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Farm Turnout Flow Recommendations for New Outlets in Cameron County Irrigation District No. 2

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FARM TURNOUT FLOW RECOMMENDATIONS FOR NEW OUTLETS

IN
CAMERON COUNTY
IRRIGATION DISTRICT NO.2

Rio Grande Basin Initiative
Irrigation Technology Center
Texas Water Resources Institute
Texas AgriLife Extension Service

Farm Turnout Flow Recommendations

for New Outlets in

Cameron County Irrigation District No. 2[1]

A Report prepared for the

Bureau of Reclamation
Cameron County Irrigation District No. 2

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by

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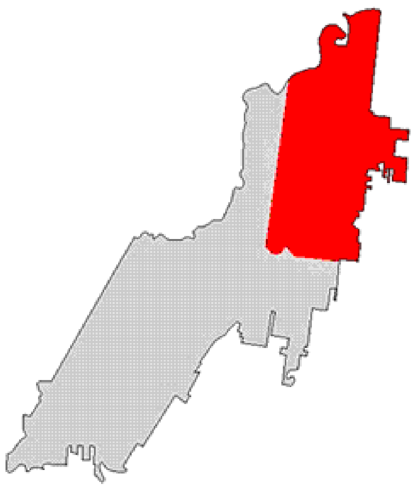
Introduction



The Bureau of Reclamation requested recommendations on flow rates and capacity requirements of new farm turnouts in Cameron County Irrigation District No. 2.

These outlets are being designed as part of a rehabilitation project which is replacing unlined canals with new underground pipelines in the portion of the district shown.

The pipeline replacement project includes the following canals: 23, 25, 27, 31, 33, 35, 37, 39, 52, 52 B-North, 52 B-South, 52 C, 55 and 56 (see Figure A-1 for map of canals).

This report provides recommendations in terms of flow rate per furrow (or row), and total flows as a function of the number of irrigation sets.

The next step is to compare these outlet flow rates to the total flow available in this portion of the district. The data in this report then can help in the:

(1) sizing the flow capacity of each farm turnout, and
(2) determining any need for rotation between fields on the same lateral under less than optimal water supply conditions.

Procedures Used

Outlet flow recommendations were developed in a 6-step process as summarized below. Details on each step are provided in the Appendix of this report.

Step 1: Determine the soil series and area of coverage for fields served by each canal.
Step 2: Determine intake curves for the soil series in the project area.
Step 3: Determine typical furrow lengths in the project area.
Step 4: Based on soil series and furrow length, determine the flow rate at the turnout that produces the maximum distribution efficiency.
Step 5: Determine the maximum irrigation volume (inches per application) based on soil series and soil replacement depth.

Step 6: Determine the maximum irrigation interval (days between irrigations) possible without introducing plant water stress.

In developing these recommendations, we relied upon design guidelines developed by the Natural Resources Conservation Service as reported in the NRCS Engineering Field Manual. These guidelines were developed specifically for the Lower Rio Grand Valley. For combinations of flow rate and soil group, these guidelines give the ***time of application*** (time for water to reach the end of the furrow) and the corresponding ***distribution efficiency***.

Flow recommendations are also based on the following design parameters:

- " The predominant furrow length in the project area is 1200 feet.
- " The most common field size is 33 acres.
- " Each irrigation (net application) is about 4.5 inches.

Recommended Outlet Flow Rates

The optimal outlet flow rate is 50 gpm per furrow. This flow rate provides the highest efficiency possible on the four soil types in the project area (Table 1). Additional details and results are provided in the Appendix of this report.

As detailed in Table A-1, a large portion of the project area has a soil type of Lyford sandy clay loam. Furrow irrigation on these soils are inheritly inefficient. Gorwers should be encourged to try surge flow irrigation or move to sprinkler and/or drip irrigation on these fields.

Table 1. Irrigation parameters of the four soils in the project areas associated with an furrow stream of 50 gpm and a furrow length of 1200 ft based on NRCS design guidelines.

Soil	Intake Curve number	Water Holding Capacity (in/ft)	Mositure replacement depth (ft)	Net Application (in)	Time of Application (hours)	Distribution Efficiency (%)	Gross Appli-cation (in)
Raymondville clay loam	0.3	1.8	4	3.6	4.2	90	4.0
Raymondville clay loam, saline	0.3	1.8	4	3.6	4.2	90	4.0
Lozano fine sandy loam	0.3	1.8	5	4.5	4.2	90	5.0
Lyford sandy clay loam	0.5	2.0	5	4.5	4.7	80	5.6

Tables 2 and 3 give total time it would take to irrigated a typical 33 acre field for outlet flow rates ranging from 1200 to 18,000 gpm.

Small flow rates increase the total time needed to complete an irrigation. For example, an outlet flow rate of 1800 gpm is commonly used in the region. However, at this flow rate, it would take 38 hours and require 10 irrigation sets to irrigate a 33-acre field with a net irrigation of 4.5 inches (see Table 2). At the other extreme, if 18,000 gpm could be supplied at the farm turnout, then a 33-acre field could be irrigated in a single set in about 4.2 hours.

However, it is unlikely that the distribution network will be designed to supply 18,000 gpm to each field. ***Our recommendation is to provide the highest turnout flow possible, and to provide no less than 2400 gpm.***

Table 2. Options for flow rates of farm turnouts and corresponding time required to apply 4.5 inches (net irrigation) on a typical 33-acre field with furrow lengths of 1200 ft for soils with a curve number of 0.3.

Flow at turnout (gpm)	**Irrigation set width (ft)***	**Number of irrigation sets**	**Hours to irrigate a 33 acre field**
1200	80	15	52.5
1800	120	10	37.6
2400	160	8	30.1
3600	240	5	21.0
4500	300	4	18.8
9000	600	2	7.5
18000	1200	1	4.2

* assuming every furrow is irrigated and 40-inch rows and providing 50 gpm/row

Table 3. Options for flow rates of farm turnouts and corresponding time required to apply 4.5 inches (net irrigation) on a typical 33-acre field for a Lyford Clay Loam (curve number of 0.5) and a furrow length of 1200			
Flow at turnout (gpm)	**Irrigation set width (ft)***	**Number of irrigation sets**	**Hours to irrigate a 33 acre field**
1200	80	15	63.8
1800	120	10	42.5
2400	160	8	30.0
3600	240	5	21.3
4500	300	4	17.0
9000	600	2	9.4
18000	1200	1	4.7

* assuming every furrow is irrigated and 40-inch rows and providing 50 gpm/row

Lower Outlet Flow Rates

Providing less than 50 gpm/row will increase irrigation times and decrease efficiency as shown in Table 4. An alternative is to encourage furrow lengths to be shorten to 1000 ft. As shown in Table 5, 1000 ft furrow length significantly reduces the time to complete an irrigation set.

Note for use of Tables 4 and 5:

" to determine total outlet capacity, the number of rows in each irrigation set is multiplied time the gpm/row;

" to determine the time to irrigate a 33 acre field, the time of application is multiplied by the number of irrigation sets.

Table 4. Irrigation time and efficiencies for furrow lengths of 1200 ft and a net irrigation of 4.5 inches.

Soil Curve Number Group	gpm/row	Time of application (hours)	Distribution Efficiency (%)
0.3	50	4.2	90
	40	5.2	89
	30	7.1	88
	20	11.2	86
0.5	50	4.7	80
	40	5.9	79
	30	8.2	77

Table 5. Irrigation time and efficiencies for furrow lengths of 1000 ft and an application of 4.5 inches.

Soil Curve Number Group	gpm/row	Time of application (hours)	Distribution Efficiency (%)
0.3	50	3.5	91
	40	4.3	91
	30	5.9	89
	20	9.2	87
0.5	50	3.8	82
	40	4.8	81
	30	6.6	79

APPENDIX: DETAILS ON PROCEDURES AND ANALYSIS

Step 1: Determine the soil series and area of coverage for fields served by each canal.

A Geographical Information System (GIS) was created of the project area which included the canals, fields boundaries and tables of attributes. A digitized NRCS soil survey of the project area was then imported into the GIS. Using various analysis tools, we next determined the percent of land (total area) covered by each soil series (Table A-1).

Table A-1. Percentage Area of Soil Series Served by Each Canal.

Canal	**Soil Curve Number 0.3**			**Soil Curve Number 0.5**
	RE	**RG**	**LR**	**LY**
23	50%	50%		
25	50%			50%
27	67%			33%
31	20%		50%	30%
33	67%		33%	
35			42%	58%
37			50%	50%
39			100%	
52	31%		17%	52%
52 B-North	57%		13%	30%
52 B-South	33%		6%	61%
52 C	33%			67%
55	72%			28%
56	72%			28%

RE = Raymondville clay loam RG = Raymondville clay loam, saline
LY = Lyford sandy clay loam LR = Lozano sandy loam

Cameron County Irrigation District No. 2

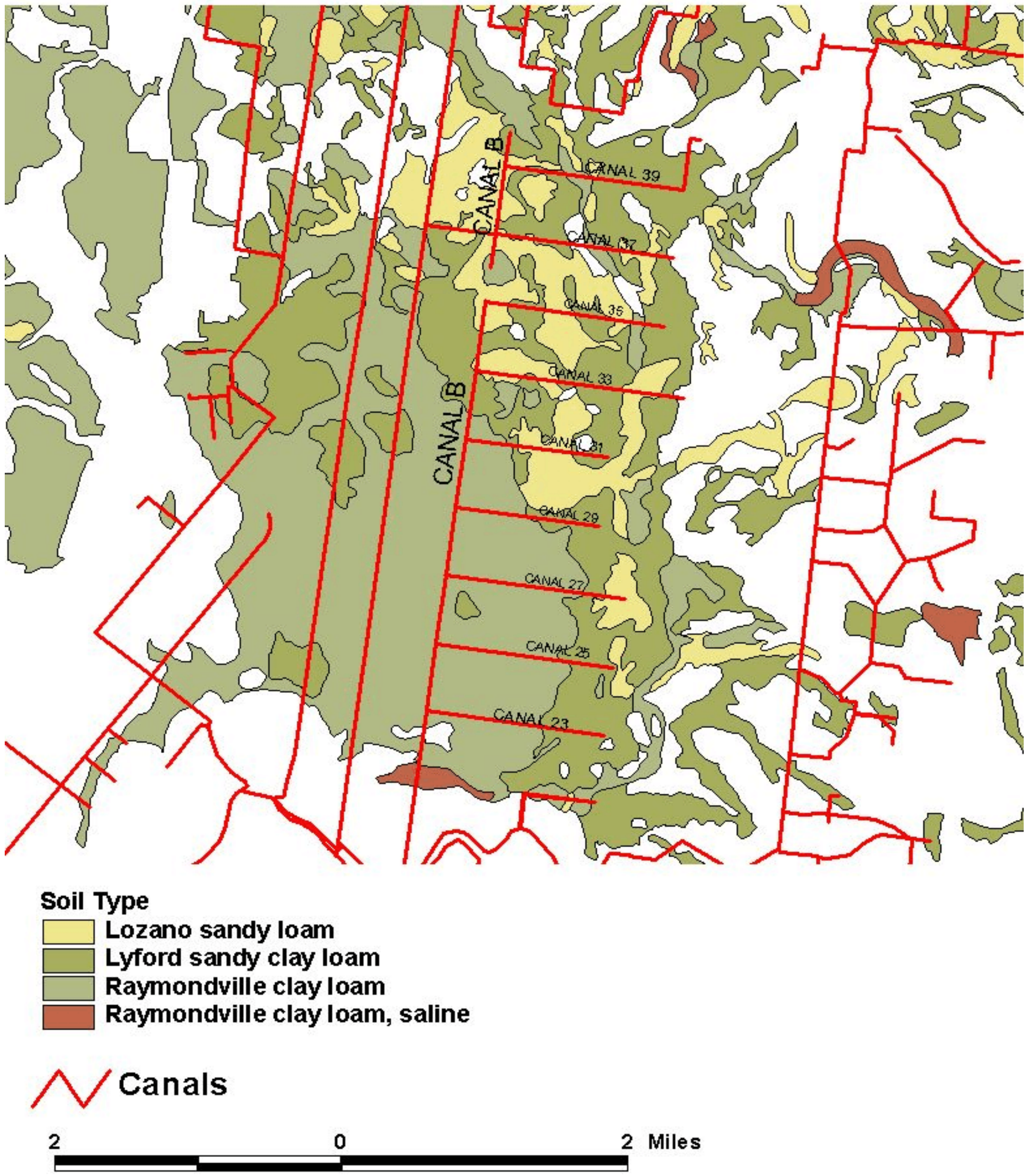


Figure A-1. Canals in the project area overlaid onto the soil series map.

Step 2. Determine intake curves for the soil series in the project area.

The four soil series in the project area fall into two *soil intake families* or two *soil intake curve numbers* (Table A-2). Soils in each families have similar hydraulic properties. A grouping of canals with similar portions of each soil series is as follows:

Canal Soil Group I - Canals 23, 33, and 39

Soils irrigated by this canal are in the hydrological group containing approximately:
- 100% Raymondville clay loam, Raymondville clay loam (saline), and Lozano sandy loam
- 0% Lyford sandy clay loam

Canal Soil Group II - Canals 27, 31, 52 B-North, 55, and 56

Soils irrigated by this canal are in the hydrological group containing approximately:
- 70% Raymondville clay loam, Raymondville clay loam (saline), and Lozano sandy loam
- 30% Lyford sandy clay loam

Canal Soil Group III - Canals 25, 35, 37, 52, 52 B-South, and 52C

Soils irrigated by this canal are in the hydrological group containing approximately:
- 50% Raymondville clay loam, Raymondville clay loam (saline), and Lozano sandy loam
- 50% Lyford sandy clay loam

Table A-2. Soil Intake Curves.

Soil	Intake curve (in/hr)
Raymondville clay loam	0.3
Raymondville clay loam (saline)	0.3
Lyford sandy clay loam	0.5
Lozano sandy loam	0.3

Step 3. Determine typical furrow lengths in the project area.

Based on an analysis of field sizes, we determined that the areas served by canals 23 and 31 were representative of the entire project area. The field sizes, widths and lengths of each account on these canals are given in Tables A-3 and A-4. NRCS uses specific furrow length groups for design purposes as shown (*Engineering Field Manual* published by the NRCS in April 1983). The predominant furrow length in the project area is 1200 ft. Below is a map of the project area with field boundaries overlaid onto an aerial photograph.

Table A-3. Furrow Lengths of Fields Served by Canal 23 and Corresponding NRCS Furrow Length Groups.

Field ID	Acres	Width (ft)	Furrow Length	NRCS Furrow Length Group	% Area of Furrow Length Group
17320-1	2.62	302	571	400-600	2.8%
10144-1	6.40	594	574	400-600	
22015-1	8.07	587	653	600-800	8.6%
17330-1	10.25	607	758	600-800	
17250-3	9.78	554	794	600-800	
4970-1	6.58	381	801	800-1000	2.0%
4810-1	15.36	623	1112	1000-1200	53.5%
22290-1	23.25	1070	1125	1000-1200	
15990-1	5.36	262	1132	1000-1200	
17250-5	15.00	617	1138	1000-1200	
3460-1	33.19	1263	1158	1000-1200	
5160-7	25.08	958	1171	1000-1200	
5160-6	34.38	1266	1181	1000-1200	
21647-19	6.47	243	1188	1000-1200	
20571-1	16.43	669	1198	1000-1200	
21647-21	17.16	636	1201	1200-1320	33.0%
21647-20	35.44	1302	1214	1200-1320	
21211-1	8.55	325	1217	1200-1320	
17250-4	36.95	1526	1220	1200-1320	
3460-6	9.67	361	1280	1200-1320	
TOTALS	326.00				99.90%

Table A-4.Furrow Lengths of Fields Served by Canal 31 and Corresponding NRCS Furrow Length Groups.

Field ID	Acres	Width (ft)	Furrow Length	NRCS Furrow Length Group	% Area of Furrow Length Group
16323-1	5.13	240	912	800-1000	1.5%
9130-22	5.29	213	1161	1000-1200	7.7%
15930-1	5.86	249	1184	1000-1200	
7150-2	14.61	587	1188	1000-1200	
932-2	8.36	302	1204	1200-1320	90.1%
3190-12	35.70	1293	1217	1200-1320	
8290-1	34.22	1240	1217	1200-1320	
950-1	7.92	295	1220	1200-1320	
530-2	15.64	594	1224	1200-1320	
12715-3	15.98	581	1227	1200-1320	
1900-2	18.35	656	230	1200-1320	
20330-2	17.27	633	1247	1200-1320	
5160-11	35.86	1257	1260	1200-1320	
12153-1	6.70	256	1270	1200-1320	
10240-1	9.61	390	1273	1200-1320	
19730-1	8.41	325	1276	1200-1320	
10260-1	23.07	804	1280	1200-1320	
9790-1	5.01	190	1283	1200-1320	
14843-1	8.60	292	1289	1200-1320	
8051-1	16.92	591	1293	1200-1320	
21647-43	36.25	1243	1299	1200-1320	
TOTALS	334.75				99.3%

Step 4. Based on soil series and furrow length, determine the flow rate at the turnout that produces the maximum distribution efficiency.

Using the design guidelines of the 1983 NRCS *Engineering Field Manual*, *Appendix B*, we determined that a flow rate of 50 gpm/row produces the maximum on-farm irrigation efficiency. These guidelines were specifically developed for furrow irrigation in the Harlingen area of the Lower Rio Grande Valley of Texas. We also used the following assumptions in our analysis:

" 40" spacing between furrows
" every row (or furrow) is irrigated
" application volumes replenish soil moisture to the replacement depth recommended by the NRCS.

Step 5. Determine the maximum irrigation volume (inches per application) based on soil series and soil replacement depth.

Soil Moisture Holding Capacity and Soil Moisture Replacement Depth values were taken from the NRCS *Engineering Field Manual* (see Table 1).

Step 6. Determine the maximum irrigation interval (days between irrigations) possible without introducing plant water stress.

The peak daily consumptive use of major crops likely to be grown in the project area (excluding sugar cane) were taken from *Consumptive Use of Water by Major Crops in Texas*, *Bulletin 6019* (Texas Board of Water Engineers, November 1960). Sugarcane consumptive use was determined using FAO crop coefficients and average monthly ETo rates taken from the web-site http://texaset.tamu.edu. Table A-5 shows these values.

Corn has the highest consumptive use, followed closely by sugar cane. During the peak consumptive use periods, each field must be irrigated before soil moisture levels become critical (Table A-5). The longest allowable intervals between irrigations are for fields receiving the recommended net application of 4.5 inches (composed of the Lozano and Lyford soils). The shortest allowable intervals are for fields composed of the Raymond soils which have a recommended net application of only 3.6 inches.

Note: applying more water than these amounts will not benefit the crop, but only be lost through deep seepage and/or runoff.

Table A-5. Peak consumptive use of major crops grown in the project area and maximum interval between irrigations.			
Crop	**Peak Consumptive Use (in/day)**	**Maximum irrigation interval (days between irrigation)**	
		4.5 inch application	**3.6 inch application**
Perennial Pasture	.25	18.4	14.4
Corn	.32	14.1	11.3
Cotton	.23	19.6	15.7
Sugarcane	.31	14.5	11.6

<u>Sample Calculations - Peak Consumptive Use</u>

(1). Maximum average historic ET_o in Brownsville is 7.59 in/month or 0.245 in/day.

(2). Peak FAO Crop Coefficient (Kc) for sugarcane is 1.25.

(3). Peak Consumptive Use = (Max. PET) x (Kc)

= (0.245 in/day) x (1.25) = 0.31 in/day

<u>Sample Calculation - Irrigation Interval</u>

Irrigation Interval = (Net Irrigation) ÷ (Peak Consumptive Use)

= (4.5 inches) x ÷ (0.31 in/day) = 14.5 days

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