Canal Ponding Test Results
Harlingen Irrigation District No.1
Harlingen, Texas

July 2000

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Ponding Test Results Summary

Seepage loss tests preformed in the Rio Grande Valley were extremely high, ranging from 90 to 1220 ac-ft/mi./yr. Generally, the highest seepage losses occurred in the smaller lined canals. High concrete canal seepage losses indicate that improper construction methods and materials are being used in the region and/or canals may have inadequate maintenance programs.
The unlined canals have seepage loss rates similar to those reported in the scientific literature by soil type, and range from 54 to 1037 ac-ft/mi./yr. We found no clear relation between visual condition and seepage loss for the unlined canals. However, for the lined canals, there was a clear relation, particularly for canals rated 5 or less (on a scale of 10).

Table 1. Ponding Test Results for Harlingen Irrigation District No.1

Test	Segments	Canal Type	Soil Type	Canal[1] Rating	Top Width (ft)	Length (ft)	Seepage Rate (gal/ft²/day)	Total Loss in Canal (ac-ft/mile) per day	per year[2]
1	canal 1, sec 2	lined	sandy loam	7.2	15	7300	1.25	0.25	73.89
2	Bowman & Sec B-B	lined	sandy loam	4.4	9	1890	3.61	0.59	177.00
P2-1[3]	HPh2	lined		6.6	38	3342	1.42	0.77	231.43

[1] on a scale of 10 to 1.
[2] based on 300 days of operation per year.
[3] test is from the Phase II Study and is not reported further in this report.

Ponding Test Procedures

1). We walked the canal test section to measure the length using a measurement wheel. We also completed the canal rating survey, took photos, and looked for leaks occurring from open valves and/or large cracks that were not representative of the canal lining. Those were then sealed.

2) Six and 8 staff-gages were placed at equal distances along the canal test section. Two locations were equipped with pressure transducers on test#2, which served as staff gage.

3) The canal test section was filled to normal operating capacity and shut down for the 24-hour test.

4) Before the test began, time was allowed to inspect and seal the check structures to prohibit any further flows into the test section. Check structures used include dirt dams, wooden side gates, and steel-plated valves. As additional sealant, dirt was back-filled around the check structures.

5) Staff-gage readings were taken every 60 minutes for the first 2 to 3 hours and for the last 2 to 3 hours on the hour for the 24-hour test.

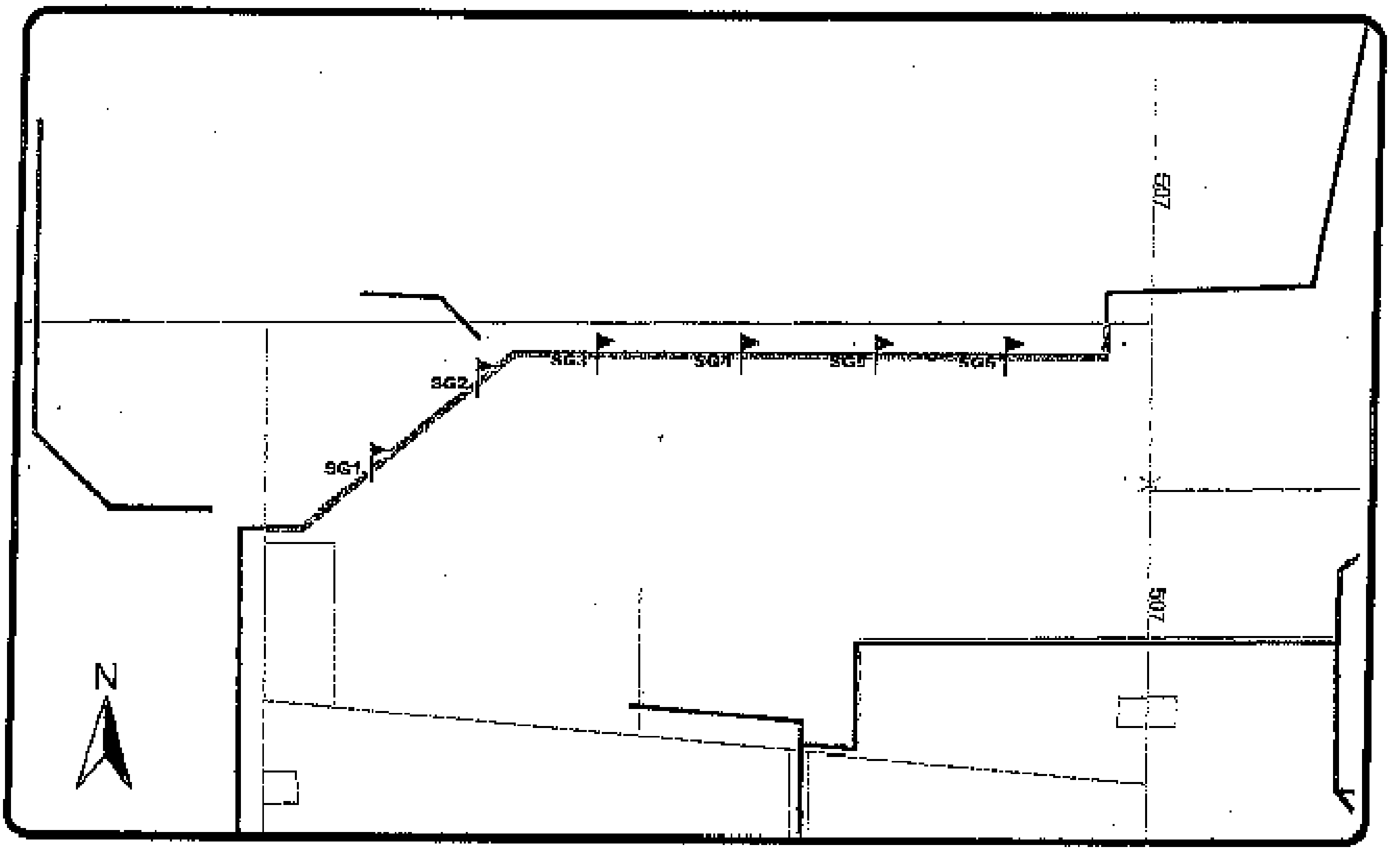
6) During the course of the test, canal dimensions were recorded including top width, bottom width, total depth, side slope angle, and cross-sectional shape. For earthen canals an average top width was calculated, and the bottom width estimated using the other canal dimensions.

Harlingen Test 1

January 31 – February 1, 2000

Harlingen - Ponding Test 1

January 31 - February 1, 2000



Staff Gage

Test Section

canal #1 sec2

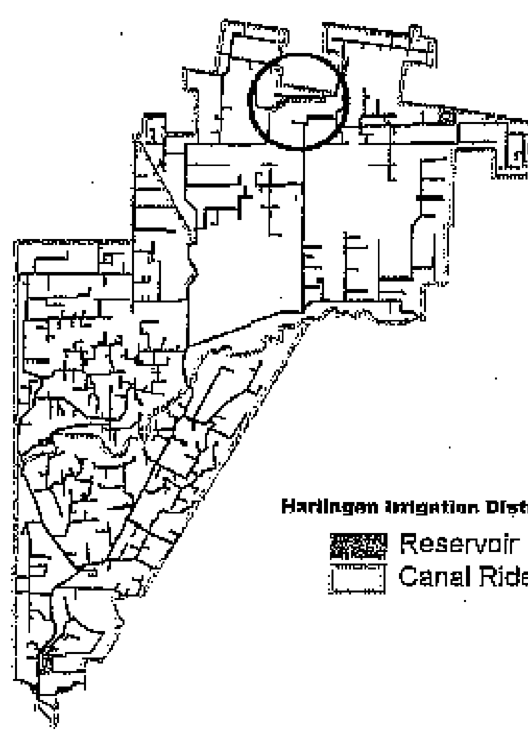
Conveyance System

canal

pipe

Roads

Projection: UTM, zone 14
Datum: NAD 83
Units: Meters



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July 2000

0 0.4 0.8 1.2 Miles

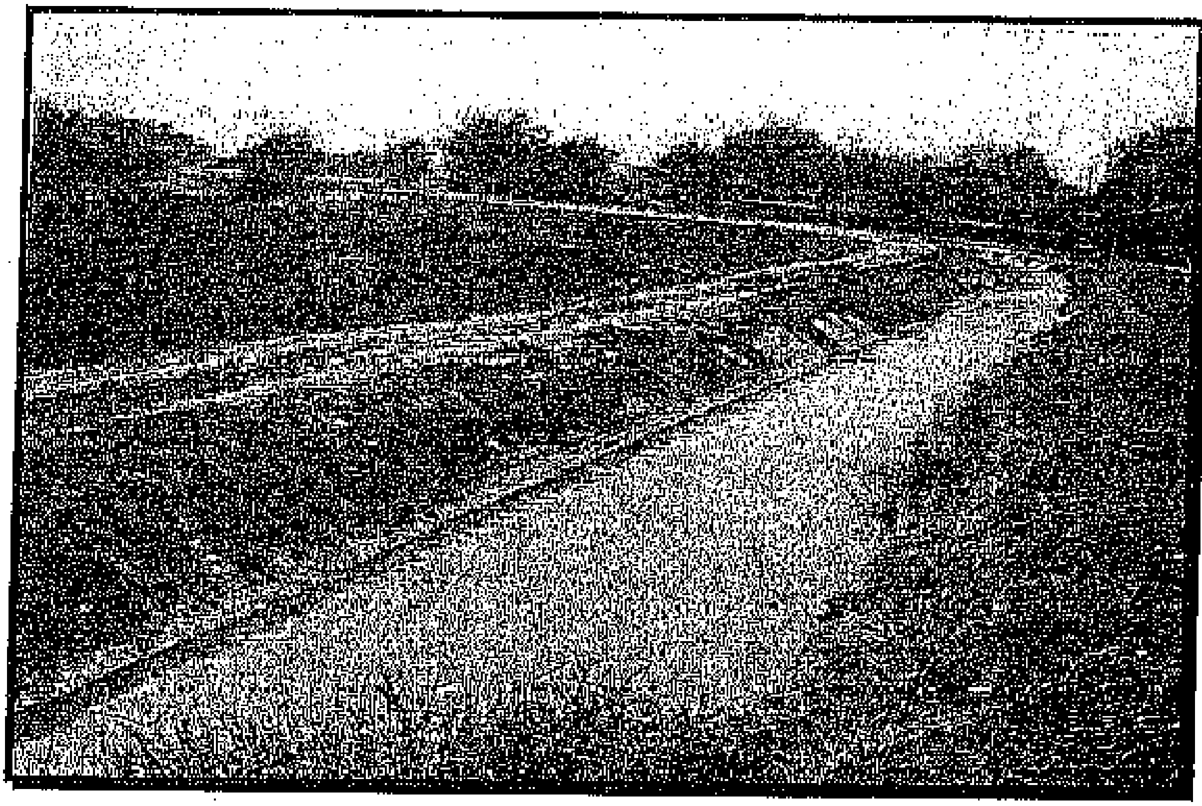


Table 2. Canal Rating[4]

Scale	lining condition	cracks/holes	frequency of cracks/holes	vegetation
1 to 5	2	2	3	2

Table 3. Rating Totals

Scale	Overall Rating
4 to 20	9
10 to 1	7.2

[4] See Canal Rating Chart in Appendix

Test 1. Information and Field Measurements

District: **Harlingen Irrigation District No.1**
Test ID: **Harlingen 1**
Canal: **#1, sec 2** Lining Type: **Concrete**
Location: **West of 507, south of Templeton Rd., and east of Goodwin Rd.**
Test Date: **January 31 – February 1, 2000**
Start Time: **2:00pm** Finish Time: **2:00pm**

Canal Dimensions

Cross Section: **Trapezoidal**
Top Width(ft): **15.0**
Bottom Width(ft): **6.0**
Total Depth(ft): **4.5**
Side Slope: **1:1**
Segment Length(ft): **7300**
Soil Type: **fine sandy loam**
Overall Canal Rating: **6.1**

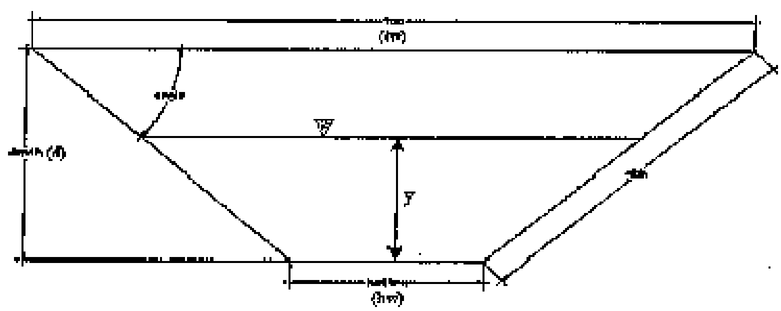


Table 4. Staff Gage Readings (feet above bottom)

Date	Time	SG1	SG2	SG3	SG4	SG5	SG6
31-Jan	2:00 PM	2.375	2.4375	2.3958	2.0833	1.9375	1.8125
	3:00 PM	2.3541	2.4375	2.375	2.0833	1.9271	1.8125
	4:00 PM	2.3541	2.4271	2.3646	2.0781	1.9219	1.7917
	5:00 PM	2.3437	2.4219	2.3437	2.0729	1.9219	1.7917
1-Feb	11:00 AM	2.2917	2.375	2.3125	2.0	1.8541	1.7292
	12:00 PM	2.2917	2.375	2.3125	2.0	1.8541	1.7292
	2:00 PM	2.2708	2.3437	2.2917	2.0	1.8541	1.7292
Segment Length (ft)		1564	1043	1043	1043	1043	1564

Table 5. Average Unit Area Loss Rate

Ft^3/ft^2/hour	Ft/day	In/day	Gal/ft^2/day	Acre-ft/mile/year[5]
0.0070	**0.17**	**2.01**	**1.25**	**73.89**

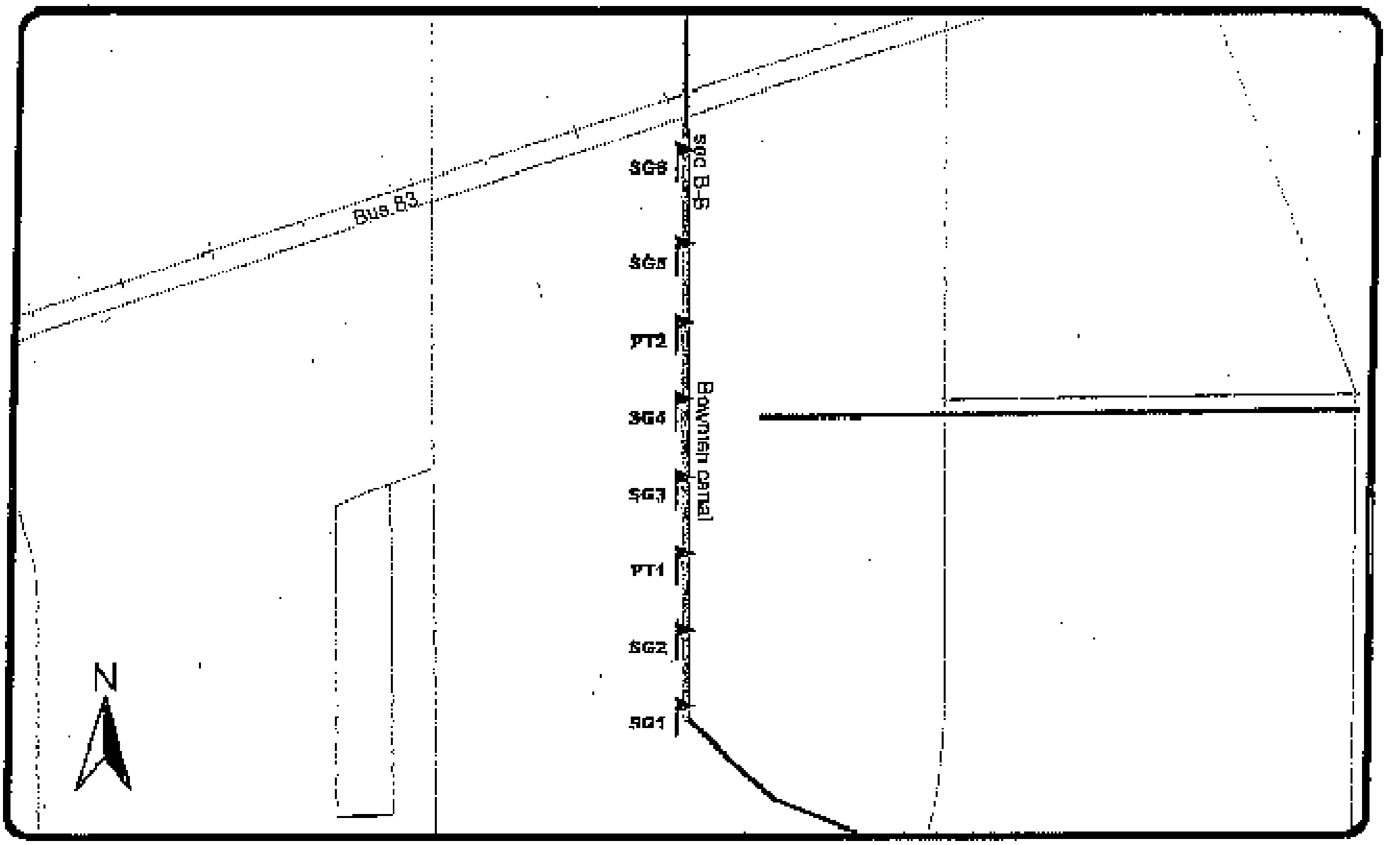
[5] Based on 300 days of operation per year.

Harlingen Test 2

February 29 – March 1, 2000

Harlingen - Ponding Test 2

February 29 - March 1, 2000



Staff Gage

Test Section

Bowman canal

sec B-B

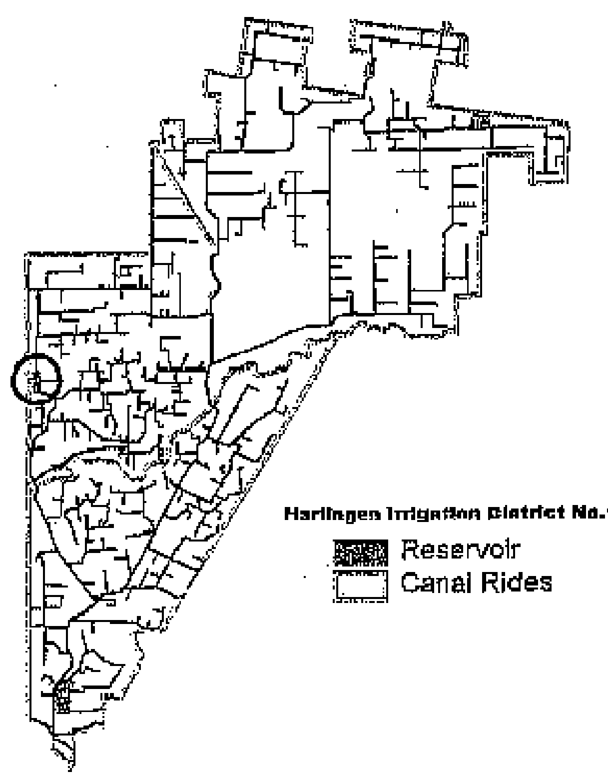
Conveyance System

canal

pipe

Roads

Projection: UTM, zone 14
Datum: NAD 83
Units: Meters



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0 0.2 0.4 0.6 Miles

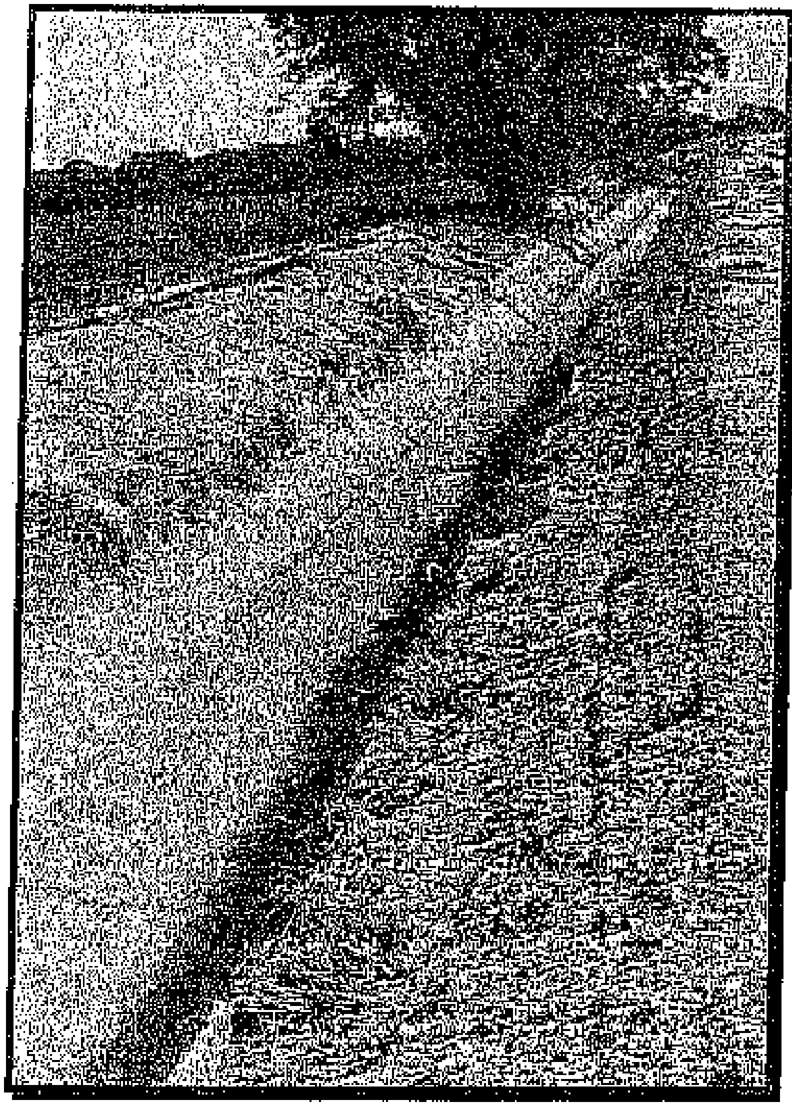

Table 6. Canal Rating[6]

Scale	lining condition	cracks/holes	frequency of cracks/holes	vegetation
1 to 5	4	4	5	1

Table 7. Rating Totals

Scale	Overall Rating
4 to 20	14
10 to 1	4.4

[6] See Canal Rating Chart in Appendix

Test 2. Information and Field Measurements

District: **Harlingen Irrigation District NO.1**
Test ID: **Harlingen 2**
Canal: **Bowman & sec B-B** Lining Type: **Concrete**
Location: **South of Business 83 and west of Baker Potts**
Test Date: **February 29 – March 1, 2000**
Start Time: **12:30pm** Finish Time: **1:30pm**

Canal Dimensions

Cross Section: **Trapezoidal**
Top Width(ft): **9.0**
Bottom Width(ft): **1.33**
Total Depth(ft): **4.0**
Side Slope: **1:1**
Segment Length(ft): **1890**
Soil Type: **sandy loam**
Overall Canal Rating: **4.4**

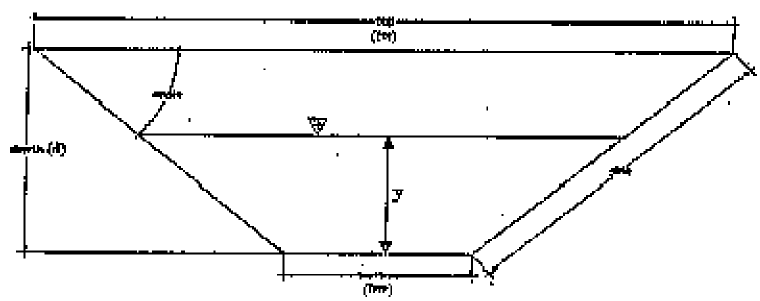

Table 8. Staff Gage Readings (feet above bottom)

Date	Time	SG1	SG2	PT1	SG3	SG4	PT2	SG5	SG6
29-Feb	12:30 PM	3.3125	3.4062	3.0208	3.2917	3.2708	2.6458	3.0	2.8021
	2:30 PM	3.25	3.3541	2.9896	3.2396	3.2396	2.5937	2.9792	2.7604
	3:30 PM	3.2396	3.3333	2.9584	3.2084	3.2292	2.5833	2.9584	2.75
	4:30 AM	3.1875	3.3229	2.9375	3.1875	3.198	2.5625	2.9271	2.7188
1-Mar	11:30 AM	2.8854	2.9792	2.6041	2.8541	2.8541	2.2292	2.5937	2.3646
	1:30 PM	2.8333	2.9375	2.5833	2.8333	2.8333	2.2084	2.5625	2.3333
Segment Length (ft)		135	405	540	540	540	540	404	134.5

Table 9. Average Unit Area Loss Rate

$Ft^3/ft^2/hour$	Ft/day	In/day	$Gal/ft^2/day$	Acre-ft/mile/year[7]
0.02	**0.48**	**5.76**	**3.61**	**177**

[7] Based on 300 days of operation per year.

Acknowledgements

DMS TEAM

Support provided by the DMS (District Management System) team of:

Stewart Beall, Research Agricultural Technician (former)
Kenneth Carpenter, Research Agricultural Technician (former)
Bryan Treese, Computer Programmer (former)
Raul Garcia, Student Technician (former)
Craig Pope, Extension Assistant

HARLINGEN IRRIGATION DISTRICT No.1

The district office personnel and canal riders provided helpful planning and assistance in canal ponding testing.

Appendix

LINED CANALS RATING SYSTEM

Lining Condition
1. excellent
2. good
3. fair
4. poor
5. serious problems

cracks/holes - size
1. a few hairline cracks
2. hairline to pencil size
3. predominately pencil size
4. pencil size and a few large cracks
5. predominately large cracks

Frequency of cracks
1. sparse
2. greater than 10' apart
3. 5' to 10' apart
4. 3' to 5 ' apart
5. less than 3' apart

Vegetation in Drainage Ditch or along base of embankment
1. normal; rain-fed weeds only
2. above average
3. moderate
4. dense
5. dense and lush

Overall Scale: 4-20

November 13, 2000

THE VALUE OF APPLIED IRRIGATION WATER AND THE IMPACT OF SHORTAGES ON RIO GRANDE VALLEY AGRICULTURE, 2001

Texas Water Development Board

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THE VALUE OF APPLIED IRRIGATION WATER AND THE IMPACT OF SHORTAGES ON RIO GRANDE VALLEY AGRICULTURE, 2001

Purpose. This study examines the economic costs to the Lower Rio Grande Valley (LRGV) region of curtailed irrigation water supplies. This paper is a collaborative effort by the Texas Water Development Board (TWDB), the Department of Agricultural Economics, Texas A&M University, and the Texas Water Resources Institute at Texas A&M University.

Water Deficits. Irrigation water shortages in the LRGV region have occurred in recent years and are again predicted for the upcoming 2001 agricultural season. These shortages are due to multiple drought years and an accumulated water supply deficit by Mexico since 1992. Recent engineering studies have concluded that Mexico has not met its requirement to release an average (over five years) of 350,000 acre-feet of water into Rio Grande tributaries during, and prior to, the latest five-year cycle[1] as stipulated by the international treaty of 1944. The impact of these deficits on LRGV agriculture were not immediately felt as the remaining irrigation water supplies in the reservoirs were consumed. Irrigation supply shortages have since occurred as water demands exceeded the available supplies, which had been drawn down during the deficit years. Recent impacts are very apparent in reduced acreages and production of some crops. Historical data on crop irrigation in the LRGV region and the agricultural sector's interaction with the regional economy imply that irrigation water shortages would have major economic impacts to the regional economy, as shown in the following table (see the Appendix for more discussion on methodology).

Table 1. Annual Impact/Acre-Foot of Applied Irrigation Water in the Deficit Period.

1. Total regional loss in business activity		**$652**
including:	a. Direct loss of crop sales	$318
	b. Total loss in gross regional product	$282
	c. Total loss in income to business and persons	$219
(Note: Items a-c are not additive, but are overlapping components of the total $652/acre-foot.)		
2. Total loss in full-time equivalent employment		**0.02 jobs**

Forecast. These figures form the basis for analyzing the economic impact of not having a given quantity of irrigation water *at the farm gate*. An evaluation based on Mexico's historical deficits is beyond the scope of this study due to complicating factors such as evaporation and transmission losses and possibly other uses of the water at numerous points in time. Section 2 presents an analysis of the aggregate economic impact of identified water shortages (with some simplifying assumptions about transmission and evaporation losses). Section 3 discusses how these aggregate economic impacts translate to the local level.

[1] R. J. Brandes Company. "Preliminary Analysis of Mexico's Rio Grande Water Deficit Under the 1944 Treaty". February 17, 2000.

Section 2. Analysis of Identified Shortages

Table 2 below identifies a range of water quantities representing potential Mexican releases into the U.S. Rio Grande River reservoir system. The deficit for the 1992-97 cycle was 1,024,000 acre-feet. Unless Mexico immediately starts making substantial payments, the cumulative deficit is projected to grow to approximately 2,000,000 acre-feet by October 2, 2000 (the end of the latest five year cycle). Thus, Mexico must deliver approximately 1,000,000 acre-feet in each of 2001 and 2002 to meet its treaty obligations. Table 2 shows the average annual economic impact of 1,000,000 acre-feet of irrigation water, compared to the 350,000 acre-feet average minimum annual release required from Mexico over a five year cycle. The range of reservoir amounts around these extremes are included for illustration. For any given release amount, there is an assumed 24% loss through evaporation, diversion losses, and transportation losses (see Appendix) to estimate the quantity available to LRGV growers for irrigation purposes (Column 2). The economic impacts in Columns 3 and 4 are based on the quantities in Column 2.

Table 2. Economic Impact of Identified Quantities of LRGV Irrigation Water.

Identified Quantify in Reservoirs	Estimate Amount Available to LRGV Growers	Value in Terms of Gross Business Activity (Direct and Indirect Effects)	Value in Terms of Full Time Equivalent Jobs
(acre-feet)	*(acre-feet)*	*(dollars per year)*	*(jobs per year)*
1,000,000	765,000	$498,780,000	15,300
900,000	688,500	$448,902,000	13,770
800,000	612,000	$399,024,000	12,240
700,000	535,500	$349,146,000	10,710
600,000	459,000	$299,268,000	9,180
500,000	382,500	$249,390,000	7,650
400,000	306,000	$199,512,000	6,120
350,000	267,750	$174,573,000	5,355
300,000	229,500	$149,634,000	4,590
200,000	153,000	$99,756,000	3,060
100,000	76,500	$49,878,000	1,530

Business Activity & Employment. Column 3 shows the annual dollars of gross business activity generated from production and sale of irrigated LRGV crops assuming application of the irrigation water amounts shown in Column 2. The gross business activity is a measure of the sales and billing receipts (not net sales) of all sectors of the LRGV regional economy. This measure incorporates the "farm gate" value of agricultural production as well as indirect, "up-stream" impacts on agricultural supply businesses sales. Irrigated LRGV agriculture is obviously very significant in terms of the regional economy. This analysis implies that if Mexico fails to release the required 1,000,000 acre-feet in 2000 and 2001, the four county LRGV region would lose an average of $498,780,000 in gross business activity in each of those years. The employment impacts are measured in jobs, defined as person-years of labor. Consequently, one *job* could represent more than one person, because the measure is in terms of full-time equivalents (FTEs). Many part-time workers are used in agriculture, so the actual numbers of people affected may be larger than the number of jobs reported. As a rule, one FTE agricultural related job is accounts for about three seasonal workers, i.e., triple the social impact.

Section 3. Local Incidence of Economic Impacts

The economic impacts in Section 2 will vary considerably across individual water districts with their own specified water rights. Table 3 illustrates the impact for selected districts with predominately irrigation uses. A comparison of projected 2001 water supplies with 1996, an extreme drought year, shows a 52% reduction in irrigable acres in 2001 relative to 1996 for these selected districts. The upcoming crop year is shaping up to be worse than the worst of the recent drought years in terms of irrigation water availability. An examination of Table 3 shows that these shortages are spread unevenly across districts, with some districts having no water for most or all of their irrigated agricultural land. The estimated losses in gross business activity and employment from Section 2 will be felt more severely in those districts with greater reductions. For example, those districts with over 90% reductions in water availability will have pronounced shifts away from high value irrigated crops like vegetables, citrus, sugarcane, and irrigated cotton. As a result, the employment losses and business activity losses will occur more heavily in these areas. In the long run, these tracts will lose their irrigated classification for property tax purposes. Property tax assessment from dryland is lower than from irrigated land, implying serious public finance implications from prolonged shortage situations.

Table 3. Projected Water Balances and Declines in Irrigated Acreage for Selected, Predominantly Agricultural Irrigation Water Districts in 2001 Relative to 1996.

Irrigation District	Authorized Water Rights (acre-feet)	Projected District Usage Balance Jan. 1, 2001[2] (acre-feet)	Inches of Water Needed to Irrigate One Acre (including diversion loss)	Projected Irrigable Acres as of Jan. 1, 2001	Irrigable Acres During 1996	Change in Irrigable Acres from 1996 to 2001	Percent Decline in Irrigable Acr since 1996
ADAMS GARDEN	18,737	2,560	7.35	4,180	7,494	-3,314	-44%
SAN BENITO	147,823	8,061	14.44	6,699	75,000	-68,301	-91%
LOS FRESNOS	52,141	0	12.53	0	15,000	-15,000	-100%
VALLEY ACRES	22,500	2,628	9.48	3,327	7,948	-4,621	-58%
MERECEDES # 9	177,151	15,659	8.4	22,370	55,000	-32,630	-59%
HARLINGEN	98,052	15,007	9.24	19,490	39,000	-19,510	-50%
LA FERIA # 3	75,625	0	11.04	0	27,500	-27,500	-100%
SANTA MARIA	10,182	736	11.04	800	3,700	-2,900	-78%
DONNA	94,063	29,607	7.66	46,382	32,000	14,382	45%
ENGLEMAN	20,031	10,326	9.24	13,410	7,761	5,649	73%
SANTA CRUZ #15	77,180	27,962	9.48	35,395	46,709	-11,314	-24%
H.C.I.D. # 19	11,776	0	9.48	0	5,000	-5,000	-100%
BAYVIEW	17,478	5,078	1.27	3,998	6,000	-2,002	-33%
DELTA LAKE	174,776	57,916	1.77	32,721	70,000	-37,279	-53%
H.C.I.D. # 5	14,234	3,863	0.95	4,066	5,700	-1,634	-29%
			TOTALS:	192,837	403,812	-210,975	-52%

[2]Derived by subtracting Oct.-Dec. 99 usage from Sept. 00 balance. Personal communication, Gordon Hill, Bayview Irrigation District.

APPENDIX

Assumptions, Methodology, and Limitations

Concepts. The approach to estimating the regional economic value of lost crop production, in this report, is termed *opportunity cost* analysis by economists. The "costs" of not producing are expressed as foregone regional economic activity that could have otherwise enhanced the region's gross regional product (value added), income and employment. A major underpinning of this analysis is that the loss of confidence that there will be any future Mexico inflows up to the minimum required by the treaty 350,000 acre-feet causes growers to curtail production. This is evidenced by recent trends in irrigated production. Even though some production was occurring during the deficit period, it was at lower and lower levels due both to a prolonged drought and the lack of expected inflows in the river. The initial task at evaluating the opportunity cost from this curtailment is to value the use of the water in a normal production year.

Data Development. The direct impact of irrigation water on the regional economy is based on an estimate of the total value of production per acre-foot of water, assuming that acreage is allocated among crops as if producers made cropping decisions anticipating no shortages of irrigation water. Crop yields per acre and crop prices are based on annual county or regional estimates published by Texas Agricultural Statistics Service. The value of output per acre for each crop is multiplied by the percentage of crop land assumed to be devoted to that crop, and these values are then summed across all crops to find the value of irrigated output for a "composite" acre of land. This typical acreage represents a conservative estimate of the value of using the irrigation water because in the likelihood that farmers have a more plentiful supply of water they would irrigate more valuable crops than, say, cotton or grain sorghum. The intent here is to show that the historical water deficits could have been used <u>at least</u> in the crop mix that was actually irrigated. The composite acre uses cotton (34.3%), sorghum (23.8%), citrus (8.8%), sugar cane (8.6%), corn (5.6 %), forages (4.5%), and vegetables and other crops (14.4%). The gross values per acre, per crop were first divided by their respective water use (acre-feet), to obtain gross value per acre-foot for each crop. This set of values was then multiplied by the acreage proportions and summed to obtain the weighted (by acreage) gross value per acre foot for the composite acre. The results are an estimate of the average direct economic impact on crop sales of an acre-foot of water used for irrigation in the region.

Another key assumption in this analysis was the relationship between water quantities in the reservoir system and irrigation supplies delivered at the LRGV farm gate. For this analysis, it was assumed that reservoir evaporation losses were 3%, river transportation losses were 8%, and 13% conveyance losses within Districts, for a total estimated loss of 24%.

Macroeconomic Analysis. All region-wide impacts on business activity, employment and income are derived from the estimates of direct production losses from the irrigated agriculture sector in the region. In its Senate Bill 1 work, the TWDB Planning Division has developed models of the water planning regions of Texas, using the IMPLAN software. These regional input-output models provide data showing the buying and selling linkages among all sectors in the economies, ultimately producing "multipliers" that allow calculations of the indirect changes on the regional economy caused by changes in individual sectors of the economy. These multipliers estimate the effect of increases or decreases in demand for goods and services on all the region's sectors.

Limitations. The procedure for calculating direct impacts (lost potential crop production) results in average, not marginal, value of water estimates. In practice, at the margin, producers notified of a reduction in anticipated water availability *after planting decisions have been made* would first reduce or eliminate irrigation of crops returning a lower value, and would eliminate irrigation of higher valued crops only in the event of larger water restrictions. Thus, the estimate of the average value of water may be higher than the marginal value, particularly in the instance of a relatively small shortage. Alternatively, if an anticipated shortage were announced *in advance of planting decisions*, producers would be more likely to first reduce acreage of crops requiring more intensive irrigation and producing higher values. In this case, the average value could be considerably less than the marginal value.

The regional economic impact of a water shortage on all businesses (Section 2) may be understated two reasons. First, the analysis assumes that farmers would have used the water that they did not receive in the same pattern as the water that they actually used in each year of the historical period. More likely, farmers assured of adequate water supplies would have expanded irrigated acreage of the higher valued crops (sugarcane and vegetables) and not the lower valued crops of cotton and grain sorghum. The value of sales from acreage of sugarcane and vegetables is significantly higher than the average of all crops as shown in the historical composite acre. Hence, the direct impacts of water shortage are likely understated. The second reason is that the analysis does not take into account any "forward linkages", the value of economic activity generated by the local processing of local farm products. Rather, the indirect impacts presented in this report account only for the interactions of farmers and their suppliers those to whom they pay for goods and services. Some level of impact exists if local food or feed processors lose local raw materials, but data are not sufficient for the analysts to estimate this phenomenon in this region. Most processing of raw farm products is thought to occur outside of the Rio Grande Valley region. However, the processing does take place throughout Texas and the United States and lost processing would cause impacts in those locations.

The farm impacts represent the best estimate of a typical irrigation crop mix in the region and can not be used to determine specific local farm damages as would be done in an analysis of disaster loss. This analysis should only be used only to provide a macroeconomic (regional) view of economic development that was prevented from benefitting the region because of the deficits. More extensive research and resources are needed to provide interested parties with data that could show actual, detailed damages done, either on-farm or area wide.