Irrigation District Efficiencies and Potential Water Savings in the Lower Rio Grande Valley of Texas

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Abstract

Agriculture holds about 90 percent of all the water rights in the Lower Rio Grande Valley. Rapidly growing municipalities and industries are focusing the need to free up water for transfer from agriculture. This paper will give the results of an analysis of the 28 irrigation districts including their current efficiencies and opportunities for water savings. The analysis is based on reported efficiencies of each district, GIS-based maps and databases of district infrastructure, measurement of canal seepage losses, accounting systems, etc. Preliminary analysis indicate a potential water savings of 54,000 to 223,000 ac-ft/yr could result from improvements in the conveyance efficiency of 28 districts through renovations such as canal lining and pipeline replacement. Implementing a combination of on-farm practices of metering, gated pipe water delivery, and improved water management and/or technology could result in a water savings of between 98,000 and 217,000 ac-ft/yr.

Background

The Lower Rio Grande Valley in Texas is located at the south most tip of the state at the end of the Rio Grande River. About 98% of all the water used in the Lower Rio Grande Valley, in both Texas and Mexico, is from the Rio Grande River. The region is undergoing rapid population and industrial growth. The Texas Water Development Board projects that by the year 2050, the population in the Valley will more than double, and municipal and industrial water demand will increase by 171% and 48%, respectively.

The lower Rio Grande River is over appropriated; that is, there are more water right permits than firm yield. Agriculture holds about 90% of the water rights and, depending on the year, accounts for about 80% of total withdrawals from the river. Thus, water to meet future demand will likely come from agriculture. The purpose of this study is to determine how much water could be "freed-up" by making improvement in the irrigation systems of the region.

In 1998, the area conducted an Integrated Water Resources Planning (IWRP) effort to identify water needs and sources over the 50 year period 2000 - 2050. This paper summarizes the protion of the project that examined potential water savings in irrigation districts and on-farm irrigation.

Description of the Irrigation Districts

This study examines 28 water districts in Hidalgo, Cameron and Willacy Counties. These districts hold authorized agricultural water rights totaling 1,468,314 ac-ft (Table 1). Based on water rights holdings, the districts vary greatly in size, with the smallest district having 625 ac-ft of water rights and the largest district 174,776 ac-ft. Generally, these districts classify their water distribution networks into two categories: the "mains" and "laterals." The total miles of canals, pipeline and resacas comprising the main irrigation water distribution networks are summarized in Tables 2 and 3. Table 2 lists the total miles of the main canals by size (based on top width) and lining status. Table 3 provides the overall summary the extent of the main distribution networks which include 641.9 miles of canals, 9.7 miles of pipelines, and 44.6 miles of resacas.

Seepage and Conveyance Losses

We conducted a review of the scientific literature on canal seepage losses and improvements in district efficiencies from rehabilitation projects. We only found a few articles that reported seepage rates for different lining materials and soil types. Seepage rates from these studies are summarized in Tables 4 and 5. Table 5 is of particular interest and gives seepage rates measured in five irrigation districts in South Texas, including the United and San Benito Irrigation Districts. Details of the literature search will be given in a later report.

We measured seepage losses in five canals and one pipeline network using the ponding method. This testing was conducted in and with assistance from four districts. The results of the ponding tests are summarized in Table 6. The three lined canals had very high seepage loss rates compared to the scientific literature, indicating problems with their construction or maintenance. The seepage rates of the two unlined canals fell in the ranges reported in the scientific literature. The pipeline network measurements took place in the Brownsville Irrigation District and showed very little seepage during the 24 hour test.

The term *conveyance efficiency* (or *water duty*) is a measurement of all the losses in an irrigation distribution system from the river (or diversion point) to the field. Conveyance efficiency is calculated from the total amount of water diverted in order to supply a specific amount of water to a field (usually 6 inches). Conveyance efficiency is expressed as efficiency, the percent of water lost, or amount of water pumped (in feet). For example, District A must pump 8 inches from the river in order to deliver 6 inches to the field. District A's losses can be expressed as a:

- conveyance efficiency of 75%,
- water duty of 25%, or
- water duty of 0.67 ft.

Table 1. The official and common names of 28 irrigation and water supply districts in the Lower Rio Grande Valley and their authorized agricultural water rights.

Official Name	Common Name	Authorized Water Right (ac-ft)
Adams Gardens Irrigation District No. 19	Adams Garden	18,737
Bayview Irrigation District No. 11	Bayview	17,978
Brownsville Irrigation and Drainage District No. 5	Brownsville	34,876
Cameron County Irrigation District No. 3	La Feria	75,626
Cameron County Irrigation District No. 4	Santa Maria	10,182
Cameron County Irrigation District No. 6	Los Fresnos	52,142

Cameron County Water Improvement District No. 10	Rutherford-Harding	10,213
Cameron County Water Improvement District No. 16	Cameron #16	3,913
Cameron County Water Improvement District No. 17	Cameron #17	625
Cameron County Water Improvement District No. 2	San Benito	151,941
Delta Lake Irrigation District	Delta Lake	174,776
Donna Irrigation District Hidalgo County No. 1	Donna	94,063
Engleman Irrigation District	Engleman	20,031
Harlingen Irrigation District No. 1	Harlingen	98,233
Hidalgo and Cameron Counties Irrigation District No. 9	Mercedes	177,151
Hidalgo County Improvement District No. 19	Sharyland	11,777
Hidalgo County Irrigation District No. 1	Edinburg	85,615
Hidalgo County Irrigation District No. 2	San Juan	147,675
Hidalgo County Water Irrigation District No. 3	McAllen #3	9,752
Hidalgo County Irrigation District No. 5	Progreso	14,234
Hidalgo County Irrigation District No. 6	Mission #6	42,545
Hidalgo County Irrigation District No. 16	Mission #16	30,749
Hidalgo County Irrigation District No. 13	Baptist Seminary	4,856
Hidalgo County Water Control and Irrigation District No. 18	Monte Grande	5,505
Hidalgo County Municipal Utility District No. 1	MUD	1,120
Santa Cruz Irrigation District No. 15	Santa Cruz	82,008
United Irrigation District of Hidalgo County	United	69,491
Valley Acres Water District	Valley Acres	22,500
		TOTAL 1,468,314

Table 2. Canal sizes and lining material for the main irrigation water distribution networks.

Top Width (feet)	**Canal Type (or lining material, miles)**	
	concrete	**earth**

< 10	41.6	1.0
10 - 20	98.0	11.9
20 - 30	25.2	52.2
30 - 40	3.8	35.1
40 - 50	1.1	60.1
50 - 75	1.4	30.9
75 - 100	0	11.1
> 100	0	9.7
Unknown Widths	99	134.5
Total Miles	270.1	346.4

Table 3. Miles of canals, pipelines and resacas for the main irrigation water distribution networks as shown on the Regional GIS Map (Fig. 1).

canals (miles)	pipelines (miles)	resacas (miles)	unknown (miles)	total (miles)
641.9	9.7	44.6	0.1	696.3

Conveyance loss includes a number of factors besides seepage and evaporation. Table 7 shows my classification system for conveyance losses which is composed of Transportation, Accounting, and Operational losses. The conveyance efficiencies as reported to us by 19 districts are listed in Table 8. The remaining 9 districts did not respond to survey and telephone requests for this information. The highest efficiencies are reported in smaller districts with extensive pipeline systems, while the lowest efficiencies are in larger districts which have undergone little rehabilitation. It should be pointed out that most districts do not have good data on their current conveyance efficiencies, and more work is needed to quantify these losses in order to target renovation programs.

We looked at the difference between the existing conveyance efficiencies and the efficiencies that which could reasonably be achieved by the districts through renovation projects. . For the present analysis, we assumed that an efficiency of 80 to 90% was obtainable for most districts. Starting with the conveyance efficiency estimates provided by the 19 districts (Table 8), we calculated the potential water savings if all districts were brought up to 80 and 90% conveyance efficiency. For the 9 districts not reporting efficiencies, we assumed a present value of 75%. **The total potential water savings from conveyance efficiency improvement for all districts is 54,000 to 223,000 ac-ft/yr.**

Water saving potentials were computed for low water use years and high water use years. A low water use year is defined as diversion of 35% of the authorized water right and a high water use year as 80%. Since water-short districts use a higher percentage of their water rights, 45 and 90% were used for low and high water use years, respectively. These portions are based on an analysis of water diversions by each district during the period 1989 - 1997.

There is some question about the accuracy of the basic information used to estimate conveyance efficiency, particularly:

1) the amount of water pumped or diverted into the system, and
2) the actual amount of water delivered to the field.

The doppler flow meters currently used at many river pumping plants were "calibrated" for each site based on estimates of the current pumping rates and/or pumping plant capacity, and on engine/motor and pump performance. Due to the physical layout of the pumping plants, it is difficult to independently verify these rates. Likewise, little metering is done at the field turn-out, and the amount delivered is also an estimate in most districts.

Table 4. Canal seepage rates reported in published studies.

Lining/Soil Type	Seepage Rate (gal/ft^2 /day)
plastic	0.08 - 3.74
concrete	0.06 - 3.22
gunite	0.06 - 0.94
compacted earth	0.07 - 0.6
clay	0.37 - 2.99
loam	4.49 - 7.48
sand	9.34 - 19.45

Sources: Bureau of Reclamation (1963); Nofziger, D.L. 1979. The influence of canal seepage on groundwater in Lugert Lake irrigation area. Oklahoma Water Resources Research Institute, OSU.

Table 5. Canal seepage rates reported in the Lower Rio Grande Valley.

Soil Type	Seepage Loss Rate (gal/ft^2 /day)
clay	1.5
silty clay loam	2.24
clay loam	2.99
silt loam earth	4.49
loam	7.48
fine sandy loam	9.35
sandy loam	11.22

Source: Texas Board of Water Engineers. 1946. Seepage Losses from Canals in Texas, Austin. July 1.

Table 6. Seepage rates measured by the DMS Team in 5 irrigation canals in the Lower Rio Grande Valley.

Test	Canal	Top	Length (ft)	Seepage Rate	Total Loss in Canal

#	Type	Width (ft)		(gal/ft^2 /day)	(ac-ft/mile)	
					per day	per year*
1	concrete	19	2557	4.28	0.81	243
2	earth (clay)	38	3342	1.62	0.82	246
3	earth (sandy clay loam)	45	6336	1.69	1.05	315
4	concrete	12	2583	2.12	0.20	60
5	concrete	12.5	9525	2.49	0.25	75

*based on 300 days per year.

Table 7. Classification of the sources of water loss in irrigation districts.

Transportation	Accounting	Operation
seepage in main, unlined canals seepage in secondary territory unlined canals (laterals) leakage from lined canals leakage from pipelines evaporation (canals and storage reservoirs)	accuracy of field-level deliveries (estimates of canal riders/irrigators) unauthorized use metering at main pumping plant water rights accounting system	charging empty pipelines and canals spills (end of canals) partial use of water in dead-end lines

Table 8. Estimated conveyance efficiency as supplied by 19 districts.

District	Conveyance Efficiency (%)	District	Efficiency (%)
Adams Garden	85	HCMUD	90
Bayview	85	HCWID#3 (McAllen)	90
Brownsville	90	HCWID#5 (Progresso)	92
CCID#2 (San Benito)	40	HCCID#9 (Mercedes)	75
CCID#6 (Los Fresnos)	60	HCID#16 (Mission)	85
Delta Lake	75	HCWCID#18	95
Donna	58	La Feria IDCC#3	75
Harlingen	85	Santa Cruz ID#15	75
HCID#1 (Edinburg)	80	Santa Maria IDCC#4	75

HCID#2 (San Juan)	77		

On-farm Potential Water Savings

On-farm irrigation efficiency is defined as the ratio of the amount of water needed to grow the crop to the amount of water delivered to a field. The amount of water needed to grow a crop is usually estimated from ET (evapotranspiration) data as adjusted for beneficial rainfall and leaching requirements. Generally, surface irrigation systems, such as found in the Lower Rio Grande Valley, have low efficiencies and ranges from 30 to 80%. Generally, we expect on-farm surface irrigation efficiencies of 60 - 70%. Various practices and field improvements can increase this efficiency to 70 - 80%, or even higher with good management and improved technology.

Table 9 provides the observed water savings reported in 4 districts (Bayview, Brownsville, Delta Lakes, San Benito) from recent experiments with layflat tubbing replacement of siphon tubes and on-farm metering. In some cases, improved technology or water management were also implemented. The numbers reported for Donna and La Feria are for metering only. It should be noted that hard data to support many of these observations do not exist.

These observations and supporting information show that significant water savings at the farm level are possible in the Lower Rio Grande Valley. However, one major limiting factor is that in about half of the area, water is delivered to the field with inadequate "head" (insufficient volume and/or pressure) to allow for efficient furrow irrigation. Without improvements in the distribution systems, on-farm water saving potential in about half the irrigated land will be limited.

For the analysis used in the IWRP project, we classified potential on-farm water savings into three components:

1) metering,
2) gated pipe replacement of field ditches and siphon tubes, and
3) high water management and/or improved irrigation technology.

Table 10 gives the expected range of water savings for each practice and the factor used in this analysis. Table 11 summarizes the assumptions used in applying these factors to this region. For example, the first two factors (metering and gated pipe) were not applied to the area currently under the practice. In addition, benefits from high water management were not applied to the half of the area with head problems. Increased on-farm efficiency can only be achieved in these areas by improvements in the distribution systems and/or adoption of pumped and pressurized irrigation systems such as drip and sprinkler irrigation. On-farm water saving potential were calculated for high and low water use years as discussed above. **The results are a potential on-farm water savings of 98,000 to 217,000 ac-ft/yr.** However, an intensive technical assistance and education program would be needed to achieve such savings.

Table 9. Water savings observed or estimated from metering and poly pipe experiments during the 1990s in the Lower Rio Grande Valley.

district	water savings observed
Bayview	36%*1*

Brownsville	33%*1*
Donna	20%*2*
La Feria	10%*2*
Delta Lakes	33%*1*
San Benito	40%*1*

1 may include additional benefits from implementing improved on-farm water management practices or due to changes in irrigation technology
2 metering only

Table 10. Factors used for calculation of on-farm water saving potential in the IWRP Project.

technique	expected water savings	factor used
metering	0 - 15 %	10 %
poly/gated pipe replacement of field ditches/siphon tubes	5 - 20 %	10 %
high management/improved irrigation technology	10 - 30 %	20 %

Table 11. Assumptions for applying water savings factors in Table 16 to the Lower Rio Grande Valley.

technique	assumptions for calculations
metering	- adopted Valley-wide by 2010 - 20% of land area is assumed to be metering - factor applied to remaining 80%
poly/gated pipe	- adopted by 90% of Valley by 2010 - approximately 50% of Valley already using gated/poly pipe - factor applied to remaining 40% of Valley not currently using poly/gated pipe (0.9 - 0.5 = 0.4)
high management/improved irrigation technology	- adopted on half of Valley by 2010 - approximately 20% of area currently under high management or using improved technologies - factor applied to 30% of area (0.5 - 0.2 = 0.3)

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