 1987 thirty-three growers cooperated in IID's program with 1,199 irrigations being monitored. The average irrigation efficiency of the monitored irrigations was 85 percent.

4. USDA Agricultural Research

IID has participated in a number of irrigation conservation research projects at the Imperial Valley USDA Irrigated Desert Research Station by constructing facilities and providing expertise. The assistance has included machinery and labor for installation of irrigation systems and research equipment such as lysimeters (devices to measure water use by vegetation). The District has also constructed a reservoir and a pumping station for the research facility as well as provided labor and equipment for research and programs.

5. USDA Natural Resources Conservation Service (NRCS)

IID entered into a Memorandum of Understanding with the Soil Conservation Service (SCS), now Natural Resource Conservation Service (NRCS), in 1945 and has worked cooperatively with the NRCS since that time. In 1985, the NRCS funding for water conservation in the Imperial Valley was estimated at about $167,000 per year in salaries and equipment, and similar funding efforts have continued to the present date. In addition, the USDA Agricultural Stabilization and Conservation Service (ASCS) has provided funds for permanent on-farm water conservation measures, such as lining of head ditches and installation of drains.

6. University of California Cooperative Extension Service

The University of California Cooperative Extension Service office in Holtville, CA, is jointly funded by federal, state, and county resources. The Cooperative Extension Service has eight farm advisors, each with a different speciality. One of the farm advisors deals primarily with irrigation. The Cooperative Extension Service currently has irrigation research programs concerning runoff reduction, impact of application of sewage sludge to farms on infiltration of water, and development of crop coefficients for vegetables. The Cooperative Extension Service also publishes a monthly newsletter containing information on agricultural issues.

7. Summary of Federal/State-IID Cooperative Programs

The water conservation and irrigation management programs that have been supported by local, state, and federal agencies have provided technical information, financial assistance, and educational programs to assist Imperial Valley farmers. The programs have helped irrigators control salinity and maintain long-term production by providing valuable information concerning drainage and leaching. The CIMIS weather network and mobile water conservation laboratory have helped schedule and manage irrigations. The University of California Cooperative Extension Service is an important agency that provides a link between growers and researchers for the exchange of information.

A tremendous amount of effort and money has been spent over the past 50 years to conserve water within IID. While records are not available to precisely document the total amount of money spent on water conservation, the information presented in this section is for actual expenditures, where available, and for estimated costs based on current values when records are unavailable.

I. FARMER EXPENDITURES

Table 4-1 contains an estimate of the present value, in 1996 equivalent dollars, of land improvements for water conservation implemented by farmers. The estimate is based on the current costs of land improvements, because records of expenditures by individual farms on water conservation are not always available. The estimated costs to farmers for water conservation measures are based on interviews with farmers and contractors. The estimated value of water conservation improvements implemented by farmers is $342 million (approximately $680 per acre).

Table 4-1
Estimated Value of Water Conservation Measures Implemented by Farmers.

Conservation Measure	Present Value Costs ($)
Concrete Ditch Lining [1]	192,000,000
Land Leveling [2]	150,000,000
Total	**342,000,000**

Notes:
(1) Concrete Ditch Lining costs are based on a total of 2,509 miles of lined farm ditches. The cost to line ditches is approximately $9.50 per foot for shaping ditch, lining, and installing gates, and checks, plus $5.00 per foot for construction of ditch pad (usually farmer provides the pad) (Lee, 1997).
(2) Land Leveling costs of $300 per acre on 500,000 acres was used to estimate the cost for the initial leveling of the irrigated land. Maintenance land leveling is not included in this estimate.

In addition to the capital improvement costs, there are a variety of maintenance and operational costs associated with on-farm water conservation. These water conservation measures include maintenance laser land leveling, increased water management, and increased labor for irrigation tailwater control. The annual costs of water conservation by farmers are difficult to obtain because many operations accomplish several objectives in the crop production process; but they are estimated at $30 million per year. This cost includes $10 million for maintenance land leveling ($20 per acre) and $20 million for irrigation operations ($40 per acre). The $20 million is about 27 percent of the $75 million farmers spend annually for irrigation. Irrigation costs average about $150 per acre, which included purchase of water, labor for irrigation, water management, and annualized costs for sprinkler and drip systems. Irrigation costs for vegetables average about $240 per acre (includes sprinkler irrigation for germination) and $125 per acre for field crops.

II. IID EXPENDITURES

Figure 4-1 shows estimated expenditures by IID (solid line). The costs are for water conservation efforts and do not include IID's normal operation or maintenance costs. IID conservation expenditures are primarily for capital costs for canal lining, regulation reservoirs, and seepage recovery, plus costs to operate and maintain these facilities. Other IID expenditures include water conservation studies, irrigation scheduling, and tailwater recovery studies. The cost for additional staff required to monitor tailwater, in-kind services such as providing space and support to the NRCS and ASCS, and monthly maintenance of CIMIS weather stations is not included in the total cost. The total water conservation expenditures since 1951 by IID, in equivalent 1996 dollars, are estimated to be approximately $170 million.

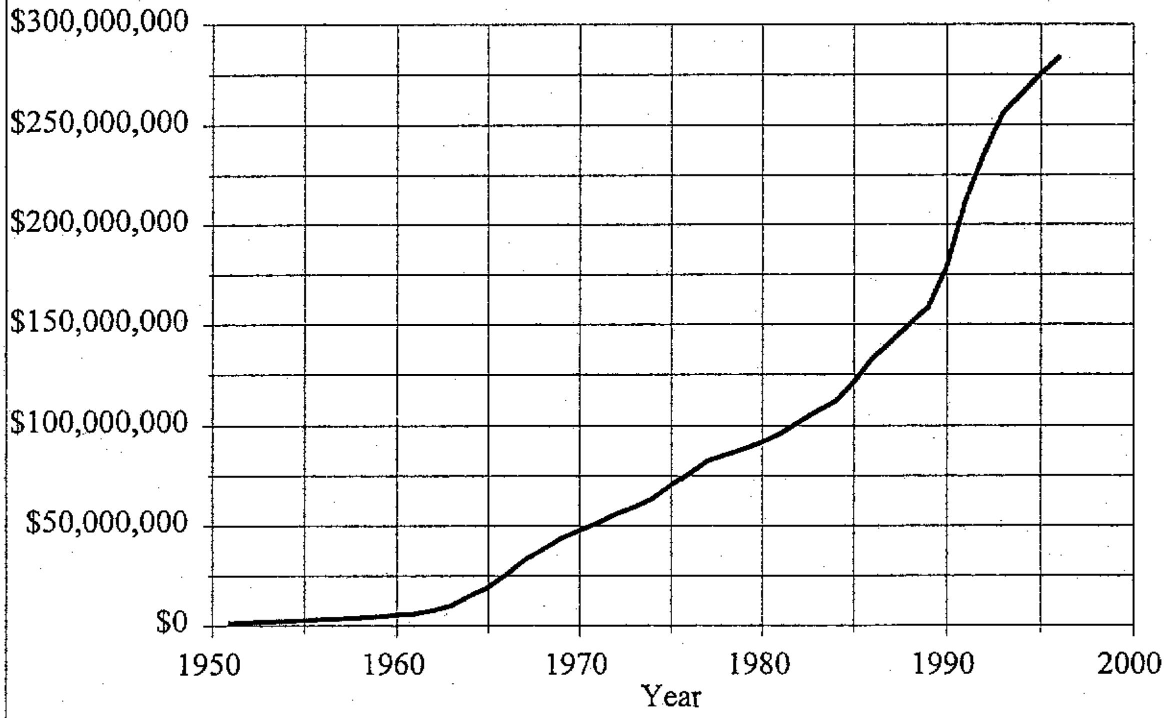
III. IID/MWD EXPENDITURES

Figure 4-1 also shows the expenditures that are part of the IID/MWD Agreement (dashed line). Most of the money provided by MWD has been for system conservation which directly conserves water through measures such as canal lining, interceptor canals, regulating reservoirs, and water control structures. The total cost (through 1996) of the water conservation measures implemented as part of the IID/MWD Agreement is over $100 million.

IV. FEDERAL/STATE EXPENDITURES

Federal and state agencies directly involved in water conservation in the Imperial Valley include the USBR, University of California Cooperative Extension Service, California DWR, USDA, NRCS, ASCS and Agricultural Experiment Station. Examples of programs sponsored by these agencies include the ASCS cost share program, SCS design and technical assistance programs, DWR CIMIS and irrigation scheduling programs, and University of California Cooperative Extension educational programs. The annual cash paid to IID farmers by the ASCS cost share program for implementation of water conservation measures is about $170,000. Considering the number of staff in the various federal and state agencies, the collective annual cost to operate the programs related to water conservation is likely over $500,000.

Figure 4-1
Estimated Cumulative Expenditures of IID and IID/MWD
for Water Conservation Measures Within IID
(1996 Equivalent Dollars)

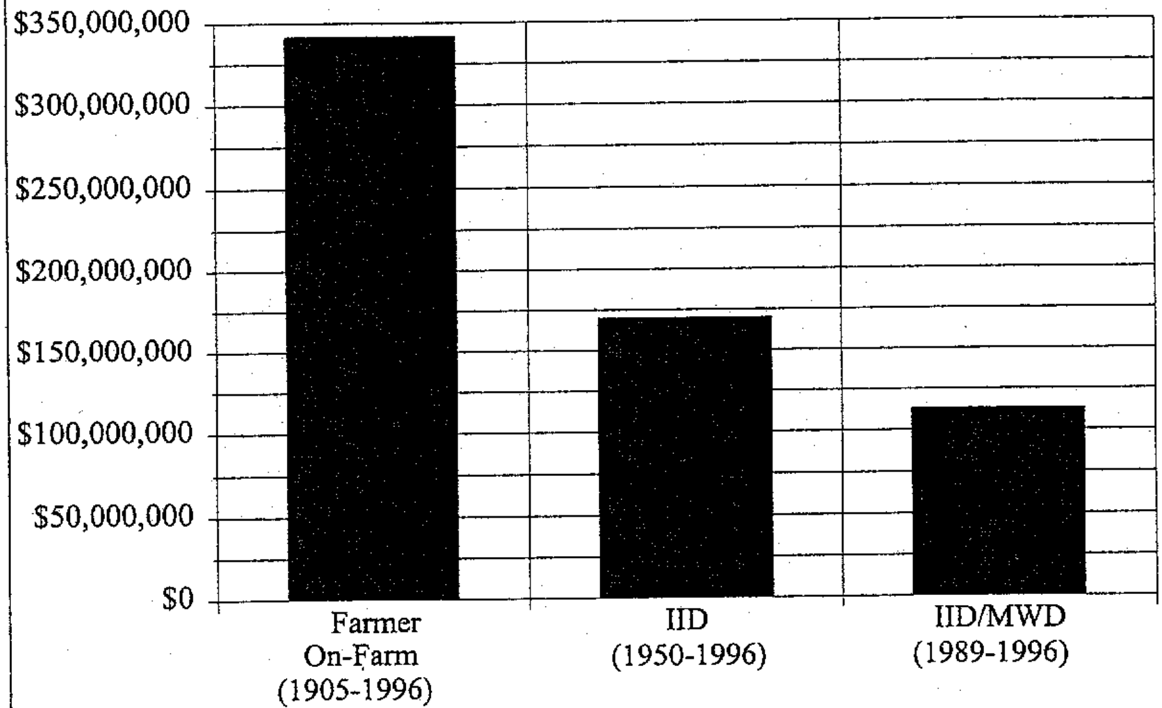


V. SUMMARY OF COSTS

Although MWD, as part of the IID/MWD Agreement, and federal and state agencies have provided considerable funds to help conserve water, the farmers, followed by IID, have invested the most heavily in water conservation over the past 50 years. Figure 4-2 shows the cumulative estimated expenditures for water conservation measures by farmers, IID, and MWD as part of the IID/MWD Agreement. The total present value costs of capital improvements for irrigation water conservation in the Imperial Valley is estimated to be over $625 million dollars, with annual farmer costs for land leveling, water management, maintenance, and operation of water conservation activities to be about $30 million per year.

Figure 4-2

Estimated Expenditures for Water Conservation Measures Within IID (1996 Dollars)



SECTION 5 EFFECTIVENESS OF WATER CONSERVATION EFFORTS

I. ESTIMATED WATER SAVINGS

Water conservation activities in the Imperial Valley can be divided into four categories based on the agency or group that implemented the activities: farmers, IID, IID/MWD, and federal/state-IID cooperative. Table 5-1 lists the programs previously described in this report, with an estimate of water savings, for each of the four groups. Some estimates of water conservation are readily apparent, while other water savings are not as discernable because of the many factors that influence water use. For example, it is rather straightforward to estimate water conserved from system improvements, such as canal seepage recovery, canal lining, regulating reservoirs and interceptor canals. The results of educational and water management programs, on the other hand, are difficult to determine due to the complexity of human and irrigation management variables.

Figure 5-1 shows water conservation measures and activities (1951 to 1997) with the approximate time frame of implementation. Although the IID/MWD Agreement has received considerable attention in recent years, IID has been actively involved in water conservation for a long period of time. Prior to the IID/MWD Agreement, IID had researched and implemented, to some degree, nearly all the water conservation measures which are part of the IID/MWD Agreement. For example, IID had installed automated water control structures, lined canals, built regulating reservoirs, installed tailwater recovery systems, increased flexibility of water delivery, and replaced headgates.

As a consequence of these improvements there has been a dramatic improvement in IID's combined conveyance and distribution efficiency since 1950. In 1950 the conveyance efficiency was about 68 percent and in 1996 it was over 90 percent, as shown in Figure 5-2. The conveyance and distribution efficiencies prior to 1964 were adjusted to reflect a change in water measurement procedures that took effect on January 1, 1964.

Based on total expenditures, farmers in IID have invested the most in water conservation measures, approximately three times as much as was recently invested by MWD. To facilitate efficient on-farm irrigation, farmers have had their farm land leveled and drained and have installed concrete lined head ditches to conserve and manage water.

Table 5-1 Water Conservation Activities and Water Conserved.	
Sponsor/Activity-Program	Estimated Water Savings (acre-feet per year)
Farmer Initiated Measures Estimate of lining of farm ditches, tile drains, land leveling, and irrigation management.	385,000[a]
Imperial Irrigation District Canal Seepage Recovery Canal Lining (not in IID/MWD program) Regulating Reservoirs (not in IID/MWD program) Water Conservation Programs (15-Point Program) Aquatic Weed Control Tailwater Box Replacement Total	 24,000[b] 58,000[b] 16,000[c] 40,000[b] 138,000
IID/MWD Water Conservation Agreement (1997)	107,160[d]
Federal/State Programs California Irrigation Management Information System Mobile Agricultural Water Conservation Laboratory Irrigation Scheduling Programs Agricultural Research Programs USDA Natural Resource Conservation Service	Included in farmer initiated measures estimate.
Total	630,160
[a.] Estimated based on on-farm efficiency improvement from 67 to 79 percent during the last 50 years and average farm deliveries from 1989 through 1996. [b.] Water Conservation Activities 1987 estimate. [c.] Estimated savings of 4,000 per reservoir. [d.] IID/MWD Agreement projected 1997 water conservation savings	

Figure 5 - 1. Approximate Timeline of Implementation of Water Conservation Programs.

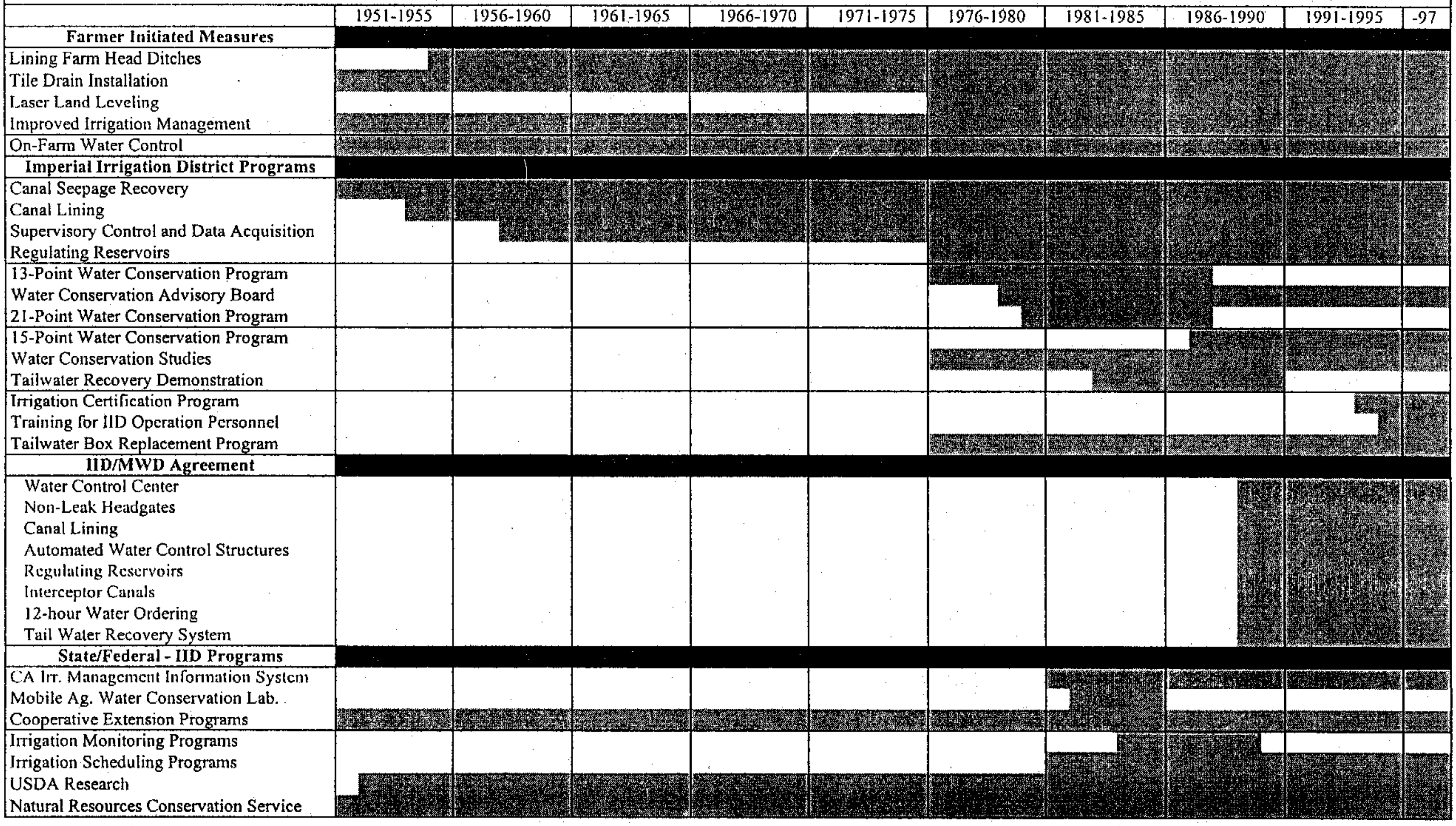
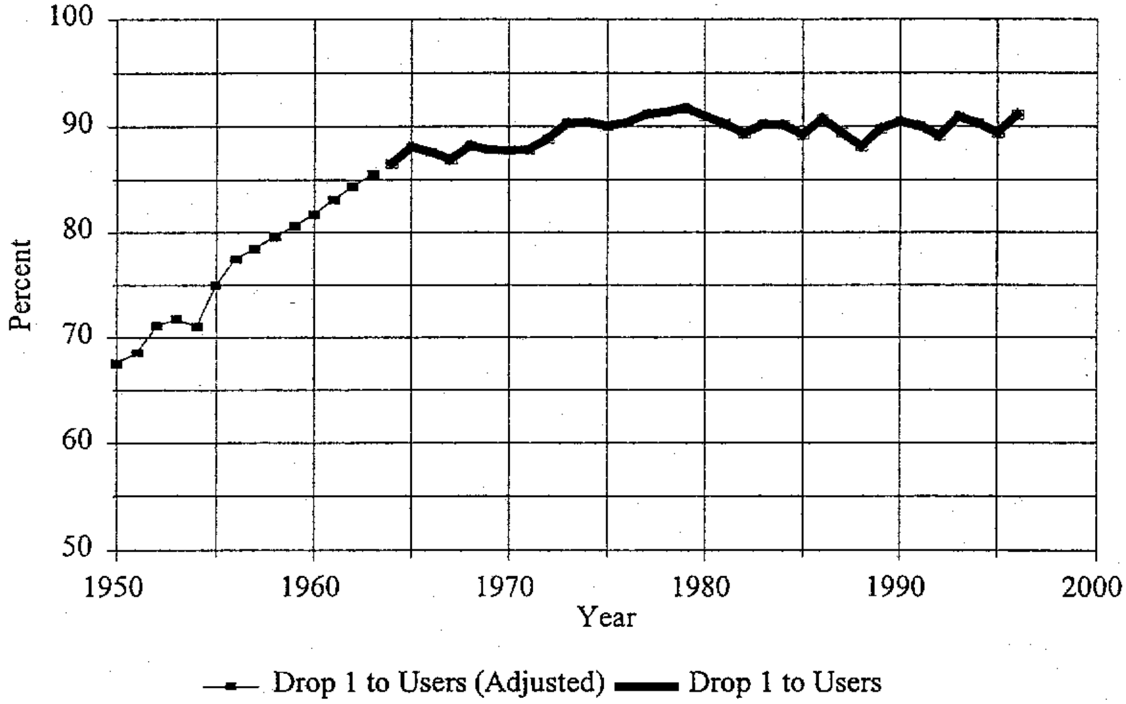


Figure 5-2

IID Conveyance and Distribution Efficiency (Drop 1 to Users)



Note: Adjusted data is based on measurement methodology that occurred in 1964.

As a result of farmers' efforts to improve their farms and irrigation systems, the average on-farm efficiency is currently about 79 percent. Based on available information, on-farm irrigation efficiencies during the last 20 years, as estimated by various groups, have ranged from 72 to 83 percent as shown in Table 5-2. The differences among estimated on-farm irrigation efficiencies results primarily from differences in estimated crop ET and leaching. By all accounts, the on-farm irrigation efficiency within IID is excellent. The estimation of on-farm irrigation efficiencies prior to the 1975 estimates is difficult to determine due to the unavailability of crop ET data.

Table 5-2
IID Estimated On-Farm Irrigation Efficiency.

Source	Period	On-Farm-Efficiency (Percent)
Bookman-Edmonston (1983)	1977 - 1989	72%
USBR (1984)	1975 - 1978	78%
Boyle (1993)	1987 - 1992	83%
TWG (1994)	1987 - 1992	78%
Jensen/USBR (1995)	1990 - 1995	77%
IID Current Estimate	1987 - 1996	79%

II. DISCUSSION CONCERNING RECENT ON-FARM WATER USE

The verification or estimation of the effectiveness of implemented water conservation measures is made by measuring or evaluating the intended water savings of each measure. For example, the water savings resulting from the operation of a lateral interceptor system is made by measuring flows entering the interceptor canal.

The overall results of on-farm water conservation efforts are difficult to quantify due to the many variables involved in efficient irrigation and the time period covered by this report. While some view the total annual water diversion as the only measure of the effectiveness of water conservation efforts, it is important to consider factors other than conservation which influence water use and reported water use such as (1) productivity (increase in productivity results in an increase of transpiration), (2) changes in cropping patterns, climatic conditions, price of crops (influences number of forage cuttings), production of forage rather than seed, etc., (3) salinity of irrigation water,

(4) water availability for leaching, distribution and conveyance efficiencies, (5) crop growing conditions (e.g. insects, damaging storms, frosts, etc.), and (6) changes in water measurement accuracy and reporting, operation policy, etc.

Others contend that water conservation can be judged by the fraction of the water delivered to Drop 1 which flows to the Salton Sea. During the last 10 years, this value has increased from about 32 to 34 percent with a peak of over 36 percent. Although there has been a slight increase during the past ten years, when the long term fraction of Drop 1 to the Salton Sea is considered, there is not a recent upward trend. Some of this variation can be attributed to on-farm water use and precipitation, because the conveyance and distribution efficiency has remained relatively constant during the last 10 years. This fraction can be viewed as an overall indicator of how well IID and its growers are managing water (a simple estimate of overall efficiency which does not include all the variables). Some have criticized IID for this apparent lack of water conservation or system efficiency improvement. However, there are technical reasons, related to crop production, for the change in the percentage of water flowing to the Salton Sea. Two of the many factors, irrigation water salinity and cropping, are discussed below.

Figure 5-3 is a graphical comparison of salinity of irrigation water with percent flow to the Salton Sea. The figure shows a logical trend of increased discharge to the Salton Sea with increased salinity of irrigation water. In response to crop stress, farmers apply additional water to compensate for the increased salinity of irrigation water. If farmers did not respond to changes in salinity in their irrigation water, the sustainability of agriculture in the Imperial Valley would be in question.

Another influence on the percent of irrigation water flowing to the Salton Sea is cropping patterns. Each specific crop requires different irrigation and water management. For example, cotton and sudan grass have inherent water requirements which differ from those of wheat and alfalfa. Figure 5-4 shows the correlation of combined acreage of cotton and sudan grass with percent of irrigation flowing to the Salton Sea. The cotton acreage was about 138,000 in 1977 and has decreased to about 5,000 in 1996. The sudan grass acreage has increased from about 22,000 in 1975 to about 82,000 in 1996.

While the two examples presented are not intended to fully explain IID's water use in recent years, they do illustrate that there are many complexities to be considered, and some variables show correlation with the overall efficiency of the irrigation system.

Figure 5-3
Average Salinity at Drop 1 v. Fraction of
Flow at Drop 1 Entering the Salton Sea

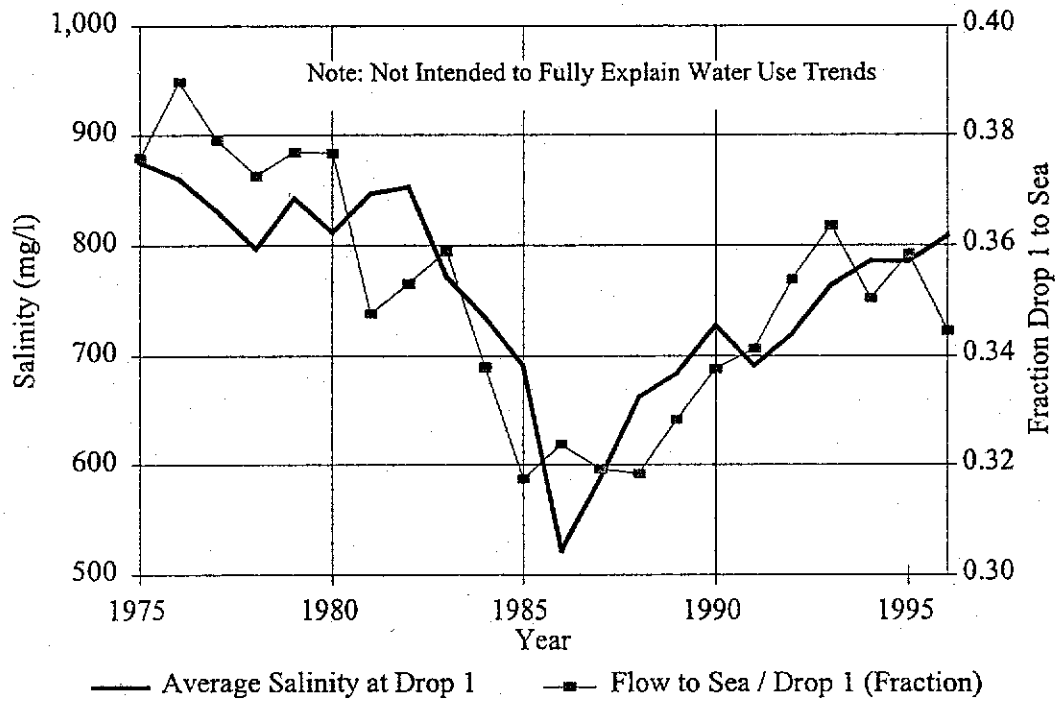
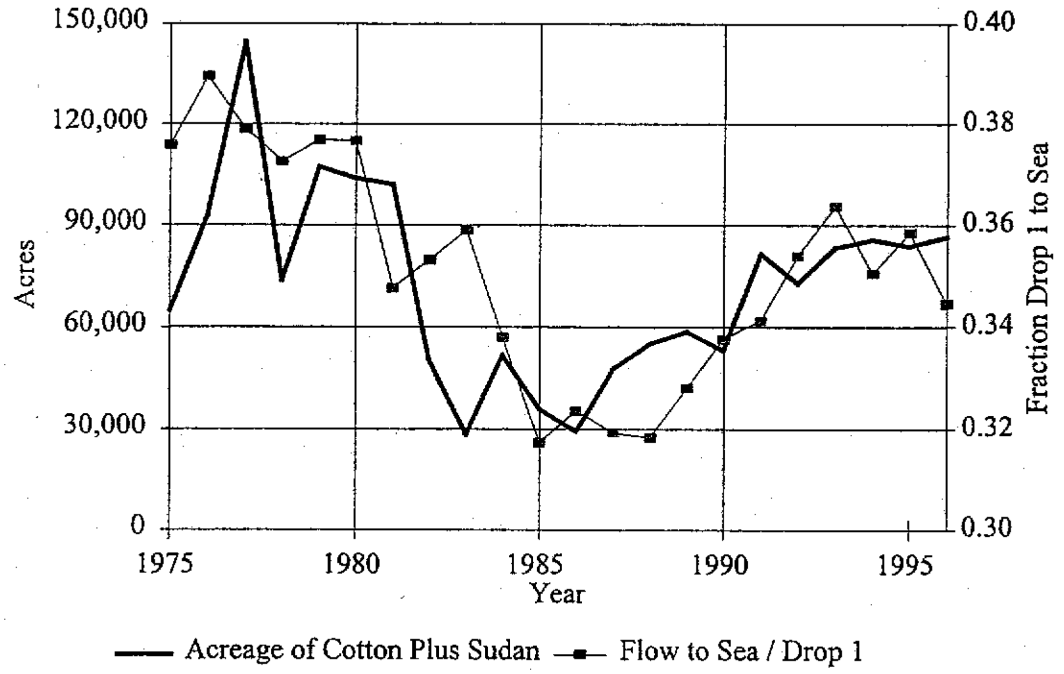


Figure 5-4
Combined Acreage of Cotton and Sudan Grass v.
Fraction of Flow at Drop 1 Entering the Salton Sea



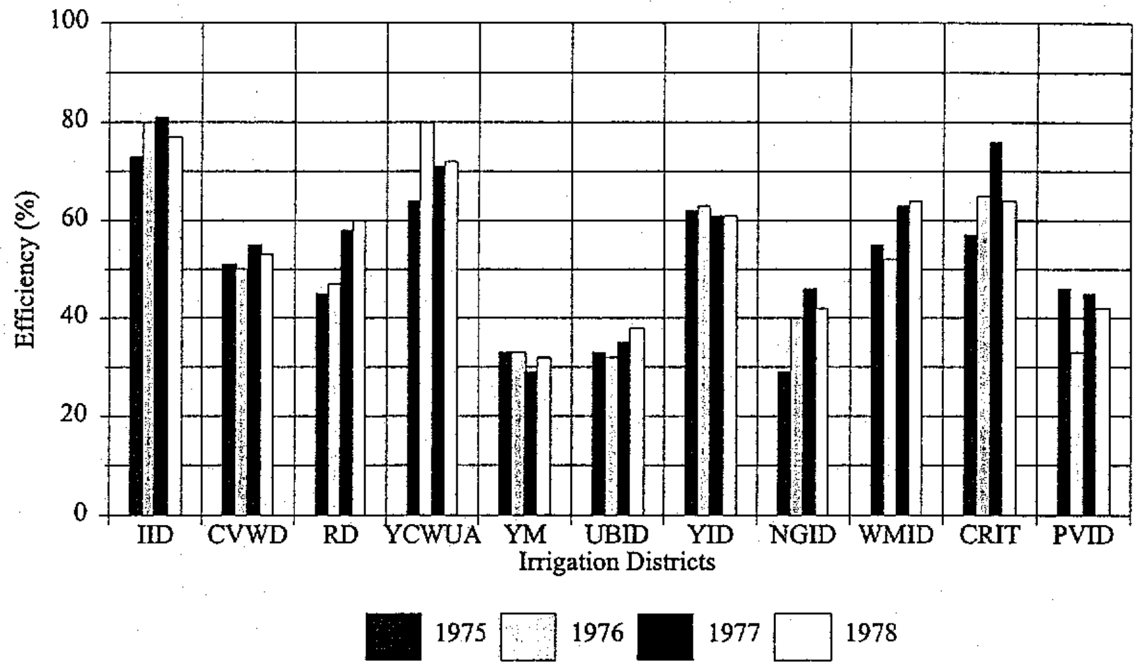
III. COMPARISON OF IID'S EFFICIENCIES TO OTHER IRRIGATION DISTRICTS

In order to appreciate the overall level of efficiency within IID, it is helpful to compare IID's situation with that of other districts or projects in the region. The comparisons provided in this section are derived from published information and were not developed based on an independent analysis of diversions and crop water use.

The USBR estimated on-farm and overall District efficiencies on 11 irrigation districts in the southwestern United States for the years 1975 through 1978, and the information was reported in IID's 1985 Water Conservation Report. The estimated on-farm and overall District efficiencies are shown in Figures 5-5 and 5-6, respectively. IID's on-farm irrigation efficiency was the highest of the evaluated districts for every year, except 1976, when Yuma Valley Unit and IID had equal on-farm irrigation efficiencies. The overall irrigation efficiency, which includes both on-farm and conveyance and distribution system efficiencies, is higher for IID than for any other irrigation district analyzed during the study period. The data are about 20 years old and some of the irrigation districts may have improved on-farm and distribution system efficiencies. However, IID has improved its distribution efficiencies substantially since the study period by implementing the variety of features discussed in this report. Additionally, Imperial Valley farmers have implemented a number of on-farm water conservation measures to improve efficiencies.

Another comparison of overall irrigation efficiencies is from the Snake River Basin above Lower Granite Dam. Diversion records, cropping acreage, and crop ET were obtained for about 2,640,000 acres included in 176 irrigation and canal companies in the Snake River Basin (Bookman-Edmonston, 1994). Based on 1989 records, the total diversions were 14,452,000 acre-feet with crop ET of 6,451,000 acre-feet, resulting in an overall efficiency of 44 percent. While the Snake River Basin is very different in climate and location, the cropping pattern is quite similar. Like the Imperial Valley farmers, Snake River Basin farmers primarily grow field crops consisting of alfalfa, small grains, and sugar beets.

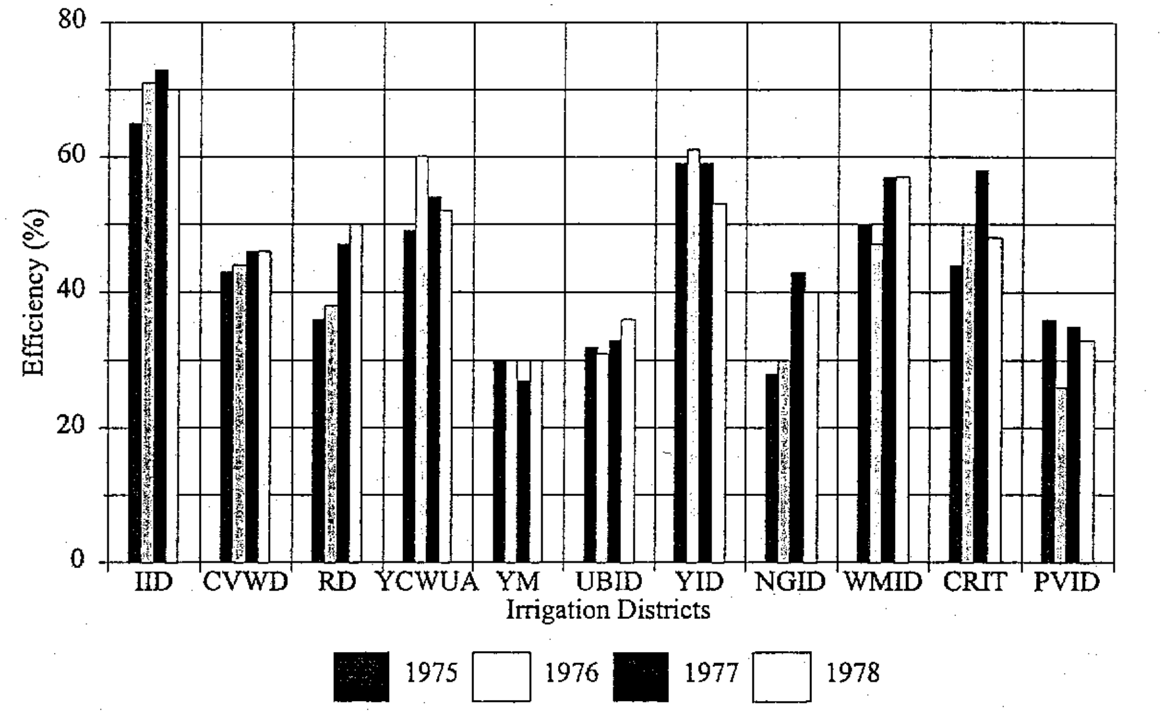
Figure 5-5
On-Farm Irrigation Efficiencies



Legend to Irrigation District Abbreviations

Imperial Irrigation District	IID
Coachella Valley Water District	CVWD
Reservation Division	RD
Yuma County Water User Assoc.	YCWUA
Yuma Mesa Irrigation and Drainag	YM
Unit "B" Irrigation District	UBID
Yuma Irrigation District	YID
North Gila Irrigation District	NGID
Wellton-Mohawk Irrigation District	WMID
Colorado River Indian Tribes	CRIT
Palo Verde Irrigation District	PVID

Figure 5-6
Overall District Efficiencies



Legend to Irrigation District Abbreviations

Imperial Irrigation District	IID
Coachella Valley Water District	CVWD
Reservation Division	RD
Yuma County Water User Assoc.	YCWUA
Yuma Mesa Irrigation and Drainag	YM
Unit "B" Irrigation District	UBID
Yuma Irrigation District	YID
North Gila Irrigation District	NGID
Wellton-Mohawk Irrigation District	WMID
Colorado River Indian Tribes	CRIT
Palo Verde Irrigation District	PVID

Table 5-3 contains information on several selected irrigation projects which receive water through USBR facilities. All the irrigation projects are located in the southwest except the Newlands Project, which is located in western Nevada and receives water from the Trucker River and the Carson River. The Newlands Project, similar to IID, is a terminal irrigation district with drainage entering the Carson Sink, Carson Pasture/Lake, or Stillwater Wildlife Refuge instead of returning to a river system for use by downstream users. The information in Table 5-3 is insufficient to determine the on-farm irrigation efficiencies which would require calculation of crop ET for each project.

Based on information in Table 5-3, IID has one of the lowest per-acre delivery rates with only CVWD, Bard Indian Unit, and the Newlands Project being lower. CVWD unit diversion is lower because growers have groundwater as a supplemental source and the cropping pattern has a lower water requirement than IID. The low unit diversion in the Newlands Project is attributed to the six-month growing season and to lower temperatures than IID. However, in comparison to the others, the conveyance efficiency of IID is high, especially considering the distance and water travel time between IID's service area and the Colorado River diversion location.

In Bulletin 160-93, California DWR singled out Imperial Irrigation District, Westlands Water District, and Kern County Water Agency as having on-farm water efficiencies between 75 and 80 percent. These on-farm efficiencies are above DWR's 2020 target of 73 percent. Based on the comparisons outlined above, it is apparent that the overall efficiency of water use within IID is very high when compared to other districts or projects in the region, and when compared to what is set as a standard by California DWR.

Table 5-3
Conveyance Efficiencies and Farm Deliveries to Irrigation Districts.

Irrigation Division or District	Irrigated Area (acres)	Diversion (ac-ft)	Farm Delivery (ac-ft)	Per Acre Delivery (ac-ft/ac)	M&I Delivery (ac-ft)	Conveyance Eft. (%)
Arizona						
Wellton-Mohawk Div.	60,324	442,140	397,836	6.60	1,080	90.2
Mesa Unit	17,454	290,747	273,927	15.69	2,018	94.9
North Gila Valley Unit	6,319	51,163	44,483	7.04	0	86.9
South Gila Valley Unit	9,628	59,595	56,551	5.87	0	94.9
Salt River Valley	54,174	840,921	333,859	6.16	291,149	74.3
Yuma Valley Division	45,761	360,020	263,048	5.75	19,564	78.5
Yuma Auxiliary	2,717	33,745	28,904	10.64	0	85.7
California						
CVWD[1]	61,052	299,237	260,060	4.26	0	86.9
IID	463,030	2,974,647	2,654,689	5.73	26,223	90.1
Bard Reservation Unit	6,689	40,642	36,046	5.39	0	88.7
Indian Reservation Unit	6,541	49,661	42,562	6.51	0	85.7
Nevada						
Newlands[2]	64,637	270,228	163,407	2.53	0	60.5

Notes

(1) A portion of the irrigated area within CVWD receives it entire water supply from groundwater. Additionally, some of the area that receives Colorado River water also receives supplemental groundwater. Because of these conditions, the total actual per-acre delivery is greater than the reported 4.26 acre-feet per acre.

(2) The Newlands Project area has a growing season of approximately six months with a much lower crop water requirement than the other irrigation districts in the comparison.

Source: USBR 1990 Summary Statistics

Farmers in the Imperial Valley grow over 100 different crops that provide winter vegetables and basic commodities such as wheat and sugar, as well as forage for the dairy and beef industries. The agricultural industry in the Imperial Valley generates approximately $1 billion per year. IID provides water to about 460,000 acres of crop land, some of which are double and triple cropped. Farmers within IID have achieved on-farm irrigation efficiencies of about 79 percent. They have continually implemented affordable and practical water conservation measures and have developed innovative methods, based on the unique conditions within IID, to conserve water. IID farmers have made these significant accomplishments despite the quality of Colorado River water and the tight clay soils of the Imperial Valley. These factors present a major challenge to farmers in the Imperial Valley to maintain proper soil salinity levels for sustained, long-term agricultural production.

IID has a large and complex conveyance and distribution system which is efficiently operated to deliver about 90 percent of the water that IID diverts from the river. During the past 50 years, IID has continuously improved its conveyance and distribution system. In recent years, IID has received attention concerning the water conservation measures implemented as part of the IID/MWD Agreement, yet nearly all the water conservation measures are extensions of measures which were already being implemented by IID.

Furthermore, the issue of IID's overall efficiency must be viewed in context: (1) each acre-foot of water diverted by IID contains about one ton of salt, (2) the soils within IID are, for the most part, very difficult to manage, (3) during much of the year, IID farmers face high temperatures, thus requiring more water and more management, and (4) IID is a huge and complex irrigation area, which compounds the difficulty of managing water efficiently. In light of these difficulties and constraints, the efficiency levels achieved by IID and the District farmers are extraordinary.

The information contained in this report was obtained from a review of previous reports concerning water conservation within IID and discussions concerning irrigation and water use with farmers, irrigators, and IID personnel. The reconnaissance-level review did not include verification of water conservation estimates and activities. If available, recorded expenditures for water conservation costs were reported; for expenditures not recorded, estimates of current costs were obtained from local contractors and farmers. The following summarizes some of the major points presented in the previous sections.

1. IID and its farmers have been actively involved in water conservation for the past 50 years.

2. IID has invested about $160 million (1996 equivalent dollars) on water conservation measures prior to the IID/MWD Agreement.

3. It is estimated that IID saves over 100,000 acre-feet of water per year from the water conservation measures it implemented prior to the IID/MWD Agreement.

4. IID's conveyance and distribution efficiency has increased from about 67 percent in 1950 to about 90 percent in recent years.

5. Farmers have invested about $340 million (1996 equivalent dollars) in land and irrigation system improvements in order to conserve about 385,000 acre-feet of water per year.

- IID's on-farm irrigation efficiency of 79 percent is high when compared with other districts that have similar climatic and soil conditions.

- Although IID's conveyance and distribution systems are extensive, IID's average conveyance and distribution efficiency is about 90 percent, which is as high as those irrigation districts that are a relatively short distance from their water sources, where water losses are expected to be low.

- In 1989, IID entered into an agreement with MWD, providing for MWD to fund water conservation measures within IID in exchange for the conserved water.

- The 1997 estimate of water conserved, as part of the IID/MWD Agreement, is about 107,160 acre-feet.

- Almost all the water conservation opportunities implemented in the IID/MWD Agreement were developed and implemented, to some degree, by IID and District farmers before the agreement.

- About 80 percent of the total lined canal length was lined by IID prior to the IID/MWD Agreement.

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APPENDIX A

LISTINGS OF IID WATER CONSERVATION PROGRAMS

13-POINT WATER CONSERVATION PROGRAM
21-POINT WATER CONSERVATION PROGRAM
15-POINT WATER CONSERVATION PROGRAM

IMPERIAL IRRIGATION DISTRICT 13-POINT PROGRAM
FOR WATER CONSERVATION

Point	Description	Targeted Water Loss Reduction
1	Construct water regulating reservoir on Westside Main Canal	Operational spills
2	Reconstruct farm outlet boxes, as required	Tailwater runoff
3	Assign adequate water regulating personnel to provide more efficient deliveries	Tailwater runoff and operational spills
4	Conduct daily inventory of surface field discharge and charge users who waste water an assessment for that day equal to three times the scheduled water rate	Tailwater runoff
5	Develop surface water evaporation ponds	Inflow to Salton Sea
6	Conduct preliminary studies for a regulating reservoir on Central Main Canal	Operational spills
7	Conduct study of the water recovery lines paralleling the East Highline and Westside Main Canals to recover seepage that is now going into the drainage system and the Salton Sea	Canal Seepage
8	Provide free drainage water to persons willing to pump and use it	Inflow to Salton Sea
9	Continue the concrete-lining program	Canal Seepage
10	Initiate a record of accrued water use by computerized billing	Tailwater Runoff
11	Install radio equipment in all water conservation-related vehicles to provide immediate communication	Tailwater runoff and operational spills
12	Initiate irrigation management services program	Tailwater runoff
13	Deliver water off-schedule when possible	Tailwater runoff

21-Point Program

The 21-Point Water Conservation Program recommended by the Water Conservation Advisory Board and adopted by the District Board is set forth as follows:

(1) The District shall establish a penalty of $100.00 for the unauthorized adjusting of delivery gates, which results in a change in the amount of water being delivered. Furthermore, whenever a water order is in the process of being pumped through a sprinkler or gated pipe system and the operator-user experiences a mechanical failure of the subject equipment, said operator-user shall be permitted to discontinue his water delivery for a period of not more than 3 hours. The free time permitted under this schedule shall be considered as separate instances, but in no event shall the combined hours so considered exceed 3 hours before a triple charge is to be assessed.

(2) The concept of installing gate control devices of a standard design is recommended and supported, such devices to be installed on structures accommodating gates that are owned, operated and maintained, as well as regulated, under the jurisdiction of the District and its personnel.

(3) Application of the assessment charge shall apply on the same basis to all types of irrigation, with the following exceptions:

(a) The percentages of surface runoff allowed when water is being used to irrigate plowed or flat unseeded ground shall be 5 percent for the last day of said irrigation; no measurable waste shall be allowed for any previous days.

(b) When water is being run in furrows to germinate crop seeds and establish a stand, no assessment charge shall be made unless one of the two consecutive measurements showing 15 percent or more runoff is made between 12:00 noon and 6:00 p.m.

(4) In the event a water user is receiving more than his confirmed order, said surplus shall be subtracted from his surface runoff for the purpose of determining if his runoff is excessive.

(5) In no event shall any water user be assessed unless his runoff is 15% or more of his running order irrespective of the quantity of water the user is receiving.

(6) Any surface runoff measurement made within 4 hours after the District has reduced the quantity of water delivered shall apply to the order in effect before said change.

(7) The application of an assessment charge based on waste measured after the delivery gate is closed shall apply on the same basis as when water was actually running. Any assessment made after the gate is closed shall be based on the order last running.

(8) In no event shall the user pay more than triple the normal charge for water, except when he adjusts the delivery gate without permission.

(9) All net proceeds from surface runoff assessment charges shall go into a special fund for conservation purposes other than the concrete lining of ditches.

(10) All District personnel whose duties include checking of surface runoff will initial any waste assessment sheet issued.

(11) Changes can be made for the last day of a run by notifying the District not later than 3:00 p.m. of the preceding day.

(12) When a water user requests an adjustment in the quantity of water delivered not to exceed 2 ft^3/s, the District shall be obliged to honor the same if it is within the ability of the District's system to accommodate such a request and if the water user notifies the zanjero in advance of beginning his daily run. The zanjero of said run shall obtain approval to make said change from his respective superior or section.

(13) A reduction in the water order shall be made to apply to the last 12 hours water is run, provided that the District is notified in advance but not later than 3:00 p.m. of the day preceding the time the order is changed. No penalty shall be charged for said reduction as long as the same does not exceed 50 percent or 5 feet of the order as confirmed, whichever is less. Water that is returned with notice after 3:00 p.m. or that exceeds the quantity that this rule authorizes shall be subject to an assessment equal to two times the regular water rate.

(14) By notifying the District before 3:00 p.m., orders can be adjusted for the last 12 hours of the run, up to 50 percent of the confirmed order or 5 ft^3/s, whichever is less.

(15) Finish heads can be ordered up to 3:00 p.m. of the day preceding the day of delivery.

(16) By notifying the District before 7:30 a.m. of the last day of a run, an order can be adjusted up to 50 percent, without penalty.

(17) One-day orders shall be checked by the appropriate District employees on the same basis as any other water order. For the application of the assessment charge, the first waste measurement shall not be made later than 18 hours after the beginning of the day's water delivery.

(18) The District shall secure whatever additional radio equipment is necessary to improve communications between the farmers and Water Department personnel.

(19) The Water Department of the District shall make 6 waste water recorders available to be installed at various locations within the service area boundaries as defined.

(20) The District shall prepare a monthly water information bulletin for distribution that shall include information submitted to the District by a committee to be appointed by the Water Conservation Advisory Board and from other sources as required to assist the water user in using all water beneficially.

(21) Routine canal cutouts shall be accomplished once every 8 weeks, except when special circumstances require more frequent cutouts.

The 21-Point Water Conservation Program (Supplement 1) defines the required policies adopted by the Board to administer and enforce the 13-Point Program.

Imperial Irrigation District

RESOLUTION NO. 18-87

WHEREAS, the Board of Directors of Imperial Irrigation District has appointed a Water Conservation Advisory Board to assist the District in recognizing matters relating to water problems; and

WHEREAS, the Water Conservation Advisory Board has adopted Bylaws with the approval of the Imperial Irrigation District; and

WHEREAS, said Bylaws state in Section 1.01 therein: "The purpose for which this Board as organized is to recommend to the Board of Directors of the Imperial Irrigation District and the Imperial Valley farming community an expanded program of irrigation efficiency in system operation and farming practices."; and

WHEREAS, prevailing circumstances have caused the Advisory Board to consider revision of the rules regarding tailwater assessment and delivery adjustments to conserve water; and

WHEREAS, the Water Conservation Advisory Board has recommended in Resolution No. 87-2 that certain rules be adopted to be known as the "Rules Concerning Tailwater Assessments and Delivery Adjustments to Conserve Water," and that these rules supersede those adopted in the 13- and 21-Point Programs; and

WHEREAS, the Imperial Irrigation District Board of Directors has reviewed and modified the rules as presented by the Water Conservation Advisory Board.

Imperial Irrigation District

RULES CONCERNING TAILWATER ASSESSMENTS

AND DELIVERY ADJUSTMENTS TO CONSERVE WATER

(To Combine the 13-Point and 21-Point Water Conservation Programs)

(1) The District shall establish a penalty of $100.00 for the unauthorized adjusting of delivery gates, which results in a change in the amount of water being delivered.

(2) An inventory of surface field discharge water will be taken daily and an assessment shall be levied against all discharges which equal 15 percent or more of the water being delivered and measurement thereof shall have been taken on two successive occasions not less than nine hours apart in a 24-hour period. The term assessment used herein shall mean the quantity of water charged (in second feet and reduced to acre-feet, times the scheduled water rate) multiplied by 3 for the day in which the measurements were taken.

Should it become necessary to levy assessments against surface field discharge measuring 15 percent or more on subsequent irrigation runs for any one (1) delivery gate in a calendar quarter, each successive assessment multiplier shall be increased by one (1); i.e., 4, 5, etc. The successive assessment multiplier shall not apply during the time ground is being irrigated for seed germination purposes. Immediately following stand establishment, the successive assessment multiplier shall be increased as indicated and shall apply to the land on which water is being used in the same manner as any other land receiving water.

(3) When a first measurement shows more tailwater than is allowable for that irrigation, a reasonable attempt shall be made to notify the water user, normally by telephone. Notification by mail of an assessment or penalty will be made within 5 normal working days.

(4) Application of the assessment charge shall apply on the same basis to all types of irrigation (including the use of water ordered for mulching purposes with proper notice), with the following exceptions:

(a) The percentage of surface runoff allowed when water is being used to irrigate plowed or flat unseeded ground shall be 5 percent for the last day of said irrigation; no measureable waste shall be allowed for any previous day.

(b) When water is being run in furrows to germinate crop seeds and to establish a stand, no assessment charge shall be made unless one of the two consecutive measurements showing 15 percent or more runoff is made between 12:00 noon and 6:00 p.m.

(5) In the event a water user is receiving more than his confirmed order, said surplus shall be subtracted from surface runoff for the purpose of determining if his runoff is excessive.

(6) In no event shall any water user be assessed unless his runoff exceeds the allowable percentage of his order irrespective of the quantity of water the user is receiving.

(7) Any surface runoff measurement made within 4 hours after the District has reduced the quantity of water delivered shall apply to the order in effect before said change.

(8) The application of an assessment charge based on waste measured after the delivery gate is closed shall apply on the same basis as when water was actually running. Any assessment made after the gate is closed shall be based on the order last running.

(9) If a water user feels that an assessment or penalty has been applied in error, he should immediately contact the Division Superintendent to specify his reasons. A water user may appeal an assessment or penalty within 30 days by notifying the District in writing of the disputed tailwater assessment. The Chairman of the Water Conservation Advisory Board shall appoint three members of the Board to serve as a committee to hear the appeal. The decision of the Tailwater Assessment Appeal Committee shall be final.

(10) Changes can be made for the last day of a run by notifying the District not later than 3:00 p.m. of the preceding day.

(11) When a water user requests an adjustment in the quantity of water delivered, not to exceed 2 cfs, the District shall be obliged to honor the same if it is within the ability of the District's system to accommodate such a request, and if the water user notifies the zanjero in advance of beginning his daily run. The zanjero of said run shall obtain approval to make said change from his respective superior or section.

(12) An adjustment in the water order may be made to apply to the last 12 hours of the water run, provided that the District is notified in advance, but not later than 3:00 p.m. preceding the time the order is changed. The District may honor changes until 4:00 p.m. if it does not disrupt service to other water users. No penalty shall be charged for a reduction as long as the same does not exceed 50 percent or 5 feet of the order as confirmed, whichever is less. Water that is returned with notice after 3:00 p.m. or that exceeds the quantity that this rule authorizes may be subject to an assessment equal to two times the regular water rate. This is in addition to the regular charge of the total order.

(13) Finish heads can be ordered up to 3:00 p.m. of the day preceding the day of delivery.

(14) Routine canal cutouts shall be accomplished no more frequently than once every 8 weeks, except when special circumstances require more frequent cutouts.

(15) Water may be delivered, off-schedule when and wherever possible, if it does not interfere with service to other water users.

THIS WILL CANCEL AND SUPERSEDE THE 13- AND 21-POINT PROGRAMS.

NOW, THEREFORE, on motion of Director ____Bornt____, seconded by Director ____Gallegos____, BE IT HEREBY RESOLVED, that the Rules Concerning Tailwater Assessments and Delivery Adjustments to Conserve Water as stated in Exhibit A attached hereto and made a part hereof, be adopted to become effective July 1, 1987.

BE IT FURTHER RESOLVED that this action will cancel and supersede the 13- and 21-Point Water Conservation Programs.

PASSED AND ADOPTED this 23rd day of June, 1987.

IMPERIAL IRRIGATION DISTRICT

By ________________
President

By Larry E. Beck
Secretary

IMPERIAL IRRIGATION DISTRICT
ORGANIZED
JULY 25, 1911
EL CENTRO, CALIFORNIA

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APPENDIX B

1998 PROJECTED IID/MWD AGREEMENT PROJECT WATER SAVINGS

LETTER FROM PROGRAM COORDINATING COMMITTEE TO
MR. MICHAEL J. CLINTON, GENERAL MANAGER
IMPERIAL IRRIGATION DISTRICT
AND
MR. JOHN R. WODRASKA, GENERAL MANAGER
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA
DATED DECEMBER 22, 1997

PROGRAM COORDINATING COMMITTEE
The Metropolitan Water District of Southern California
and
Imperial Irrigation District
P. O. Box 937
Imperial, CA 92251

JOSEPH B. SUMMERS - CHAIRMAN
KIRK DIMMITT - MWD
JESSE SILVA - IID

Telephone
(760) 339-9263

Telecopier
(760) 339-9262

December 22, 1997

Mr. Michael J. Clinton, General Manager
Imperial Irrigation District
P. O. Box 937
Imperial, CA 92251

Mr. John R. Wodraska, General Manager
Metropolitan Water District of Southern California
P. O. Box 54153 - Terminal Annex
2 California Plaza, 350 South Grand Avenue
Los Angeles, California 90071

Gentlemen:

The Program Coordinating Committee hereby submits, based on the Water Conservation Measurement Committee's recommendation, the water availability schedule for 1998. This submittal is consistent with the Water Conservation Agreement between Imperial Irrigation District and the Metropolitan Water District of Southern California.

The amount of water available under the agreement for calendar year 1998 is 107,160 acre feet.

Very truly yours,

Joseph B. Summers
Chairman

JBS/p
Enclosure
cc w/encl: Members of the Water Conservation Measurement Committee

PROJECTS OF CONSERVATION AND AUGMENTATION PROGRAM[1]
1997 PROVISIONAL AND VERIFIED ANNUAL AMOUNT OF WATER CONSERVED
(In Acre Feet)

Project No.	Project	Water Conserved Acre Feet		
		1988 Agreement	Provisional[2]	Verified[3]
1	Trifolium (Carter) Reservoir	4,600		4,470
2	South Alamo Canal Lining, Phase 1	1,510		510
3	Lateral (Plum-Oasis) Interceptor	5,700		6,650
4	Z (Galleano) Reservoir	3,850		5,230
5	South Alamo Canal Lining, Phase II	2,400		900
6	Sperber Outlet (Deleted)	465	---	---
7	Lateral Canal Lining	29,150		24,250
8	Trifolium Interceptor	10,700	14,700	
9	12 Hour Delivery	12,000	22,290	
10	Vail Supply Canal Lining	2,000		10
11	Rositas Supply Canal Lining	2,000		130
12	Non-Leak Gates	3,550		630
13	Tailwater Assessment (Deleted in Approval Agreement)	0	0	0
14	Irrigation Water Management	3,400	510	
15	System Automation	9,075	13,490	
16	Westside Main Canal Lining, North	4,600		260
17	Modified East Lowline (Mulberry - D) Interceptor	7,390		8,460
18	Additional Irrigation Water Management	3,720		4,670
	Totals	106,110	50,990	56,170
	Current Provisional and Verified Totals		107,160	

[1] Trifolium (Carter) Reservoir and South Alamo Canal Lining, Phase 1, constitute the Augmentation Projects. All the remaining projects, excluding the Tailwater Assessment, constitute the Conservation Program.

[2] "Provisional" values are based on information/analysis completed to date and is subject to change based on further study.

[3] The "Verified" conservation values for projects 2, 5, 7, 10, 11, 12, and 16 are based on information/analysis which are considered final and are not expected to change.
The remaining verified values contain components which are variable and therefore may change