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Water Loss Test Results for the West Main Pipeline United Irrigation District of Hidalgo County

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Texas Water Resources Institute
make every drop count

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United Irrigation District of Hidalgo County

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IRRIGATION TECHNOLOGY CENTER
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Summary

In 2004, United Irrigation District of Hidalgo County (United) replaced 1.7 miles of their West Main Canal with underground reinforced concrete pipeline (Figure 3). The West Main, a concrete lined canal (Figure 1), meanders northward for approximately 10 miles, beginning at the district's 3rd re-lift pump station at 2 Mile Road and just east of Inspiration Road. Over this stretch, the canal reduces in capacity and narrows in top width from 24 to 3.5 feet.

Figure 1. West Main Canal

Prior to the pipeline installation, water loss tests were conducted on three segments of the canal using the ponding test method to measure seepage. The ponding tests took place during July 2001 and February 2002, respectively.

The water loss rates for the West Main Canal were measured between 2.11 – 2.29 gal/ft^2/day, or 132.2 – 214.3 ac-ft/mi/yr. Table 1 summarizes the test results using methods commonly used for characterizing water loss from canals.

After completion of the new pipeline and at the district's request, we started a series of water loss tests to evaluate the performance of the pipeline and document the water savings. Currently, six tests have been conducted between March 2004 and August 2006. Table 2 summarizes the test results.

The first two tests were conducted in March and May of 2004 with water losses measured at 26,402 and 40,990 gal/mile/day, or projected annual losses of 30.0 and 46.0 ac-ft/mi/yr, respectively. When compared to losses measured from the original canal we see an average water savings of 78%. While this would be considered much improvement, the district's expectations for their new pipeline were higher.

Following minor repairs, due to the apparent leakage occurring along side of the pipeline (shown in figure 2); we retested the pipeline in July 2004 and again in May 2005 and August 2006. Test results found that losses were reduced on average by 1448 gal/mile/day or a projected annual loss of 1.6 ac-ft/yr; a 95.7% water loss reduction compared with Test 2, and as much as **99% savings** when compared to the original canal losses.

Figure 2. Visible leaks shown after construction

Table 1. Water Loss Test Results for the West Main Canal.					
Test ID	Test Date	Top Width (ft)	Water Loss Rates		
			gal/ft2/day	gal/mi/day	ac-ft/mi/yr*
UN1	July 2001	11.79	2.29	192,252	214.3
UN2	July 2001	8.17	2.11	117,306	132.2
UN3	Feb. 2002	18.46	2.11	149,891	167.8
Average			2.17	153,150	171.4

* Annual water amounts given are based on an in-service of 365 days.
Note: For further information on these three tests, the complete report is posted at http://idea.tamu.edu

Table 2. Water Loss Test Results for the West Main Pipeline					
Test No.	Test Date	Avg. Δ in Total Depth (ft)	Total Volume Loss (ft^3)	Water Loss Rates	
				gal/mi/day	ac-ft/mi/yr*
1	Mar. 2004	1.71	367	26,402	30
2	May 2004	2.53	580	40,940	46
The following tests were conducted after the segment was patched.					
3	July 2004	0.11	18	1,119	1.3
5	May 2005	0.16	27	1,839	2.1
6	August 2006	0.12	20	1,407	1.6
Average		0.13	22	1,455	1.7

* Annual water amounts given are based on an in-service of 365 days.
Note: Data from Test #4 was not used as it was inconsistent, indicating measurement problems/errors.

Table 3 shows an estimated error range of the rate of drop in water level per hour and seepage loss rates. Error range is calculated by ± 1/2 inch of the beginning and ending measurements or a ± 1 inch total change in depth.

Table 3. Water Loss Results with Estimated Error Range [Total Δ Depth ± 0.083 (ft)]					
Test No.	Error Range	Seepage Loss Rate			
		(gal/mile/day)		(ac-ft/mile/year)	
	Avg. Δ Depth(ft/hour)	Low	High	Low	High
1	1.166 ± 0.057	25101	27702	28	31
2	1.693 ± 0.056	39604	42278	44	47
The following tests were conducted after the segment was patched.					
3	0.063 ± 0.050	232	2006	0.3	2.3
5	0.104 ± 0.054	890	2805	1.0	3.1
6	0.080 ± 0.055	431	2481	0.5	2.8
Average	0.082 ± 0.053	518	2431	0.6	2.7

Note: Data from Test #4 was not used as it was inconsistent, indicating measurement problems/errors.

United Irrigation District of Hidalgo County

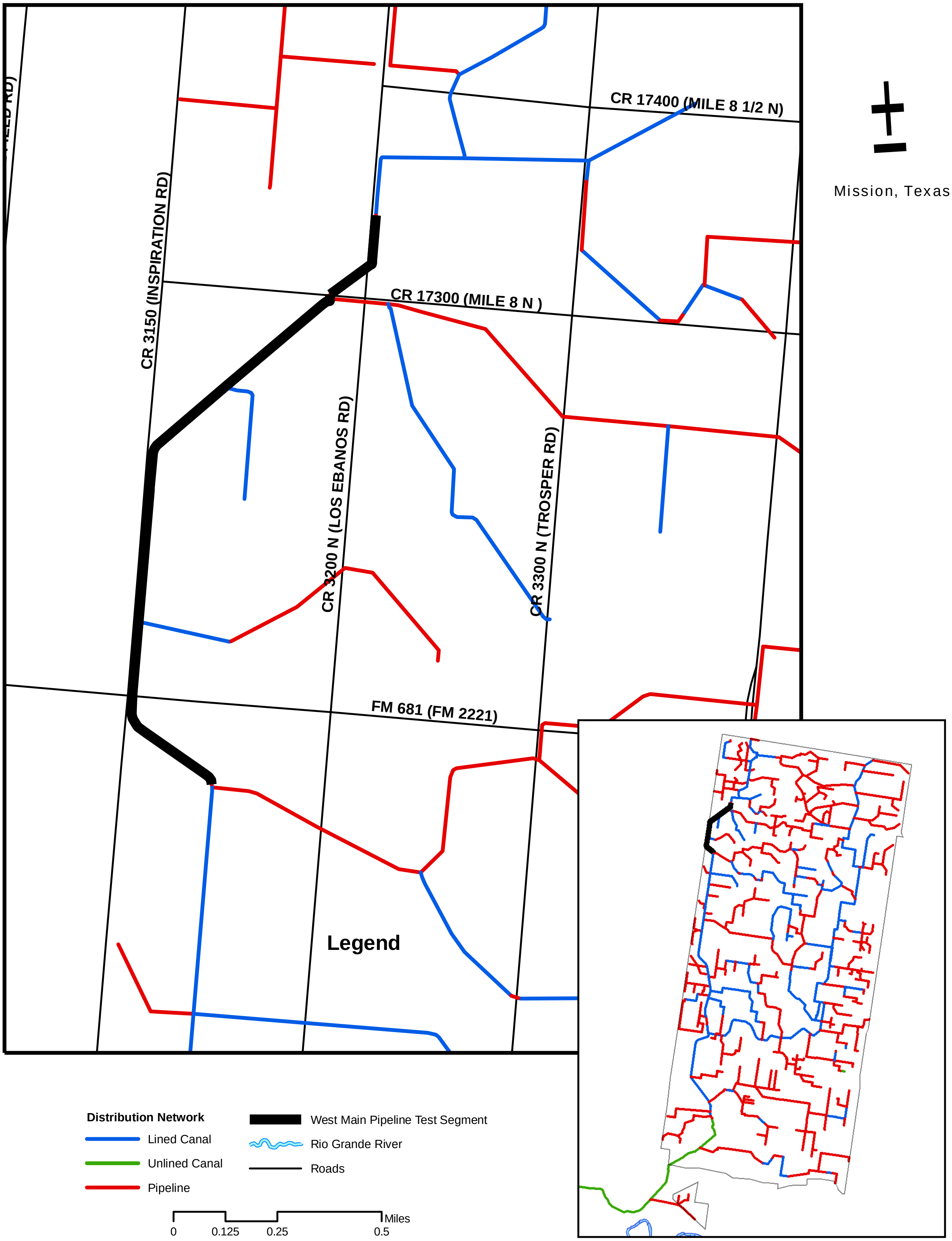

Figure 3. United Irrigation District map shows the location of the new West Main Pipeline section.

Pipeline Testing Procedures

The West Main Pipeline was tested using the ponding method, measuring the total water loss rate. The total loss test accounts for all leaks occurring from gates, valves, and pipeline joints that are either undetectable or are difficult to measure.

These tests were performed under the district's normal operating water levels. Once the pipeline was filled, all downstream check-gates and turnout valves were inspected for leaks.

After the head gate was shut, water surface elevations were measured at selected standpipe stations with a water sounding meter shown in Figure 4 and referenced to the inside top rim of the standpipe. Each test lasted between 2.5 to 4 hours, taking a measurement at 30 minute intervals (6-9 measurements per test).

Figure 4. Askar is shown here measuring the drop in water level with the sounding meter.

Our team was provided with basic design and attribute information on the new pipeline from the assigned engineering firm. Based on their data, we assumed several parameters:

- All box structure walls and ceilings are one foot thick;
- The 12 inch standpipe nor the box structure at station 1+20 was consider in the test segment due to the location of the head gate within the box structure;
- That all 12 inch standpipes due not extend past the inside ceilings of the box structures. Once the water level drops below the bottom of the standpipe the surface area and volume of the box structure as assumed (Figure 5).

Figure 5. Inside view of a 12 inch standpipe and box structure.

The box structures and selected standpipes were surveyed and referenced using a survey grade GPS instrument and a transit unit. The box structure elevations are based on an average of the GPS measurements on 3 or more corners (see Figure 6). Table 4 provides the survey measurements in Appendix A, and a foldout diagram of the pipeline is provided at the back of the report.

Figure 6. Showing an exposed box structure

Appendix A: Survey Measurements and Pipeline Diagram

Table 4. Structure Measurements and Elevations					
Structure	Station	Top Elevation	Ceiling Elevation	Interior Dimensions	Surface Area (ft^2)
Upstream Canal	0+00	196.717	-	-	-
Box Structure	1+20	193.769*	192.769	6.417 x 8.875 ft*	56.95
12” Standpipe	1+20	No survey	-	12” Diameter	0.79
30” Standpipe	2+07	201.927	-	30” Diameter	4.91
30” Standpipe	2+92	No survey	-	30” Diameter	4.91
30” Standpipe	8+00	No survey	-	30” Diameter	4.91
30” Standpipe	16+25	202.044	-	30” Diameter	4.91
30” Standpipe	17+25	No survey	-	30” Diameter	4.91
Box Structure	26+38	195.847*	194.847	5.000 x 8.083 ft*	40.42
12” Standpipe	26+38	201.784	-	12” Diameter	0.79
30” Standpipe	54+47	No survey	-	30” Diameter	4.91
30” Standpipe	55+47	No survey	-	30” Diameter	4.91
Box Structure	60+50	197.033*	196.033	5.385 x 8.063 ft*	43.42
12” Standpipe	60+50	205.054	-	12” Diameter	0.79
48” Standpipe	62+18	202.517	-	48” Diameter	12.57
30” Standpipe	65+62	No survey	-	30” Diameter	4.91
Box Structure	77+45	197.727*	196.727	7.400 x 9.000 ft*	65.46
12” Standpipe	77+45	204.456	-	12” Diameter	0.79
30” Standpipe	84+45	No survey	-	30” Diameter	4.91
Box Structure	90+00	194.121*	193.121	5.210 x 8.000 ft*	41.67
12” Standpipe	90+00	200.646	-	12” Diameter	0.79

* Elevations and interior dimensions are based on averages

Appendix B: Water Level Measurements

Table 5. Test 1 - Standpipe Water Level Measurements for the West Main Pipeline (March 24, 2004)

Reading #	**STA: 2+07**		**STA: 16+25**		**STA: 62+18**		**STA: 77+45**		**STA: 84+45**		**STA: 90+00**	
	Time	Water Level	Time	Water Level	Time	Water Level	Time	Water Level	Time	Water Level	Time	Water Level
1	-	-	9:26	13.74	9:31	13.72	9:44	13.56	9:36	12.61	09:38	12.55
9:50 Shut Upstream Gate												
2	10:20	12.53	10:31	12.18	10:41	11.87	10:48	11.57	10:56	11.41	10:54	11.43
3	11:54	10.53	11:59	10.47	11:40	8.77	-	-	-	-	-	-
4	-	-	-	-	13:14	6.77	-	-	13:37	8.79	13:41	8.72
5	14:51	7.16	14:51	7.09	-	-	-	-	15:10	6.75	15:06	6.78

Note: Water levels zeroed at elevation 182.000 (ft) from survey.

Table 6. Test 2 - Standpipe Water Level Measurements for the West Main Pipeline (May 21, 2004)

Reading #	**STA: 16+25**		**STA: 17+25**		**STA: 62+18**		**STA: 65+62**		**STA: 84+45**		**STA: 90+00**	
	Time	Water Level	Time	Water Level	Time	Water Level	Time	Water Level	Time	Water Level	Time	Water Level
1	9:26	12.27	9:29	12.27	9:38	11.91	9:40	11.91	9:44	11.61	9:46	11.48
2	9:57	11.25	9:58	11.30	10:07	10.92	10:09	10.94	10:13	10.63	10:16	10.51
3	10:26	10.35	10:29	10.40	10:36	10.13	10:38	10.14	10:42	9.86	10:45	9.74
4	10:51	9.72	10:59	9.66	11:08	9.37	11:11	9.37	11:15	9.13	11:17	9.03
5	11:26	9.00	11:29	9.04	11:36	8.80	11:41	8.79	11:45	8.50	11:48	8.43
6	11:55	8.41	11:59	8.48	12:10	8.04	12:13	8.00	12:17	7.69	12:20	7.57

Note: Water levels zeroed at elevation 182.000 (ft) from survey.

Table 7. Test 3 - Standpipe Water Level Measurements for the West Main Pipeline (July 30, 2004)												
Reading #	**STA: 16+25**		**STA: 17+25**		**STA: 62+18**		**STA: 65+62**		**STA: 84+45**		**STA: 90+00**	
	Time	Water Level	Time	Water Level	Time	Water Level	Time	Water Level	Time	Water Level	Time	Water Level
1	10:00	13.52	10:03	13.58	10:06	13.50	10:08	13.54	10:10	13.34	10:12	13.30
2	10:30	13.35	10:33	13.41	10:35	13.36	10:38	13.41	10:40	13.20	10:42	13.17
3	11:00	13.26	11:03	13.34	11:05	13.27	11:07	13.34	11:10	13.15	11:12	13.11
4	11:30	13.23	11:32	13.31	11:35	13.26	11:37	13.31	11:40	13.12	11:42	13.09
5	12:00	13.22	12:02	13.30	12:05	13.26	12:07	13.31	12:09	13.12	12:12	13.09
6	12:30	13.23	12:32	13.30	12:35	13.25	12:37	13.31	12:39	13.11	12:42	13.09

Note: Water levels zeroed at elevation 182.000 (ft) from survey.

Table 8. Test 5 - Standpipe Water Level Measurements for the West Main Pipeline (May 20, 2005)												
Reading #	**STA: 16+25**		**STA: 17+25**		**STA: 62+18**		**STA: 65+62**		**STA: 84+45**		**STA: 90+00**	
	Time	Water Level	Time	Water Level	Time	Water Level	Time	Water Level	Time	Water Level	Time	Water Level
1	13:00	13.43	13:00	13.36	13:03	13.31	13:05	13.30	13:07	13.10	13:08	13.44
2	13:30	13.13	13:31	13.26	13:33	13.11	13:35	13.20	13:37	13.00	13:38	12.94
3	14:00	13.04	14:02	13.07	14:04	13.01	14:06	13.10	14:08	12.90	14:09	12.84
4	14:30	12.93	14:31	13.07	14:34	12.97	14:35	13.06	14:37	12.86	14:39	12.80
5	15:00	12.89	15:00	12.96	15:03	12.91	15:04	13.00	15:06	12.80	15:08	12.80
6	15:30	12.83	15:31	12.86	15:38	12.87	15:39	12.90	15:44	12.80	15:45	12.74
7	16:00	12.83	16:01	12.86	16:04	12.87	16:06	12.90	16:08	12.76	16:10	12.70
8	16:30	12.79	16:31	12.86	16:33	12.81	16:34	12.90	16:36	12.71	16:38	12.65

Note: Water levels zeroed at elevation 182.000 (ft) from survey.

Table 9. Test 6 - Standpipe Water Level Measurements for the West Main Pipeline (August 4, 2006)												
Reading #	STA: 16+25		STA: 17+25		STA: 62+18		STA: 65+62		STA: 84+45		STA: 90+00	
	Time	Water Level	Time	Water Level	Time	Water Level	Time	Water Level	Time	Water Level	Time	Water Level
1	9:00	13.04	9:03	13.12	9:07	13.11	9:10	13.13	9:13	12.96	9:15	12.90
2	9:30	13.01	9:34	13.07	9:38	13.04	9:42	13.06	9:45	12.90	9:47	12.85
3	10:00	12.97	10:02	13.03	10:06	13.00	10:08	13.02	10:12	12.86	10:14	12.81
4	10:30	12.93	10:33	12.99	10:36	12.96	10:39	12.98	10:42	12.82	10:44	12.77
5	11:00	12.89	11:02	12.95	11:06	12.92	11:08	12.94	11:11	12.78	11:13	12.73
6	11:30	12.85	11:32	12.91	11:37	12.88	11:39	12.90	11:42	12.74	11:44	12.69
7	12:00	12.81	12:02	12.87	12:06	12.84	12:08	12.86	12:11	12.70	12:13	12.65
8	12:30	12.75	12:33	12.81	12:37	12.78	12:40	12.80	12:43	12.64	12:45	12.59
9	13:00	12.69	13:04	12.75	13:08	12.72	13:13	12.74	13:16	12.58	13:18	12.53

Note: Water levels zeroed at elevation 182.000 (ft) from survey.

Appendix C: Other Reported Seepage Rates and Water Loss Test Results

Texas Cooperative Extension has conducted approximately 50 total loss tests and seepage loss tests in the Lower Rio Grande River Basin since 1998. The results are summarized in Tables 10 – 12. Table 13 gives seepage rates versus lining type as reported in the scientific literature.

Table 10. Results of seepage loss tests conducted by Texas Cooperative Extension in the Lower Rio Grande River Basin.

Test ID	Year	Canal Width (ft)	Canal Depth (ft)	Class*	Loss Rate gal/ft2/day	Loss Rate ac-ft/mi/yr
Lined						
16HC2	03			M		
LF1	03	12	5	M	1.77	152.9
LF2	03	10	6	M	4.61	369.1
MA4	03	12	5	S	8.85	529.7
SJ4	00	15	4	M	1.17	111.2
SJ5	02	14	5	M	1.38	145.5
UN1	01	12	6	M	2.32	217.7
UN2	01	8	3	M	2.09	121.2
Unlined						
BR1	03	60	11	M	3.14	794.6
MA3	03	19	5	S	13.9	1690.1
RV1	03	38	4	M	0.15	23.0
SB4	02	16	4	S	0.64	68.3
SB5	02	18	3	S	1.67	188.3
SB6	02	20	5	S	1.44	189.0
SB7	02	16	4	S	0.42	47.4
SB8	02	20	5	S	0.83	104.0

*Classification of canal: M = main, S = secondary

Table 11. Results of total loss tests in lined canals (leaking gates and valves may have contributed to measured loss rates) conducted by Texas Cooperative Extension in the Lower Rio Grande River Basin.

Test ID	**Year**	**Canal Width (ft)**	**Canal Depth (ft)**	**Class***	**Loss Rate** gal/ft2/day	ac-ft/mi/yr
Lined						
16HC1	03	14	5	M	1.89	192.4
BV1	99	10	5	M	7.97	510.5
BV2	99	9	4	M	8.53	451.5
DL1	00	20	6	M	0.16	18.8
DL2	00	7	4	S	4.12	236.2
DO1	03	5	3	S	1.68	65.2
DO2	03	6	4	S	2.18	121.5
DO3	03	6	3	S	2.71	107.2
ED1	00	6	4	S	34.32	1519.6
ED2	00	6	4	S	21.5	858.2
ED3	00	3	2	T	10.22	308.2
ED4	00	4	3	S	18.72	567.7
ED6	99	9	4	M	8.53	451.5
HA2	00	10	4	M	2.26	135.2
HA3	98	15	2	S	0.64	45.5
ME1	98	38	7	M	1.26	281.9
ME2	98		4	M	1.88	163.5
SJ1	99	12	5	M	2.58	126.8
SJ6	03	12	3	M	1.88	1.63
SJ7	03	19	4	M	1.98	227.1
UN3	02	12	6	M	2.02	154.3

*Classification of canal: M = main, S = secondary, T = tertiary

Table 12. Results of total loss tests in unlined canals (leaking gates and valves may have contributed to measured loss rates) conducted by Texas Cooperative Extension in the Lower Rio Grande River Basin.						
Test ID	**Year**	**Canal Width (ft)**	**Canal Depth (ft)**	**Class***	**Loss Rate**	
					Gal/ft2/day	**ac-ft/mi/yr**
BV3	99	55	8	M	0.15	53.4
ED5	02	105	7	M	2.39	1213.2
MA1	99	50	10	M	1.98	227.1
MA2	99	20	5	S	4.32	371.4
SB1	00	29	7	S	1.27	215.5
SJ2	00	23	6	M	2.74	293.2
SJ3	00	30	5	S	0.95	132.6

*Classification of canal: M = main, S = secondary

Table 13. Canal seepage rate reported in published studies.

Lining/soil type	**Seepage rate (gal/ft^2/day)**
Unlined[1]	2.21-26.4
Portland cement[2]	0.52
Compacted earth[2]	0.52
Brick masonry lined[3]	2.23
Earthen unlined[3]	11.34
Concrete[4]	0.74 - 4.0
Plactic[4]	0.08-3.74
Concrete[4]	0.06-3.22
Gunite[4]	0.06-0.94
Compacted earth[4]	0.07-0.6
Clay[4]	0.37-2.99
Loam[4]	4.49-7.48
Sand[4]	4.0-19.45

[1] DeMaggio (1990). Technical Memorandum: San Luis unit drainage program project files. US Bureau of Reclamation, Sacramento. [2] U.S. Bureau of Reclamation (1963). Lining for Irrigation Canals. [3] Nayak, et al. (1996). The influence of canal seepage on groundwater in Lugert Lake irrigation area. Oklahoma Water Resources Research Institute. [4] Nofziger (1979). Profit potential of lining watercourses in coastal commands of Orissa. Environment and Ecology 14(2):343-345.

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United Irrigation District

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IRRIGATION TECHNOLOGY CENTER
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West Main Pipeline Diagram

(not to scale)