
TAILWATER RECOVERY DEMONSTRATION PROGRAM STUDY

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The Imperial Irrigation District (IID) completed a five-year study in 1990 evaluating the installation and operation of five tailwater recovery systems. The IID is located in the low desert area of Southern California and diverts Colorado River water to nearly 490,000 acres of irrigated land. The study was designed to evaluate the technical and economic aspects of operating tailwater recovery systems in the unique environment of the Imperial Valley. The systems were installed on cooperated fields and monitored to determine potential impacts on soil and water resources. This technical paper is a summary of the final report compiled at the end of the study.

Tailwater represents the component of total applied water required to achieve a uniform surface irrigation of an entire field. Without tailwater, the lower end of the field will not receive enough water and will potentially suffer yield decreases. A tailwater recovery system conserves water by capturing surface runoff that would normally flow to a district drain and returns that water to the head of the field for reapplication. A tailwater recovery system basically consists of a reservoir for storage, a pump station, and a return pipeline.

Background

The IID diverts and distributes approximately 2.6 million acre-feet of Colorado River water to nine cities and nearly 490,000 acres of agricultural lands in the Imperial Valley. Imperial Dam is the diversion point on the Colorado River from which water is delivered to users in Arizona, Mexico, and California. Water is conveyed from this point to the Imperial Valley via the 82-mile-long All-American Canal, which was built by the U.S. Bureau of Reclamation in the 1930s. Through this gravity flow canal, the Colorado River water is conveyed to the head of the IID system at Drop No. 1. Several main canals branch off the All-American: the East Highline, Central Main, Westside main, and New Briar Canals. Service to Imperial Valley is provided from these four main canals or from the tributary lateral canals that they supply. A total of 1,675 miles of irrigation canals is within the IID. Five regulating reservoirs with a total storage capacity of 1,904 acre-feet are included within the distribution system.

The Water Control Section of the IID's Water Department is responsible for the transmission of water through the main canal system and its diversion to the laterals for distribution to the users. Water distribution is a complicated task that involves adjusting the appropriate check, delivery,

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and other structures. There are 3,228 check structures and 5,420 delivery structures within the system. A coordinated procedure has evolved to handle this complex distribution process.

Need for Tailwater Recovery Systems.

The district slopes to a previously dry lake (Salton Sea) where agricultural runoff and drainage flows are discharged. About 1 million acre-feet flow into the Salton Sea annually from the district. Water conservation efforts in the district are in response to environmental concerns over increasing water levels of the Salton Sea and the potential reimbursement of conserved water by other Colorado River water users.

IID records indicate tailwater volumes represented 15.6 percent of water delivered to the on-farm level. Records indicate that tailwater amounts vary significantly depending on crop type and irrigation method. Border strip or flat crop irrigation events resemble a sine-wave pattern of tailwater flow (Figure 1a). Furrow and row crop irrigation tends to have flow rates that resemble a bell-shaped curve throughout the irrigation event. Tailwater recovery system designs for border strip fields require less stringent design constraints due to tailwater volumes distributed evenly throughout the irrigation cycle. Growers have successfully implemented tailwater recovery systems on fields using either surface irrigation method. Although this method of water conservation has many benefits, there were potential problems cited by district growers. The five-year study was designed to address those concerns.

Tailwater Recovery Demonstration Program Study

IID collected data throughout the five-year program in order to answer some of the on-farm environmental and economic questions with respect to tailwater recovery systems. To address scalding and salinity issues, the IID performed extensive data collection of the water being utilized to irrigate the selected study fields. To address the amount of water conserved, water

quantity measurements were collected for each irrigation event on each study field during the duration of the program. To address the economic questions, the IID installed the facilities and tracked installation costs as well as annual operation and maintenance costs. Grower interviews were performed near the conclusion of the program to provide qualitative data regarding the performance of the systems. Table 1 is a summary of the growers' responses at the completion of the study.

The focus of this report was to provide quantitative and qualitative analysis of the collected data to answer the primary questions asked about tailwater pumpback systems.

- ❖ Is the operation of a tailwater pumpback system technically and physically feasible given the unique production characteristics of the Imperial Valley?
- ❖ Is irrigation efficiency improved by installation of a tailwater pumpback system?
- ❖ Can water be conserved and how much?
- ❖ What are the water temperature effects of using a tailwater pumpback system?
- ❖ How was the salinity of the water impacted? Was there a buildup of
- ❖ salts in the soil? Was weed control adversely impacted? Were disease problems identified that may have been caused by operation of the tailwater pumpback systems?
- ❖ Were any thefts or acts of vandalism reported during the program?
- ❖ Did the reservoirs create an "attractive nuisance"?
- ❖ How much do tailwater recovery systems cost and what are the associated annual operation and maintenance costs?

A typical district-designed tailwater recovery system consisted of a collection ditch located at the lower end of a sloping surface irrigation system. The collection ditch was connected by an 18-inch-diameter culvert to a storage pond de-

signed to temporarily contain the tailwater flow. Pond storage volume ranged from 3 to 10 acre-feet. A Gorman-Rupp trash pump was located on the bank of the storage pond. A 12-inch-diameter PVC return pipeline connected the pump to the farm head ditch. The capacity of the pond is important in the design of a system and is dependent on such factors as volume of applied water and tailwater, the field acreage served, and the irrigation method practiced.

In order to determine the amount of water conserved by utilization of the tailwater recovery systems, water quantity measurements were evaluated on each of the irrigation events for each of the fields during the entire 5-year program. Measurements included the total volume and rate of water applied, the volume and rate of water returned by the pump, and the amount of water spilled to the drain.

Soil salinity was measured on three occasions during the program. The first sampling took place during the summer of 1985. This provided the baseline data for evaluating the long-term impacts of the pumpback systems. The second sampling took place during the summer of 1988. The last set of data was collected in the winter of 1990. Soil salinity varies through the season due to such factors as increased leaching during the winter months. One of the reasons for the increased leaching during the winter is the decrease in evapotranspiration (ET) demand. The temporary water table or saturated soil condition has an opportunity to leach down through the soil profile during the winter. During the summer, the ET demand is much higher, and saturated soil condition occurs for fewer days with some water actually moving upward from the saline water table to

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supply water for ET. The data was collected during the winter of 1990 to provide additional information on seasonal changes in the soil salinity.

Water salinity and temperature were measured throughout the program with the exception of 1989. Samples were collected from five separate sample locations at each pumpback system. The delivery water was sampled be-

fore mixing with the tailwater. The delivery water was sampled after mixing with returned tailwater. The tailwater at the end of the field was sampled. The pond water was sampled, and a sample was occasionally collected from the tile water discharging to the IID drain. Water electrical conductivity and temperature were measured and transferred to computer media.

Table 2 summarizes the significant results from the data analysis. The results are summarized as follows:

- ❖ 12 percent potential savings of delivered water.
- ❖ Cooperators verified the potential for water conservation using pumpback systems
- ❖ Potential annual irrigation water conservation estimated at 87 acre-feet per 145-acre block. Soil salinity levels varied non-uniformly throughout the program.
- ❖ Changes in soil salinity ranged from a 29 percent increase to a 38 percent decrease. Variation in soil salinity was influenced by soil texture, cropping pattern, irrigation practices, and other unknown variables.
- ❖ Soil salinity levels were highest near the pumpback pond and near the lower end of the fields. They were lowest near the upper end of the fields and close to the water deliv-

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ery points. This is consistent with most fields in the Imperial Valley. Soil salinity levels down the field increased by dissolution of soil salts and lateral salt movement caused by larger wetted perimeters in cracking clay soils.

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- ❖ Scalding was not a problem. The cooperators reported that weed control costs increased slightly. Disease, vandalism, and "attractive nuisance" were not problems.

Conclusions

Analyses of the data generated by the study indicate that tailwater recovery systems are a viable approach to promote agricultural water conservation in the district. Based on the five-year study and interviews with the grower/cooperators, the Tailwater Recovery Demonstration Program study successfully demonstrated the feasibility of the operating tailwater recovery systems in the district.

The estimated capital cost of a system designed by the IID was about \$480/acre (1990 cost basis). The cost estimate includes facilities such as the pumping station, pipelines, and required valving. This cost also reflects pond construction, providing electrical service to the site, and engineering. The annualized system cost is about \$70/acre (1990 cost basis), which includes annualized capital and operation/maintenance. The Metropolitan Water District of Southern California has entered into a 35-year agreement to reimburse the district about \$233 million in exchange for an annual diversion of over 100,000 acre-feet annually. This will involve water conservation on a number of district projects such as concrete lining canals. There is an on-farm water conservation component of the agreement that will fund about 24 additional district-sponsored tailwater recovery systems. The IID is currently installing these systems using the study as the foundation for design and operation criteria.

Reference

Boyle Engineering Corporation, Tailwater Recovery Demonstration Program Study, Special Technical Report for Imperial Irrigation District, September 1990.

