Flow Measurement
for Rehabilitation Planning

Report Prepared for
Cameron County Irrigation District No. 2
by
Eric Leigh and Guy Fipps
November 22, 2002

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Assistance Requested

Cameron County Irrigation District No. 2 (CCID2) contracted with the Bureau of Reclamation to complete a project plan for rehabilitation of a portion of the district as shown on the right. The district plans on replacing earthen canals with pipelines in this area.

The Bureau of Reclamation requested our assistance in obtaining data and conducting measurements to support this project. This report summarizes the portion of this study relating to the determination of flow rates in existing canals and at specific location of the irrigation water distribution system.

Measurement Methods

Flows were measured in four canals using a current meter and at 14 farm turnouts using propeller flow meters by Eric Leigh and Martin Barroso of Texas Cooperative Extension (TCE) and Freddie Ortega of CCID2.

Current-meter measurements were taken at the inlets of canals B, C, 13, and lateral 33. Propeller flow meter measurements were taken of farm turnout valves in canals 23, 25, 27, 33, 35, 39, C, E, 52-B, 52-C, 13-A, and 13-A1 (see map).

Current Meter Measurements

Current-meter (velocity) readings were taken along the cross-section of canals B, C, 13, and at the inlet structure of lateral 33. Equipment used was a Price Type AA current meter (model 1220) with conventional round wading rod, and a Scientific Instruments model CMD 9000 digimeter.

We followed USGS recommended procedures, and used both the two-point and the six-tenths-depth methods in measuring mean velocities in a vertical line. The two-point method was used in canals sections with a water depth greater than 2 feet. For canals with a water depth 2 feet or less, the six-tenths-depth method used.

Table 1 gives the average flows rates calculated with the USGS midsection method. Table 2 gives the flow rates calculated using all three USGS methods. Detailed data sets on each canal section and velocity measurements are given in Tables A1- A4.
Table 1: Canal identifications, attributes and flow calculated using the USGS midsection method from velocity meter measurements.

<table>
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<tr>
<th>Canal</th>
<th>Width (ft)</th>
<th>Avg. Depth (ft)</th>
<th>Area (ft²)</th>
<th>Avg. Velocity (FPS)</th>
<th>Total Discharge</th>
<th>Head*</th>
<th>Turns on Gate**</th>
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* corresponding head based on the relationship 1 head = 3 CFS  
**corresponding “turns of the gate” based on 4 turns = 1 head.

Table 2: Canal flow rates (CFS) calculated using three USGS current-meter discharge computation methods from velocity meter measurements.

<table>
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<th>Method</th>
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<th>Canal C</th>
<th>Canal 13</th>
<th>Lateral 33</th>
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USGS Calculation Methods

According to the U.S. Bureau of Reclamation Manual (Chapter 10, section 31-32):

Simpson's parabolic rule method is particularly applicable to river channels and old canals that have cross sections conforming in a general way to the arc of a parabola or to a series of arcs of different parabolas. Simpson's method requires equally spaced verticals. The simple average and the midsection methods do not require equally spaced verticals. Thus, these two methods are well suited to computing discharges in canals that conform closely to their original trapezoidal rectangular shapes.
Notes, discussions and photographs

Canal B

Flow in canal B was measured 65 yards downstream of the main head gates of Canal A (Figure 1). Measurements were taken on the upstream side of a culvert (Figure 2). Before the test could begin, a CCID2 maintenance crew helped remove excessive amounts of aquatic vegetation clogging canal B’s inlet. The detailed data (Table A-1) clearly shows that the aquatic vegetation drastically hinders flow in the upper portion of the canal cross-section.

Figure 1. Head gate inlet into canal B (one operational gate).
Figure 2. Culvert clogged by aquatic vegetation (Water Hyacinth)

Canal C

Figure 3 shows the culvert downstream of the head gates of canal C, located at Nelson Road and Line 20, at which flow measurements were taken.

Figure 3. Canal C’s flow measurement location.
Canal 13

While measuring flow in canal 13, the canal rider informed us that he was unable to produce a water level equal to normal or maximum operating conditions in the canal due to low water use downstream. As a result, flow measurements were taken with a water level of 1.5 ft. This represents 37% of canal’s capacity based on the high water level marking of 4 ft.

![Image](Canal_13.jpg)

**Figure 4.** Canal 13’s flow measurement location.

Flow Measurement Problems

We attempted to measure velocities with the current meter in the following canals and laterals: 23, 25, 27, 31, 35, 37, 39, 52, 52-B, 52-C, 55, 56, and E. However, this method of flow measurement proved to be very difficult due to inconsistent (unstable) flows, dead-end flows (with no irrigation occurring), and the lack of control structures. For example, Figure 5 shows the inlet to canal E. This inlet has no control gates to regulate downstream flow. Head levels of canal E are maintained and controlled by the inflows to canal C and through other withdraws in system.
Propeller Meter Measurements

As discussed above, it was difficult to impossible to obtain current meter readings in the remaining canals of interest. As an alternative, we measured the flows at selected farm turnout valves using propeller flow meters. A vertical propeller flow meter calibrated for 14-inch pipes was obtained from San Benito Irrigation District and was used along with an in-line saddle flow meter. Table 3 summarizes the farm turnout flow data. The map shows the locations where these measurements were obtained. A standard survey transit was used to obtain elevations.

Figure 5. Inlet to Canal E from Canal C.

Figure 6. Typical 14-inch *Fresnos* alfalfa valve used in the district.
Figure 6. Vertical flow meter ready to measure farm outlet.

Figure 7. A typical 15-inch steel pipe feeding a black poly-riser, usually fitted with a 12-inch pipe outlet feeding into poly-pipe.
Figure 8. Recording flows with in-line saddle propeller meter.

Figure 9. A box head gate situation that typically occurs at the beginning of a canal or after a road crossing. This controls downstream, levels and supplies usually two farm turnouts.
Figure 10. Root-gate usually made of wood.

Figure 11. Farm turnout valve at canal 27 and B.
Table 3: Measured Farm Turnouts (valves are 14 inch in diameter).

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A) Water level elevation above valve  
B) High-water mark elevation above valve
## Appendix

Table A-1. Canal B - Current-meter field notes and computations using the midsection method.

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<th>Revolutions</th>
<th>Time in seconds</th>
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<th>Avg. Velocity</th>
<th>Total Area</th>
<th>Total Discharge</th>
</tr>
</thead>
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<td>GPM × 448.8</td>
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</tr>
<tr>
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<td>HEAD ÷ 3</td>
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Table A-2. Canal C - Current-meter field notes and computations using the midsection method.

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<th>Dist. from initial point (in)</th>
<th>Width (ft)</th>
<th>Measuring Point (in)</th>
<th>Depth (ft)</th>
<th>Observation</th>
<th>Revolutions</th>
<th>Time in seconds</th>
<th>VELOCITY (FPS) At Point</th>
<th>Mean Avg</th>
<th>Area (ft²)</th>
<th>Discharge (cfs)</th>
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</tr>
</tbody>
</table>

Avg. Velocity: 0.574

Total Area: 54.129

Total Discharge: 30.914

GPM × 448.8: 13874

HEAD ÷ 3: 10.305

---

Table A-3. Canal 13 - Current-meter field notes and computations using the midsection method.

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<tr>
<th>Section</th>
<th>Dist. from initial point (in)</th>
<th>Width (ft)</th>
<th>Measuring Point (in)</th>
<th>Depth (ft)</th>
<th>Observation</th>
<th>Revolutions</th>
<th>Time in seconds</th>
<th>VELOCITY (FPS) At Point</th>
<th>Mean Avg</th>
<th>Area (ft²)</th>
<th>Discharge (cfs)</th>
</tr>
</thead>
<tbody>
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<td>0.900</td>
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<td>40.1</td>
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</table>

Avg. Velocity: 1.966

Total Area: 19.054

Total Discharge: 20.355

GPM × 448.8: 9135.1

HEAD ÷ 3: 6.785

---

Top Width: 12.75 ft

Total Depth: 4.5 ft

High Water Mark: 4.0 ft
Table A-4. Canal 33 – Current-meter field notes and computations using the midsection method.

<table>
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<tr>
<th>Section</th>
<th>Dist. from initial point (m)</th>
<th>Width (ft)</th>
<th>Measuring Station (ft)</th>
<th>Depth (ft)</th>
<th>Observation</th>
<th>Revolutions</th>
<th>Time in seconds</th>
<th>VELOCITY (FPS)</th>
<th>Area (ft²)</th>
<th>Discharge (cfs)</th>
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Avg. Velocity 0.9061
Total Area 6.25
Total Discharge 5.6633
GPM × 448.8 2542
HEAD ÷ 3 1.8878